

AGRICULTURAL POLICY / ENVIRONMENTAL EXTENDER MODEL



USER'S MANUAL
VERSION 1501

NOVEMBER 2023

AGRICULTURAL POLICY/ENVIRONMENTAL EXTENDER MODEL

USER'S MANUAL

VERSION 1501

E.M. STEGLICH¹, J. OSORIO², L. DORO², J. JEONG²,
AND J.R. WILLIAMS²

NOVEMBER 2023



¹NATURAL RESOURCES CONSERVATION SERVICE
808 EAST BLACKLAND ROAD ♦ TEMPLE, TEXAS 76502

²BLACKLAND RESEARCH AND EXTENSION CENTER
720 EAST BLACKLAND ROAD ♦ TEMPLE, TEXAS 76502

CONTENTS

THE APEX MODEL—USER'S MANUAL

CHAPTER 1

OVERVIEW	9
1.1 Master File (APEXFILE.DAT)	12

CHAPTER 2

INPUT FILES	16
2.1 APEX Run File (APEXRUN.DAT)	16
2.2 The APEX Control File (APEXCONT.DAT)	18
2.3 The APEX Site Files (FILENAME.SIT)	34
2.4 The APEX Site List (SITE****.DAT)	38
2.5 The Subarea File (FILENAME.SUB)	40
2.6 APEX Subarea List File (SUBA****.DAT)	64
2.7 The Soil Files (FILENAME.SOL)	66
2.8 The APEX Soil List File (SOIL****.DAT)	76
2.9 The Operation Schedule Files (FILENAME.OPS)	78
2.10 APEX Operation Schedule List File (OPSC****.DATA)	88
2.11 DAILY Weather Files (FILENAME.DLY)	90
2.12 The Daily Weather List File (WDLST****.DAT)	94
2.13 The Monthly Weather Files (FILENAME.WP1)	96
2.14 The APEX Monthly Weather Data List (WPM1****.DAT)	100
2.15 The Wind Data File (FILENAME.WND)	102
2.16 The Wind Data List File (wind.dat)	106
2.17 The Tillage File (TILL****.DAT)	108
2.18 The Crop File (CROP****.DAT)	114
2.19 The Fertilizer File (FERT****.DAT)	130
2.20 The Pesticide File (PEST****.DAT)	134
2.21 The APEX Multi-run File (MLRN****.DAT)	136
2.22 The APEX PARM File (PARM****.DAT)	138
S-curve parameter definitions	138
PARM definitions	142
2.23 The Print File (PRNT****.DAT)	153
2.24 The Herd File (HERD****.DAT)	163
2.25 The Point Source List File (PSO****.DAT)	167
2.26 The Point Source File (FILENAME.PSO)	169
2.27 The Within-Storm Rainfall List File (RFDT****.DAT)	171
2.28 The Within-Storm Rainfall File (FILENAME.HLY)	173
2.29 The APEX Dimension File (APEXDIM.DAT)	175

CHAPTER 3

OUTPUT DATA VARIABLES.....	177
3.1 *.SUS – Subarea Summary File	177
3.2 *.WSS – Watershed Summary File	178
3.3 *.SPS – Pesticide Subarea Summary File	180
3.4 *.SWN – Special WAtershed Summary for NRCS Farm Planning File	180
3.5 *.SCX – Summary Soil Organic Carbon and Nitrogen File	180
3.6 *.STR – Summary of Subareas and Watershed for NRCS STAR Tool	181
3.7 *.SAO – Special Subarea File for GIS	182
3.8 *.RCH – Special Reach File for GIS	185
3.9 *.ASA – Annual Subarea File	187
3.10 *.AWS – Annual Watershed Outlet File	188
3.11 *.ACY – Annual Subarea Crop Yield File	188
3.12 *.MAN – Special Manure Management Summary File	189
3.13 *.ACN - Annual Soil Organic Carbon and Nitrogen File	191
3.14 *.SWT – Watershed Output to SWAT	192
3.15 *.AWP – Annual CEAP File	192
3.16 *.APS – Annual Pesticide File	193
3.17 *.ACO – Annual Cost File	194
3.18 APEXBUF.OUT – Special File for Buffer Strips	194
3.19 *.MSA – Monthly Subarea File	195
3.20 *.MWS – Monthly Watershed File	197
3.21 *.MSW – Monthly Output to SWAT	198
3.22 *.DPS – Daily Subarea Pesticide File	198
3.23 *.SAD – Daily Subarea File	199
3.24 *.DRS – Daily Reservoir File	200
3.25 *.DWS – Daily Watershed Outlet File	200
3.26 *.DGZ – Daily Grazing File	201
3.27 *.DUX – Daily Manure Application File	201
3.28 *.DDD – Daily Dust Distribution	202
3.29 *.DCN – Daily Soil Organic Carbon and NItrogen File	202
3.30 *.EFR – Runoff Event Flood Routing File	203
3.31 *.EHY – Runoff Event Hydrographs File	203
3.32 *.DPW – Daily Watershed Pesticide File	207
3.33 *.DHY – Daily Subarea Hydrology File	207
3.34 *.DMR – Daily Watershed Nutrient and Sediment Concentration	208
3.35 *.MRH – Monthly Reach File	208
3.36 *.MGZ – Monthly Grazing File	208
3.37 *.DNC – Daily Nitrogen/Carbon Cesar Izaurralde	208
3.38 *.DHS – Daily Hydrology/Soil	208
3.39 *.SW4 – Daily Output For Selected Command #'s (From .SIT)	208
3.40 *.DGN – Daily General OUtput (VAR After Command Loop in BSIM)	209
3.41 *.DPD – Daily Paddy Output	209

CHAPTER 4

APEX OUTPUT ANALYZER.....	210
4.1 <i>Failed runs</i>	210
4.2 <i>Problems that may or may not cause failed run.....</i>	210
4.3 <i>Problems that cause near 0 crop yield.....</i>	211
4.4 <i>General problems</i>	211
4.5 <i>Completed runs--examine *.OUT files</i>	211
Preliminary investigation.....	211
Runoff problems--things to check	211
4.6 <i>APEX****.out (The detailed simulator output file).....</i>	215

CHAPTER 5

VALIDATION	216
5.1 <i>Validation of Crop Yields</i>	216
5.2 <i>Model Adjustment for Validating Runoff and Sediment Losses</i>	218
Method 1: For the Layman User.....	218
Method 2: For the Technical User	219

APPENDICES.....	222
<i>Appendix A—Manning's N Surface Roughness (UPN).....</i>	223
<i>Appendix B—Routing Reach & Channel Manning's N (RCHN & CHN).....</i>	224
<i>Appendix C—APEX publications</i>	225
<i>Appendix D—APEX Balances Variable Definitions</i>	231

REFERENCES	236
-------------------------	------------

CHAPTER 1

OVERVIEW

APEX is a tool for managing whole farms or small watersheds to obtain sustainable production efficiency and maintain environmental quality. APEX operates on a daily time step and is capable of performing long term simulations (1-4000 years) at the whole farm or small watershed level. The watershed may be divided into many homogeneous (soils, land use, topography, etc.) subareas (<4000). The routing component simulates flow from one subarea to another through channels and flood plains to the watershed outlet and transports sediment, nutrients, and pesticides. This allows evaluation of interactions between fields in respect to surface run-on, sediment deposition and degradation, nutrient and pesticide transport and subsurface flow. Effects of terrace systems, grass waterways, strip cropping, buffer strips/vegetated filter strips, crop rotations, plant competition, plant burning, grazing patterns of multiple herds, fertilizer, irrigation, liming, furrow diking, drainage systems, and manure management (feed yards and dairies with or without lagoons) can be simulated and assessed.

Most recent developments in APEX1501 include:

- Enhanced water movement through the soil profile
- Capability to use wells and reservoirs as irrigation water supply
- Rice paddy functions
- Flexible grazing schedule of multiple owners and herds across landscape and paddocks.
- Wind dust distribution from feedlots.
- Manure erosion from feedlots and grazing fields.
- Optional pipe and crack flow in soil due to tree root growth.
- Enhanced filter strip consideration.
- Extended lagoon pumping and manure scraping options.
- Enhanced burning operation.
- Carbon pools and transformation equations similar to those in the Century model with the addition of the Phoenix C/N microbial biomass model.
- Enhanced water table monitoring
- Enhanced denitrification methods
- Variable saturation hydraulic conductivity method
- Irrigation using reservoir and well reserves
- Paddy module for use with rice or wetland areas

Data Structure. The framework of the APEX data structure consists of three files—APEXFILE.DAT, APEXCONT.DAT, and APEXRUN.DAT. APEXFILE is a list of the file names that are used in the run and provide a reference for APEX in determining what data is to be used for each run. APEXCONT contains data that controls the run i.e. run length, option selections, defaults, etc. APEXRUN is a list of run names and numbers that specify the site, weather parameter, and subarea files. An overview of the files and data flow is given in Figure 1.1.

Note: in the following, where *filename.** is used, this indicates that the user may supply the file name, with the appropriate * extension; those file names must be listed appropriately in *APEXFILE.DAT*).

Constant Data. The *APEXCONT.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.

Sites. The study may involve several sites (fields, farms, or watersheds). A file named *filename.sit* is used to describe each site. *SITECOM.DAT* (or user chosen name) is used to reference the numbered list of the sites and their file names.

Weather. Weather stations are numbered and identified in *WPMIMO.DAT*, and wind data for the stations are numbered and identified in *WINDMO.DAT*. *WPMIMO.DAT* (or user chosen name) and *WINDMO.DAT* (or user chosen name) are used to reference the numbered list of the weather stations and their file names. A file named *filename.wpl* is used to describe each weather station statistics while a file named *filename.wnd* is used to describe each wind station statistics.

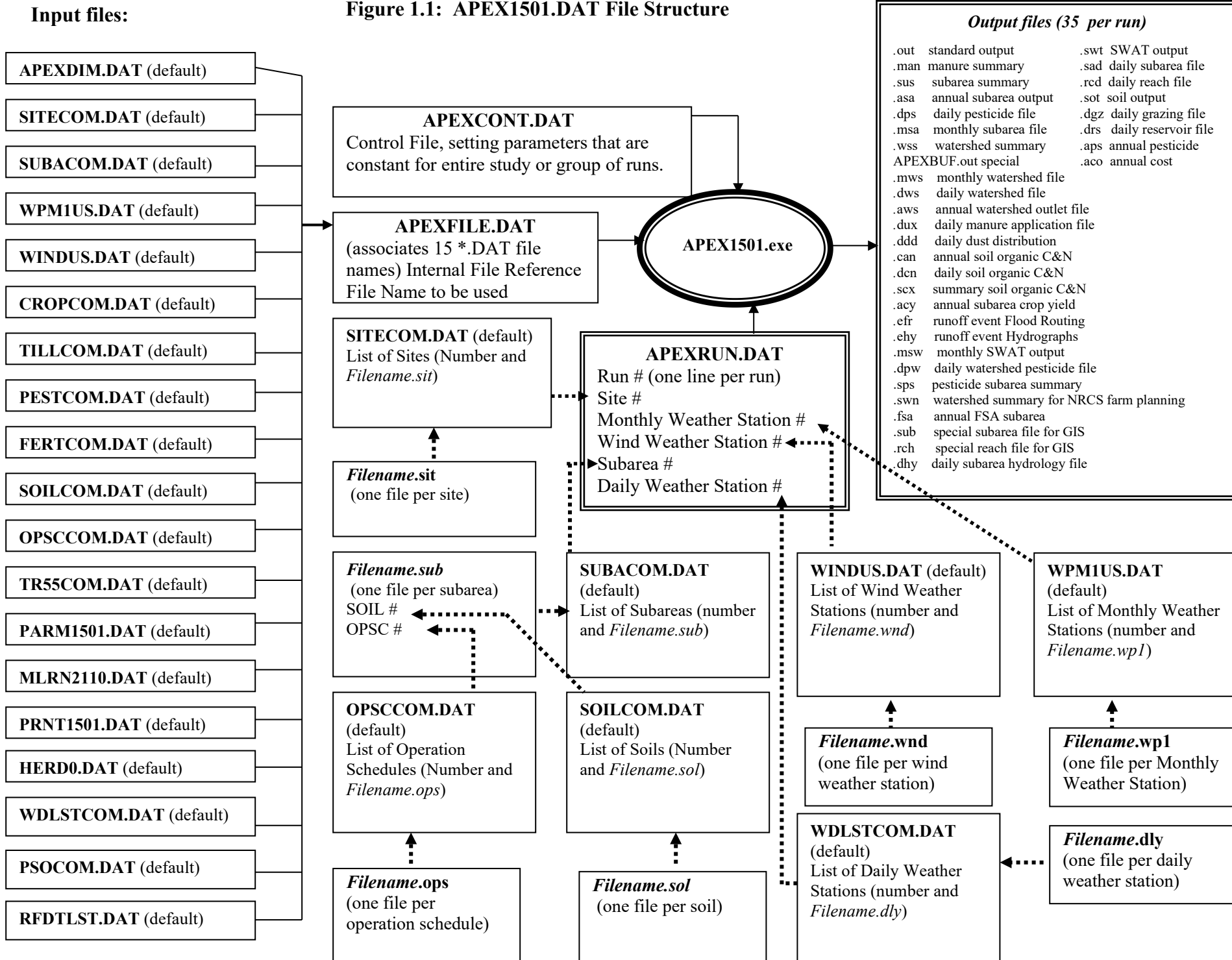
Subarea. Each site in the study may involve several subarea arrangements (e.g. fields/subareas with or without buffers and filter strips, etc.). A file named *filename.sub* is used to describe each subarea or Hydrologic Landuse Unit (HLU), which is homogenous with respect to climate, soil, landuse, and topography. The subareas may be linked with each other with respect to the water routing direction towards a single or multiple watershed or farm outlet(s) (explained later in the documentation). Within each *filename.sub* the user needs to specify a dominant soil and operation schedule for each subarea from the list of soils in *SOILCOM.DAT* and list of operation schedule in *OPSCCOM.DAT*. *SUBACOM.DAT* (or user chosen name) is used to reference the numbered list of the subareas and their file names.

Soils. The study may involve several different soils for the farm or watershed analysis. A file named *filename.sol* is used to describe each soil and the *SOILCOM.DAT* file (or user chosen name) is used to reference the numbered list of the soils and their file names.

Operation Schedules. Each subarea or field of the watershed 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*. Each operation schedule must be numbered and listed in the *OPSCCOM.DAT* (or user specified file), which is used as a reference to the numbered list of the operation schedules and their file names.

Execution of Runs. Once all of the files have been set up properly, APEX1501, a compiled FORTRAN program, can be executed by opening a DOS command prompt window, changing to the directory where the program files have been copied, and typing the command “APEX1501.exe”.

Figure 1.1: APEX1501.DAT File Structure



1.1 MASTER FILE (APEXFILE.DAT)

APEX FILE NAME LINKS

Table 1.1 is a list of file names and descriptions associated with APEX files referenced in the APEXFILE.DAT file. Table 1.2 is a list of APEX file names and descriptions.

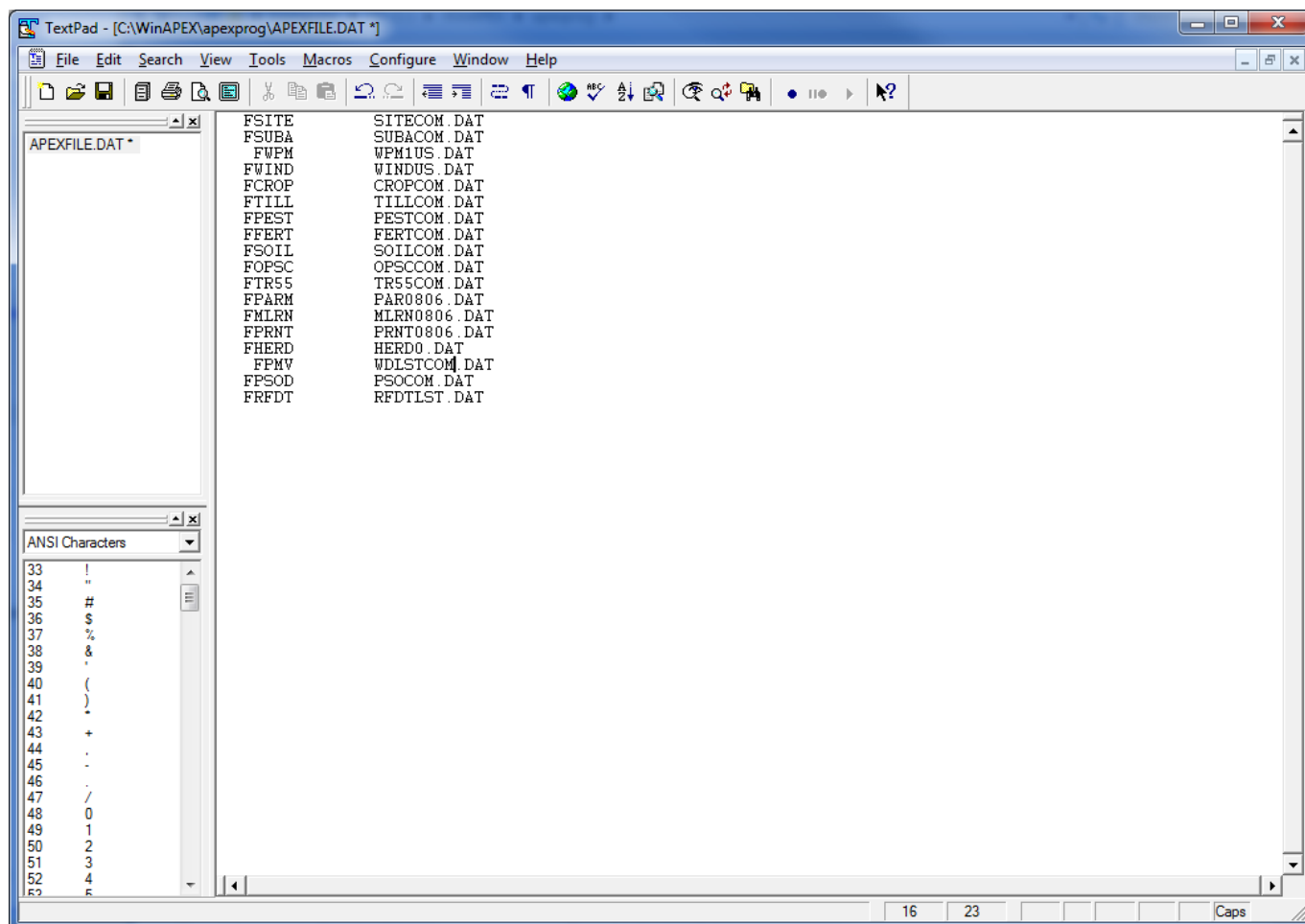
*FORMAT: F****; TEN (10) SPACES FOLLOWED BY TWENTY (20) ALPHA CHARACTERS. SEE FIGURE 1.2.*

Table 1.1: List of file names referenced in APEXFILE.DAT

Default File Name (*.DAT)	Description
SITECOM	A list of site files that can be selected to create runs. The input data for each of the site files is contained in the <i>filename.sit</i> files.
SUBACOM	A list of subareas that can be selected to create runs. The input data for each of the subarea files is contained in the <i>filename.sub</i> files.
WPM1US	A list of monthly weather stations, ordered by weather station number which can be used in creating runs. This file also gives the latitude, longitude, state and location of the weather station.
WINDUS	A list of wind stations, ordered by wind weather station number, which can be used in creating runs. This file also gives the latitude, longitude, state and location of the wind station.
CROPCOM	Crop parameter file. This file is a list of crops and the associated crop parameters needed by APEX to simulate crop growth.
TILLCOM	A list of field operations (equipment) and the associated tillage input data.
PESTCOM	A list of pesticides and the associated input data.
FERTCOM	A list of fertilizers and the associated input data.
SOILCOM	A list of soil files that can be selected to create runs. The input data for each of the soil files is contained in the <i>filename.sol</i> files.
OPSCCOM	List of available operation schedules which can be used to create runs. The input data for each of the operation files is contained in the <i>filename.ops</i> files.
TR55COM	Data for TR55 runoff estimation
PARM1501	Equation parameters and coefficients

Default File Name (*.DAT)	Description
MLRN1501	Provides for multiple runs at the same site by including an option for selecting consecutive weather seeds and water erosion without reloading the inputs.
PRNT1501	Includes the control data for printing select output variables in the sections of the APEX1501.out file and other summary files.
HERD0	Includes parameters for simulating herds of animals and grazing.
WDLSTCOM	A list of daily weather stations and their corresponding latitude and longitude values ordered by weather station number which can be used in creating runs.
PSOCOM	A list of point source files.
RFDTCOM	A list of less-than-daily interval (hourly, quarter hourly, etc.) weather stations.

Figure 1.2: Sample APEXFILE.DAT screen



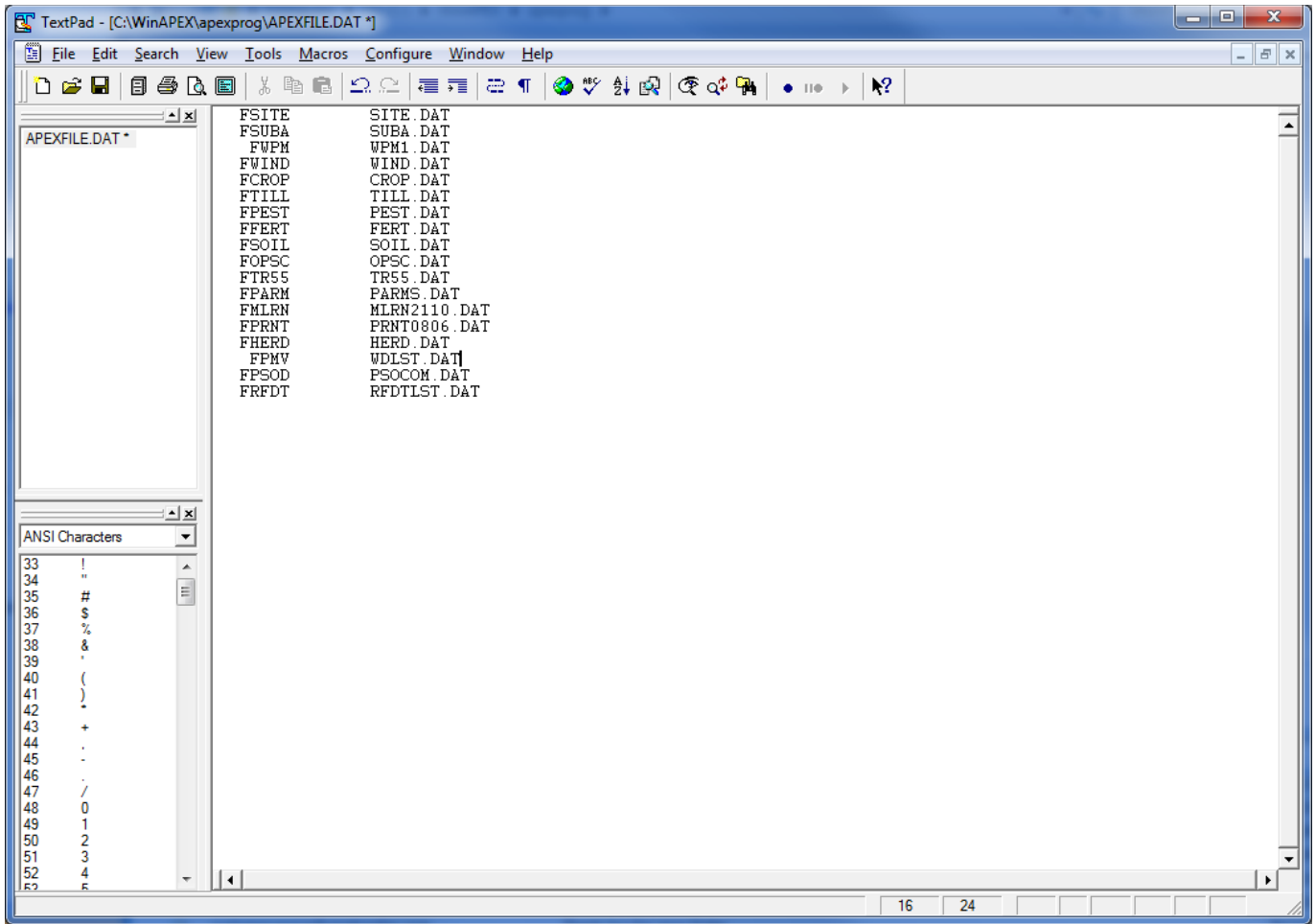


Table 1.2 APEX filenames and descriptions

Default File Name	Description
APEXRUN.DAT	Rows of data organized by run name and numbers identifying site, weather station, wind station and subarea files needed for each run
APEXCONT.DAT	Control file—specifies run length, option selections, defaults, etc. This input data does not change between runs included in APEXRUN.dat.
filename.SIT	Input data which describes each site. Includes data that does not vary across subareas associated with the site.
filename.WP1	Monthly weather statistics input data for the weather station.
filename.WND	Monthly wind statistics input data for the weather station.
filename.SUB	Includes input data that characterize each subarea.
filename.SOL	Includes input data that characterize each soil.
filename.OPS	Includes input data for all operation schedules.
filename.DLY	Daily weather input data for the weather station
APEXDIM.DAT	Dimension variables for various arrays. This allows the user to set the arrays according to their needs and ensure the model runs most efficiently for the given data.
CROP.DAT	Includes input data that characterizes crop growth for over 100 crops.
TILL.DAT	Includes input data that characterizes tillage equipment.
PEST.DAT	Includes input data that characterizes numerous pesticides.
FERT.DAT	Includes input data that characterizes numerous fertilizers.

CHAPTER 2

INPUT FILES

2.1 APEX RUN FILE (APEXRUN.DAT)

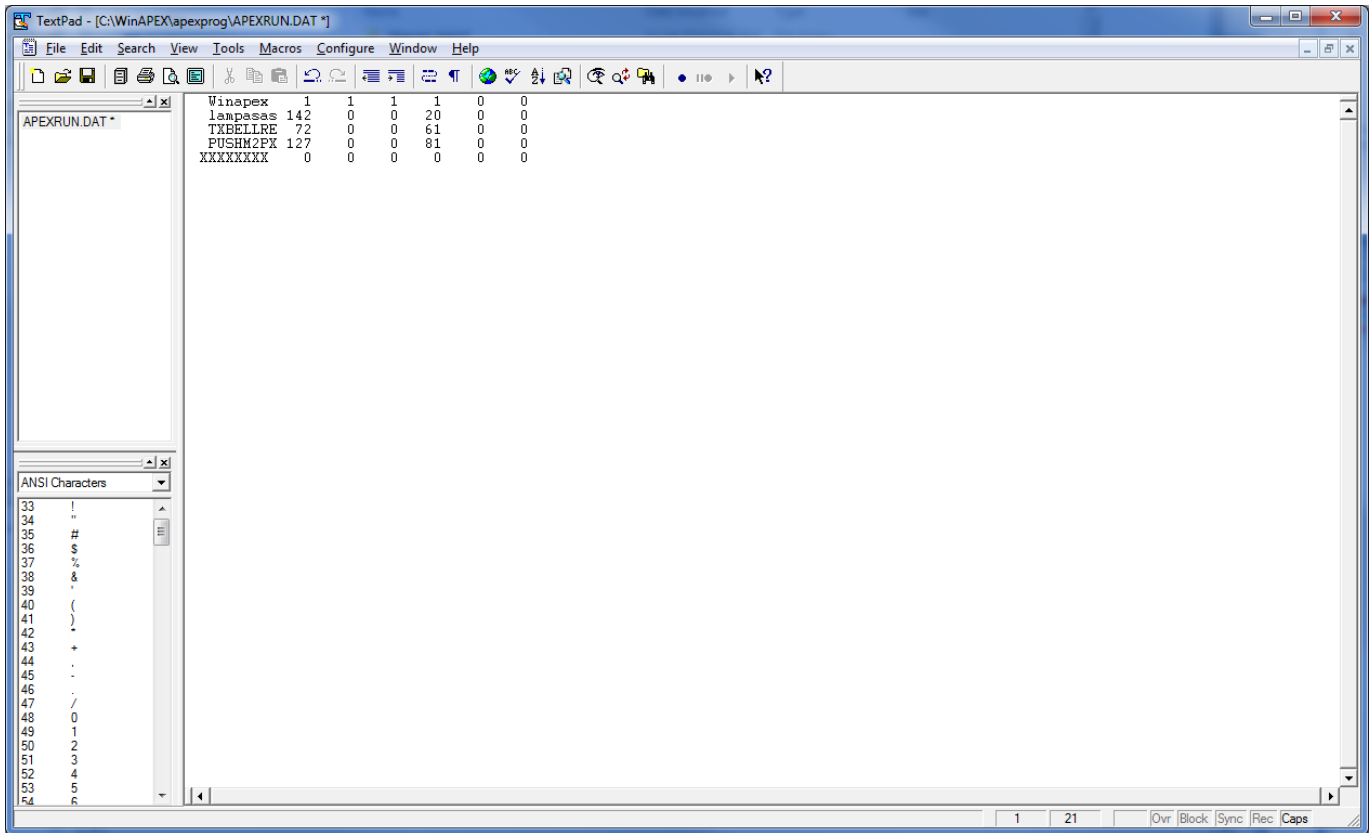
When APEX is executed, each row in the APEXRUN.DAT file is read to determine the configuration of the runs to be made (one row per run). Figure 2.1 shows the structure of the APEXRUN.DAT file. Numerous runs can be set up; however, not all must be run at the same time. To tell the model to stop, a “XXXXXXXX 0 0 0 0 0” line is inserted after the last run to be simulated. Each line consists of a new run.

FORMAT: SIX (6) FIELDS; FREE FORMAT; SEE FIGURE 2.1

Field	Variable	Description
1	ASTN	Run name and/or #number (provides a unique id for each run so that output files are not written over)
2	ISIT	Site number; must be one of the sites listed in the SITECOM.dat file.
3	IWPM	Monthly weather station number; must be one of the stations in the WPM1US.dat file; if left blank, APEX will use the latitude and longitude from ISIT to choose a station with a latitude and longitude closest to the latitude and longitude identified in the ISIT.
4	IWND	Wind Station number; must be one of the stations in the WINDUS.dat file; if left blank, APEX will use the lat and long from ISIT to choose a station.

- 5 ISUB Subarea number; must be one of the subarea data files listed in the SUBACOM.dat file.
- 6 ISOL 0 for normal run
 > 0 for runs using .SOT files
- 7 IRFT Within storm rainfall station number from RFDTLST.DAT

Figure 2.1: Sample APEXRUN.DAT screen showing numerous runs



2.2 THE APEX CONTROL FILE (APEXCONT.DAT)

One file, APEXCONT.DAT, includes a variety of data parameters that will be held constant for all of the runs defined in the APEXRUN.DAT. APEXCONT.DAT includes the following data elements:

Field	Variable	Description
LINE 1:		<i>FORMAT: FREE FORMAT</i>
1	NBYR	<p><i>Number of Years for Simulation Duration</i> The number of years can be any number from 1 to hundreds of years; however, 20 to 30 years may be adequate to estimate frequency distributions used to solve many problems. (Range: 1-100)</p>
2	IYR	<p><i>Beginning Year of Simulation</i> If the starting year is before the first year of the historical weather data, ALL weather will be generated. Once the model starts generating weather, it continues until the end of the simulation. For example, if the historical weather data begins on Jan. 1, 1960 and the beginning year of the simulation is 1956, then all of the weather will be generated starting on Jan. 1, 1956 and continue to the end of the simulation period.</p> <ul style="list-style-type: none"> • If the simulation period starts on a year included in the historical weather file, but the weather data does not extend out for the complete simulation period, weather will be generated from the point the historical weather data ends to the end of the simulation period. For example, if the historical weather data begins on Jan. 1, 1960 and extends to Dec. 31, 2000 and the simulation period is from Jan. 1, 1996 to Dec. 31, 2005, then generated weather will be used beginning Jan. 1, 2001 and continue to the end of the simulation period (Dec. 31, 2005). <p>(Range: 1-2040)</p>
3	IMO	<p><i>Beginning Month of Simulation</i> Most long-term simulations start on January 1. Starting after January 1 may be convenient for simulating systems where data are only recorded during the growing season. (Range: 1-12)</p>
4	IDA	<p><i>Beginning Day of Simulation</i> Most long-term simulations start on January 1. Starting after January 1 may be convenient for simulating systems where data are only recorded during the growing season. (Range: 1-31)</p>

Field	Variable	Description
5	IPD	<p><i>Print Code for Type of Output</i></p> <p>The print code (IPD) allows the user to specify daily, monthly, or annual output, with or without printing tables describing soil conditions. Annual printouts minimize output volume and may be useful for some long-term simulations. Monthly outputs enable the user to evaluate model performance within the growing season or to examine seasonality of runoff, erosion, and other processes more closely than with annual printouts. Monthly outputs are normally obtained in short-term (1-10 year) simulations and are particularly useful in model testing. Daily outputs are also useful for model testing and for comparison with detailed experimental data. To obtain the desired type of output, IPD can be set to values from 0 to 9, as described below. (Range: 0-9)</p> <p>N0 for annual watershed output 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</p>
6	NGN	<p><i>Input Code for Weather Variables</i></p> <p>APEX allows the user to read one or more daily weather variables from an external file that is specified by the user. The weather input code, NGN, specifies which variables will be read; all others will be generated by APEX's stochastic weather data generator. (Range: -1 to 2345)</p> <p>If NGN is not set to zero, precipitation is read from the external file designated at the end of the APEX input dataset. In addition to precipitation, any combination of the other daily weather variables can be read. The integers 1 through 5 are used to identify specific weather inputs, as follows:</p> <p>[1] Precipitation [2] Maximum and minimum temperatures [3] Solar radiation [4] Average wind speed [5] Average relative humidity</p> <p>If any daily weather variables are input, precipitation must also be input. Thus it is not necessary to specify ID=1 unless rain is the only input variable. Example values of NGN are given below.</p>

Field	Variable	Description
NGN, cont.	NGN=[0]	Generate all weather variables (spatially distributed).
	NGN=[-1]	Generate all weather variables (same values for all subareas)
	NGN=[1]	Read precipitation; generate other variables.
	NGN=[2]	Read maximum and minimum temperatures and precipitation; generate other variables.
	NGN=[3]	Read solar radiation and precipitation; generate other variables
	NGN=[4]	Read wind speed and precipitation; generate other variables.
	NGN=[5]	Read relative humidity and precipitation; generate other variables.
	NGN=[23]	Read maximum and minimum temperatures, solar radiation, and precipitation; generate wind speed and relative humidity.
	NGN=[2345]	Read all weather 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.

NOTE: If weather data is not available for selected parameters, weather data is automatically generated. The model will use all available data for the selected parameters, and generate when data for those select parameters is missing.

7 IGN ***Number of Times Random Number Generator Cycles Before Simulations Starts***

The random number generator is used to generate stochastically a series of daily weather data for input into other components of APEX. By changing IGN, the user can alter the sequence of generated weather data without changing its long-term statistical properties. (Range: 0-100)

To use the default random numbers, the user should set IGN to 0. This is the default value for IGN.

In some situations, a user may wish to vary the weather sequence between runs. This is done by setting IGN to a different number each time the model is run.

This code will activate a random number generator, which will replace the default set of random numbers with a new set. The value to which IGN is set determines the number of times the random number generator is cycled before the simulation begins. The seeds produced by the random number generator are then used by the weather generator instead of the default values. Historical weather data read into the model is not affected by this variable. However, if the historical weather data contains missing data, the weather generator will be

Field	Variable	Description
	IGN, cont.	<p>used to generate data to replace the missing data. The generated data used to replace the missing data is affected by this variable.</p> <p>If IGN and the monthly weather statistics are not changed, successive simulations will have identical weather sequences.</p>
8	IGSD	<p><i>Day Weather Generator Stops Generating Daily Weather</i></p> <p>This variable is used for real time simulations. When IGSD is a negative integer, it indicates the total number of whole and partial years of input weather data. Normally, only a partial year (January 1 to planting date, for example) of measured weather data are used, thus IGSD = -1. To estimate 20 alternative yield possibilities using inputted weather data for only part of a year, set NBYR to 20 and IGSD to -1. (Range: -n to 366)</p> <p>IGSD can also be used to simulate yield where the same weather data set is used many times. For example, if IGSD is set to -3, this tells the model to reuse the three years of inputted weather data then rewind and use it again multiple times until NBYR is met.</p> <p>0 Normal operation of weather model n Duplicate weather in a given year up to date n -n Rewinds weather after n years 366 Gives a rough estimate of the average yield with only two years of simulation.</p>
9	LPYR	<p><i>Leap Year Considered</i> (Range: 0-1)</p> <p>0 Leap year is considered 1 Leap year is ignored. Tells the model to expect only 365 days of input and generate only 365 days of weather ignoring February 29th. February 29th should be deleted from the weather input file.</p>
10	IET	<p><i>Potential Evapotranspiration Equation Code</i></p> <p>During the past 50 years, agricultural scientists have developed several empirical equations to estimate potential evapotranspiration (PET), the evaporation from a well-watered turf or crop in which the canopy completely covers the soil surface. APEX enables the user to choose which equation will be used to estimate PET. (Range: 0-5)</p> <p>0 (default) Hargreaves</p> <p>1 *Penman-Monteith (usually for windy conditions) – adds a logarithmic eddy diffusion function and canopy resistance to the Penman equations.</p> <p>2 *Penman – adds relative humidity, wind speed, and elevation of wind measurements to the required weather inputs.</p>

Field	Variable	Description
	IET cont.	<p>3 Priestley-Taylor – requires radiation, as well as temperature as an input.</p> <p>4 Hargreaves – has two parameters which can be adjusted to calibrate the model for factors such as proximity to a major water body.</p> <p>5 Baier-Robertson</p> <p>* Requires the entry of elevation (ELEV), monthly mean wind velocities (WVL). These equations also need relative humidity; however, if relative humidity is blank, EPIC will estimate relative humidity. Dew point can also be used.</p>
11	ISCN	<p><i>Stochastic CN Estimator Code</i></p> <p>The final step in APEX’s estimation of runoff volume is an attempt to account for uncertainty. The runoff retention parameter or curve number is based on land use, management, hydrologic soil group, land slope, soil water content and distribution. It is also adjusted for frozen soil. However, many natural processes and management factors that can affect runoff are not accounted for in the model. APEX enables the user to use either a deterministic or a stochastic method of estimating CN. If the deterministic method is chosen, the curve number is adjusted daily for soil water content (and frozen soil). If the stochastic method is chosen, the deterministic value is varied stochastically on a daily basis using a triangular distribution. The extremes of the distribution are +/- 5 curve numbers from the mean. (Range: 0-1)</p> <p>0 Stochastic curve number estimator (default) >0 Rigid curve number estimator (Deterministic)</p>
12	ITYP	<p><i>Peak Rate Estimate Code</i></p> <p>Types I and IA represent the Pacific maritime climate with wet winters and dry summers. Type III represents Gulf of Mexico and Atlantic coastal areas where tropical storms bring large 24-hour rainfall amounts. Type II represents the rest of the country. For more precise distribution boundaries in a state having more than one type, contact the SCS State Conservation Engineer (SCS 1986). (Range: -1 to 4)</p> <p>0 Modified Rational EQ Stochastic Peak Rate Estimate -1 Modified Rational EQ Rigid Peak Rate Estimate >0 SCS TR55 Peak Rate estimate</p> <p>1 → Type 1 rainfall pattern 2 → Type 1A rainfall pattern 3 → Type 2 rainfall pattern 4 → Type 3 rainfall pattern</p>

Field	Variable	Description
13	ISTA	<p>Static Soil Code</p> <p>This code is set up to allow EPIC to estimate soil erosion but not change the soil profile other than readily available nutrients and water. With this option set at 1 it is possible to simulate multiple years of weather on the same soil and estimate erosion under alternative weathers. (Range: 0-1)</p> <p>0 Normal erosion of soil profile 1 Static soil profile</p>
14	IHUS	<p>Automatic Heat Unit Scheduling</p> <p>Based on potential heat units (PHU) (Range: 0-1)</p> <p>0 Normal operation 1 Automatic heat unit schedule (Number of growing degree units needed for crop to reach maturity (PHU) must be input at planting)</p> <p>NOTE: This option works as follows: In the first year of the run, all operations are assigned a heat unit fraction based on the total number of heat units inputted at planting and dates assigned to each operation. Calculation of heat units is based on monthly weather statistics. In the following years all operations will occur based on the heat unit schedule assigned to them. This can be used to help adjust operations to the weather (temperatures) from year to year.</p> <p>Operations occurring from planting to harvest are based on heat units set at planting. Operations occurring before planting are based on total annual heat units, which are calculated by the model.</p>
15	NVCN	<p>Non-varying CN-CN2 Used (Range: 0-4)</p> <p>0 Variable daily CN nonlinear CN/SW with depth soil water weighting (<i>Use Parm 92 to adjust</i>) 1 Variable daily CN nonlinear CN/SW 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) (<i>Use Parm 42 to adjust</i>)</p>
16	INFL	<p>Runoff (Q) Estimation Methodology (Range: 0-4)</p> <p>0 CN estimate of Q 1 Green & Ampt estimate of Q, Rain Fall Exponential Distribution, Peak Rainfall Rate simulated 2 G&A Q, Rainfall Exponential Distribution, Peak Rain Fall Input 3 G&A Q, Rainfall uniformly Distribution, Peak RF Input 4 G&A Q, Rainfall input at time interval DTHY</p>

Field	Variable	Description
17	MASP	<i>Pesticide Application Mass</i> (Range: 0-1) 1 Pesticides applied in g/ha 1000 Pesticides applied in kg/ha
18	IERT	<i>Enrichment Ratio Method</i> Sets how much organic material is lost in runoff. (Range: 0-1) 0 EPIC enrichment ratio method 1 GLEAMS enrichment ratio method
19	LBP	<i>Soluble Phosphorus Runoff Estimate Equation</i> (Range: 0-2) 0 Soluble Phosphorus runoff estimate using GLEAMS pesticide equation 1 Langmuir equation
20	NUPC	<i>N and P plant uptake concentration code</i> (Range: 0-1) 0 Smith Curve 1 S-Curve
LINE 2		<i>FORMAT: FREE FORMAT</i>
1	MNUL	<i>Manure application code</i> (Range: 0-3) 0 Auto application to subarea with minimal labile P concentration 1 Variable P rate limits on annual application based on Jan. 1 labile P concentration 2 Variable N rate limits on annual application based on Jan. 1 labile P concentration. 3 Same as 1 except applications occur on one subarea at a time until labile P concentration reaches 200 ppm. Then another subarea is used, etc.
2	LPD	<i>Lagoon pumping</i> (Range: 0-365) 0 Does not trigger extra pumping >0 Day of year to trigger lagoon pumping disregarding normal pumping trigger- usually before winter or high rainfall season.
3	MSCP	<i>Solid manure scraping</i> (Range: 0-365) 0 Does not scrape extra manure from feeding area >0 Interval for scraping solid manure form feeding area in days
4	ISLF	<i>Slope length/steepness factor</i> (Range: 0-1) 0 RUSLE slope length / steepness factor >0 MUSLE slope length / steepness factor

Field	Variable	Description
5	NAQ	<i>Air Quality Analysis</i> (Range: 0-1) 0 No air quality analysis 1 Air quality analysis
6	IHY	<i>Flood Routing</i> (Range: 0-2) 0 No flood routing; 1 VSC Flood routing 2 SVS Flood routing 3 Muskingum-Cunge VC 4 Muskingum-Cunge 4 point VC
7	ICO2	<i>Atmospheric CO₂</i> (Range: 0-2) 0 Constant atmospheric CO ₂ 1 Dynamic atmospheric CO ₂ . Base year = 1880; base conc. = 280 ppm 2 Dynamic atmospheric CO ₂ . Inputted through daily weather file.
8	ISW	<i>Field Capacity/Wilting Point Estimation</i> (Range: 0-5) 0 Field capacity/wilting point estimated using the Rawls method (dynamic) 1 Field capacity/wilting point inputted using Rawls method (dynamic) 2 Field capacity/wilting point estimated using Rawls method (static) 3 Field capacity/wilting point inputted (static) 4 Field capacity/wilting point nearest neighbor (dynamic) 5 Field capacity/wilting point nearest neighbor (static) 6 Field capacity/wilting point Behrman-Norfleet-Williams (BNW) (dynamic) 7 Field capacity/wilting point Behrman-Norfleet-Williams (BNW) (static)
9	IGMX	<i>Number of times generator seeds are initialized for a site</i> (Range: 1-100)
10	IDIR	<i>Data Directory</i> (Range: 0-1) 0 Reading data from working directory 1 Reading from a directory other than the working directory
11	IMW	<i>Minimum Interval between auto mow</i> This refers to the minimum length of time (days) set between mowings when the Auto Mow function is used in the operation schedule. The crop will be mowed at this interval given the crop height is greater than the cutting height set on the mower used in the operation. If the IMW is set in the control table, there is no need to set the IMW in the Subarea file unless 1 or more subarea IMW intervals differ from the interval set here. In all cases, for the IMW to take effect, an automatic mower must be in the operation schedule. (Range: 0-365)

Field	Variable	Description
12	IOX	<i>O₂ – depth function</i> (Range: 0-1) 0 Original EPIC Oxygen/Depth function >0 Armen Kemanian Carbon/Clay function
13	IDNT	<i>Denitrification subprogram</i> (Range: 0-1) 1 Original EPIC Denitrification subprogram 2 Armen Kemanian Denitrification subprogram 3 Cesar Izaurralde Denitrification subprogram (Original DW) 4 Cesar Izaurralde Denitrification subprogram (New DW)
14	IAZM	<i>Latitude source</i> (Range: 0-1) 0 Using input latitudes for subareas >0 Computing equivalent latitude based on azimuth orientation of land slope
15	IPAT	<i>Auto-Phosphorus Switch</i> (Range: 0-1) 0 Turns off auto-Phosphorus application >0 Turns auto-Phosphorus application on.
16	IHRD	<i>Grazing Mode</i> (Range: 0-2) Set NY & XTP in Subarea file for all cases 0 Level 0 (manual) grazing mode (no herd file required) 1 Level 1 (hybrid) grazing mode (herd file required) 2 Level 2 (automatic) grazing mode (herd file required)
17	IWTB	<i>Duration of antecedent period for rainfall and PET accumulation to drive water table.</i> (Range: 5 - 45)
18	IKAT	<i>Auto-Potassium Switch</i> (Range: 0-1) 0 Turns off auto-Potassium application >0 Turns auto-Potassium application on.
19	NSTP	<i>Real time day of year</i> (Range: 0-365) Day of year selected to be the stopping point up until which weather, crop growth, etc. are known. Remainder of the year is projected.
20	IPRK	<i>Soil Water Percolation Method</i> (Range: 0-1) 0 Original Saturation Hydraulic Conductivity Method. The default percolation method with which soil moisture content (SW) greater than field capacity (FC) drains subsoil layers instantly. 1 Variable Saturation Hydraulic Conductivity Method. This method moves water down through the soil in small increments based on effective hydraulic conductivity. Percolation of SW greater than FC is simulated iteratively as a function of Parm 82 and KSat in which SW is released no more than 4 mm in each iteration. This option keeps SW>FC for an extended time. Water can also move up in the soil profile if the water table saturates a lower layer.

Field	Variable	Description
21	ICP	<i>Carbon/Nitrogen Mineralization Method</i> (Range 0-1) 0 Phoenix Method. This method simulates mineralization and immobilization of N and C using pools following Century (Izaurrealde et al. 2006) and C/N of microbial biomass following the Phoenix method (McGill et al. 1981). This method is an enhancement over the original Century microbial biomass functions. The default method is the Phoenix method. 1 Century Method. This method simulates mineralization and immobilization of N and C using pools following Century (Izaurrealde et al. 2006). The C/N of microbial biomass is calculated using the Century method.
22	NTV	<i>Nitrogen Volatilization Method</i> (Range: 0-1) 0 Original APEX nitrogen volatilization equations 1 Revised nitrogen volatilization equations by C. Izaurrealde
23	IREM	<i>SSK for Water Erosion Setting</i> (Range: 0-1) 0 SSK (C Factor calculation) from REMX (Daily soil loss equation for rangelands using erosion equations taken from RHEM.) 1 SSK (C Factor calculation) from USLE
24	IHAY	<i>Supplemental Hay Feeding</i> (Range: 0-1) 0 No hay feeding 1 Supplemental hay feeding when forage is less than grazing limit (GZLM)
25	ISAP	<i>Enter subarea number (NBSA) to print monthly .OUT for 1 subarea</i> (Range: 1-1000)

LINE 3 *FORMAT: FREE FORMAT*

Field	Variable	Description
1	RFN	<i>Average concentration of nitrogen in rainfall</i> The average concentration of N in rainfall may vary slightly for different locations. However, since the rainfall N contribution is a relatively small component of the N cycle, a value of 0.8 ppm or mg N/liter is generally satisfactory. If site-specific information is available, the user is free to set the value appropriately. (Range: 0.5-1.5)
2	CO2	<i>Carbon dioxide concentration in atmosphere</i> Current amount of carbon dioxide in the atmosphere in ppm. Currently the level is 380 ppm. (Range: 0-1000)
3	CQN	<i>Concentration of NO3-N in irrigation water in ppm</i> (Range: 0-1000)

Field	Variable	Description
4	PSTX	<i>Pest damage scaling factor</i> (Range: 0-10) The factor scales the growth of pests (insects and diseases only) in terms of population growth. It ranges from 0 (no pest growth-pest damage function is shut off) to 10 (maximum pest growth). Under default conditions this parameter is set to 1.00 which produces only minimal pest growth and does not affect yield. This parameter works in conjunction with Parm 9 and 10. Pest damage function can be regulated from very mild (0.05-0.1) to very severe (1.0-10.0)
5	YWI	<i>Number years of maximum monthly 0.5 hour rainfall available.</i> Can be obtained from the U.S. Department of Commerce (0 if WI is not inputted.) (Range: 0-20)
6	BTA	<i>COEF (0-1) governing wet-dry probabilities given days of rain.</i> Used to estimate wet-dry rainfall probabilities if information is only available for the average monthly number of wet days. Generally the number of wet days is much more readily available than the wet-dry rainfall probabilities. A value of 0.75 for BTA usually gives satisfactory estimates of the wet-dry probabilities. May be left zero if daily rainfall is inputted. May be left zero if rainfall is generated and wet-dry probabilities are input. (Range: 0-1)
7	EXPK	<i>Parameter used to modify exponential rainfall amount distribution</i> The modified exponential distribution is used to generate rainfall amounts if the standard deviation and skew coefficient are not available. An EXPK value of 1.3 gives satisfactory results in many locations. May be set to 0.0 if unknown or if standard deviation of rainfall and skew coefficient for daily precipitation are input. (Range: 0-2)
8	QG	<i>Channel Capacity Flow Rate</i> 2 year frequency 24-h rainfall. Estimates reach channel geometry in mm/h if unknown. (Range: 1-100) (0 if channel geometry is input by Channel bottom width/depth (BWD))
9	QCF	<i>Exponent in watershed area flow rate equation.</i> (Range: 0.4-0.6)
10	CHSO	<i>Average upland slope (m/m) in watershed</i> (Range: 0.001-0.7)
LINE 4	<i>FORMAT: FREE FORMAT</i>	
1	BWD	<i>Channel bottom width/depth in m/m; Channel flow rate (QG) > 0.</i> (Range: 1-20)
2	FCW	<i>Floodplain width/channel width in m/m</i> (Range: 2-50)

Field	Variable	Description
3	FPS0	<i>Floodplain saturated hydraulic conductivity adjustment factor</i> (Range: 0.1-10) Fraction multiplied by the 2 nd soil layer saturated conductivity.
4	GWSO	<i>Maximum ground water storage in mm</i> (Range: 5-200)
5	RFTO	<i>Ground water residence time in days</i> (Range: 0-365)
6	RFPO	<i>Return Flow / (Return Flow + Deep Percolation)</i> (Range: 0-1) Setting this value closer to 1.0 means more flow will be partitioned to return flow.
7	SATO	<i>Saturated Conductivity adjustment factor</i> (use with Green & Ampt). (Range: 0.01-10) Fraction multiplied by the 2 nd soil layer saturated conductivity to estimate Green & Ampt saturated conductivity (SATK)
8	FL	<i>Field length (if wind erosion is to be considered) in kilometers</i> If the normal wind erosion calculation is to be utilized (Wind Erosion Adjustment Factor (ACW) = 1.), field dimensions and orientation must be specified. This variable refers to the length of the field that is exposed to the wind. Without trees, FL = length of the field. With trees, FL < length of the field. If wind erosion is simulated for specific sites, FL, FW and ANG can be measured easily. However, hypothetical sites are often used in long-term simulations associated with large-scale decision making. In such cases, values of FL, FW and ANG should be chosen to represent typical field configurations of the area. Efforts to match field dimensions and drainage area are not necessary. The field dimensions are used only to estimate wind erosion, with the exception that FL is used to estimate water erosion from furrow irrigation. Thus, the simulation site may be a small area (1 ha) in a field of 1.0 by 0.5 km. It should be noted that the change in simulated wind erosion is not large for any FL > 0.3 km. Therefore, estimations of FL and FW are not usually critical for fields with areas greater than about 10 ha. When fields larger than 10 ha are strip cropped, however, the estimation of FW becomes more important. To evaluate the effect of strip cropping, FW is estimated as the average width of the strips. FL may be left at 0.0 if unknown, and it will be estimated. (Range: 0.001-12)
9	FW	<i>Field width (if wind erosion is to be considered) in kilometers</i> See variable FL for further information. FW may be left at 0.0 if unknown, and it will be estimated. (Range: 0.001-12)
10	ANG	<i>Clockwise angle of field length from north (if wind erosion is to be considered)</i> See variable FL for further information. ANG may be left at 0.0 if unknown, and it will be estimated. If ANG is known, enter the value in degrees. (Range: 0-360)

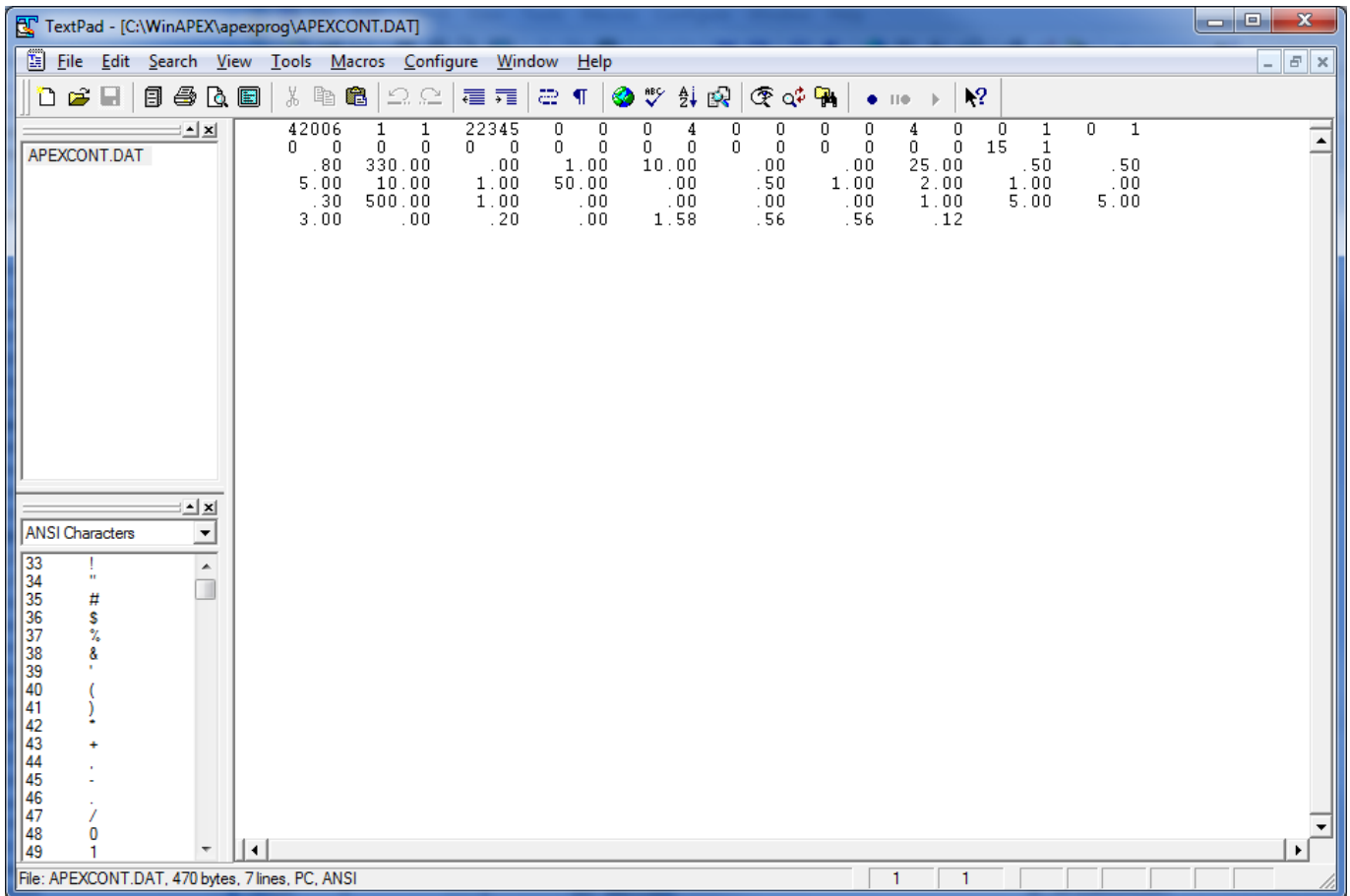
LINE 5 *FORMAT: FREE FORMAT*

Field	Variable	Description
1	UXP	<p><i>Power Parameter of Modified Exponential Distribution of Wind Speed (if wind erosion is to be considered)</i> The power parameter of the modified, exponential wind speed distribution ranges from about 0.3 to about 0.7. A value of [.50] usually gives satisfactory estimates of daily wind speed. UXP may be left at 0.0 if unknown, and it will be estimated. (Range: 0-1)</p>
2	DIAM	<p><i>Soil Particle Diameter(if wind erosion is to be considered)</i> If value is known enter it in micron. Normally this value ranges from 300 – 500 um (sands). Used only in wind erosion. May be set to 0.0 if unknown. (Range: 100-500)</p>
3	ACW	<p><i>Wind Erosion Adjustment Factor</i> The wind erosion adjustment factor is used along with PEC values to shut off or accelerate erosion. As with water erosion, wind erosion can be shut off by setting ACW = 0. If normal wind erosion calculation is desired, set ACW = 1. Also, AWC can be increased to a high level ACW=10.00 as a short cut in estimating wind erosion effects on the soil profile. Since ACW is related linearly to wind erosion, 1000year' simulation can be approximated by 100 years' simulation using ACW=10. (Range: 0-10)</p> <p>ACW = 0 No wind erosion ACW = 1 Normal simulation ACW > 1 Accelerates wind erosion (condenses time)</p>
4	GZL0	<p><i>Grazing limit</i> This is the minimum amount of plant material (t/ha) that must be present in order to allow grazing. Grazing will not be initiated until this limit has been reached. Grazing will also stop when the amount of plant material remaining reaches this limit. (Range: 0.001-5.0)</p> <p><i>Optional</i> - If > 0, overrides all herd minimum grazing limits in owner's table.</p>
5	RTN0	<p><i>Number of years of cultivation at start of simulation</i> This parameter affects the partitioning of nitrogen and carbon into the passive and slow humus pools. The number of years of cultivation before the simulation starts is used to estimate the fraction of the organic N pool that is mineralizable. Mineralization is more rapid from soil recently in sod. Also increasing the number of years the field has been in cultivation increases the amount of C and N in the passive pool. This means it will take longer for the carbon and nitrogen to become available. (Range: 0-1000)</p>

Field	Variable	Description
6	BXCT	Linear coefficient of change in rainfall from east to west (PI/PO/KM) (Range: 0-1) PI = Average Annual precipitation on East side of watershed PO = Average Annual precipitation on West side of watershed
7	BYCT	Linear coefficient of change in rainfall from south to north (PI/PO/KM) (Range: 0-1) PI = Average Annual precipitation on South side of watershed PO = Average Annual precipitation on North side of watershed
8	DTHY	Time interval for flood routing (hours) (Range: 0.5-12)
9	QTH	Routing Threshold (mm) – VSC routing used when QVOL>QTH (Range: 0-200000) VSC = Variable Storage coefficient QVOL = Daily volume of runoff QTH = Routing Threshold
10	STND	VSC Routing used when reach storage > STND (Range: 0-200000) VSC = Variable Storage coefficient STND = Storage in reach daily
LINE 6	FORMAT: FREE FORMAT	
1	DRV	Equation for Water Erosion (Range: 1-6) 1 RUSLE2 Modified RUSLE 2 USLE Universal Soil loss Equation 3 MUSS Small Watershed MUSLE 4 MUSL Modified USLE 5 MUST Modified MUSLE theoretical based equation 6 REMX Modified Rangeland Hydrology Erosion Model (RHEM)
2	PCO0	Fraction of subareas controlled by ponds (Range: 0-1) The exact location of the ponds is unknown.
3	RCC0	USLE Crop Management Channel Factor Must be entered. This number can be overridden if RCHC in the Subarea file is set. With bare channel condition, RCHC should be 0.1- 0.6, and if the channel has very good land cover, it should have a value of 0.0001 (Range is 0.0001 - 0.6)
4	CSLT	Salt Concentration in Irrigation Water (cols. 25-32) ppm
5	CPV0	Fraction of inflow partitioned to vertical crack or pipe flow (Range: 0-0.05) Applies only to forested lands.
6	CPH0	Fraction of inflow partitioned to horizontal crack or pipe flow (Range: 0-0.05) Applies only to forested lands.

Field	Variable	Description
7	DZDN	<i>Layer thickness for differential equation solution to gas diffusion equations (m)</i>
8	DTG	<i>Time interval for gas diffusion equations (h)</i>

Figure 2.2: Sample APEXCONT.DAT screen



2.3 THE APEX SITE FILES (*FILENAME.SIT*)

A study may involve several sites (fields, farms, or watersheds), which can be listed in SITECOM.DAT (or user chosen name). Each site is described and saved with *filename.SIT* and includes the following data elements:

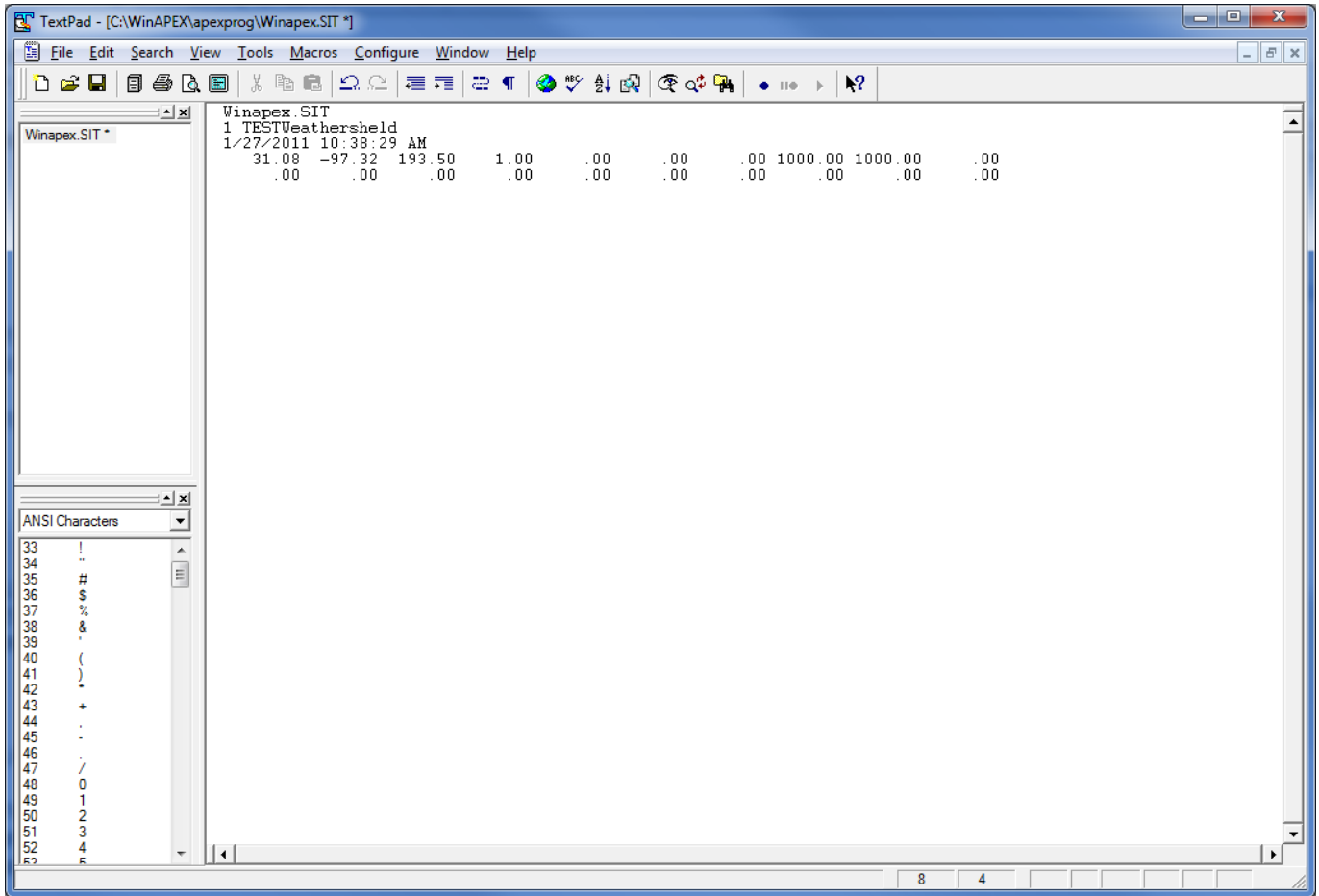
LINE 1-3

Three title lines are available for individual site description.

Field	Variable	Description
LINE 4	<i>FORMAT: 10 FIELDS; EIGHT (8) COLUMNS PER FIELD INCLUDING UP TO TWO DECIMAL PLACES (FLOATING)</i>	
1	YLAT	<i>Latitude of watershed in decimal degrees (cols. 1-8)</i> The latitude of the field or watershed (YLAT) is used to estimate day length. It must be supplied by the user. Units are degrees. Latitudes in the Southern Hemisphere are in negative degrees and positive in the Northern Hemisphere. (Range: -90 to 90)
2	XLOG	<i>Longitude of watershed in decimal degrees (cols. 9-16)</i> (Range: -180 to 180)
3	ELEV	<i>Average watershed elevation (cols. 17-24)</i> The average watershed elevation should be input if the Penman or the Penman-Monteith approach is used to estimate potential evapotranspiration. Units are meters. (Range: -200 to 8000)
4	APM	<i>Peak runoff rate – rainfall energy adjustment factor (cols. 25-32)</i> The peak runoff-rate-rainfall energy adjustment factor provides a means for fine tuning the energy factor used in estimating water erosion. Normally, an APM value of 1 gives satisfactory results. 0 is unknown. (Range: 0-1)
5	CO2X	<i>CO₂ Concentration in the atmosphere (ppm) (cols. 33-40)</i> A non-zero value overrides the CO ₂ input in APEXCONT.DAT. (Range: 0-1000)
6	CQNX	<i>Concentration of NO₃ in irrigation water (ppm) (cols. 41-48)</i> A non-zero value overrides the CQN input in the APEXCONT.DAT. (Range: 0-1000)
7	RFNX	<i>Average concentration of Nitrogen in rainfall (ppm) (cols. 49-56)</i> (Range: 0.5-1.5)
8	UPR	<i>Manure application rate to supply P uptake rate in kg/ha/yr (cols. 57-64)</i> (Range: 0-1000)

Field	Variable	Description
9	UNR	Manure application rate to supply N uptake rate in kg/ha/yr (cols. 65-72) (Range: 0-1000)
10	FIR0	Factor to adjust auto irrigation volume (cols. 73-80) Used to adjust the amount of auto irrigation is applied. FIRG (from subarea file) x FC (field capacity). (Range: 0.5 – 5.0)
LINE 5	FORMAT: TEN (10) FIELDS; EIGHT (8) COLUMNS PER FIELD INCLUDING UP TO TWO DECIMAL PLACES (FLOATING)	
1-5	Leave Blank	
6	GWSP	Ground water slope (m/m) Total head of the shallow aquifer storage is estimated using the slope of the aquifer.
7-8	Leave Blank	
9	BCHL	SWAT Basin Channel Length in kilometers (cols. 65-72)
10	BCHS	SWAT Basin Channel Slope in m/m (cols. 73-80)
LINE 6	FORMAT: TWENTY (20) ALPHA CHARACTERS	
	Leave Blank	
LINE 7	FORMAT: TWENTY (20) FIELDS; FOUR (4) COLUMNS PER FIELD (INTEGER)	
	Weather parameter number (from WPM1US.DAT or other such weather station listing). For spatial weather generation. The format allows for 20 fields; however, only 10 fields are read.	
LINE 8	FORMAT: TEN (10) FIELDS; EIGHT (8) COLUMNS PER FIELD INCLUDING UP TO TWO DECIMAL PLACES (FLOATING)	
	Fraction of watershed area (WSA) represented by weather station number selected above (IWPM). For spatial weather generation (Range: 0-1)	
LINE 9	FORMAT: TEN (10) FIELDS; EIGHT (8) COLUMNS PER FIELD (INTEGERS)	
	ICMO	Command numbers of watershed outlets

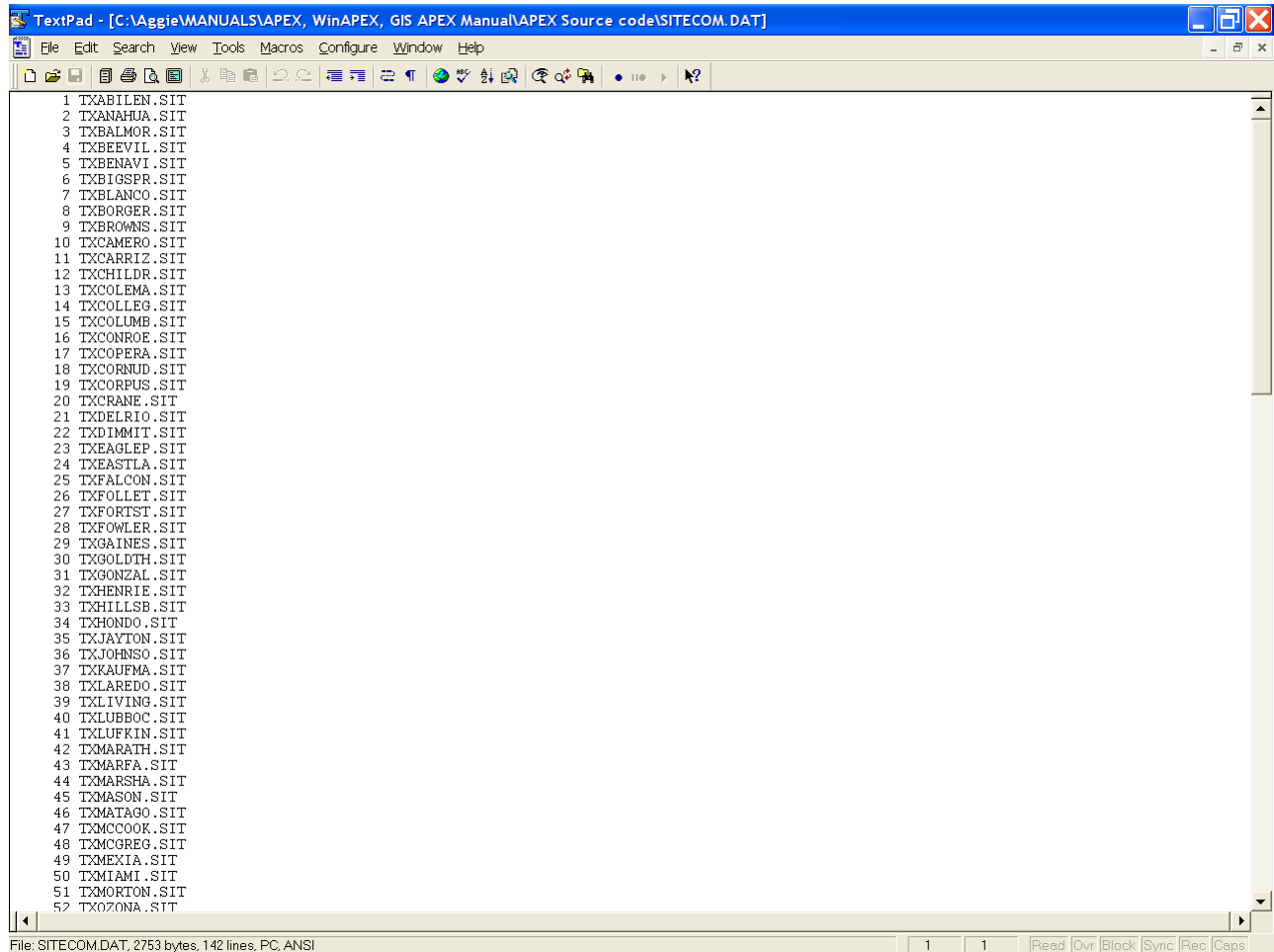
Figure 2.3: Sample *.SIT file screen



2.4 THE APEX SITE LIST (SITE****.DAT)

The APEX Site list is a listing of all site files which have been previously created following the format described in section 2.3 and are available for use in creating runs. The Site list consists of a numbered listing of all site files which can be referenced by number in the APEXRUN.DAT file. The file is in FREE FORMAT. See Figure 2.4 for an example of the SITECOM.DAT file. The Site list file name may be user defined; however, it must be properly identified in the APEXFILE.DAT file.

Figure 2.4. Sample SITECOM.DAT file

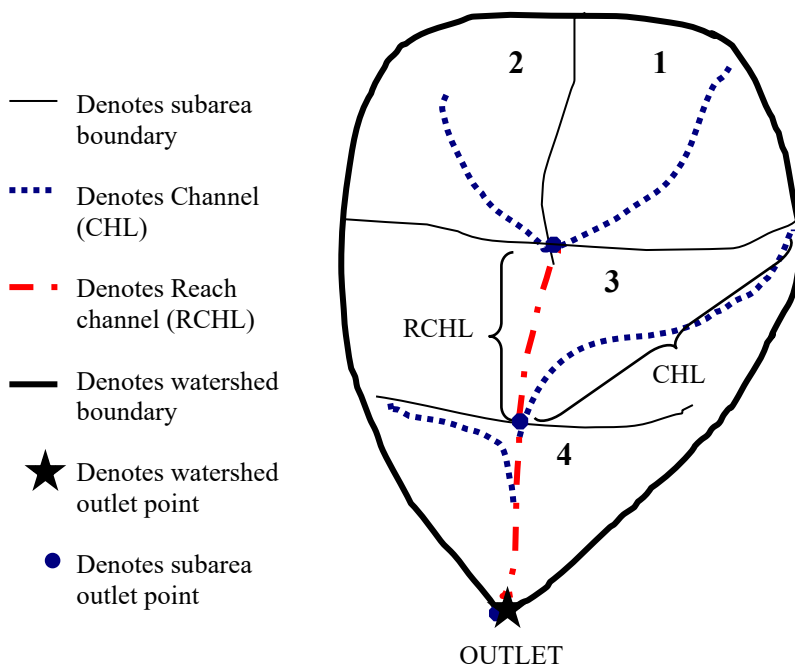


The image shows a screenshot of a TextPad window titled "TextPad - [C:\Aggie\MANUALS\APEX, WinAPEX, GIS APEX Manual\APEX Source code\SITECOM.DAT]". The window displays a list of 52 site files, each on a new line, numbered from 1 to 52. The files are listed in the following order: 1 TXABILEN.SIT, 2 TXANAHUA.SIT, 3 TXBALMOR.SIT, 4 TXBEEVIL.SIT, 5 TXBENAVI.SIT, 6 TXBIGSPR.SIT, 7 TXBLANCO.SIT, 8 TXBORGER.SIT, 9 TXBROWNS.SIT, 10 TXCAMERO.SIT, 11 TXCARRIZ.SIT, 12 TXCHILDR.SIT, 13 TXCOLEMA.SIT, 14 TXCOLLEG.SIT, 15 TXCOLUMB.SIT, 16 TXCONROE.SIT, 17 TXCOPERA.SIT, 18 TXCOORNUD.SIT, 19 TXCORPUS.SIT, 20 TXCRANE.SIT, 21 TXDELRIO.SIT, 22 TXDIMMIT.SIT, 23 TXEAGLEP.SIT, 24 TXEASTLA.SIT, 25 TXFALCON.SIT, 26 TXFOLLET.SIT, 27 TXFORTST.SIT, 28 TXFOWLER.SIT, 29 TXGAINES.SIT, 30 TXGOLDTH.SIT, 31 TXGONZAL.SIT, 32 TXHENRIE.SIT, 33 TXHILLSB.SIT, 34 TXHONDO.SIT, 35 TXJAYTON.SIT, 36 TXJOHNSO.SIT, 37 TXKAUFMA.SIT, 38 TXLAREDO.SIT, 39 TXLIVING.SIT, 40 TXLUBBOC.SIT, 41 TXLUFKIN.SIT, 42 TXMARATH.SIT, 43 TXMARFA.SIT, 44 TXMARSHA.SIT, 45 TXMASON.SIT, 46 TXMATAGO.SIT, 47 TXMCCOOK.SIT, 48 TXMCGREG.SIT, 49 TXMEXIA.SIT, 50 TXMIAMI.SIT, 51 TXMORTON.SIT, 52 TXOZONA.SIT. The status bar at the bottom of the window indicates "File: SITECOM.DAT, 2753 bytes, 142 lines, PC, ANSI".

2.5 THE SUBAREA FILE (*FILENAME.SUB*)

The farm or watershed study may involve several fields, or subareas, or as generally called homogenous hydrologic landuse units (HLU). Each subarea is homogenous in climate, soil, landuse (operation schedule), and topography. Therefore, the heterogeneity of a watershed/farm is determined by the number of subareas. Each subarea may be linked with each other according to the water routing direction in the watershed, starting from the most distant subarea towards the watershed outlet. The subareas are described in *filename.sub*. All *filename.sub* files need to be listed in SUBACOM.DAT (or user chosen name) to reference the numbered list of the subareas and their file names. Figure 2.5 illustrates a simple watershed with four subareas, which should help the user to understand how the routing mechanism can be set up in APEX.

Figure 2.5: Illustration of a watershed and rules for using the routing mechanism in APEX



Rules for routing:

1. $CHL = RCHL$

Identifies an extreme (headwaters) area
 CHL = distance from subarea outlet to most distant point of subarea
 $RCHL$ = distance of routing reach (main stream or channel) flowing through the subarea. In the case of an extreme subarea, water is not being routed through the subarea, therefore, no true routing reach has been established at this point. A true routing reach is defined when the water moves from one end of the subarea (point at which water enters the subarea from the upstream subarea) completely through the subarea to the opposite end (outlet) of the subarea.

2. $CHL \neq RCHL$

Identifies a downstream subarea (only if subarea were a narrow canyon of 0 width would $RCHL = CHL$)

3. -WSA

A negative watershed area (WSA) causes stored information to be added (here, 2 is added to 1 before being routed through 3). A negative WSA is used to indicate a subarea in which routed sediment, water, pesticides, etc from another subarea is being added to.

In APEX, there are only three variables (CHL , $RCHL$, and WSA), which need to be specified to determine the routing mechanism of every watershed. To identify extreme areas in a watershed, channel length (CHL) and channel length of routing reach ($RCHL$) have to be the same ($CHL = RCHL$). Whenever $CHL > RCHL$, the model knows that it is a downstream subarea. A negative watershed area ($-WSA$) indicates that the information of the subarea is added to another subarea(s) before entering the downstream subarea. The routing mechanism of the example in Figure 2.5 is specified as follows:

	WSA	CHL	RCHL
	in ha	in km	in km
Subarea 1 (extreme area)	50	1.25	1.25
Subarea 2 (extreme area)	- 45	1.16	1.16
Subarea 3 (downstream area)	70	1.45	0.85
Subarea 4 (downstream area)	30	0.95	0.55

The *filename.sub* includes the following data elements:

Field	Variable	Description
LINE 1		
1	SNUM	Subarea ID number (cols. 1-8; INTEGER) This is the number given by the user.
2	TITLE	Description of the subarea (cols. 9-28; ALPHA)
LINE 2	FORMAT:	FREE FORMAT; SEE FIGURE 2.6.
1	INPS	Soil number from soil list (SOIL1501.DAT)
2	IOPS	Operation schedule from operation schedule list (OPSC1501.DAT) Notes: <ul style="list-style-type: none"> 1. If Cropping System is type Dryland then Irrigation Auto Trigger (BIR) must be 0. 2. If Owner has herds and this is a feedlot subarea then fallow (one crop only) is the only crop that can be used. 3. If feedlot has a lagoon then Irrigation must be a Lagoon Irrigation type.
3	IOW	Owner ID # Must be entered
4	II	Feeding area 0 for non feeding area Herd # for feeding area If the herd is grazing on a pasture, set to 0; otherwise, select the herd which will be confined in this area (feedlot area). (Range: 0-10) Note: if II = 0 then Fraction of Subarea controlled by lagoon (DALG) must be 0
5	IAPL	Manure application area 0 non manure application area Use the positive subarea ID of the feedlot where manure is coming from to indicate solid manure application and the negative subarea ID of the feedlot where manure is coming from (lagoon) to indicate liquid manure application. (Range: -10000 to 10000)

Field	Variable	Description
6		Not used (enter 0)
7	NVCN	<p>CN-CN2 code (Range: 0-4)</p> <p>0 Variable daily CN nonlinear CN/SW with depth soil water weighting</p> <p>1 Variable daily CN nonlinear CN/SW without depth weighting</p> <p>2 Variable daily CN linear CN/SW no depth weighting</p> <p>3 Non-varying CN – CN2 used for all storms</p> <p>4 Variable daily CN SMI (soil moisture index)</p>
8	IWTH	<p>Input daily weather station number</p> <p>This is used only if the variable NGN in the control table is greater than 0.</p> <p>Note: you must have .dly(s) to use this option</p>
9	IPTS	Point source number
10	ISAO	<p>Outflow release method (Range: 0-10000)</p> <ul style="list-style-type: none"> • 0 for Normal reservoir principal spillway release • ID of subarea receiving outflow from buried pipe outlet. This captures overland flow from one subarea and releases it onto the designated subarea.
11	LUNS	<p>Land Use Number</p> <p>This number is from the NRCS land use-hydrologic soil group table. This number will override the LUN set in the Operation (OPSC****.DAT) file. If the LUN has been set for individual tillage operations, then the difference between LUNS and LUN will be added or subtracted accordingly from each of the operations which have a land use number set. For example, if LUNS equals 29 and LUN equals 25, then the land use number set on the individual tillage operations will be increased by 4. (Range: 1-35)</p> <p>See LUN under OPSC****.DAT file section 2.6 to view NRCS land use-hydrologic soil group table.</p>

Field	Variable	Description
12	IMW	<p><i>Minimum Interval between Auto Mow</i></p> <p>This refers to the minimum length of time (days) set between mowings when the Auto Mow function is used in the operation schedule. The crop will be mowed at this interval given the crop height is greater than the cutting height set on the mower used in the operation. If the IMW variable was set in the Control table, this value will override the Control table value. In order for this variable to be effective, an automatic mower must be in the operation schedule. (Range: 0-365)</p>
<p>LINE 3 <i>FORMAT:</i> <i>FREE FORMAT; SEE FIGURE 2.6.</i></p>		
<p>Initial Conditions</p>		
1	SNO	<p><i>Water content of snow on ground at start of simulation</i></p> <p>The water content of snow on the ground at the beginning of the simulation is user specified. For long-term simulations used in decision making, SNO is usually not known, but in most cases the estimate is not very critical. If a measured value of SNO is available at the beginning of a simulation, it should be used. Units are mm of water content in the snow (inches in English units). (Range: 0-1000)</p>
2	STDO	<p><i>Standing dead crop residue</i></p> <p>The STD variable allows input of initial, standing dead crop residue in t/ha. STD may be left at 0 if unknown; however, year one will not have standing dead residue prior to crop growth. Only after the first crop cycle will crop residue be present. (Range: 0-1000)</p>
3	YCT	<p><i>Y Coordinate(Latitude) of subarea centroid</i></p> <p>It needs to be entered if dust distribution and air quality is considered in the study. It also needs to be entered if the Spatially Generated Weather option is to be used. Spatially Generated Weather is set by entering 0 for the variable NGN in the control table. Note: A minus degree designates the southern hemisphere. (Range: -90 to 90)</p>
4	XCT	<p><i>X Coordinate(Longitude) of subarea centroid</i></p> <p>It needs to be entered if dust distribution and air quality is considered in the study or if the Spatially Generated Weather option is to be used. Spatially Generated Weather is set by entering 0 for the variable NGN in control table. Note: A minus degree designates western hemisphere. (Range: -180 to 180)</p>
5	AZM	<p><i>Azimuth Orientation of Land Slope</i> (degrees clockwise from North)</p>
6	SAEL	<p><i>Subarea elevation (m)</i></p>
7	FL	<p><i>Field Length(if wind erosion is to be considered) in kilometers</i></p> <p>If the normal wind erosion calculation is to be utilized (Wind Erosion Adjustment Factor (ACW) = 1.), field dimensions and orientation must be specified. This variable refers to the length of the field that is exposed to the wind. Without trees, FL = length of the field. With trees, FL < length of the field. If wind</p>

Field	Variable	Description
	FL cont.	<p>erosion is simulated for specific sites, FL, FW and ANG can be measured easily. However, hypothetical sites are often used in long-term simulations associated with large-scale decision making. In such cases, values of FL, FW and ANG should be chosen to represent typical field configurations of the area. Efforts to match field dimensions and drainage area are not necessary. The field dimensions are used only to estimate wind erosion, with the exception that FL is used to estimate water erosion from furrow irrigation.</p> <p>Thus, the simulation site may be a small area (1 ha) in a field of 1.0 by 0.5 km. It should be noted that the change in simulated wind erosion is not large for any FL > 0.3 km. Therefore, estimations of FL and FW are not usually critical for fields with areas greater than about 10 ha. When fields larger than 10 ha are strip cropped, however, the estimation of FW becomes more important. To evaluate the effect of strip cropping, FW is estimated as the average width of the strips. FL may be left at 0.0 if unknown, and it will be estimated. (Range: 0.001-12)</p>
8	FW	<p><i>Field Width(if wind erosion is to be considered) in kilometers</i> See variable FL for further information. FW may be left at 0.0 if unknown, and it will be estimated. (Range: 0.001-12)</p>
9	ANGL	<p><i>Clockwise Angle of Field Length from North(if wind erosion is to be considered)</i> See variable FL for further information. ANGL may be left at 0.0 if unknown, and it will be estimated. If ANGL is known, enter the value in degrees. (Range: 0-360)</p>

LINE 4 *FORMAT: FREE FORMAT; SEE FIGURE 2.6.*

Catchment Characteristics

Field	Variable	Description
1	WSA	<p><i>Watershed (drainage) area</i> Size is in (ha). If this is a second extreme and its flow joins the first extreme area flow but does not flow through the first extreme area a (-) sign is added to the front of the second extreme area WSA making it a negative number. This tells the program to add the second area WSA to the first extreme area when pertaining to water flow.</p>

Field	Variable	Description
2	CHL	<i>Distance from outlet to most distant point on watershed (Channel length)</i> The channel length is the distance along the channel from the outlet to the most distant point in the subarea. Often in small areas there is no defined channel. In such cases the length is measured along a concentrated flow path or it can simply be estimated from the length-width ratio of the watershed. For areas ≤ 20 ha, the channel length measurement is not critical. In such cases where channel data is not available, CHL can be set to 0 and allow the model to estimate CHL. Units are kilometers (metric) or miles (English). If this is an EXTREME subarea then Channel Length of Routing Reach MUST EQUAL Distance from Outlet. If this is a DOWNSTREAM subarea then Channel Length of Routing Reach can NOT BE EQUAL to Distance from Outlet. If channel data is not available, enter 0.
3	CHD	<i>Channel depth</i> Depth of the channel in meters. If unknown, enter 0.
4	CHS	<i>Mainstream channel slope</i> The average channel slope is computed by dividing the difference in elevation between the watershed outlet and the most distant point by CHL. For small areas this measurement is not critical because CHL and CHS are only used in estimating the watershed time of concentration. The dominant portion of the time of concentration is involved with overland rather than channel flow in small watersheds. Slope is expressed as units of drop per unit of distance. (m/m). If unknown, enter 0.
5	CHN	<i>Manning's N for channel.</i> If the channel conducting runoff to the edge of the field is winding and/or contains obstructions, water flow rates will be reduced, and sediment will have an opportunity to settle. The channel roughness factor is referred to as the Manning's "n" value. The table contains suggested values of Manning's "n" for various condition channel flow (Chow 1959). Chow has a very extensive list of Manning's roughness coefficients. These values represent only a small portion of those listed in his book. If unknown, enter 0.

Table 2.1: Suggested values of Manning's "n" for various condition channel flow (Chow 1959)

<i>Characteristics of Channel</i>	<i>Value Chosen</i>	<i>Range</i>
A. Excavated or dredged		
1. Earth, straight and uniform	0.0250	0.016 – 0.033
2. Earth, winding and sluggish	0.0350	0.023 – 0.050
3. Not maintained, weeds and brush	0.0750	0.040 – 0.140
B. Natural Streams		
1. Few trees, stones or brush	0.0500	0.025 – 0.065
2. Heavy timber and brush	0.1000	0.050 – 0.150

Field	Variable	Description
6	STP	<p><i>Average Upland Slope</i> Slope is in m/m. Must be entered. The average watershed slope can be estimated from field measurement or by using the Grid-Contour Method (Williams and Berndt 1977).</p>
7	SPLG	<p><i>Average Upland Slope Length</i> Length in m. Must be entered. The watershed slope length can be estimated by field measurement as described by Wischmeier and Smith (1978) or from topographic maps using the Contour-Extreme Point Method (Williams and Berndt 1977).</p> <p>This is the distance that sheet flow is the dominant surface runoff flow process. Slope length should be measured to the point that flow begins to concentrate. This length is easily observable after a heavy rain on a fallow field when the rills are well developed. In this situation, the slope length is the distance from the subarea divide to the origin of the rill. This value can also be determined from topographic maps.</p> <p>Terraces divide the slope of the hill into segments equal to the horizontal terrace interval. With terracing, the slope length is the terrace interval. For broadbase terraces, the horizontal terrace interval is the distance from the center of the ridge to the center of the channel for the terrace below. The horizontal terrace interval for steep backslope terraces is the distance from the point where cultivation begins at the base of the ridge to the base of the frontslope of the terrace below.</p> <p>Slope length is a parameter that is commonly overestimated. As a rule of thumb, 90 meters (300 ft) is considered to be a very long slope length.</p>

Field	Variable	Description
8	UPN	<p><i>Manning's N for Upland</i></p> <p>The surface roughness factor is Manning's "n" values. This table contains suggested values and possible ranges of Manning's 'n' for various condition overland flow (Engman 1983).</p>

Table 2.2: Suggested values and possible ranges of Manning's "n" for various condition overland flow (Engman 1983).

<i>Type of Surface</i>	<i>Value Chosen</i>	<i>Range</i>
Fallow, no residue	0.0100	0.008 – 0.012
Conventional tillage, no residue	0.0900	0.060 – 0.120
Conventional tillage, residue	0.1900	0.160 – 0.220
Chisel plow, no residue	0.0900	0.060 – 0.120
Chisel plow, residue	0.1300	0.100 – 0.160
Fall disking, residue	0.4000	0.300 – 0.500
No till, no residue	0.0700	0.040 – 0.100
No till, with residue (0.5 – 1.0 t/ha)	0.1200	0.070 – 0.170
No till, with residue (2.0 – 9.0 t/ha)	0.3000	0.170 – 0.470
Rangeland (20% cover)	0.6000	--
Short grass prairie	0.1500	0.100 – 0.200
Dense grass	0.2400	0.170 – 0.300
Bermudagrass	0.4100	0.300 – 0.480

*If unknown, enter 0.

9	FFPQ	<p><i>Fraction of floodplain flow</i></p> <p>Partitions surface flow through filter strips and buffers. This is the fraction of the flow that travels through the filter strip from the subarea entering the filter strip. This value should be entered for the filter strip subarea. If FFPQ for example = 0.90, then 10 percent of the runoff will be concentrated flow. FFPQ depends on the topographical shape of the buffer or filter. If the topography is flat, FFPQ will be very near 1.00. If however, the topography includes dips and hills, FFPQ will be nearer to 0. Contoured buffer strips are designed to catch a large amount of the surface runoff and are therefore fairly efficient as a filter strip and FFPQ would be near 1.00. (Range: 0-1)</p>
---	------	--

FFPQ cont.

Shape of buffer when looking at horizon.



FFPQ = 1.00. The buffer strip should be intercepting nearly 100% of the surface flow coming from the above field.



FFPQ < 1.00. The fraction of the buffer that is intercepting surface flow from the field above the filter may only be about 20% because it is being channelized due to the shape of the land.

10 URBF

Fraction of Subarea which is Urban

This is the fraction of the subarea which is considered urban. This portion of the subarea will be simulated using an impervious land use and all output for this subarea will be weighted based on this fraction. (Range: 0-1)

LINE 5 FORMAT: FREE FORMAT; SEE FIGURE 2.6.

Channel Geometry of Routing Reach through Subarea

Field	Variable	Description
1	RCHL	<i>Channel Length of Routing Reach</i> The length (distance) in km between where channel starts or enters the subarea and leaves the subarea. If this is an EXTREME subarea, then Routing Reach Length MUST EQUAL Longest Distance from Outlet (CHL). If this is a DOWNSTREAM subarea, then Routing Reach Length cannot be equal to Longest Distance from Outlet (CHL). RCHL ≠ 0 for a downstream subarea.
2	RCHD	<i>Channel Depth of Routing Reach</i> Depth of the channel for the routing reach in meters. If unknown, enter 0.
3	RCBW	<i>Bottom Width of Channel of Routing Reach</i> Width in meters of the bottom of the channel of routing reach. If unknown, enter 0.
4	RCTW	<i>Top Width of Channel of Routing Reach</i> Width in meters of the top of the channel of routing reach. If unknown, enter 0.
5	RCHS	<i>Channel Slope of Routing Reach</i> Slope of the routing reach channel in m/m. If unknown, enter 0.

Field	Variable	Description
6	RCHN	Channel Manning's N of Routing Reach The table contains suggested values of Manning's "n" for various condition channel flow (Chow 1959). Chow has a very extensive list of Manning's roughness coefficients. These values represent only a small portion of those listed in his book. If unknown, enter 0.

Table 2.3: Suggested values of Manning's "n" for various condition channel flow (Chow 1959).

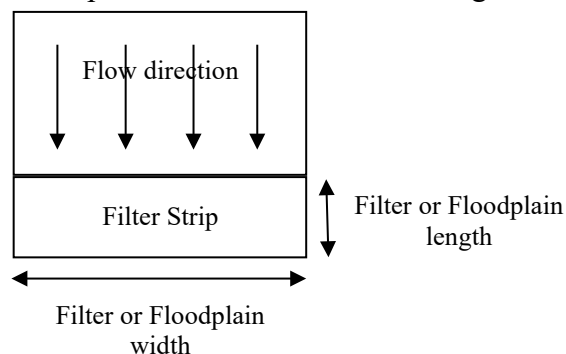
<i>Characteristics of Channel</i>	<i>Value Chosen</i>	<i>Range</i>
A. Excavated or dredged		
1. Earth, straight and uniform	0.0250	0.016 – 0.033
2. Earth, winding and sluggish	0.0350	0.023 – 0.050
3. Not maintained, weeds and brush	0.0750	0.040 – 0.140
B. Natural Streams		
1. Few trees, stones or brush	0.0500	0.025 – 0.065
2. Heavy timber and brush	0.1000	0.050 – 0.150

7 RCHC **USLE Crop Management Channel (C)Factor**
If set, RCHC will override the RCC0 value in the Control file. With bare channel condition, RCHC should be 0.1- 0.6, and if the channel has very good land cover, it should have a value of 0.0001 (Range is 0.0001 - 0.6)

8 RCHK **USLE Erodibility Channel (K)Factor**
Must be entered. With a rock condition, RCHK should be 0.0001; with loess (silt/mud) condition, it should be 0.30.(Range is 0.0001 - 0.5)

9 RFPW **Reach Floodplain width**
This is the width of the filter or buffer strip. $(\text{Drainage Area}(\text{WSA}) \times 10000) / (\text{Floodplain length} (\text{RFPL}) \times 1000)$, in (m). If unknown, enter 0.

10 RFPL **Floodplain length**
Length of buffer or floodplain, km. This is the flow length. If unknown, enter 0.



Field	Variable	Description
11	SAT1	Saturated Conductivity (Green & Ampt) Adjustment Factor (Range: .01-10) (use with Green & Ampt). (Range: 0.01-10) Fraction multiplied by the 2 nd soil layer saturated conductivity to estimate Green & Ampt saturated conductivity (SATK)
12	FPS1	Floodplain Saturated Conductivity Adjustment Factor (Range: 0.0001-10) Fraction multiplied by the 2 nd soil layer saturated conductivity.

LINE 6 *FORMAT: FREE FORMAT; SEE FIGURE 2.6.*

Reservoir Data

Field	Variable	Description
1	RSEE	Elevation at emergency spillway (meters)
2	RSAE	Total reservoir surface area at emergency spillway elevation (RSEE) in ha.
3	RSVE	Storage volume at emergency spillway elevation in mm. Volume in mm = (volume in m ³ /10)/(WSA * 10) where WSA is in ha. A typical volume at the emergency spillway for a PL566 dam is approximately 150 mm.
4	RSEP	Elevation at principal spillway (meters)
5	RSAP	Total reservoir surface area at principal spillway elevation (RSEP) in ha.
6	RSVP	Storage volume at principal spillway elevation in mm. Volume in mm = (volume in m ³ /10)/(WSA * 10) where WSA is in ha.
7	RSV	Initial reservoir volumes in mm. Volume in mm = (volume in m ³ /10)/(WSA * 10) where WSA is in ha. A typical volume at the principal spillway for a PL566 dam is approximately 20 mm.
8	RSRR	Average principal spillway release rate in days. Days to draw down from the emergency spillway to the principle spillway volume.
9	RSYS	Initial sediment concentration in reservoirs in ppm
10	RSYN	Normal sediment concentration in reservoirs in ppm.

LINE 7 *FORMAT: FREE FORMAT; SEE FIGURE 2.6.*

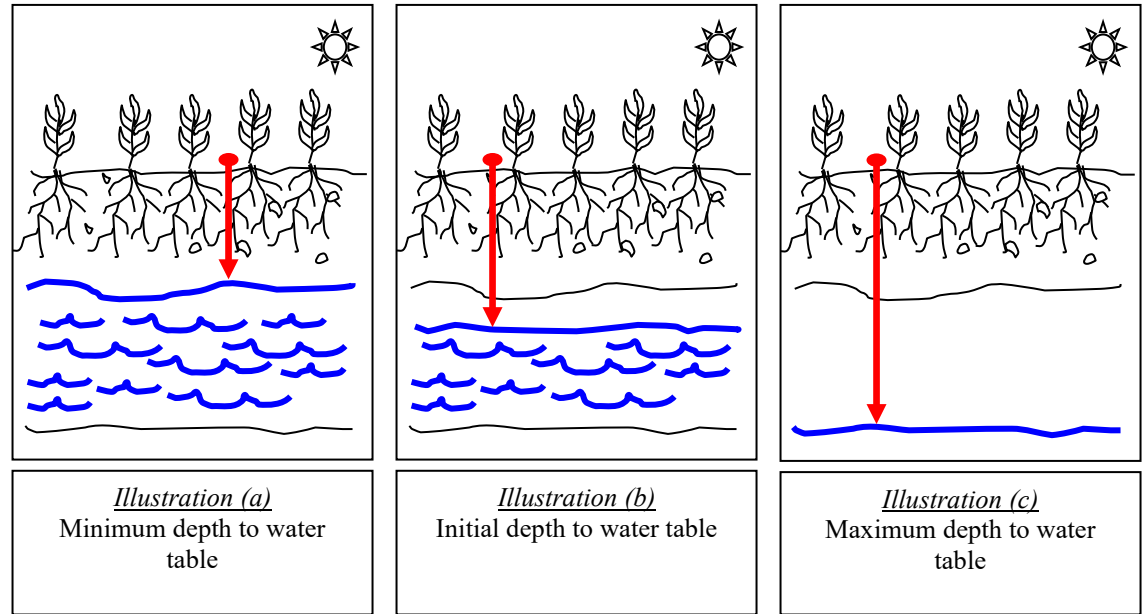
Reservoir Data

Field	Variable	Description
1	RSHC	Hydraulic conductivity of reservoir bottoms in mm/h.
2	RSDP	Time for Sediment Concentrations to Return to Normal Time required in days for the sediment in the reservoir to return to the normal concentrations following a runoff event. Good average is 10-20 days. (Range: 0-365)

Field	Variable	Description
3	RSBD	<i>Bulk density of sediment in reservoir (t/m³)</i>
4	PCOF	<i>Fraction of subarea controlled by ponds</i> Fraction of the subarea which flows through ponds. This affects only the hydrology that originates in this subarea. Inflow from other subareas is not routed through the ponds in this subarea. (Range: 0-1)
5	BCOF	<i>Fraction of the Subarea controlled by Buffers</i> This is the fraction of the subarea which is controlled by buffer strips. This affects only the hydrology that originates in this subarea. Inflow from other subareas is not routed through the buffer strips in this subarea. This variable should be used when the exact location of the buffer strips is not known. If the exact location is known, the buffer strip should be treated as another subarea. (Range: 0-1) Assumptions: 1. All buffer strips have grass cover
6	BFFL	<i>Buffer Flow Length (m)</i> The distance the flow must travel through the buffer strips. This is the cumulative flow length if several separate buffers are located in succession within the subarea. This variable should be set if BCOF is greater than 0.
7	WTMN	<i>Minimum depth to water table</i> (Range: 0-100) This is the depth (m) from the soil surface to the water table when the water table is at its highest level. See Figure 2.11 (a). NOTE 1. If this depth is greater than 6 feet (1.8 meters), its affect on the model results are minimal. With the depth set at zero, the model automatically sets the depth deep enough to remove any affects. Set to 0 if unknown. 2. Fluctuation in the water table is a function of rainfall and ET. If the ratio of the 30-day antecedent rainfall minus the 30-day antecedent PET to the 30-day antecedent PET is less than 0, the water table drops. If the ratio is greater than 0, the water table rises.
8	WTMX	<i>Maximum depth to water table</i> (Range: 0-100) This is the depth (m) from the soil surface to the water table when the water table is at its lowest level. Set to 0 if unknown. See Figure 2.11 (c).
9	WTBL	<i>Initial water table height (cols. 41-48)</i> (Range: 0-100) This is the depth (m) from the soil surface to the current water level at which the model will begin simulating. Throughout the simulation the water level will fluctuate up and down. See Figure 2.11 (b). NOTE This depth must be greater than or equal to the Minimum depth to the water table (WTMN) and less than or equal to the Maximum depth to the water table (WTMX).

The last three parameters are very important when the field contains a water table that is very near the surface. Default settings assume the water table is deep enough not to affect plant growth; however, if the water table is within several feet of the surface, it can provide an extra supply of water that ordinarily would not be accounted for in the model.

Figure 2.11: Illustrations of depth to water table.



- 10 GWST **Groundwater storage** (Range: 0-200)
The amount of groundwater storage (mm) available in mm at the beginning of the simulation.
Set to 0 if unknown.
- 11 GWMX **Maximum groundwater storage** (Range: 10-500)
The maximum amount of groundwater storage available in mm
Set to 0 if unknown.
- 12 RFTT **Groundwater residence time in days** (Range: 1-365)
Set to 0 if unknown.
- 13 RFPK **Return flow/(return flow + deep percolation)** (Range: 0.01-0.99)
Set to 0 if unknown.

LINE 8 FORMAT: FREE FORMAT

Management Information

Field	Variable	Description
1	NIRR	<p>Rigidity of Irrigation Code (Range: 0-2)</p> <p>0 <u>For flexible (variable) applications.</u> Applies minimum of volume input, soil water field capacity (FC-SW) and maximum single irrigation application volume (ARMX).</p> <p>1 <u>For rigid (fixed) applications.</u> Applies input amount or ARMX.</p> <p>The irrigation code is used to specify the irrigation strategy. There are two modes of irrigating -- manual and automatic. The following details how the model handles the combination of rigid and flexible applications and manual and automatic irrigation.</p> <ol style="list-style-type: none"> 1. <u>Fixed/Rigid</u> If MANUAL irrigation is used, irrigation is applied according to the amounts and dates specified by the user in the operation schedule. If AUTOMATIC irrigation is used, the amount applied per application is equal to the maximum single application amount (ARMX) which is set for each subarea, and irrigation is applied when the irrigation trigger (BIR) is reached. In all cases the EFI is removed through runoff prior to infiltration into the soil. If the amount of irrigation is greater than the amount of water needed to bring the soil to field capacity, the model will run off the fraction (EFI), fill the profile to field capacity and the remaining water will be percolated through the soil. This may cause leaching of nutrients, however. Soluble nutrients are leached through the soil or removed with runoff. 2. <u>Variable/Flexible</u> If MANUAL irrigation is used, irrigation is applied on the date specified in the operation schedule in a volume equal to the minimum of the specified volume, maximum single application volume, or the volume required to fill the root zone to field capacity calculated as $((\text{Field capacity} - \text{storage}) / (1 - \text{EFI}))$. EFI will be taken into account regardless of the option chosen. If AUTOMATIC irrigation is used, irrigation is applied based on the irrigation trigger (BIR) and according to the minimum (ARMN) and maximum (ARMX) single irrigation application rates as well as maximum annual irrigation amount (VIMX) and the irrigation interval (IRI) set for each subarea. In all cases the EFI is removed through runoff prior to infiltration into the soil and is calculated as $((\text{Field capacity} - \text{storage}) / (1 - \text{EFI}))$. <p>2 <u>For paddy irrigation applications</u> This allows the user to simulate a paddy or wetland situation.</p>

Field	Variable	Description
1	IRR	<p><i>Irrigation Code</i> (Range: 0-5)</p> <p>0 for dryland 1 for sprinkler irrigation 2 for furrow/flood irrigation 3 for fertigation (irrigation with fertilizer added) 4 for lagoon (irrigation from a lagoon) 5 for drip irrigation</p> <p>The irrigation code is used to specify whether irrigation is used and the type of irrigation.</p> <ul style="list-style-type: none"> • If furrow/flood irrigation is specified, irrigation induced erosion is calculated. • If fertigation is specified, IDFT identifies the type of fertilizer and FNP identifies the amount of fertilizer for each irrigation. • If lagoon is specified, the concentration in tons of soils per m³ of effluent is specified by FNP and the nutrient fraction by creating a fertilizer in the Fert1501.DAT file with the appropriate nutrients and selecting it with IDFT. <p>NOTE: NIRR and IRR are entered as one number. For example, a rigid drip irrigation regime would be entered as 15.</p>
2	IRI	<p><i>Minimum application interval for automatic irrigation</i></p> <p>This sets the number of days between automatic irrigation events. Irrigation will not occur until the minimum number of days has been met regardless if the BIR has already been met. If IRR = 0, then set IRI to 0. IRI will also affect manual irrigation. If manual irrigations are applied at a daily interval less than set in IRI, then manual irrigations will only be applied at the interval set in IRI. (Range: 0-365)</p>
3	IFA	<p><i>Minimum fertilizer application interval for auto option</i></p> <p>This sets the number of days between automatic fertilization events. Fertilization will not occur until the minimum number of days has been met regardless if the BFT has already been met. (Range: 0-365)</p>
4	LM	<p><i>Liming Code</i> (Range: 0-1)</p> <p>APEX enables the user to simulate application of agricultural limestone to increase soil pH and/or reduce soil aluminum saturation. For many soils and applications of APEX, this feature is not needed; therefore, it can be turned off by setting LM to 1.</p> <p>Long term simulations with noncalcareous soils and either nitrogen fertilizer or nitrogen-fixing legumes often require liming to prevent acidification of the soil and reduction of crop growth.</p> <p>0 Lime applied automatically as needed to prevent acidification of the soil 1 No lime applied.</p>

Field	Variable	Description
5	IFD	<p><i>Furrow Dike Code</i> Furrow dikes (or tied ridges) are small dams constructed, usually by tillage equipment, in the furrows. They are designed to impede runoff and promote infiltration of rainfall and/or sprinkler irrigation. APEX simulates the construction, function, and destruction of furrow dikes. The furrow dike code IFD is used to determine whether dikes are simulated. (Range: 0-1)</p> <p>0 Furrow dike system not simulated 1 Furrow dike system simulated</p>
6	IDR	<p><i>Drainage code</i> Artificial drainage systems (tiles, perforated pipes, open ditch drains, etc.) are often installed to remove excess water from fields. (Range: 0-2500)</p> <p>0 No drainage >0 Enter depth to drainage system in mm.</p>
7	IDF1	<p><i>Fertilizer Number Used for Fertigation from Lagoon.</i> Fertilizer identification number for fertigation or automatic fertilization from lagoon.</p> <p>Enter 0 for no fertigation or automatic fertilization from a lagoon. To apply fertigation from a lagoon put in the number of fertilizer from lists provided (FERT1501.DAT). If no number is set, the model defaults to fertilizer #69. It is wise to set this number even if there are no current plans to use this function so that the selected fertilizer number matches the correct number in the fertilizer list which is being used.</p>

NOTES

1. MNUL in Control File MUST BE SET.
If no lagoon is present or turned on, then this function will not take effect even if a fertilizer number is set.

Field	Variable	Description
8	IDF2	<p><i>Fertilizer Number Used for Automatic Solid Manure Application from Feeding Area Stock Pile.</i> Fertilizer identification number for automatic fertilization using solid manure from the feeding area stock pile.</p> <p>Enter 0 for no automatic fertilization using solid manure. To automatically apply solid manure from the feeding area stock pile put in the number of the fertilizer from lists provided (FERT1501.DAT). If no number is set, the model defaults to fertilizer #68. It is wise to set this number even if there are no current plans to use this function so that the selected fertilizer number matches the correct number in the fertilizer list which is being used.</p> <p>NOTES</p> <ol style="list-style-type: none"> 1. FNP2 in subarea file MUST BE SET 2. MNUL in Control File MUST BE SET
9	IDF3	<p><i>Fertilizer Number Used for Automatic Commercial Phosphorus Application</i> Enter number of fertilizer from lists provided (FERT1501.DAT). If no number is set, the model defaults to fertilizer #53. It is wise to set this number even if there are no current plans to use this function so that the selected fertilizer number matches the correct number in the fertilizer list which is being used.</p> <p>NOTE: IPAT must be set to 1 in the Control Table for automatic P application to function.</p>
10	IDF4	<p><i>Fertilizer Number Used for Automatic Commercial Nitrogen Application.</i> Enter number of fertilizer from lists provided (FERT1501.DAT). If no number is set, the model defaults to fertilizer #52. It is wise to set this number even if there are no current plans to use this function so that the selected fertilizer number matches the correct number in the fertilizer list which is being used.</p> <p>NOTES</p> <ol style="list-style-type: none"> 1. BFT, FNP4 and IFA in subarea file MUST BE SET.
11	IDF5	<p><i>Fertilizer Number Used for Automatic Solid Manure Application</i> To automatically apply solid manure (can come from an external source) enter the fertilizer number from the lists provided (FERT1501.DAT). If no number is set, the model defaults to fertilizer #68. It is wise to set this number even if there are no current plans to use this function so that the selected fertilizer number matches the correct number in the fertilizer list which is being used.</p> <p>NOTES</p> <ol style="list-style-type: none"> 1. FNP5 and IFA from the subarea file MUST BE SET. 2. MNUL in the control table MUST BE SET.

Field	Variable	Description
12	IDF6	<i>Fertilizer Number Used for Automatic Application of Commercial Potassium</i> Enter number of fertilizer from lists provided (FERT1501.DAT). If no number is set, the model defaults to fertilizer #54. It is wise to set this number even if there are no current plans to use this function so that the selected fertilizer number matches the correct number in the fertilizer list which is being used. NOTE: IKAT must be set to 1 in the Control Table for automatic K application to function.
13	IRRS	<i>ID of the Subarea Supplying Irrigation Water from a Reservoir</i> 0 No Reservoir supply or no irrigation >0 Subarea number containing the reservoir to be used as irrigation water supply
14	IRRW	<i>ID of Subarea Supplying Irrigation Water from a Well</i> 0 No Well supply or no irrigation >0 Subarea number containing the well to be used as irrigation water supply

LINE 9 *FORMAT: FREE FORMAT; SEE FIGURE 2.6.*

Field	Variable	Description
1	BIR	<i>Water stress factor to trigger automatic irrigation.</i> To trigger automatic irrigation, the water stress factor is set: 0 manual irrigation 0 – 1.0 Plant water stress factor. (1 – BIR) equals the fraction of plant water stress allowed 1.0 Does not allow water stress < 0.0 Plant available water deficit in root zone (number is in mm and must be negative) > 1.0 Soil water tension in top 200mm (Absolute number is in kilopascals) -1000 Sets water deficit high enough that only manual irrigations will occur. Effectively turns auto irrigation off.

NOTES

1. When BIR is set and used with a cropping system that includes more than one crop in rotation, the BIR will apply to all crops in the rotation. When using a BIR based on anything other than plant water stress (0-1), be aware that irrigation will be applied outside of the growing season if the soil water deficit or soil water tension reaches BIR. This will reduce the amount of water available for irrigation during the growing season.

Field	Variable	Description
2	EFI	<p><i>Runoff Vol/Vol Irrigation Water Applied.</i> The irrigation runoff ratio specifies the fraction of each irrigation application that is lost to runoff. Soluble nutrient loss through runoff applies. Changes in soil slope do not affect this amount dynamically. EFI must be set accordingly. Set to 0 if IRR = 0 (dryland) (Range: 0-1)</p>
3	VIMX	<p><i>Maximum annual irrigation volume</i> This is the maximum irrigation volume allowed each year in mm. If several crops are grown in one year, the first crop's needs will be supplied as needed and any remaining water will be applied as needed to the next crop. If all of the water allocated by VIMX is used on the first crop, the second crop will not receive any irrigation. This also applies to manual irrigation. Once the amount of irrigation applied equals VIMX, then no additional irrigation will be applied, regardless if it's manually or automatically applied.</p>
4	ARMN	<p><i>Minimum single application volume</i> This is the minimum amount of irrigation allowed for each auto irrigation application in mm.</p>
5	ARMX	<p><i>Maximum single application volume</i> This is the maximum amount of irrigation allowed for each auto irrigation application in mm. This is the amount applied if rigid automatic irrigation is selected.</p>
6	BFT	<p><i>N stress factor to trigger auto fertilization.</i> The automatic fertilizer trigger functions much like BIR for irrigation. When the plant nitrogen stress level reaches BFT, nitrogen fertilizer may be applied automatically. If this value is greater than 0, IDFT must be the Number of the Fertilizer application.</p> <p>0.00 For manual fertilizer 0 – 1 Allows percentage of plant nitrogen stress (1 – BFT) equals the fraction of N stress allowed. 1.00 No N stress, auto-fertilization when needed. >1 If BFT is greater than 1, BFT is the PPM(g/t) N in soil at which automatic fertilizer is triggered</p>

Field	Variable	Description
7	FNP4	<p><i>Auto Fertilization Application Rate (N)</i> Variable rate of automatic commercial application (amount of fertilizer applied as needed to lower N stress); fixed rate of automatic commercial application (set amount of fertilizer applied each time N stress is reached). The units for this parameter are in kg/ha.</p> <p>NOTES</p> <ol style="list-style-type: none"> 1. BFT (Auto Fertilizer Trigger) must be set 2. IDF4 (Automatic commercial Fertilizer Application) cannot be 0 for this variable to work.
8	FMX	<p><i>Maximum annual N fertilizer applied</i> Maximum amount of nitrogen fertilizer available for application per year in kg/ha. If more than one crop is grown per year, nitrogen will be applied to the first crop as specified. Nitrogen fertilizer will be applied to successive crops up to the maximum annual value. After the annual value has been met, no additional fertilizer will be applied. This variable can be overridden in the operation schedule where it can be set per crop. Refer to section 2.6 for further information on setting the maximum annual amount per crop.</p> <p>NOTE</p> <p>If this variable is set either in the subarea file or in the operation schedule and manual fertilization is applied, the model will only apply up this maximum amount regardless of the amount specified in the manual fertilization operation.</p>
9	DRT	<p><i>Time requirement for drainage system to end plant stress in days.</i> Artificial drainage systems may be very efficient and quickly reduce water tables or it may take several days for the water level to decline sufficiently to eliminate aeration stress. The variable DRT is used to specify the time needed for the drainage system to eliminate stress. In this case time is measured in days. If drainage is not considered, enter 0. (Range: 0-365)</p>
10	FDSF	<p><i>Furrow Dike Safety Factor</i> Fraction of furrow dike volume available for water storage. FDSF controls the volume of water that can be stored in the dike before water tops over the dike. This variable is used to account for uncertainty in the volume of the furrow dike. The volume is calculated from the height of the row, row interval (width of row), length of dike and height of dike. If these values are not very certain, it may be wise to set FDSF to a low number which indicates that the certainty of dike design is not very high. This will cause the dikes to overflow much quicker, however, which will affect runoff and erosion. If the certainty of design of the dike is great, FDSF can be set to 0.9 or higher, which will lessen dike overflow as well as runoff and erosion. (Range: 0-1)</p>

LINE 10 *FORMAT: FREE FORMAT; SEE FIGURE 2.6.*

Field	Variable	Description
1	PEC	<p><i>Erosion control practice factor.</i> The erosion-control-practice factor normally ranges from about 0.1 to 0.9 depending upon the effectiveness of the conservation practice. Default = 1.0 for non-contoured fields. However, PEC can be set to 0.0 to eliminate water erosion entirely. When this is done, the soil profile remains relatively static because it is reset to initial conditions at the end of each year. This feature is very convenient for a given soil profile. At the other extreme, (PEC=10.) erosion rates are increased 10 times to improve log-term simulation efficiency. This feature is a big time saver in estimating water erosion effects on soil properties over periods of up to 1000 years. Obviously, the 1000-year period can be approximated with a 100-year simulation using PEC=10. (Range: 0-10)</p>

Table 2.4: P values and slope length limits for contouring.

Land Slope(%)	P value	Maximum length (feet)
1 to 2	0.60	400
3 to 4	0.50	300
6 to 8	0.50	200
9 to 12	0.60	120
13 to 16	0.70	80
17 to 20	0.80	60
21 to 25	0.90	50

Proper setting of the PEC value will improve the simulated erosion amount

NOTE

1. Maximum length may be increased by 25% if residue cover after crop seeding will regularly exceed 50%.

2 DALG ***Fraction of Subarea controlled by lagoon.***
 This is only needed when IRR = 4 (Range: 0-1)

3 VLGN ***Lagoon Volume Ratio***
 Normal Lagoon Volume as a fraction of Maximum Lagoon Volume. (Normal Lagoon Volume/Maximum lagoon volume) (fraction). (Range: 0-1)
 Needed only when IRR = 4.

NOTE

1. If Fraction of Subarea controlled by lagoon (DALG) = 0 then VLGN must = 0

Field	Variable	Description
4	COWW	<p><i>Lagoon Input From Wash Water</i> Needed only when IRR = 4 and owner has at least one head of livestock. (Average normal value is 0.15) (Range: 0-1)</p> <p>NOTE</p> <ol style="list-style-type: none"> 1. If Fraction of Subarea controlled by lagoon (DALG) = 0 then COWW must = 0 (m³/animal unit/day).
5	DDLG	<p><i>Time to Reduce Lagoon Storage From Maximum to Normal</i> Needed only when IRR = 4. (Range: 0-365)</p> <p>NOTE</p> <ol style="list-style-type: none"> 1. If Fraction of Subarea controlled by lagoon (DALG) = 0 then DDLG must = 0 (days).
6	SOLQ	<p><i>Ratio Liquid/Total Manure Produced in this Feedlot Subarea.</i> Fraction of total manure produced that goes into a lagoon as liquid. Needed only when IRR = 4 (Range: 0-1)</p> <p>NOTE</p> <ol style="list-style-type: none"> 1. If Fraction of Subarea controlled by lagoon (DALG) = 0 then SOLQ must = 0
7	SFLG	<p><i>Safety factor for lagoon design</i> This number is expressed as a fraction. It is needed only when IRR = 4. $VLG = VLG0/(1-SFLG)$ where VLG equals the lagoon volume and VLG0 is the initial lagoon volume. (Range: 0-1)</p>
8	FNP2	<p><i>Feeding Area Stock Pile Auto Solid Manure Application Rate</i> Used in solid waste area when a feedlot has been assigned to IAPL and IDF2 > 0. (kg/ha)</p>
9	FNP5	<p><i>Automatic Manure application rate</i> Activated only if IDF5 > 0. This function allows manure to be applied as needed in kg/ha. The manure applied can come from an external source.</p>
10	FIRG	<p><i>Factor to Adjust Automatic Irrigation Volume</i> The adjustment factor allows the profile to be filled to a fraction of field capacity. FIRG can be set >1 to allow for over application of irrigation . $FIRG \times FC$. (Range: 0.5 – 5.0)</p>

LINE 11 *FORMAT: FREE FORMAT; SEE FIGURE 2.6.*

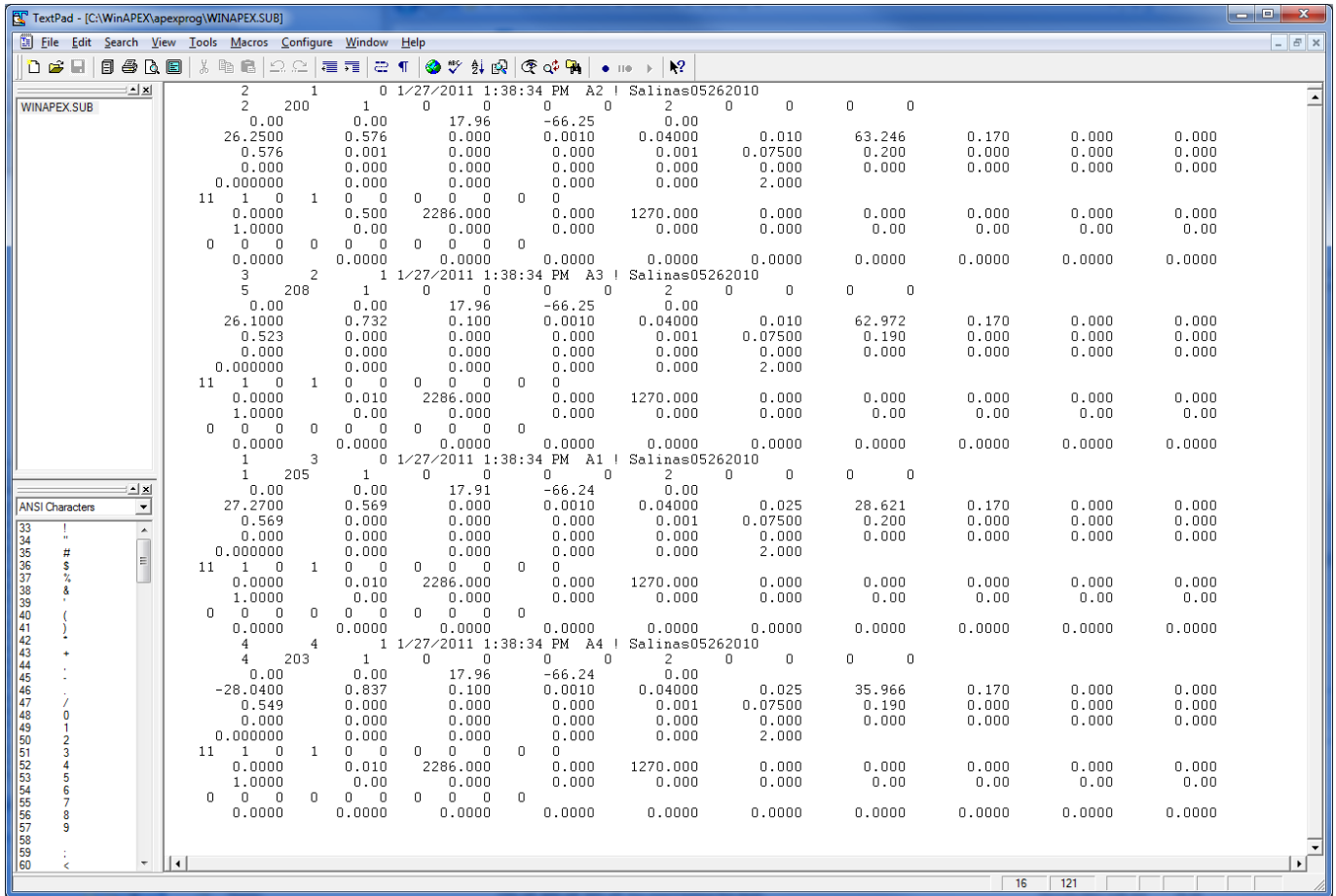
Field	Variable	Description
1	NY(1)	<i>Herd(s) Eligible for Grazing this Crop</i> Select none (0) if no herd is used in this Subarea or select herd number(s) (NCOW from site file) eligible to feed in area. If herd is selected, set the grazing lower limit (GZLM in control table or XTP in subarea file.) in the pasture area. (Range: 0-10)
		NOTE
		1. NY must be set in order for a herd to be eligible to graze this crop.
		2. Management budget must have a Start Graze operation for this Crop in order for grazing to be initiated. If owner has no herds (from Owner table) then NY and XTP field cannot be set
		3. If Min Fraction of Day (FFED) is set to 1 (in HERD file) the herd will not show up in select list.
:	:	:
10	NY(10)	<i>Herd(s) Eligible for Grazing this Crop</i> Select none (0) if no herd is used in this Subarea or select herd number(s) (NCOW from site file) eligible to feed in area. If herd is selected, set the grazing lower limit of feed (GZLM) in the pasture area. (Range: 0-10)

LINE 12 *FORMAT: FREE FORMAT; SEE FIGURE 2.6.*

Field	Variable	Description
1	XTP (1)	<i>Grazing limit for each herd (cols. 1-8)</i> This is the minimum amount of plant material (t/ha) that must be present for grazing to occur. When herd grazes down to this limit, grazing is stopped and herd is placed on supplementary feed. If XTP is not set in the subarea file, the grazing limit (GZLM) in the control table will be used.
:	:	:
10	XTP(10)	<i>Grazing limit for each herd (cols. 73-80)</i> This is the minimum amount of plant material (t/ha) that must be present for grazing to occur. When herd grazes down to this limit, grazing is stopped and herd is placed on supplementary feed.

LINE 1 THROUGH 12 ARE REPEATED FOR EACH SUBAREA IN THE WATERSHED.

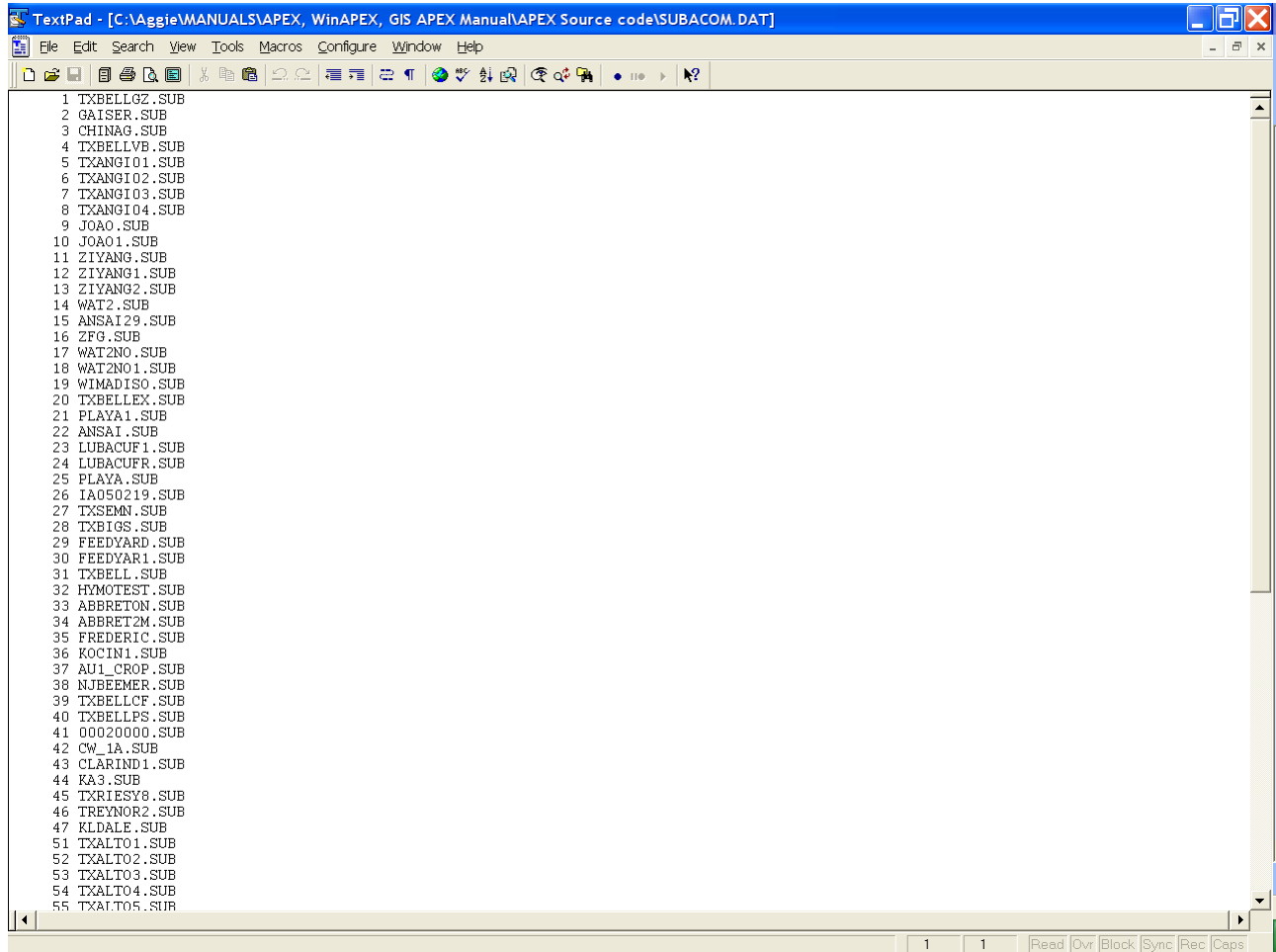
Figure 2.6: Sample Subarea (*.SUB) file screen.



2.6 APEX SUBAREA LIST FILE (SUBA****.DAT)

The APEX Subarea list file is a listing of all subarea files which have been previously created following the format described in section 2.5 and are available for use in creating runs. The Subarea list consists of a numbered listing of all subarea files which can be referenced by number in the APEXRUN.DAT file. The file is in FREE FORMAT. See Figure 2.7 for an example of the SUBACOM.DAT file. The Subarea list file name may be user defined; however, it must be properly identified in the APEXFILE.DAT file

Figure 2.7. Sample SUBACOM.DAT file



```
1 TXBELLGZ.SUB
2 GAISER.SUB
3 CHINAG.SUB
4 TXBELLVB.SUB
5 TXANGI01.SUB
6 TXANGI02.SUB
7 TXANGI03.SUB
8 TXANGI04.SUB
9 JOAO.SUB
10 JOAO1.SUB
11 ZIYANG.SUB
12 ZIYANG1.SUB
13 ZIYANG2.SUB
14 WAT2.SUB
15 ANSAI29.SUB
16 ZFG.SUB
17 WAT2NO.SUB
18 WAT2NO1.SUB
19 WIMADISO.SUB
20 TXBELLEX.SUB
21 PLAYA1.SUB
22 ANSAI.SUB
23 LUBACUF1.SUB
24 LUBACUFR.SUB
25 PLAYA.SUB
26 IA050219.SUB
27 TXSEMN.SUB
28 TXBIGS.SUB
29 FEEDVARD.SUB
30 FEEDVAR1.SUB
31 TXBELL.SUB
32 HYMOTEST.SUB
33 ABBRETON.SUB
34 ABBRET2M.SUB
35 FREDERIC.SUB
36 KOCIN1.SUB
37 AU1_CROP.SUB
38 NJBEEMER.SUB
39 TXBELLCF.SUB
40 TXBELLPS.SUB
41 00020000.SUB
42 CW_1A.SUB
43 CLARIND1.SUB
44 KA3.SUB
45 TXRIESY8.SUB
46 TREYNOR2.SUB
47 KLDALD.SUB
51 TXALTO1.SUB
52 TXALTO2.SUB
53 TXALTO3.SUB
54 TXALTO4.SUB
55 TXALTO5.SUB
```


2.7 THE SOIL FILES (*FILENAME.SOL*)

Data for each soil is maintained in a separate soil file, *filename.sol*. In *SOIL1501.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 the following data elements:

LINE 1 *FORMAT:* *TWENTY (20) ALPHA CHARACTERS*
General description line for soil type.

LINE 2 *FORMAT:* *10 FIELDS; EIGHT (8) COLUMNS PER FIELD INCLUDING UP TO TWO DECIMAL PLACES (FLOATING)*

Field	Variable	Description
1	SALB	<p>Soil albedo. (cols.1-8) (Range: 0-1) The ratio of the amount of solar radiation reflected by the soil to the amount incident upon it, often expressed as a fraction. The value for albedo should be reported when the soil is at or near field capacity.</p>
2	HSG	<p>Soil hydrologic group (1=A, 2=B, 3=C, or 4=D). (cols. 9-16) (Range: 1-4) The U.S. Natural Resource Conservation Service (NRCS) classifies soils into four hydrologic groups based on infiltration characteristics of the soils. NRCS Soil Survey Staff (1996) defines a hydrologic group as a group of soils having similar runoff potential under similar storm and cover conditions. Soil properties that influence runoff potential are those that impact the minimum rate of infiltration for a bare soil after prolonged wetting and when not frozen. These properties are depth to seasonally high water table, saturated hydraulic conductivity, and depth to a very slowly permeable layer. The definitions for the different classes are:</p> <p>A Soils having high infiltration rates even when thoroughly wetted, consisting chiefly of sands or gravel that are deep and well to excessively drained. These soils have a high rate of water transmission (low runoff potential).</p> <p>B Soils having moderate infiltration rates when thoroughly wetted, chiefly moderately deep to deep, moderately well to well drained, with moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission.</p> <p>C Soils having slow infiltration rates when thoroughly wetted, chiefly with a layer that impedes the downward movement of water or of moderately fine to fine texture and a slow infiltration rate. These soils have a slow rate of water transmission (high runoff potential).</p> <p>D Soils having very slow infiltration rates when thoroughly wetted, chiefly</p>

Field	Variable	Description
	HSG cont.	clay soils with a high swelling potential; soils with a high permanent water table; soils with a clay pan or clay layer at or near the surface; and shallow soils over nearly impervious materials. These soils have a very slow rate of water transmission.

Guidelines used by USDA Soil Survey to categorize soils into Hydrologic Groups are summarized in Table 2.5

Table 2.5: Hydrologic Group Rating Criteria

Criteria*	Hydrologic Soil Groups			
	A	B	C	D
Final constant infiltration rate (mm/hr)	7.6-11.4	3.8-7.6	1.3-3.8	0-1.3
Mean permeability: surface layer (mm/hr)	> 254.0	84.0-254.0	8.4-84.0	< 8.4
Mean permeability: most restrictive layer below the surface layer to a depth of 1.0 m (mm/hr)	> 254.0	84.0-254.0	8.4-84.0	< 8.4
Shrink-swell potential: most restrictive layer**	Low	Low	Moderate	High, Very High
Depth to bedrock or cemented pan (mm)	> 1016	> 508	> 508	< 508
DUAL HYDROLOGIC GROUPS	A/D	B/D	C/D	
Mean depth to water table (m)	< 0.61	< 0.61	< 0.61	

* These criteria are guidelines only. They are based on the theory that the minimum permeability occurs within the uppermost 50 cm. If the minimum permeability occurs between a depth of 50 to 100 cm, then the Hydrologic Soil Group is increased one group. For example, C to B. If the minimum permeability occurs below a depth of 100 cm, the Hydrologic Soil Group is based on the permeability above 100 cm, using the rules previously given.

** Shrink-swell potential is assigned to a profile using the following guidelines:
Low: All soils with sand, loamy sand, sandy loam, loam or silt loam horizons that are at least 50 cm thick from the surface without a clay horizon within 100 cm of the surface.
Medium: All soils with clay loam horizons within 50 cm of the surface or soils with clay horizons from 50 to 100 cm beneath the surface.
High: All soils with clay horizons within 50 cm of the surface. Lower the shrink-swell potential one class when kaolinite clay is dominant.

3	FFC	Initial Soil Water Content (cols. 17-24) (Range: 0-1) Initial soil water content as a fraction of field capacity. Set at 0 if unknown.
4	Not Used	
5	Not Used	
6	Not Used	
7	Not Used	
8	Not Used	
9	Not Used	
10	Not Used	

Field	Variable	Description
LINE 3	FORMAT:	10 FIELDS; EIGHT (8) COLUMNS PER FIELD INCLUDING UP TO TWO DECIMAL PLACES (FLOATING)
1	TSLA	<p>Maximum number of soil layers after splitting (cols. 1-8) (Range: 3-10)</p> <p>This sets the maximum number of soils layers that the model will simulate after the original soil profile has been split. Splitting the original soil layers into shallower layers enables for more accurate movement of water, nutrients and roots from one layer to the next. When plant roots penetrate a layer the model assumes they have full access to the entire pool of nutrients and water in that layer. If the layer is thick, this in essence provides the plants access to a greater pool of nutrients and water than they would actually have available to them. The maximum number of soil layers (TSLA) may range from 3 to 10. If TSLA is not inputted, the model automatically uses 10 layers. If less than TSLA layers are inputted, the model splits layers to obtain the proper number. Layers are split in half from the soil surface downward. Initially the model splits layers with thicknesses greater than ZTK. Setting the value to 0 causes no splitting to initially occur. Refer to ZQT, ZF and ZTK for further information.</p>
2	XIDS	<p>Soil weathering code. (cols. 9-16) (Range: 0-4)</p> <p>The soil weathering factor is used to provide information for estimating the phosphorus sorption ratio. If no weathering information is available or if the soil contains CaCO₃, XIDS is left at 0.</p> <ul style="list-style-type: none"> 0 Calcareous and non-calcareous soils without weathering information. 1 Non CaCO₃ slightly weathered. 2 Non CaCO₃ moderately weathered. 3 Non CaCO₃ highly weathered. 4 Input Phosphorus sorption ratio (PSP) or active + stable mineral P (kg/ha).
3	RTN1	<p>Number of Years of Cultivation at Start of Simulation (cols. 17-24) (Range: 0-300)</p> <p>This parameter affects the partitioning of nitrogen and carbon into the passive and slow humus pools. The number of years of cultivation before the simulation starts is used to estimate the fraction of the organic N pool that is mineralizable. Mineralization is more rapid from soil recently in sod. Also increasing the number of years the field has been in cultivation increases the amount of C and N in the passive pool. This means it will take longer for the carbon and nitrogen to become available.</p>
4	XIDK	<p>Soil Grouping (cols. 25-32) (Range: 1-3)</p> <ul style="list-style-type: none"> 1 Kaolinitic soil group. 2 Mixed soil group. 3 Smectitic soil group.

Field	Variable	Description
5	ZQT	<i>Minimum Thickness of Maximum Layer (cols. 33-40)</i> (Range: 0.01-0.25) The model splits the first layer with thickness greater than ZQT (user specified minimum thickness (meters) for splitting). As soil layers are eroded and lost from the system, layer splitting continues until the number of layers equals TSLA. This splitting scheme produces thinner layers near the soil surface throughout the simulation period. Since most activity (tillage, root growth, microbial activity, rainfall/runoff interaction, etc.) occurs relatively near the soil surface, concentrating computational effort in that zone by using thin layers is very desirable. When the thickest soil layer reaches ZQT, no further splitting occurs. Instead, the number of soil layers is reduced until only two layers remain. At that time, the simulation stops. The simulation will also stop if the user-specified, minimum soil-profile thickness (ZF) is reached. If ZQT and ZF are not inputted, the model sets both of them to 0.1 m. Refer to TSLA, ZF and ZTK for further information.
6	ZF	<i>Minimum profile thickness (cols. 41-48)</i> (Range: 0.05-0.25) This is the minimum thickness of the profile that is allowed. If the profile is eroded to this thickness, the simulation will stop. If ZF is not inputted, the model sets it to 0.1 m. Refer to TSLA, ZQT, and ZTK for further information.
7	ZTK	<i>Minimum layer thickness for beginning simulation layer. (cols. 49-56)</i> (Range: 0.05-0.25) The model splits the first layer with thickness greater than ZTK (m); if none exists the thickest layer is split. This is only done once to make certain there are no extremely thick layers even at lower depths. Refer to TSLA, ZQT and ZF for further information.
8	FBM	<i>Fraction of Org C in Biomass Pool (cols. 57-64)</i> (Range: 0.03 – 0.05)
9	FHP	<i>Fraction of Humus in Passive Pool (cols. 65-72)</i> (Range: 0.3 – 0.7)
10	XCC	<i>Code written automatically by .SOT (NOT USER INPUTTED) (cols. 73-80)</i>

From LINE 4 onward, one column of data per soil layer (up to 10 layers)

FORMAT: 20 FIELDS; EIGHT (8) COLUMNS PER FIELD INCLUDING UP TO TWO DECIMAL PLACES (FLOATING)

The soil is divided vertically into layers (maximum of 30 layers of user specified thickness). Data are input 10 layers at a time. Thus 10 values of the following data are input on specified lines.

Field	Variable	Description
LINE 4	Z	Depth to bottom of layer (Range: 0.01-10) Depth from the soil surface to the bottom of the layer (m)
LINE 5	BD	Moist Bulk Density (Range: 0.5-2.5) (t/m ³). The soil bulk density expresses the ratio of the mass of solid particles to the total volume of the soil, $\rho_b = M_S/V_T$. In moist bulk density determinations, the mass of the soil is the oven dry weight and the total volume of the soil is determined when the soil is at or near field capacity. Bulk density values should fall between 1.1 and 1.9 Mg/m ³ .
LINE 6	UW	Soil water content at wilting point (Range: 0.01-.5) Soil water content at 1500 KPa or -15 bars (m/m) (0 if unknown).
LINE 7	FC	Soil Water Content at field capacity (Range: 0.1-0.6) Soil water content at 33 KPa or -1/3 bars (m/m) (0 if unknown).
LINE 8	SAN	Sand Content (Range: 1-99) Percentage of sand in the soil. The percentage of soil particles which have a diameter between 2.0 and 0.05 mm.
LINE 9	SIL	Silt Content (Range: 1-99) Percentage of silt in the soil. The percentage of soil particles which have an equivalent diameter between 0.05 and 0.002 mm.
LINE 10	WN	Initial organic N Concentration (Range: 100-5000) Users may define the concentration of organic nitrogen (dry weight basis) contained in humic substances for all soil layers at the beginning of the simulation. If the user does not specify initial nitrogen concentrations, APEX will initialize levels of organic nitrogen. (g N/Mg or ppm) (0 if unknown).

Field	Variable	Description
LINE 11	PH	Soil pH. (Range: 3-9) The pH of a solution in equilibrium with soil. It is determined by means of a glass, quinhydrone, or other suitable electrode or indicator at a specified soil-solution ratio in a specified solution, usually distilled water, 0.01 M CaCl ₂ or 1 M KCl.
LINE 12	SMB	Sum of Bases (Range: 0-150) The sum of bases (Ca ⁺⁺ , K ⁺ , etc.) on the cation exchange complex. (cmol/kg) (0 if unknown).
LINE 13	WOC	Organic carbon concentration (%) .(Range: 0.1-10)
LINE 14	CAC	Calcium carbonate content of soil (%) (Range: 0-99) A compound, CaCO ₃ is found in nature as calcite and aragonite and in plant ashes, bones, and shells. CaCO ₃ is found in calcareous soils. It is also used as a liming agent to increase the pH of a soil (0.0 if unknown).
LINE 15	CEC	Cation exchange capacity (Range: 0-150) The cation exchange capacity of a soil is the quantify of positive ions necessary to neutralize the negative charge of a unit quantity of soil, under a given set of conditions. (cmol/kg) (0 if unknown).
LINE 16	ROK	Coarse fragment content (Range: 0-99) The percent of the sample which has a particle diameter > 2 mm, i.e. the percent of the sample which does not pass through a 2 mm sieve. Expressed as a percentage (whole number). (0 if unknown).
LINE 17	CNDS	Initial soluble N concentration (Range: 0.01-500) Users may define the concentration of nitrate (dry weight basis) for all soil layers at the beginning of the simulation. (g/Mg) (0 if unknown).
LINE 18	SSF	Initial soluble P concentration (Range: 0.01-500) Users may define the concentration of solution P (dry weight basis) for all soil layers at the beginning of the simulation. (g/Mg) (0 if unknown).
LINE 19	RSD	Crop residue (Range: 0-20) The amount of biomass left in/on the soil from previous crops. (t/ha), (0 if unknown).
LINE 20	BDD	Dry Bulk density (oven dry) (Range: 0-2.0) Density of the soil after oven drying (t/m ³). (0 if unknown)

Field	Variable	Description
LINE 21	PSP	Phosphorus sorption ratio. (Range: 0-0.9) The fraction of phosphorus adsorbed on soil particle surfaces. This may be left at 0.0 if unknown. The model will calculate this ratio. The soil weathering code XIDS must be set to 4.0 to input these values.
LINE 22	SATC	Saturated conductivity (Range: 0.00001-100) Rate at which water passes through the soil layer, when saturated. The saturated hydraulic conductivity relates soil water flow rate (flux density) to the hydraulic gradient and is a measure of the ease of water movement through the soil. The saturated conductivity is the reciprocal of the resistance of the soil matrix to water flow. (mm/h). (0 if unknown)
LINE 23	HCL	Lateral hydraulic conductivity (Range: 0.00001-10) (mm/h), (0 if unknown).
LINE 24	WPO	Initial organic P concentration (Range: 50-1000) Users may define the concentration of organic phosphorus (dry weight basis) contained in humic substances for all soil layers at the beginning of the simulation. (g/t), (0 if unknown).
LINE 25	DHN	Exchangeable K Concentration (Range: 0-200) The amount of potassium on the surface of soil particles that can be readily replaced with a salt solution. (g/t)
LINE 26	ECND	Electrical Conductivity (Range: 0-50) Conductivity of electricity through water or an extract of soil. Commonly used to estimate the soluble salt content in solution. (mmho/cm)
LINE 27	STFR	Fraction of Storage Interacting With Nitrate Leaching (Range: 0.05-1) (0 if unknown)
LINE 28	SWST	Initial Soil Water Storage (Range: 0.001-1) Fraction of field capacity initially available at the start of the simulation. m/m
LINE 29	CPRV	Fraction inflow partitioned to vertical crack or pipe flow (Range: 0-0.05) (0 if unknown). Applies to all crops, not just forest lands.
LINE 30	CPRH	Fraction inflow partitioned to horizontal crack or pipe flow (Range: 0-0.05) (0 if unknown). Applies to all crops, not just forest lands.
LINE 31	WLS	Structural litter (Range: 0-10000) One of the two litter components that contains all the lignin from plant residues and roots. The structural litter component has a fixed C/N ratio. (kg/ha) (0 if unknown)

Field	Variable	Description
LINE 32	WLM	Metabolic litter (Range: 0-10000) One of the two litter components made up of readily decomposable and water soluble organic matter. (kg/ha) (0 if unknown)
LINE 33	WLSL	Lignin Content of Structural Litter (Range: 0-10000) Lignin is a complex polymer that binds to cellulose fibers and gives strength to the cell walls of plants. It is very resistant to decomposition. (kg/ha) (0 if unknown)
LINE 34	WLSC	Carbon Content of Structural Litter (Range: 0-10000) Carbon makes up almost half of the elemental composition of the dry matter in plants and is a common constituent of all organic matter. It is also present in the atmosphere in the form of CO ₂ . See WLS for more information. (kg/ha) (0 if unknown)
LINE 35	WLMC	Carbon Content of Metabolic Litter (Range: 0-10000) See WLSC and WLM for more explanation (kg/ha) (0 if unknown)
LINE 36	WLSLC	Carbon Content of Lignin of Structural Litter (Range: 0-10000) See WLSC, WLSL and WLS for more explanation (kg/ha) (0 if unknown)
LINE 37	WLSLNC	Nitrogen Content of Lignin of Structural Litter (Range: 0-10000) The amount of nitrogen found in the lignin portion of the structural litter. See WLSL and WLS for more information. (kg/ha) (0 if unknown)
LINE 38	WBMC	Carbon Content of Biomass (Range: 0-10000) The carbon content of the living plant matter. (kg/ha) (0 if unknown)
LINE 39	WHSC	Carbon Content Slow Humus (Range: 0-10000) Slow humus is a conceptual component of soil organic matter that decomposes at rates intermediate between the microbial and passive humus components. (kg/ha) (0 if unknown)
LINE 40	WHPC	Carbon Content of Passive Humus (Range: 0-10000) Passive humus is a conceptual component composed of old or stable soil organic matter. (kg/ha) (0 if unknown)
LINE 41	WLSN	Nitrogen Content of Structural Litter (Range: 0-10000) See WLS for more information. (kg/ha) (0 if unknown)
LINE 42	WLMN	Nitrogen Content of Metabolic Litter (Range: 0-10000) See WLM for more information. (kg/ha) (0 if unknown)
LINE 43	WBMN	Nitrogen Content of Biomass (Range: 0-10000) The nitrogen content of the living plant matter.(kg/ha) (0 if unknown)

Field	Variable	Description
LINE 44	WHSN	<i>Nitrogen Content of Slow Humus</i> (Range: 0-10000) See WHSC for more information. (kg/ha) (0 if unknown)
LINE 45	WHPN	<i>Nitrogen Content of Passive Humus</i> (Range: 0-10000) See WHPC for more information. (kg/ha) (0 if unknown)
LINE 46	FE26	<i>Iron Content (%)</i>
LINE 47	SULF	<i>Sulfur Content (%)</i>
LINE 48	ASHZ	<i>Soil Horizon (A,B,C)</i>
LINE 49	CGO2	<i>O₂ Concentration in Gas Phase (g/m³ of soil air)</i>
LINE 50	CGCO2	<i>CO₂ Concentration in Gas Phase (g/m³ of soil air)</i>
LINE 51	CGN2O	<i>N₂O Concentration in Gas Phase (g/m³ of soil air)</i>

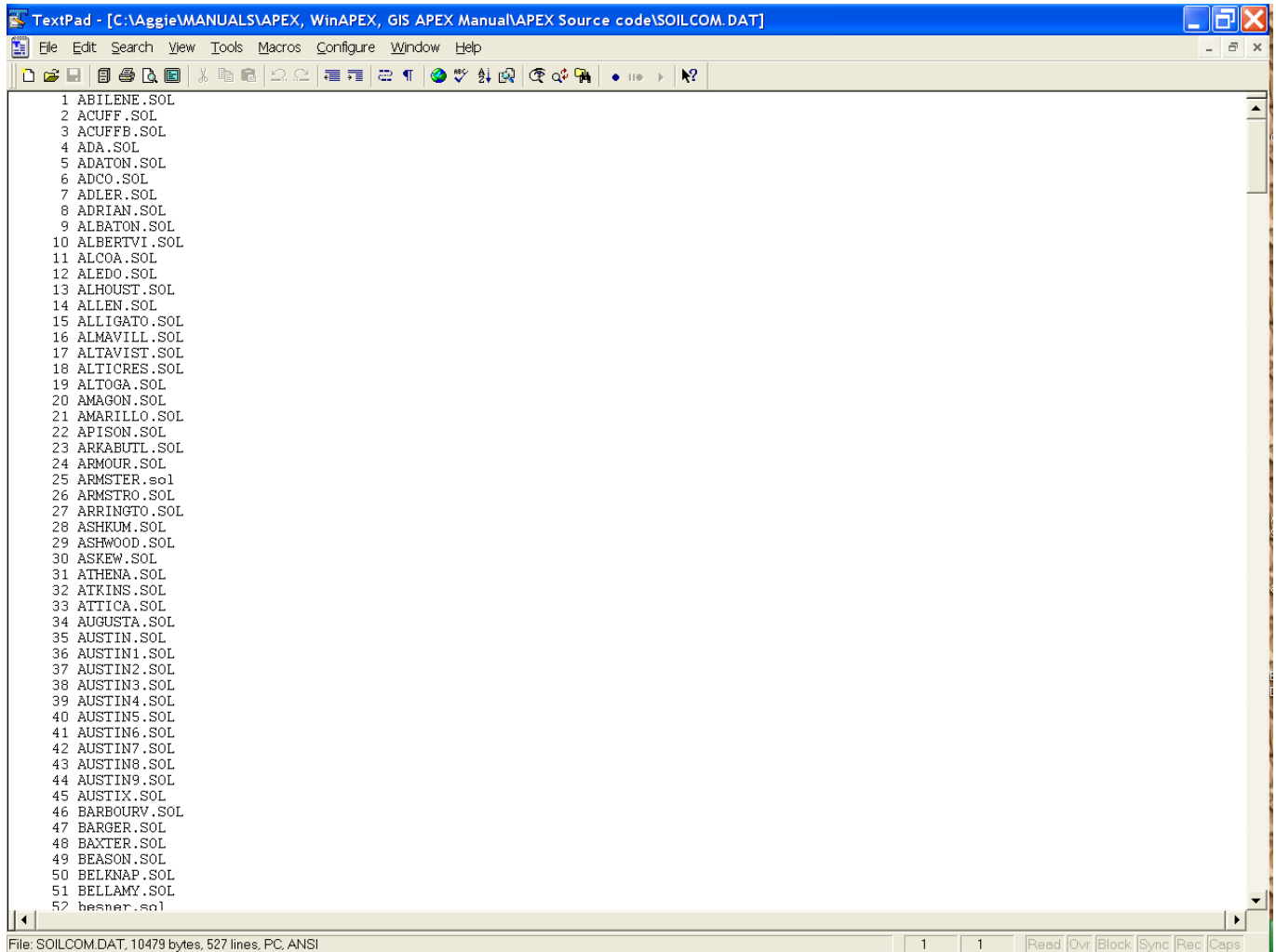
Figure 2.12: Sample Soil (*.SOL) file screen.

ALTOGA (LgC)	(SIC)	Runnumber 1								
.15	3.	.80	50.00	100.00	75.00	25.00	50.00	.00	.00	
10.00	0.	162.	2.	.10	.10	.15	.04	.89	1.00	
.01	.06	.14	.23	.34	.46	.57	.69	.98	1.45	
1.19	1.18	1.22	1.32	1.41	1.42	1.40	1.40	1.20	1.20	
.17	.17	.17	.18	.19	.19	.17	.17	.16	.11	
.37	.37	.36	.36	.37	.37	.35	.35	.33	.28	
14.82	14.82	14.82	12.49	8.60	8.60	12.30	12.30	10.40	22.20	
61.89	61.89	61.89	59.23	60.10	60.10	59.40	59.40	64.20	61.30	
1664.00	2006.00	1598.00	990.00	615.00	550.00	407.00	406.00	216.00	108.00	
7.07	7.07	7.07	7.07	7.20	7.20	7.30	7.30	7.30	7.40	
15.95	15.95	15.95	15.95	24.00	24.00	23.10	23.10	21.80	19.00	
1.82	1.99	1.59	.98	.61	.55	.41	.40	.21	.11	
.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	
17.50	17.50	17.50	20.90	27.50	27.50	25.20	25.20	22.90	19.60	
.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	
37.03	32.33	57.88	42.32	28.00	15.50	14.77	15.12	64.68	322.03	
42.33	25.32	26.70	22.45	16.33	14.83	10.14	5.99	7.88	7.33	
.18	.33	.11	.06	.04	.03	.03	.09	.30	.27	
1.19	1.18	1.22	1.32	1.41	1.42	1.40	1.40	1.20	1.20	
.50	.50	.50	.50	.50	.50	.50	.50	.50	.50	
8.52	8.52	8.52	6.44	5.63	5.63	6.65	6.65	7.66	10.47	
.09	.09	.09	.06	.06	.06	.07	.07	.08	.10	
20.80	19.67	17.40	16.39	10.23	10.42	19.96	39.59	19.46	10.60	
575.50	170.01	105.75	71.91	48.55	31.62	29.46	20.99	36.82	98.46	
.00	.00	.00	.00	.00	.00	.00	.00	.00	.06	
1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
-1.44	.50	.92	.99	1.00	.14	.01	.01	.02	.02	
112.00	268.00	92.00	50.00	34.00	25.00	23.00	65.00	195.00	160.00	
63.00	66.00	21.00	10.00	7.00	6.00	9.00	28.00	108.00	109.00	
3.00	6.00	2.00	1.00	.00	.00	.00	1.00	4.00	3.00	
47.00	113.00	39.00	21.00	14.00	10.00	9.00	27.00	82.00	68.00	
26.00	27.00	8.00	4.00	3.00	2.00	4.00	12.00	45.00	46.00	
1.00	3.00	1.00	.00	.00	.00	.00	.00	2.00	1.00	
46.00	110.00	38.00	21.00	14.00	10.00	9.00	26.00	80.00	67.00	
51.00	299.00	208.00	113.00	79.00	54.00	46.00	93.00	260.00	179.00	
576.00	2622.00	2127.00	968.00	668.00	480.00	528.00	835.00	1166.00	834.00	
1427.00	9283.00	13112.00	10473.00	8696.00	8675.00	5650.00	5765.00	5656.00	4823.00	
.31	.75	.26	.14	.09	.07	.06	.18	.55	.45	
1.69	1.74	.54	.20	.11	.10	.16	.51	1.87	1.91	
9.83	75.93	57.44	32.45	23.79	16.31	13.11	28.10	77.63	46.65	
36.00	209.00	171.00	77.00	54.00	39.00	45.00	76.00	105.00	76.00	
146.00	960.00	1331.00	1057.00	877.00	875.00	568.00	577.00	567.00	483.00	

2.8 THE APEX SOIL LIST FILE (SOIL****.DAT)

The APEX Soil list file is a listing of all soil files which have been previously created following the format previously described in section 2.7 and are available for creating runs. The Soil list consists of a numbered listing of all soil files which can be referenced by number in the APEX Subarea file. This file is in FREE FORMAT. See Figure 2.13 for an example of the SOILCOM.DAT file. The Soil list file name may be user defined; however, it must be properly identified in the APEXFILE.DAT file

Figure 2.13. Sample SOILCOM.DAT file.



The image shows a screenshot of a TextPad window titled "TextPad - [C:\Aggie\MANUALS\APEX, WinAPEX, GIS APEX Manual\APEX Source code\SOILCOM.DAT]". The window displays a list of 52 soil file names, each preceded by a number from 1 to 52. The list includes names like ABILENE.SOL, ACUFF.SOL, ADA.SOL, ADATON.SOL, ADCO.SOL, ADLER.SOL, ADRIAN.SOL, ALBATON.SOL, ALBERTVI.SOL, ALCOA.SOL, ALEDO.SOL, ALHOUST.SOL, ALLEN.SOL, ALLIGATO.SOL, ALMAVILL.SOL, ALTAVIST.SOL, ALTICRES.SOL, ALTOGA.SOL, AMAGON.SOL, AMARILLO.SOL, APISON.SOL, ARKABUIL.SOL, ARMOUR.SOL, ARMSTER.SOL, ARMSTRO.SOL, ARRINGTO.SOL, ASHKUM.SOL, ASHWOOD.SOL, ASKEW.SOL, ATHENA.SOL, ATKINS.SOL, ATTICA.SOL, AUGUSTA.SOL, AUSTIN.SOL, AUSTIN1.SOL, AUSTIN2.SOL, AUSTIN3.SOL, AUSTIN4.SOL, AUSTIN5.SOL, AUSTIN6.SOL, AUSTIN7.SOL, AUSTIN8.SOL, AUSTIN9.SOL, AUSTIX.SOL, BARBOURV.SOL, BARGER.SOL, BAXTER.SOL, BEASON.SOL, BELKNAP.SOL, BELLAMY.SOL, and besner.sol. The status bar at the bottom indicates "File: SOILCOM.DAT, 10479 bytes, 527 lines, PC, ANSI".

```
1 ABILENE.SOL
2 ACUFF.SOL
3 ACUFFB.SOL
4 ADA.SOL
5 ADATON.SOL
6 ADCO.SOL
7 ADLER.SOL
8 ADRIAN.SOL
9 ALBATON.SOL
10 ALBERTVI.SOL
11 ALCOA.SOL
12 ALEDO.SOL
13 ALHOUST.SOL
14 ALLEN.SOL
15 ALLIGATO.SOL
16 ALMAVILL.SOL
17 ALTAVIST.SOL
18 ALTICRES.SOL
19 ALTOGA.SOL
20 AMAGON.SOL
21 AMARILLO.SOL
22 APISON.SOL
23 ARKABUIL.SOL
24 ARMOUR.SOL
25 ARMSTER.SOL
26 ARMSTRO.SOL
27 ARRINGTO.SOL
28 ASHKUM.SOL
29 ASHWOOD.SOL
30 ASKEW.SOL
31 ATHENA.SOL
32 ATKINS.SOL
33 ATTICA.SOL
34 AUGUSTA.SOL
35 AUSTIN.SOL
36 AUSTIN1.SOL
37 AUSTIN2.SOL
38 AUSTIN3.SOL
39 AUSTIN4.SOL
40 AUSTIN5.SOL
41 AUSTIN6.SOL
42 AUSTIN7.SOL
43 AUSTIN8.SOL
44 AUSTIN9.SOL
45 AUSTIX.SOL
46 BARBOURV.SOL
47 BARGER.SOL
48 BAXTER.SOL
49 BEASON.SOL
50 BELKNAP.SOL
51 BELLAMY.SOL
52 besner.sol
```


2.9 THE OPERATION SCHEDULE FILES (FILENAME.OPS)

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 must be listed in OPSC1501.DAT (or user specified name).

Field	Variable	Description
LINE 1:		<i>Description</i> <i>FORMAT: TWENTY (20) ALPHA CHARACTERS</i>
LINE 2:		<i>FORMAT: TWENTY (20) FIELDS; FOUR (4) COLUMNS PER FIELD (INTEGER)</i>
1	LUN	Land use number from NRCS Land Use-Hydrologic Soil Group Table (cols. 1-4) (Range: 1-35) Refer to the column labeled Land User Number in the table below. This number along with the hydrologic soil group is used to determine the curve number.

Table 2.6: Runoff curve numbers for hydrologic soil-cover complexes

Land use	Cover Treatment or practice	Hydrologic condition	Hydrologic soil group				Land Use Number
			A	B	C	D	
Fallow	Straight row	----	77	86	91	94	1
Row crops	Straight row	Poor	72	81	88	91	2
	" "	Good	67	78	85	89	3
	Contoured	Poor	70	79	84	88	4
	" "	Good	65	75	82	86	5
	Contoured & terraced	Poor	66	74	80	82	6
	" "	Good	62	71	78	81	7
Small grain	Straight row	Poor	65	76	84	88	8
	" "	Good	63	75	83	87	9
	Contoured	Poor	63	74	82	85	10
	" "	Good	61	73	81	84	11
	Contoured & terraced	Poor	61	72	79	82	12
	" "	Good	59	70	78	81	13

Close-seeded legumes ¹ or rotation meadow	Straight row	Poor	66	77	85	89	14
	" "	Good	58	72	81	85	15
	Contoured	Poor	64	75	83	85	16
	" "	Good	55	69	78	83	17
	Contoured & terraced	Poor	63	73	80	83	18
	" "	Good	51	67	76	80	19
Pasture or range							
<50% groundcover or heavily grazed		Poor	68	79	86	89	20
50-75% ground cover & not heavily grazed		Fair	49	69	79	84	21
>75% ground cover & lightly grazed		Good	39	61	74	80	22
Above characteristics & Contoured		Poor	47	67	81	88	23
	" "	Fair	25	59	75	83	24
	" "	Good	6	35	70	79	25
Meadow (continuous grass, not grazed and generally mowed for hay)		Good	30	58	71	78	26
Woods							
Small trees and brush (heavy grazing & regular burning)		Poor	45	66	77	83	27
Woods are grazed by not burned, some litter covers soil		Fair	36	60	73	79	28
Woods are not grazed, litter & brush cover soil		Good	25	55	70	77	29
Farmsteads		----	59	74	82	86	30
Roads (dirt) ²		----	72	82	87	89	31
(hard surface) ²		----	74	84	90	92	32
Sugarcane			39	61	74	80	33
Bermuda grass			49	69	79	84	34
Impervious (Pavement, urban area)		----	98	98	98	98	35

1 Close-drilled or broadcast.

2 Including right of way.
Service 1972).

Taken from the National Engineering Handbook
(U.S. Department of Agriculture, Soil Conservation

Field	Variable	Description
-------	----------	-------------

The following six variables are optional; however, it is wise to set them because it is possible that the default operation numbers will not match exactly with the TILL.DAT file being used causing unexpected simulation results.

2	IAUI	<i>Auto Irrigation Equipment # (cols. 5-8)</i> (Range: 1-∞) If auto irrigation is used, this irrigation equipment (found in the TILLCOM.DAT file) will be used to apply irrigation water. If none is specified, the default is operation #500.
3	IAUF	<i>Auto Commercial Fertilizer Equipment # (cols. 9-12)</i> (Range: 1-∞) If auto commercial fertilizer is used, this fertilizer equipment (found in the TILLCOM.DAT file) will be used to apply commercial inorganic fertilizer. If none is specified, the default is operation #261.
4	IAMF	<i>Auto Manure Deposition by Animals Operation # (cols. 13-16)</i> (Range: 1-∞) If manure is to be automatically deposited by animals to a field or feedlot, this operation (found in the TILLCOM.DAT file) will be used to apply manure. If none is specified, the default is operation #268.
5	ISPF	<i>Auto Solid Manure Application Equipment # (cols. 17-20)</i> (Range: 1-∞) If auto solid manure is used, this equipment (found in the TILLCOM.DAT file) will be used to apply solid manure either from a stock pile or from another location. If none is specified, the default is operation #266.
6	ILQF	<i>Auto Liquid Manure from Lagoons Application Equipment # (cols. 21-24)</i> (Range: 1-∞) If auto liquid manure is used, this operation (found in the TILLCOM.DAT file) will be used to apply liquid manure from a lagoon. If none is specified, the default is operation #265.
7	IAUL	<i>Auto Lime Application Equipment # (cols. 25-28)</i> (Range: 1-∞) If auto lime is used, this equipment (found in the TILLCOM.DAT file) will be used to apply lime automatically. If none is specified, the default is operation #267.

Field	Variable	Description
-------	----------	-------------

LINES *FORMAT:* *THREE (3) FIELDS WITH THREE (3) COLUMNS PER FIELD (INTEGER)*
3 - N: *FOLLOWED BY FOUR (4) FIELDS WITH FIVE (5) COLUMNS PER FIELD*
 (INTEGER) FOLLOWED BY SEVEN (7) FIELDS WITH EIGHT (8) COLUMNS
 INCLUDING DECIMAL PLACES (FLOATING)

(one line per operation):

- | | | |
|---|--------|---|
| 1 | JX (1) | <p><i>Year of operation. (cols. 1-3)</i> (Range: 1-100)
 Refers to the year the operation occurs.
 1 = operation occurs in 1st year of cropping system
 2 = operation occurs in 2nd year of cropping system
 :
 Nth year</p> |
| 2 | JX (2) | <p><i>Month of operation. (cols. 4-6)</i> (Range: 1-12)
 The month the operation occurs in (1-12).</p> |
| 3 | JX (3) | <p><i>Day of operation (cols. 7-9)</i> (Range: 1-31)
 Day of the month the operation occurs.</p> |
| 4 | JX (4) | <p><i>Equipment ID Number (cols.10-14)</i> (Range: 1-∞)
 Refers to the ID number that is given to each tillage operation or piece of equipment. (from TILL1501.DAT)</p> |
| 5 | JX (5) | <p><i>Tractor ID (cols. 15-19)</i> (Range: 1-∞)
 Refers to the ID number given to each tractor in the TILL1501.DAT file.</p> |
| 6 | JX (6) | <p><i>Crop ID number (cols. 20-24)</i> (Range: 1-∞)
 Refers to the crop ID number given to each crop as listed in CROP1501.DAT.</p> |

THE FOLLOWING VARIABLES WILL VARY IN THE TYPE OF DATA VALUES DEPENDING ON THE TYPE OF OPERATION IT IS PERTAINING TO.

- | | | |
|---|--------|--|
| 7 | JX (7) | <p>1 <i>XMTU</i> - Time from planting to maturity (Y), FOR PLANTING OPERATION OF TREES ONLY. This refers to the time to complete maturity of the tree (full life of the tree). No potential heat units are entered for trees. This value is calculated from XMTU. (<i>cols. 25-29</i>) (Range: 5-300)</p> <p>2 <i>LYR</i> - Time from planting to harvest in years, FOR HARVEST OPERATION OF TREES ONLY (portion of full maturity) (<i>cols. 25-29</i>) (Range: 5-100)</p> <p>3 <i>Pesticide ID number</i> from PEST1501.DAT. FOR PESTICIDE OPERATION ONLY (<i>cols. 25-29</i>) (Range: 1-∞)</p> <p>4 <i>Fertilizer ID number</i> from FERT1501.DAT. FOR FERTILIZER OPERATION ONLY (<i>cols. 25-29</i>) (Range: 1-∞)</p> |
|---|--------|--|

Field	Variable	Description
8	OPV1	<p>1 Potential heat Units (PHU) for planting. FOR PLANTING OPERATION ONLY. Total number of heat units or growing degree days needed to bring the plant from emergence to physiological maturity. Used in determining the growth curve. Enter 0 if unknown. (<i>cols. 30-37</i>) (Range: 1-5000)</p> <p>For trees, no PHU are entered. They are calculated from XMTU. For crops other than trees PHU are accumulated annually and reset to 0 at the end of the year. Trees are a special case in which PHUs continue to accumulate from year to year. Deciduous trees are also a special case within trees in which PHUs are calculated annually (similar to non-tree crops) in order to simulate leaf drop as well as accumulate PHUs from year to year to simulate the maturity of the tree.</p> <p>1 Stocking Rate in ha/hd. FOR GRAZING OPERATION ONLY. This variable is used to set the stocking rate in number of hectares/animal. Using this feature, the user can change the number of animals in the herd at any point in time simulating buying/selling of animals. (<i>cols. 30-37</i>) (Range: 0-200)</p> <p>2 Irrigation Application volume in mm. FOR IRRIGATION OPERATION ONLY (<i>cols. 30-37</i>) (Range: 1-5000)</p> <p>3 Fertilizer application rate in kg/ha. FOR FERTILIZER OPERATION ONLY. For variable rate set equal to 0. (<i>cols. 30-37</i>) (Range: 0-500)</p> <p>4 Pesticide application rate in kg/ha. FOR PESTICIDE OPERATION ONLY. (<i>cols. 30-37</i>) (Range: 0-500)</p> <p>5 Target ponding depth in mm FOR PUDDLE OPERATION ONLY. This sets the weir height and adjusts soil layer 2 Ksat to Parm 39. (See Appendix E for more information on paddy simulation)</p>
9	OPV2	<p>1 2 Condition SCS Runoff Curve number, or Land Use number (optional). The land use number set previously can be overridden at this point if an operation has caused the land condition to change. (<i>cols. 38-45</i>) (Range: 1-35)</p> <p>2 Pest Control factor FOR PESTICIDE OPERATION ONLY (fraction of pests controlled). This factor is used to control pest populations by applying pesticides. It only applies to insects and diseases. Weeds are handled through intercropping. (<i>cols. 38-45</i>) (Range: 0-1)</p> <ul style="list-style-type: none"> • If this factor is set to 0.99, 99% of the pests will be killed. After each treatment, the population will begin to regrow based on several parameters set in the Control file (PSTX), Crop file (PST) and Parm file (parm 9 and 10). • Currently the model is set so that very minimal damage is caused by pests and therefore does not reduce yield.

Field	Variable	Description
	OPV2 cont.	<ul style="list-style-type: none"> Pest growth is dependent on temperature and humidity. Warm and wet conditions favor pest growth while dry and cool conditions inhibit pest growth.
10	OPV3	<p>Automatic Irrigation Trigger (cols. 46-53) (Range: -1000 to 1000)</p> <p>This is the same irrigation trigger function as in the subarea file. The subarea file value can be overridden by setting the trigger value in the operation schedule. Leaving OPV3 = 0 no modifications will be made to the irrigation trigger as set in the subarea file.</p> <p>To trigger automatic irrigation, the water stress factor is set:</p> <ul style="list-style-type: none"> 0 manual irrigation or model uses BIR set in subarea file 0 – 1.0 Plant water stress factor. (1 – BIR) equals the fraction of plant water stress allowed 1.0 Does not allow water stress < 0.0 Plant available water deficit in root zone (number is in mm and must be negative) > 1.0 Soil water tension in top 200mm (Absolute number is in kilopascals) -1000 Sets water deficit high enough that only manual irrigations will occur. Effectively turns auto irrigation off. 9999 Allows for automatic paddy irrigation (See Appendix E for more information on paddy simulation)

NOTES

When using a BIR based on anything other than plant water stress (0-1), be aware that irrigation will be applied outside of the growing season if the soil water deficit or soil water tension reaches BIR. This will reduce the amount of water available for irrigation during the growing season.

- Once the trigger has been set within a operation schedule, it will remain in effect until changed within the operation schedule. If the schedule is used in rotation with other schedules, the trigger will stay as set even into the next schedule. When setting the irrigation trigger within an operation schedule, it is wise to set the irrigation trigger to -1000 mm at the end of the schedule so that when the operation schedule is used in rotation with another non-automatically irrigated crop, the second crop is not influenced by the irrigation trigger.

Initial Leaf Area Index (LAI) for transplants (cols 46-53)

FOR PLANTING OPERATION ONLY. This sets the leaf area index of transplants at the time of planting. The seed weight (SDW) must also be set greater than zero in the crop file. PHUs (see OPV1) should be decreased to account for the heat units acquired before the plants were transplanted. Normally PHUs are calculated from emergence to physiological maturity.

Field	Variable	Description
11	OPV4	Runoff vol/vol irrigation water applied. (cols. 54-61) (Range: 0-1) Setting the runoff fraction (EFI) within the operation schedule overrides the EFI set within the subarea file. The irrigation runoff ratio specifies the fraction of each irrigation application that is lost to runoff. Soluble nutrient loss through runoff applies. Changes in soil slope do not affect this amount dynamically. EFI must be set accordingly. (Range: 0-1)
12	OPV5	<ol style="list-style-type: none"> Plant population (cols. 62-69) (Range: 0-500) (plants/m²) If crop is a TREE crop (IHC = 7, 8, or 10), then units are plants/ha, FOR PLANTING OPERATION ONLY. APEX does not simulate tillering. In crops such as wheat and sugarcane which produce higher numbers of yielding tillers compared to the number of seeds or shoots planted, the plant population must be estimated based on the final yield producing tiller number. Factor to adjust automatic irrigation volume (cols. 62-69) (FIRG*FC). For more information see FIRG in Subarea file. (Range: 0.5 – 5.0)
13	OPV6	Maximum annual N fertilizer applied to a crop (cols. 70-77) (Range: 0 - 1000) (0 does not change FMX; >0 sets new FMX. FOR PLANTING OPERATION ONLY. In the subarea file FMX was set which set a limit on the amount of fertilizer that could be applied on an annual basis regardless of the number of crops grown within a year. Refer to FMX in section 2.4 for further information. The maximum annual amount of nitrogen fertilizer can also be set here in the operation schedule and can be set per crop so that each crop has a specified amount of nitrogen fertilizer available to it. This is especially important when automatically applying fertilizer.
NOTE		
<ol style="list-style-type: none"> If this variable is set either in the subarea file or in the operation schedule and manual fertilization is applied, the model will only apply up to this maximum amount regardless of the amount specified in the manual fertilization operation. 		
Minimum ponding depth that triggers paddy irrigation in mm (cols. 70-77)		
<ol style="list-style-type: none"> Paddy irrigation is triggered when the set ponding depth is reached. (See Appendix E for more information on paddy simulation) 		
14	OPV7	Time of operation as fraction of growing season (cols. 78-85) (Range: 0-1.5) This is also referred to as heat unit scheduling. Heat unit scheduling can be used to schedule operations at a particular stage of growth. For example, irrigation could be scheduled at 0.25, 0.5, and 0.75 which might represent varying stages of crop growth. Irrigation would then be applied at 25%, 50%, and 75% of the potential heat units set at planting.

OPV7 cont. When setting up an operation using heat unit scheduling it is best to enter earliest possible month and day (JX(2) & JX(3)) that the operation could occur on because in order for the operation to occur the date of the operation as well as the number of heat units scheduled must be met. This is especially true for harvest operations. It is recommended that the harvest date be set 10-14 days before actual harvest is expected to occur. This is recommended so that the date of the operation will be met before the heat units are met. If the date is set too late and the heat units are met before the date of the operation is met, the crop will continue to grow longer than expected which can affect yield.

Within APEX the following process is followed: first the program checks to see that the date of the operation has been met; then it checks to see if the fraction of heat units has been met. See the table below for further explanation.

Table 2.7: Occurrence of operation based on date/heat unit.

1. Date	2. Heat units	Action
Date is met	Heat unit fraction has not been met	Operation will not occur until heat units have been met
Date is not met	Heat unit fraction is met	Operation will occur as soon as date is met. Note: excess GDUs will accumulate causing the operation to occur later in the growing cycle than expected
Date is met	Heat unit fraction is met	Operation will occur immediately

Heat unit scheduling can also be used to adjust operations to the weather (temperatures) from year to year.

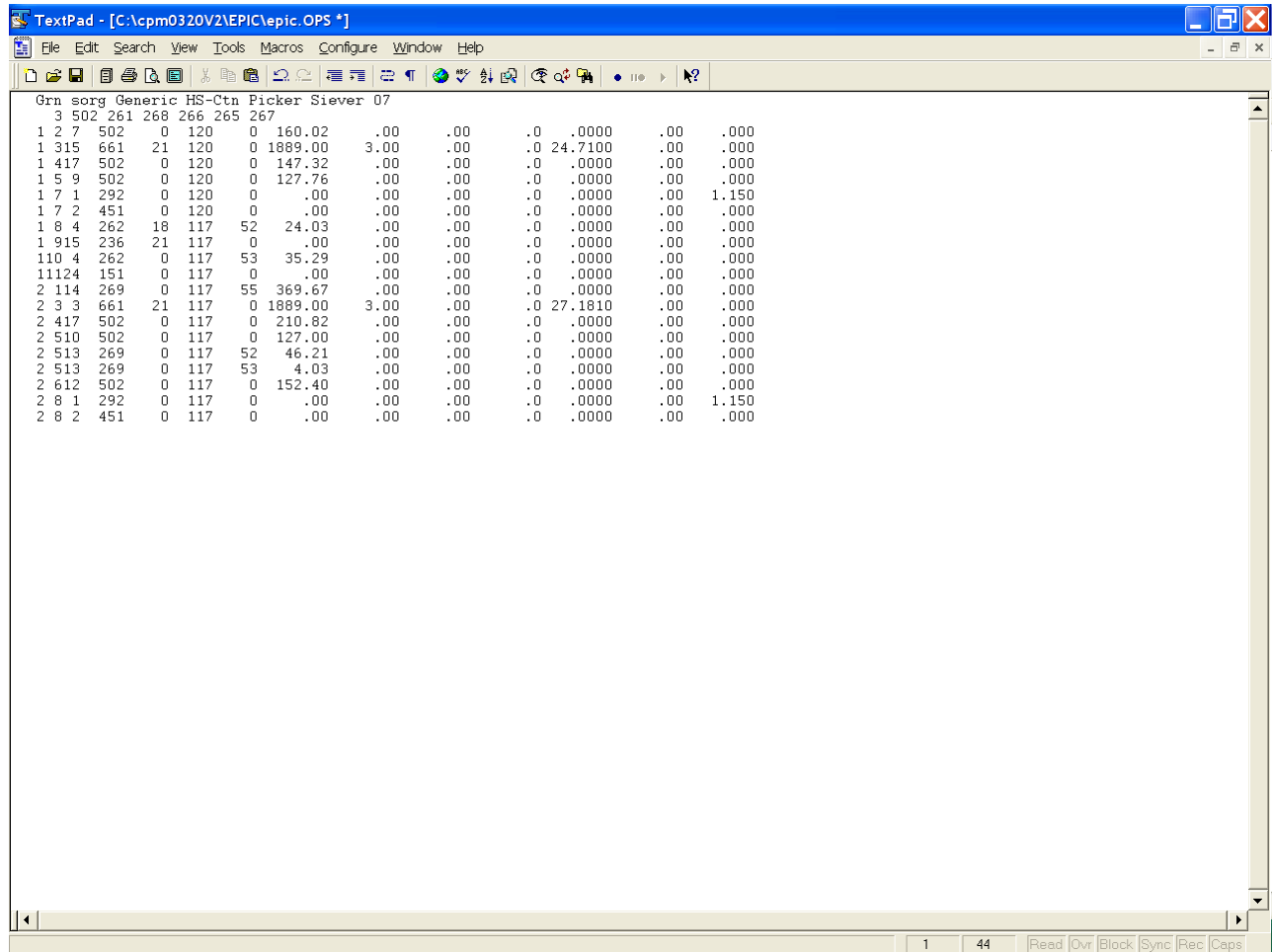
If heat units are not scheduled (set to 0), operations will occur on the date as scheduled in the operation schedule. The will occur on the same date every year the crop is grown.

Heat unit scheduling operations which occur from planting to harvest are based on the heat units set at planting. Operations which occur before planting are based on the total annual heat units which are calculated by the model.

For some grain crops an in-field dry-down period is allowed. It is expressed as a fraction of the total heat units set at planting. In most cases the dry-down period is 10% to 15% of the total heat units. If a dry-down period is required, heat unit schedule the harvest operation to occur at 1.10, 1.15 or another appropriate fraction.

In the case of forage harvesting, the forage is actually harvested well before the crop reaches full maturity. In this case heat unit schedule the forage harvest to 0.55 or another appropriate fraction.

Figure 2.14: Sample Operation (*.OPS) file screen.



2.10 APEX OPERATION SCHEDULE LIST FILE (OPSC****.DATA)

The APEX Operation Schedule list file is a listing of all operation schedule files which have been previously created following the format previously described in section 2.9 and are available for creating runs. The Operation Schedule list consists of a numbered listing of all operation schedule files along with a brief description of the type of operation schedule (crop and number of years) which can be referenced by number in the APEX Subarea file. This file is in FREE FORMAT. See Figure 2.15 for an example of the OPSCCOM.DAT file. The Operation Schedule list file name may be user defined; however, it must be properly identified in the APEXFILE.DAT file

Figure 2.15. Sample OPSCCOM.DAT file.

```
1 CBH.OPC 1Y COASTAL BERM HAY
2 PNUT.OPC 1Y PEANUT MEDIUM TILL
3 CBWH.OPC 1Y COASTAL BERM/WHHT
4 CRSE.OPC 2Y CORN SOYBEAN
5 SUWH.OPC 1Y SCHY/WHHT HAY
6 FINESGUM.OPC PINE & SWEETGUM
7 WWSFL.OPC 3Y WHHT/GRSG/FALL
8 PINE.OPC 1Y PINE
9 BOW.OPC 2Y BERM/WHHT GRAZ
10 FINEFESC.OPC 1Y PINE FESCUE HAY
11 LBSO.OPC 1Y LBST/SOAT NM
12 RGHM.OPC 1Y RANGE HAY NM
13 ROCR.OPC 1Y RANGE CRP
14 CRGTCF.OPC 1Y CORN GRAIN MED TILL
15 CRGHI.OPC 1Y CORN GRAIN HIGH TILL
16 CRGMI.OPC 1Y CORN GRAIN MED TILL
17 CRGNT.OPC 1Y CORN GRAIN NO TILL
18 CRGR.OPC 1Y CORN GRAIN RYE GRASS
19 PINETEST.OPC 50Y PINE
20 WWS.OPC 1Y WHEAT GRAIN
21 CTGSSW.OPC 3Y COIN/GRSG/WHHT
22 CTGSGAF.OPC 2Y COIN/GRSG AF
23 SWHTFAL.OPC 2Y SPRING WHEAT FALLOW
24 BGLAWN.OPC 1Y BERM LAWN
27 BOWWGMF.OPC 2Y BERM/WHHT GRAZ MAN F
28 TRB-SWNT.OPC 2Y GRSG/WHHT
29 CCSW8.OPC
34 BERMHAY.OPC
38 RICE123.OPC
39 POT.OPC
40 PINE1.OPC
41 BERMHAY.OPC
42 FINEES.OPC
43 FALLOW.OPC
44 CORNW1.OPC
45 CORNW11.OPC
46 PESTIEST.OPC
47 PESTIES1.OPC
48 MESQUITE.OPC
49 COTS.OPC 1Y COTTON IRR
50 WWSH.OPC 1Y WHHT GRAIN SOUTHERN HEMISPHERE
51 WHH.OPC 1Y WHHT HAY
52 CRNTSH.OPC 1Y CORN SOUTHERN HEMISPHERE
53 SPH.OPC 1Y SPAS HAY
54 POT.OPC 1Y POTATOES
55 LBSO.OPC 1Y LBST/SOAT
56 GSCR.OPC 2Y GRAIN SORG/CORN
57 SGBT.OPC 1Y SGBT IRR
58 SUNF.OPC
59 CSUN.OPC
60 FALW.OPC
61 WHHT.OPC
```


2.11 DAILY WEATHER FILES (*FILENAME.DLY*)

Historical daily weather data can be used in two ways: First, it can be directly used in APEX 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 APEX weather input data.

FORMAT: TWO (2) BLANK SPACES FOLLOWED BY THREE (3) FIELDS OF FOUR (4) COLUMNS (INTEGER) FOLLOWED BY NINE (9) FIELDS OF SIX (6) COLUMNS INCLUDING DECIMAL PLACES (FLOATING)

Variable	Description
YEAR	Year must be in 4-digit format and is REQUIRED data (cols. 3-6)
MONTH	Month is REQUIRED data (cols. 7-10)
DAY	Day is REQUIRED data (cols. 11-14)
SRAD	Solar radiation must be in MJ/m ² but is NOT REQUIRED data. Solar radiation, in this case, refers to the total solar radiation that reaches the Earth's surface. If data is not available, leave a blank field. (cols. 15-20)
TMAX	Maximum temperature must be in °C and is NOT REQUIRED data. (cols. 21-26)
TMIN	Minimum temperature must be in °C and is NOT REQUIRED data. (cols. 27-32)
PRCP	Precipitation must be in mm and is REQUIRED data. (cols. 33-38)
RH	Relative humidity must be in fraction format and is NOT REQUIRED data. If data is not available, leave a blank field. (cols. 39-44)
WSPD	Wind speed must be in m/s and is NOT REQUIRED data. If data is not available, leave a blank field. (cols. 45-50)
CO2I	Carbon dioxide concentration in the atmosphere in ppm. NOT REQUIRED. Data does not need to be entered for each day. CO ₂ concentration can be entered at any regular or irregular interval. Concentration will change based on the value set for the day and will remain at that concentration until a new value is indicated. (cols. 51-56)

- REP Peak Rainfall Rate in mm/h. NOT REQUIRED. Data does not need to be entered for each day. Peak rainfall rate can be entered at any regular or irregular interval. (cols. 57-62)
- ORSO Observed Soil Surface Crop Residue in t/ha. NOT REQUIRED. Data does not need to be entered for each day. Crop residue cover can be entered at any regular or irregular interval. (cols. 63-68)

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). APEX will generate the missing record automatically when using measured weather in a simulation. NOTE: IF DAILY DATA HAS MISSING RECORDS, IT IS VERY IMPORTANT TO MAKE THE MONTHLY STATISTICAL FILE (.WP1) BEFORE ENTERING 9999 FOR ANY OF THE MISSING RECORDS. IF 9999 IS ENTERED IN MISSING RECORDS BEFORE THE MONTHLY FILE IS CREATED, THE PROGRAM (WXPM.EXE) USED TO MAKE THE MONTHLY FILE WILL INCLUDE 9999 IN THE CALCULATIONS AND WILL CAUSE THE MONTHLY STATISTICS TO BE INCORRECT.

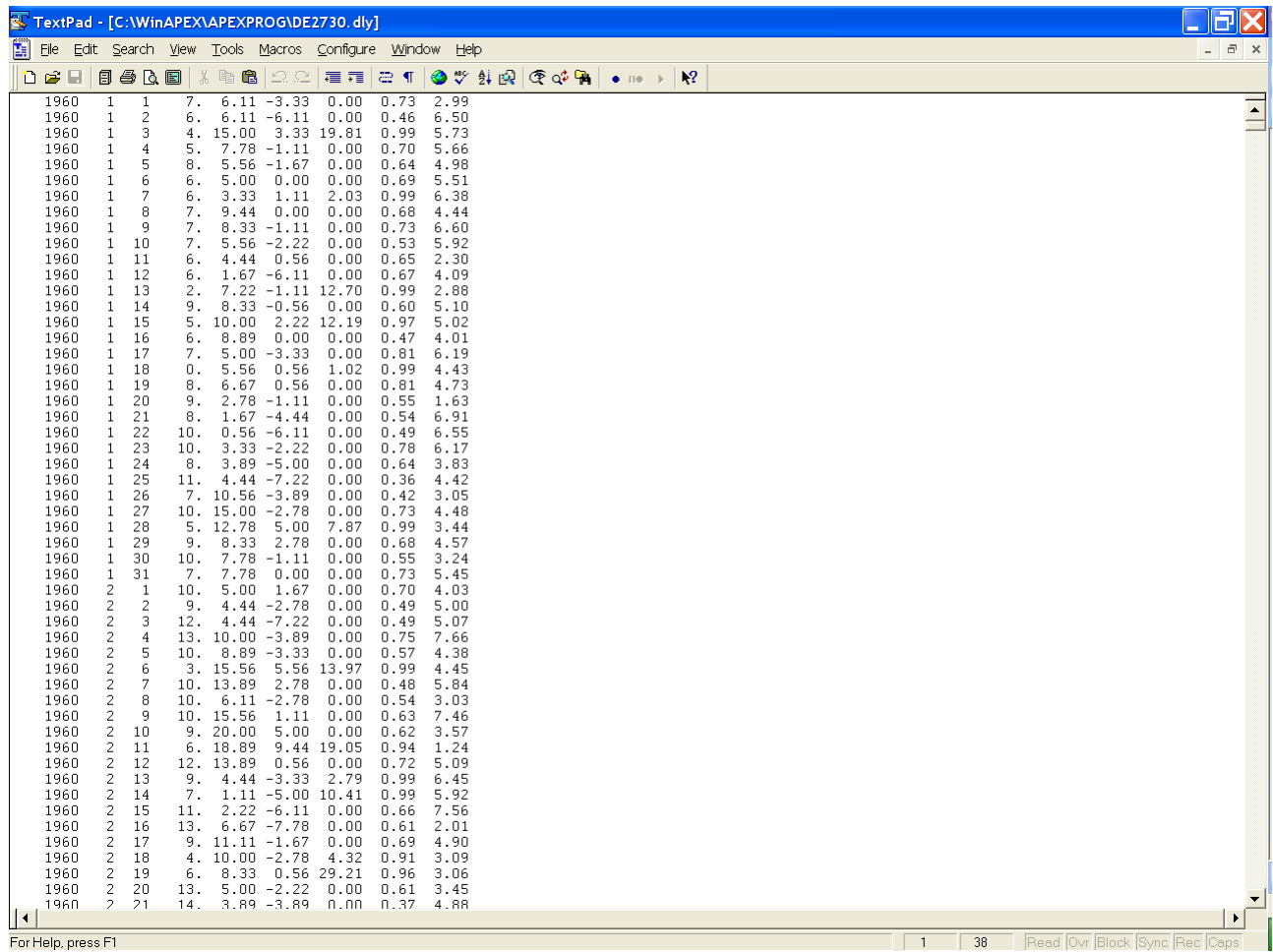
Format of Daily Weather Input Files

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 a tab delimited *.txt file. The APEX weather program (WXPM3020.exe) will read this *.txt file to create the generated weather file (.wp1).

Run APEX 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 WXPMPRUN.DAT file. This can be done by putting the actual daily weather file name (*.dly) on the first line in WXPMPRUN.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 WXPMPRUN.DAT file. By doing so, the WXPM3020.exe will read all the daily weather files listed in WXPMPRUN.DAT and generate all the monthly weather files. When WXPMPRUN.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 APEX simulation. To be consistent, this *.INP file should be renamed as *.WP1. The *.WP1 file will be listed in the weather list file (WPM11501.DAT). For the content of *.WP1 file, please refer to the next section of WPM1MO.DAT.

Figure 2.16. Sample Daily weather file



2.12 THE DAILY WEATHER LIST FILE (WDLST***.DAT)

This is a listing of daily weather stations as well as the corresponding latitude, longitude and weather station location name. The model references this file to determine which weather station (*.DLY) will be used for daily weather. When NGN in the APEXCONT.DAT file is equal to 1, 2, 3, 4, 5 or some combination of these, this indicates that daily weather is to be used. If a daily weather station is not indicated in the APEXRUN.DAT file, then the program references XCT and YCT in the subarea file to determine the latitude and longitude of the subarea centroid which it then uses to find a weather station in the WDLSTCOM.DAT file with the closest latitude and longitude. If XCT and YCT are not identified in the SUBAREA file, the program then references YLAT and XLOG in the SITE file to determine the latitude and longitude of the watershed which it then uses to find a weather station in the WDLSTCOM.DAT file with the closest latitude and longitude. Weather list file is FREE FORMAT.

Figure 2.17: Sample list of weather stations found in the WDLSTCOM.DAT file

1	TX0428.DLY	30.32	-97.76	TX	AUSTIN CAMP MABR
2	TX0691.DLY	32.65	-97.44	TX	BENBROOK DAM
3	TX0923.DLY	33.64	-96.17	TX	BONHAM 3 NNE
4	TX0984.DLY	33.55	-97.85	TX	BOWIE
5	TX1048.DLY	30.16	-96.40	TX	BRENHAM
6	TX1063.DLY	33.21	-97.77	TX	BRIDGEPORT
7	TX1138.DLY	31.68	-98.96	TX	BROWNWOOD
8	TX1348.DLY	30.85	-96.97	TX	CAMERON
9	TX1800.DLY	32.33	-97.40	TX	CLEBURNE
10	TX1889.DLY	30.59	-96.36	TX	COLLEGE STATION EAST
11	TX2019.DLY	32.11	-96.47	TX	CORSICANA
12	TX2404.DLY	33.20	-97.11	TX	DENTON 2 SE
13	TX2598.DLY	32.10	-98.33	TX	DUBLIN
14	TX2715.DLY	32.40	-98.82	TX	EASTLAND
15	TX3183.DLY	29.68	-97.11	TX	FLATONIA
16	TX3415.DLY	33.64	-97.14	TX	GAINSVILLE
17	TX3420.DLY	33.65	-97.06	TX	GAINSVILLE 5 EN
18	TX3485.DLY	31.38	-97.72	TX	GATESVILLE 4 SSE
19	TX3668.DLY	33.10	-98.58	TX	GRAHAM
20	TX3734.DLY	33.17	-96.10	TX	GREENVILLE KNVL
21	TX4093.DLY	33.81	-98.20	TX	HENRIETTA
22	TX4137.DLY	31.99	-98.03	TX	HICO
23	TX4182.DLY	32.02	-97.11	TX	HILLSBORO
24	TX4517.DLY	33.23	-98.15	TX	JACKSBORO
25	TX4705.DLY	32.56	-96.27	TX	KAUFMAN 3 SE
26	TX5094.DLY	33.03	-96.48	TX	LAVON DAM
27	TX5429.DLY	29.67	-97.66	TX	LULING
28	TX5766.DLY	33.17	-96.62	TX	MC KINNEY 3 S
29	TX5869.DLY	31.68	-96.48	TX	MEXIA
30	TX5958.DLY	32.78	-98.06	TX	MINERAL WELLS FC
31	TX6276.DLY	29.73	-98.12	TX	NEW BRAUNFELS
32	TX6636.DLY	33.37	-98.77	TX	OLNEY
33	TX6794.DLY	33.67	-95.57	TX	PARIS
34	TX7633.DLY	32.08	-98.97	TX	RISING STAR 1 S
35	TX7983.DLY	29.87	-97.92	TX	SAN MARCOS
36	TX8274.DLY	33.70	-96.63	TX	SHERMAN
37	TX8415.DLY	30.02	-97.15	TX	SMITHVILLE
38	TX8861.DLY	30.57	-97.41	TX	TAYLOR
39	TX8910.DLY	31.08	-97.32	TX	TEMPLE
40	TX9014.DLY	33.18	-99.19	TX	THROCKMORTON
41	TX9016.DLY	33.29	-99.10	TX	THROCKMORTON 7 N
42	TX9419.DLY	31.61	-97.23	TX	WACO REGIONAL AP
43	TX9522.DLY	32.42	-96.85	TX	WAXAHACHIE
44	TX9532.DLY	32.75	-97.77	TX	WEATHERFORD
45	TX9715.DLY	31.85	-97.37	TX	WHITNEY DAM
46	TX0246.DLY	30.76	-97.86	TX	ANDICE
47	TXBIGS.DLY	32.23	-101.50	TX	BIG SPRING
48	WREC0104.DLY	38.92	-76.15	MD	CARMICHAEL
49	CRESTON.DLY	47.00	-80.00		
50	P410440.DLY	32.13	-96.87		
51	RIESRG69.WTH	31.	-97.	TX	RIESEL
52	TX9588.DLY	32.	-97.	TX	WESLACO 2 E
53	TXTEMPLE.DLY	31.08	-97.32	TX	TEMPLE
54	00020050.wth	37.95	-97.		
55	PCPTEMP.DLY	31.08	-97.32		
56	PCPTEEX.DLY	31.08	-97.32		
57	PCPTEX1.DLY	31.08	-97.32		
58	ELBAYO2.DLY	40.	-95.		
59	TXTEMPMO.DLY	31.08	-97.32		
60	RIES4006.DLY	31.	-97.		
100	WISCONSI.DLY	43.18	-89.21	WI	SUN PRAIRIE
101	VAORANGE.DLY	38.22	-78.12	VA	ORANGE

2.13 THE MONTHLY WEATHER FILES (*FILENAME.WP1*)

Monthly weather statistics of a single weather station are maintained in filename.wp1. The files must be listed in WPM1MO.DAT (or user chosen name). The model references the WPM1MO.DAT file to determine which weather station (*.wp1) will be used for monthly weather. When NGN in the APEXCONT.DAT file is equal to 0 or -1, this indicates that monthly weather is to be used to generate all weather variables. Monthly weather is also used to generate weather when no daily weather data is available. If a monthly weather station is not indicated in the APEXRUN.DAT file, then the program references XCT and YCT in the subarea file to determine the latitude and longitude of the subarea centroid which it then uses to find a weather station in the WPM1MO.DAT file with the closest latitude and longitude. If XCT and YCT are not identified in the SUBAREA file, the program then references YLAT and XLOG in the SITE file to determine the latitude and longitude of the watershed which it then uses to find a weather station in the WPM1MO.DAT file with the closest latitude and longitude.

LINE 1: TITLE *Description line. FORMAT: TWENTY (20) ALPHA CHARACTERS*

LINE 2: TITLE *Description line. FORMAT: TWENTY (20) ALPHA CHARACTERS*

LINE 3-15 *FORMAT: TWELVE (12) FIELDS OF TEN (10) COLUMNS INCLUDING UP TO THREE DECIMAL PLACES (FLOATING)*

FILENAME.WP1 FILE (LINES 3 TO 15 EACH HAVE 12 FIELDS, ONE FOR EACH MONTH, JANUARY – DECEMBER):

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 (mm).*

- May be left zero if daily rainfall is input
- May be left zero if unknown (enter zero).

LINE 9: RST3 *Monthly skew coefficient for daily precipitation)*

- May be left zero if daily rainfall is input
- May be left zero if unknown (enter zero).

- LINE 10:** PRW1 ***Monthly probability of wet day after dry day***
- May be left zero if unknown and average number of days of rain per month (WVL) is available
 - May be left zero if daily rainfall is input.
- LINE 11:** PRW2 ***Monthly probability of wet day after wet day***
- May be left zero if unknown and average number of days of rain per month (WVL) is available.
 - May be left zero if daily rainfall is input.
- LINE 12:** UAVM ***Average number days of rain per month (days).***
- May be left zero if rainfall is generated and wet/dry probabilities are available.
- LINE 13:** WI ***Monthly max 0.5h rainfall (mm).***
- 3 options are available:
- Monthly maximum .5 hour rainfall (mm) for period in YWI.
 - Alpha (Mean .5 hour rain/mean storm amount).
 - May be left zero if unknown.
- LINE 14:** OBSL ***Average monthly solar radiation (MJ/M**2 or LY (Langley))***
- Special note if you intend to use daily weather files 3 options are available:
- Entering MJ/M**2 here indicates you will be reading MJ/m².
 - Entering LY here indicates you will be reading LY.
MJ/m² = LY x 0.0419
 - May be left zero if unknown.
- LINE 15:** RH ***Monthly average relative humidity (fraction), (3 options).***
- 3 options are available:
- Average Monthly relative humidity (Fraction, e.g. 0.75)
 - Average Monthly dewpoint temp (Deg C)
 - May be left zero if unknown.
- NOTE:
1. Conversion using 'E' in the number for English, will convert the number entered to Deg C for dewpoint temperature.
 2. May be left zero unless a PENMAN equation is used to estimate potential evaporation. See variable IET.
- LINE 16** UAV0 ***Average Monthly Wind Speed (m/s)***

Figure 2.18: Sample Weather (*.WP1) file screen.

```
10 TX CAMERON
LATT = 30.85 LONG = 96.98 ELEV = 118.9 TPs .5H = 86.9 TP6 6.H = 187.5
15.96 18.36 22.63 26.71 30.07 33.59 35.93 36.39 33.08 28.19 21.87 17.13
3.28 5.11 8.83 13.38 17.64 21.19 22.73 22.49 19.69 14.02 8.42 4.40
7.38 6.71 5.98 4.26 3.36 2.76 2.62 2.76 3.92 4.88 5.81 6.38
6.46 5.87 5.76 4.96 3.56 2.47 1.49 1.85 3.54 5.16 5.98 5.90
61.20 65.10 60.70 94.20105.30 62.60 36.90 40.80 80.40 74.30 68.90 71.70
12.20 11.70 11.70 18.80 18.50 15.50 15.70 15.00 21.10 20.10 15.00 14.70
1.89 0.61 0.69 2.30 1.37 1.28 3.63 2.38 4.28 2.38 0.99 2.27
0.16 0.17 0.16 0.17 0.17 0.11 0.09 0.09 0.13 0.12 0.13 0.14
0.44 0.40 0.35 0.40 0.42 0.44 0.34 0.36 0.44 0.37 0.44 0.51
6.89 6.40 6.12 6.62 7.03 4.93 3.72 3.82 5.65 4.96 5.65 6.89
15.00 23.40 16.50 29.50 48.30 31.80 47.50 32.30 33.00 38.60 14.50 13.20
11.23 13.85 17.67 19.59 23.17 26.51 26.03 24.60 20.78 16.72 12.66 10.51
3.36 5.11 6.78 12.43 17.56 20.37 20.92 20.14 18.01 13.23 7.33 4.58
4.51 4.55 4.84 4.89 4.34 4.22 3.94 3.63 3.34 3.63 4.16 4.21
```

For Help, press F1

3 2 Read Ovr Block Sync Rec Caps

2.14 THE APEX MONTHLY WEATHER DATA LIST (WPM1****.DAT)

The APEX Monthly Weather Data list is a listing of all monthly weather station files which have been previously created following the format previously described in section 2.11 and are available for use in creating runs. The Monthly Weather Data list consists of a numbered listing of all monthly weather files along with the latitude, longitude and a brief description of the location of the weather station which can be referenced by number in the APEXRUN.DAT file. The file is in FREE FORMAT. See Figure 2.19 for an example of the WPM1US.DAT file. The Monthly Weather list file name may be user defined; however, it must be properly identified in the APEXFILE.DAT file

Figure 2.19. Sample WPM1US.DAT file.

```
1 ALBANKHE.WP1 33.45 -87.35 AL BANKHEAD LOCK
2 ALBIRMIN.WP1 33.57 -86.75 AL BIRMINGHAM WB AP
3 ALBRANTL.WP1 31.58 -86.27 AL BRANTLEY
4 ALFRISCO.WP1 31.43 -87.40 AL FRISCO CITY
5 ALGREENS.WP1 32.70 -87.60 AL GREENSBORO
6 ALHEFLIN.WP1 33.65 -85.60 AL HEFLIN
7 ALHUNTSV.WP1 34.65 -86.77 AL HUNTSVILLE WSO AP
8 ALMOBILE.WP1 30.68 -88.25 AL MOBILE WB AIRPORT
9 ALMONTGO.WP1 32.30 -86.40 AL MONTGOMERY WB AP
10 ALMUSCLE.WP1 34.73 -87.60 AL MUSCLE SHOALS CAA
11 ALOPELIK.WP1 32.63 -85.38 AL OPELIKA
12 ALOZARK.WP1 31.47 -85.65 AL OZARK
13 ALROBERT.WP1 30.55 -87.60 AL ROBERTSDALE 7 E
14 ALVALLEY.WP1 34.57 -85.60 AL VALLEY HEAD
15 ARBENTON.WP1 34.55 -92.62 AR BENTON
16 ARCLARKS.WP1 35.47 -93.47 AR CLARKSVILLE
17 ARCORNNI.WP1 36.40 -90.58 AR CORNING
18 ARDUMAS.WP1 33.88 -91.50 AR DUMAS 1
19 AREUREKA.WP1 36.40 -93.75 AR EUREKA SPRINGS
20 ARFORDVC.WP1 33.70 -92.37 AR FORDVCE
21 ARFORTSM.WP1 35.33 -94.37 AR FORT SMITH WB AP
22 ARHOPE.WP1 33.72 -93.55 AR HOPE
23 ARJONESB.WP1 35.83 -90.70 AR JONESBORO
24 ARMAMOT.WP1 36.48 -91.53 AR MAMMOTH SPRING
25 ARMORRIL.WP1 35.13 -92.73 AR MORRILTON
26 ARMOUNTI.WP1 34.55 -93.63 AR MOUNT IDA 1
27 ARMOUNTA.WP1 36.33 -92.38 AR MOUNTAIN HMC OF ENG
28 ARNEWPOR.WP1 35.60 -91.28 AR NEWPORT
29 ARSILOAM.WP1 36.18 -94.55 AR SILOAM SPRINGS
30 ARSTUITG.WP1 34.47 -91.42 AR STUITTGART 9ESE
31 AZAGUILA.WP1 33.95 -113.18 AZ AGUILA
32 AZAJO.WP1 32.37 -112.87 AZ AJO
33 AZBETATA.WP1 36.68 -110.53 AZ BETATAKIN
34 AZBLACKR.WP1 33.48 -109.77 AZ BLACK RIVER PUMPS
35 AZBOWIE.WP1 32.33 -109.48 AZ BOWIE
36 AZCANELO.WP1 31.55 -110.52 AZ CANELO RS
37 AZDOUGLA.WP1 31.45 -109.60 AZ DOUGLAS B D AP
38 AZELOUY.WP1 32.75 -111.55 AZ ELOY
39 AZHEBER.WP1 34.38 -110.58 AZ HEBER
40 AZJACOBL.WP1 36.72 -112.22 AZ JACOB LAKE
41 AZKEAMSC.WP1 35.82 -110.20 AZ KEAMS CANYON
42 AZKLAGET.WP1 35.55 -109.70 AZ KLAGETOH 12 WNW
43 AZKOFAMO.WP1 33.27 -113.87 AZ KOFA MOUNTAINS
44 AZLEESFE.WP1 36.87 -111.58 AZ LEES FERRY
45 AZLITCHF.WP1 33.50 -112.37 AZ LITCHFIELD PARK
46 AZLURACH.WP1 36.42 -109.23 AZ LURACHUKAI
47 AZMONTEZ.WP1 32.57 -111.83 AZ MONTEZUMA CASTLE NM
48 AZORACLE.WP1 32.57 -110.72 AZ ORACLE 4 SE
49 AZPRESCO.WP1 34.55 -112.47 AZ PRESCOTT
50 AZSAINTJ.WP1 34.50 -109.37 AZ SAINT JOHNS
51 AZSANCAR.WP1 33.17 -110.52 AZ SAN CARLOS RESRVOIR
52 AZSASARE.WP1 31.48 -111.55 AZ SASARE
```


2.15 THE WIND DATA FILE (*FILENAME.WND*)

Monthly wind weather statistics of a single wind weather station are maintained in *filename.wnd*. The files need to be listed in *WINDMO.DAT* (or user chosen name). APEX considers 16 wind directions, which are crucial if the user analyzes issues of wind erosion as well as dust distribution and air quality from feedlots.

LINE 1: TITLE *Description line. FORMAT: TWENTY (20) ALPHA CHARACTERS*

LINE 2: TITLE *Description line. FORMAT: TWENTY (20) ALPHA CHARACTERS*

LINES 3-15 *FORMAT: TWELVE (12) FIELDS OF SIX (6) COLUMNS INCLUDING UP TO TWO DECIMAL PLACES (FLOATING)*

FILENAME.WND FILE (LINES 3 TO 19 EACH HAVE 12 FIELDS, ONE FOR EACH MONTH, JANUARY – DECEMBER):

LINE 3: UAVM *Average monthly wind speed (m/s) REQUIRED*

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.

UAVM is required to simulate wind erosion ($ACW > 0$, See ACW). It is also required if Penman or Penman-Monteith equations are used to calculate potential ET (See IET).

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.

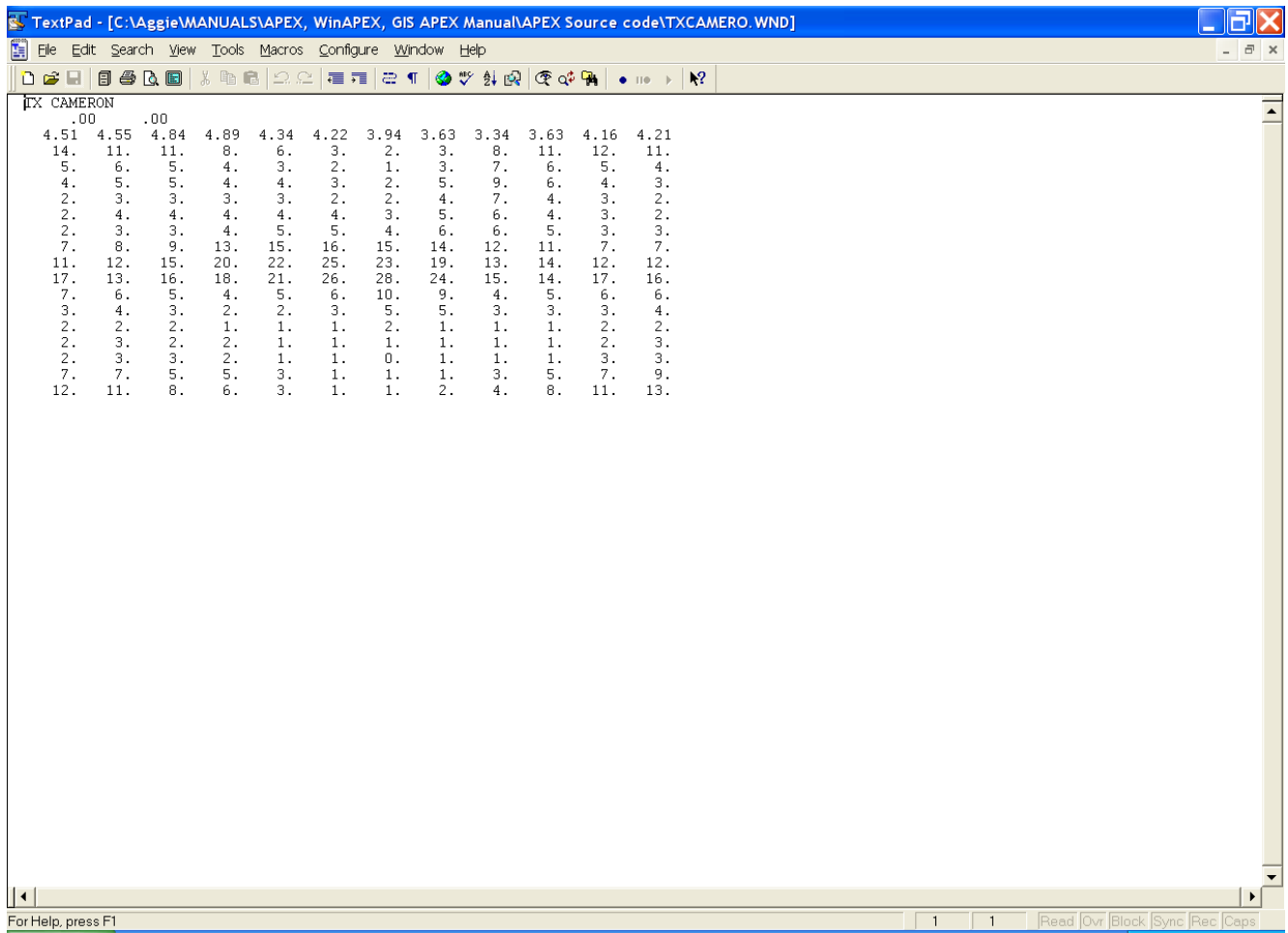
LINE 6: DIR3 *Monthly % wind from North East.*
May be left zero if wind erosion is not estimated.

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.

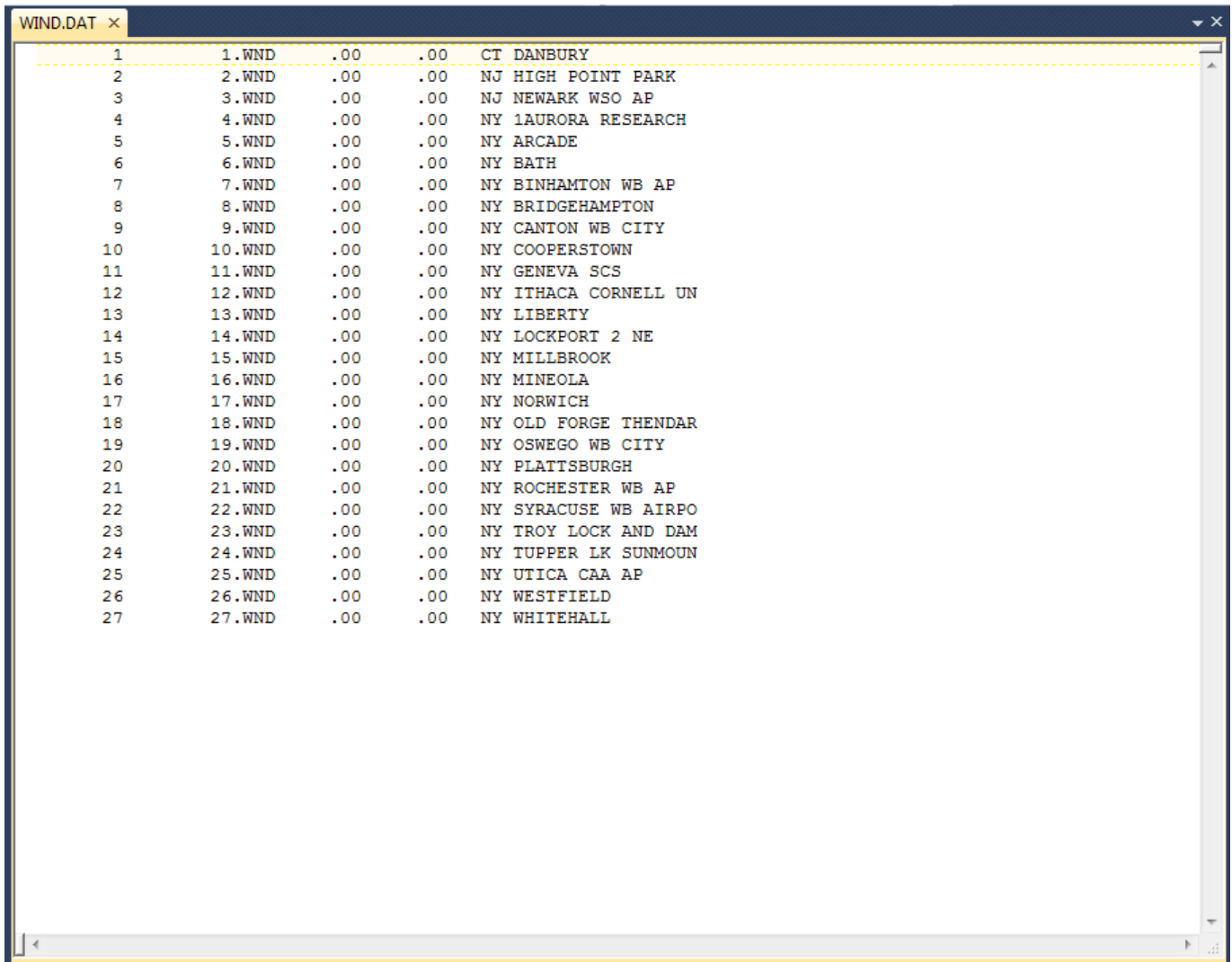
Figure 2.20: Sample Wind (*.WND) file screen.



2.16 THE WIND DATA LIST FILE (*WIND.DAT*)

The APEX Wind Data list is a listing of all wind station files which have been previously created following the format previously described in section 2.15 and are available for use in creating runs. The Wind Data list consists of a numbered listing of all wind files along with the latitude, longitude and a brief description of the location of the wind station which can be referenced by number in the APEXRUN.DAT file. The file is in FREE FORMAT. See Figure 2.21 for an example of the WIND.DAT file. The Wind list file name may be user defined; however, it must be properly identified in the APEXFILE.DAT file

Figure 2.21: Sample Wind List (WIND.DAT) file screen.



The screenshot shows a text editor window titled "WIND.DAT" with a list of 27 wind station entries. Each entry consists of a line number, a file name, two decimal values, and a location description. The entries are as follows:

Line	File Name	Lat	Long	Location
1	1.WND	.00	.00	CT DANBURY
2	2.WND	.00	.00	NJ HIGH POINT PARK
3	3.WND	.00	.00	NJ NEWARK WSO AP
4	4.WND	.00	.00	NY LAURORA RESEARCH
5	5.WND	.00	.00	NY ARCADE
6	6.WND	.00	.00	NY BATH
7	7.WND	.00	.00	NY BINHAMTON WB AP
8	8.WND	.00	.00	NY BRIDGEHAMPTON
9	9.WND	.00	.00	NY CANTON WB CITY
10	10.WND	.00	.00	NY COOPERSTOWN
11	11.WND	.00	.00	NY GENEVA SCS
12	12.WND	.00	.00	NY ITHACA CORNELL UN
13	13.WND	.00	.00	NY LIBERTY
14	14.WND	.00	.00	NY LOCKPORT 2 NE
15	15.WND	.00	.00	NY MILLBROOK
16	16.WND	.00	.00	NY MINEOLA
17	17.WND	.00	.00	NY NORWICH
18	18.WND	.00	.00	NY OLD FORGE THENNDAR
19	19.WND	.00	.00	NY OSWEGO WB CITY
20	20.WND	.00	.00	NY PLATTSBURGH
21	21.WND	.00	.00	NY ROCHESTER WB AP
22	22.WND	.00	.00	NY SYRACUSE WB AIRPO
23	23.WND	.00	.00	NY TROY LOCK AND DAM
24	24.WND	.00	.00	NY TUPPER LK SUNMOUN
25	25.WND	.00	.00	NY UTICA CAA AP
26	26.WND	.00	.00	NY WESTFIELD
27	27.WND	.00	.00	NY WHITEHALL

2.17 THE TILLAGE FILE (TILL****.DAT)

The tillage operations in TILL1501.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 TILL1501.DAT file. The first two lines of TILL1501.DAT are descriptive lines and consist of columns of eight (8) alpha characters.

Field	Variable	Description
LINES 3-N	FORMAT:	ONE (1) BLANK COLUMN FOLLOWED BY ONE (1) FIELD OF FOUR (4) COLUMNS (INTEGER) FOLLOWED BY ONE (1) BLANK COLUMN FOLLOWED BY ONE FIELD OF EIGHT (8) ALPHA CHARACTERS FOLLOWED BY ONE BLANK COLUMN FOLLOWED BY ONE FIELD OF FOUR (4) ALPHA CHARACTERS FOLLOWED BY TWENTY- NINE (29) FIELDS OF EIGHT (8) COLUMNS INCLUDING UP TO THREE DECIMAL PLACES (FLOATING)
1	TNUM	Equipment number (cols.2-5) (Range: 1-∞) Operations are accessed by the Equipment Number. For example, if operation #251 is used in the operation schedule file, the model will look for this number in the TILL1501.dat file.
2	TIL	Tillage/Equipment operation name. (cols. 7-14) A descriptive name of the operation
3	PCD	Power code. (cols. 16-19) (Range: 1- 5) <ol style="list-style-type: none"> 1. POWE: the machine with its own engine for power is generally used to pull other machinery or equipment, like a tractor 2. SELF: the machine has its own engine for power but it does the operation by itself like a combine 3. NON: the machine (or equipment) has no engine for power and it must be pulled by other machinery with engine power 4. IRRI: irrigation equipment 5. CUST: customized equipment.
4	PRIC	Purchase price (\$) (cols. 20-27) (Range: 0- 999999) EXCEPTION: for a custom operation = cost (\$/ha) The amount of money the equipment was actually purchased for. To estimate purchase price subtract 10% from the initial list price.
5	XLP	Initial list price in current (\$) (cols. 28-35) (Range: 0- 999999) The price of the equipment when new. The dollar amount takes into account inflation. To estimate Initial list prices add 10% to the purchase price.
6	HRY	Annual use (h) (cols. 36-43) (Range: 0- 8760) Amount of time per year the equipment is used.

Field	Variable	Description
7	HRL	Life of equip (h) (cols. 44-51) (Range: 0- 999999) The amount of time the equipment will be capable of being used.
8	PWR	Power of unit (KW) (cols. 52-59) (Range: 0- 900) This is the horsepower or the number of kilowatts of the equipment Kilowatts x 1.341 = horsepower
9	WDT	Width of pass (m) (cols. 60-67) (Range: 0- 50) This refers to the width the equipment covers when it is moved across the land.
10	SPD	Operating speed (km/h) (cols. 68-75) (Range: 0- 200) The speed at which the equipment is operated at.
11	RC1	Repair cost coef 1 (cols. 76-83) (Range: 0-1) Refer to the American Society of Agricultural Engineers Standards Engineering Practices Data handbook for this value
12	RC2	Repair cost coef 2 (cols. 84-91) (Range: 0-5) Refer to the American Society of Agricultural Engineers Standards Engineering Practices Data handbook for this value
13	XLB	Lubricant factor (cols. 92-99) (Range: 0-1) Refer to the American Society of Agricultural Engineers Standards Engineering Practices Data handbook for this value
14	FCM	Fuel consumption multiplier (cols. 100-107) (Range: 0-1) Refer to the American Society of Agricultural Engineers Standards Engineering Practices Data handbook for this value
15	RFV1	Remaining farm value parm 1 (cols. 108-115) (Range: 0-2) Refer to the American Society of Agricultural Engineers Standards Engineering Practices Data handbook for this value
16	RFV2	Remaining farm value parm 2 (cols. 116-123) (Range: 0-2) Refer to the American Society of Agricultural Engineers Standards Engineering Practices Data handbook for this value
17	EFM	Machine efficiency (cols. 124-131) (Range: 0-1) The fraction of efficiency loss due to the overlap of passes. For example, if each time when a pass is made across the field, the implement covers 10% of the last pass, then the machine efficiency is 0.90. In the case of irrigation systems, this machine efficiency applies to the efficiency of the system. This would include losses from the well or channel to the soil surface. These losses include leaks in channels, pipes, and other equipment deficiencies as well as

Field	Variable	Description
	EFM cont.	evaporation of water before it reaches the soil surface as is the case with sprinkler irrigation systems.
18	RTI	Annual real interest rate (\$/\$) (cols. 132-139) (Range 0.001 – 0.15) The difference between the nominal interest rate (current rate of interest) and the inflation rate.
19	EMX	Mixing efficiency (cols. 140-147) (Range: 0-1) The mixing efficiency of the operation (EMX) is the fraction of materials (crop residue, pesticides and nutrients) on the soil surface that is mixed uniformly in the plow depth of the implement. The remaining fraction of residue and nutrients is left in the original location (soil surface or layer).
20	RR	Random surface roughness created by tillage operation in mm. (cols. 148-155) (Range: 0-100) This characterizes the soil surface roughness due to soil aggregates. Random roughness has been used to describe the effects of tillage on surface roughness and to estimate the surface roughness after tillage based on the tillage implement used. (Potter, K.N. 1990. Soil properties effect on random roughness decay by rainfall. Transactions of the ASAE 33 (6) 1889-1892.) The random roughness index is the standard error of adjusted natural log transformed surface elevations.
21	TLD	Tillage depth in mm. (cols. 156-163) (Range: -2000 to 500) 1. (+) Positive depth is below the surface; 2. (-) Negative indicates above ground cutting height. 3. Also used as the lower limit of grazing height (mm)
22	RHT	Ridge height in mm (cols. 164-171) (Range: 0-1000) The height of the ridge created by the implement. This affects wind erosion.
23	RIN	Ridge interval in m (cols. 172-179) (Range: 0-200) The distance between ridges created by the implement. Also known as row spacing. To set the row spacing of the crop, the ridge interval should be set accordingly for the planter in the TILL1501.DAT file.
24	DKH	Height of furrow dikes in mm. (zero if dikes are not used) (cols. 180-187) (Range: 0-1000) This will affect the amount of water the furrow dike is capable of storing.
25	DKI	Distance between furrow dikes in m. (zero if dikes are not used) (cols. 188-195) (Range: 0-200)

Field	Variable	Description
26	IHC	<p>Operation Code: (cols. 196-203) (Range: 0-26)</p> <ul style="list-style-type: none"> 0 Plow, cultivate, other 1 Kill crop. 2 Harvest without kill. 3 Harvest once during simulation without kill 4 Tractor 5 Plant in rows. 6 Plant with drill. 7 Apply pesticide. 8 Irrigate 9 Fertilize 10 Bagging and Ties (cotton) 11 Ginning 12 Hauling 13 Drying 14 Burn 15 Puddle 16 Destroy puddle 17 Builds furrow dikes 18 Destroys furrow dikes 19 Start grazing 20 Stop grazing 21 Scrape manure from pens 22 Auto mow 23 Plastic cover 24 Remove plastic cover 25 Stop drainage system flow 26 Resume drainage flow 27 Add mulch
27	HE	<p>Harvest efficiency (0-1), or Pesticide application efficiency. (cols. 204-211) (Range: 0-1)</p> <p>As a harvest operation (IHC=2.0): This is the ratio of crop yield removed from the field to total crop yield.</p> <p>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).</p> <p>As pesticide application efficiency, it is the fraction of the pesticide which is deposited on the foliage or soil surface. The remaining is lost.</p>

Field	Variable	Description
28	ORHI	<p><i>Override Harvest Index for Forage and Root Crops (cols. 212-219)</i> (Range: 0-1) The ratio of the economic or harvestable yield to the total biomass of the crop. This value overrides the harvest index set in CROP1501.DAT if a forage or root crop is chosen.</p> <p>Over rides simulated Harvest Index (HI) if $0. < \text{ORHI} < 1$ or it equals the grazing rate (kg/ha/d) if $\text{ORHI} > 1$.</p> <p>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. 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.</p> <p>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).</p>
29	FRCF	<p><i>Fraction of soil compacted (cols. 220-227)</i> (Range: 0-1) (tire width/tillage width).</p>
30	FPOP	<p><i>Fraction plant population reduced by operation. (cols. 228-235)</i> (Range: 0-1) This operation can be used for thinning operations to reduce the plant population which was actually planted. It can also be used to decrease plant population after a harvest (i.e. sugarcane) or due to a tillage operation. It is a correction to the seeded rate. Each time an operation that has an FPOP >0 occurs, the current plant population is reduced accordingly.</p>
31	TCEM	<p><i>Carbon Emission (cols. 236-243)</i> (Range: 0-9999) Carbon emitted from use of equipment. (kg/ha)</p>
32	STIR	<p><i>STIR value for operation (cols. 244-251)</i> (Range:0-200) STIR is the soil tillage intensity rating.</p>

Figure 2.22: Sample Tillage file screen.

TextPad - [C:\Aggie\MANUALS\APEX, WinAPEX, GIS APEX Manual\APEX Source code\TILLCOM.DAT]

#	NAME	PCD	PR1C	2	3	4	5	6	7	8	9	10	11	12	13	14	15
			HRV	HRL	PWR	WDT	SPD	RC1	RC2	XLB	FCM	VR1	VR2	EFM	RTI		
1	TR2W40LP	POWE	16237.	17861.	320.	12000.	30.	0.3	0.00	0.007	2.000	0.100	0.680	0.680	0.920	0.000	0.00
2	TR2W40GS	POWE	16600.	18260.	320.	12000.	30.	0.3	0.00	0.007	2.000	0.100	0.530	0.680	0.920	0.000	0.00
3	TR2W40DS	POWE	16600.	18260.	320.	12000.	30.	0.3	0.00	0.007	2.000	0.100	0.420	0.680	0.920	0.000	0.00
4	TR2W55LP	POWE	22000.	24200.	340.	12000.	41.	0.3	0.00	0.007	2.000	0.100	0.680	0.680	0.920	0.000	0.00
5	TR2W55GS	POWE	22000.	24200.	340.	12000.	41.	0.3	0.00	0.007	2.000	0.100	0.530	0.680	0.920	0.000	0.00
6	TR2W55DS	POWE	22000.	24200.	340.	12000.	41.	0.3	0.00	0.007	2.000	0.100	0.420	0.680	0.920	0.000	0.00
7	TR2W85LP	POWE	34200.	37620.	550.	12000.	63.	0.3	0.00	0.007	2.000	0.100	0.680	0.680	0.920	0.000	0.00
8	TR2W85GS	POWE	34200.	37620.	550.	12000.	63.	0.3	0.00	0.007	2.000	0.100	0.530	0.680	0.920	0.000	0.00
9	TR2W85DS	POWE	34200.	37620.	550.	12000.	63.	0.3	0.00	0.007	2.000	0.100	0.420	0.680	0.920	0.000	0.00
10	TR2100LP	POWE	43400.	47740.	525.	12000.	75.	0.3	0.00	0.007	2.000	0.100	0.680	0.680	0.920	0.000	0.00
11	HORSE	POWE	2190.	2409.	900.	9000.	0.	0.3	3.22	1.000	0.002	0.100	0.000	0.600	0.885	0.750	0.00
12	TR2100DS	POWE	43400.	47740.	525.	12000.	75.	0.3	0.00	0.007	2.000	0.100	0.420	0.680	0.920	0.000	0.00
15	TR2135DS	POWE	56288.	61916.	640.	12000.	101.	0.3	0.00	0.007	2.000	0.100	0.420	0.680	0.920	0.000	0.00
18	TR2160DS	POWE	71619.	78781.	660.	12000.	119.	0.3	0.00	0.007	2.000	0.100	0.420	0.680	0.920	0.000	0.00
21	TR2175DS	POWE	84254.	92679.	660.	12000.	130.	0.3	0.00	0.007	2.000	0.100	0.420	0.680	0.920	0.000	0.00
24	TR2205DS	POWE	103428.	113771.	685.	12000.	153.	0.3	0.00	0.007	2.000	0.100	0.420	0.680	0.920	0.000	0.00
27	TR2225DS	POWE	116240.	127864.	800.	12000.	168.	0.3	0.00	0.007	2.000	0.100	0.420	0.680	0.920	0.000	0.00
30	TR2290DS	POWE	147253.	161978.	999.	12000.	216.	0.3	0.00	0.007	2.000	0.100	0.420	0.680	0.920	0.000	0.00
33	TR4W40DS	POWE	15908.	17499.	320.	12000.	30.	0.3	0.00	0.003	2.000	0.100	0.420	0.680	0.920	0.000	0.00
36	TR4W55DS	POWE	18650.	20515.	340.	12000.	41.	0.3	0.00	0.003	2.000	0.100	0.420	0.680	0.920	0.000	0.00
39	TR4W85DS	POWE	29862.	32848.	550.	12000.	63.	0.3	0.00	0.003	2.000	0.100	0.420	0.680	0.920	0.000	0.00
42	TR4100DS	POWE	38492.	42342.	525.	12000.	75.	0.3	0.00	0.003	2.000	0.100	0.420	0.680	0.920	0.000	0.00
45	TR4135DS	POWE	54791.	60270.	640.	12000.	101.	0.3	0.00	0.003	2.000	0.100	0.420	0.680	0.920	0.000	0.00
48	TR4160DS	POWE	69716.	76687.	660.	12000.	119.	0.3	0.00	0.003	2.000	0.100	0.420	0.680	0.920	0.000	0.00
51	TR4175DS	POWE	81881.	90069.	660.	12000.	130.	0.3	0.00	0.003	2.000	0.100	0.420	0.680	0.920	0.000	0.00
54	TR4205DS	POWE	100515.	110567.	685.	12000.	153.	0.3	0.00	0.003	2.000	0.100	0.420	0.680	0.920	0.000	0.00
57	TR4225DS	POWE	127000.	139700.	800.	12000.	168.	0.3	0.00	0.003	2.000	0.100	0.420	0.680	0.920	0.000	0.00
60	TR4290DS	POWE	143107.	157418.	999.	12000.	216.	0.3	0.00	0.003	2.000	0.100	0.420	0.680	0.920	0.000	0.00
63	4W40HPDS	POWE	159080.	174990.	320.	12000.	30.	0.3	0.00	0.003	2.000	0.100	0.420	0.680	0.920	0.000	0.00
66	4W55HPDS	POWE	18650.	20515.	340.	12000.	41.	0.3	0.00	0.003	2.000	0.100	0.420	0.680	0.920	0.000	0.00
69	4W85HPDS	POWE	29862.	32848.	550.	12000.	63.	0.3	0.00	0.003	2.000	0.100	0.420	0.680	0.920	0.000	0.00
72	4W100DS	POWE	38492.	42342.	525.	12000.	75.	0.3	0.00	0.003	2.000	0.100	0.420	0.680	0.920	0.000	0.00
75	4W135DS	POWE	54791.	60270.	640.	12000.	101.	0.3	0.00	0.003	2.000	0.100	0.420	0.680	0.920	0.000	0.00
81	4W175DS	POWE	81881.	90069.	660.	12000.	130.	0.3	0.00	0.003	2.000	0.100	0.420	0.680	0.920	0.000	0.00
84	4W205DS	POWE	100515.	110567.	685.	12000.	153.	0.3	0.00	0.003	2.000	0.100	0.420	0.680	0.920	0.000	0.00
87	4W225DS	POWE	112969.	124266.	800.	12000.	168.	0.3	0.00	0.003	2.000	0.100	0.420	0.680	0.920	0.000	0.00
90	4W290DS	POWE	143107.	157418.	999.	12000.	216.	0.3	0.00	0.003	2.000	0.100	0.420	0.680	0.920	0.000	0.00
93	CR4W40DS	POWE	15908.	17499.	320.	12000.	30.	0.3	0.00	0.003	2.000	0.100	0.420	0.680	0.920	0.000	0.00
96	CR4W55DS	POWE	18650.	20515.	340.	12000.	41.	0.3	0.00	0.003	2.000	0.100	0.420	0.680	0.920	0.000	0.00
99	CR4W85DS	POWE	29862.	32848.	550.	12000.	63.	0.3	0.00	0.003	2.000	0.100	0.420	0.680	0.920	0.000	0.00
102	CRW100DS	POWE	38492.	42342.	525.	12000.	75.	0.3	0.00	0.003	2.000	0.100	0.420	0.680	0.920	0.000	0.00
105	CRW135DS	POWE	54791.	60270.	640.	12000.	101.	0.3	0.00	0.003	2.000	0.100	0.420	0.680	0.920	0.000	0.00
108	CRW160DS	POWE	69716.	76687.	660.	12000.	119.	0.3	0.00	0.003	2.000	0.100	0.420	0.680	0.920	0.000	0.00
111	CRW175DS	POWE	81881.	90069.	660.	12000.	130.	0.3	0.00	0.003	2.000	0.100	0.420	0.680	0.920	0.000	0.00
112	CRW205DS	POWE	100515.	110567.	685.	12000.	153.	0.3	0.00	0.003	2.000	0.100	0.420	0.680	0.920	0.000	0.00
115	CRW225DS	POWE	112969.	124266.	800.	12000.	168.	0.3	0.00	0.003	2.000	0.100	0.420	0.680	0.920	0.000	0.00
120	CRW290DS	POWE	143107.	157418.	999.	12000.	216.	0.3	0.00	0.003	2.000	0.100	0.420	0.680	0.920	0.000	0.00
121	DRFT PNTFR 2	NON	44130.	48543.	100.	2000.	0.	7.3	6.44	0.320	2.100	0.000	0.000	0.600	0.885	0.650	0.00

TextPad - [C:\WinAPEX\APEXPROG\till.dat]

RTI	EMX	RR	TLD	RHT	RIN	DKH	DKI	IHC	HE	ORHI	FRCP	FP0P	COTL	EQP
.000	.000	.000	.000	.000	.000	.000	.000	4.000	.000	.000	.000	.000	.000	TRACTOR 2WD 40 HP LP
.000	.000	.000	.000	.000	.000	.000	.000	4.000	.000	.000	.000	.000	.000	TRACTOR 2WD 40 HP GAS
.000	.000	.000	.000	.000	.000	.000	.000	4.000	.000	.000	.000	.000	.000	TRACTOR 2WD 40 HP DIESEL
.000	.000	.000	.000	.000	.000	.000	.000	4.000	.000	.000	.000	.000	.000	TRACTOR 2WD 55 HP LP
.000	.000	.000	.000	.000	.000	.000	.000	4.000	.000	.000	.000	.000	.000	TRACTOR 2WD 55 HP GAS
.000	.000	.000	.000	.000	.000	.000	.000	4.000	.000	.000	.000	.000	.000	TRACTOR 2WD 55 HP DIESEL
.000	.000	.000	.000	.000	.000	.000	.000	4.000	.000	.000	.000	.000	.000	TRACTOR 2WD 85 HP LP
.000	.000	.000	.000	.000	.000	.000	.000	4.000	.000	.000	.000	.000	.000	TRACTOR 2WD 85 HP GAS
.000	.000	.000	.000	.000	.000	.000	.000	4.000	.000	.000	.000	.000	.000	TRACTOR 2WD 85 HP DIESEL
.000	.000	.000	.000	.000	.000	.000	.000	4.000	.000	.000	.000	.000	.000	TRACTOR 2WD 100 HP LP
.000	.000	.000	.000	.000	.000	.000	.000	4.000	.000	.000	.000	.000	.000	HORSE OR MULE, DRAFT
.000	.000	.000	.000	.000	.000	.000	.000	4.000	.000	.000	.000	.000	.000	TRACTOR 2WD 100 HP DIESEL
.000	.000	.000	.000	.000	.000	.000	.000	4.000	.000	.000	.000	.000	.000	TRACTOR 2WD 135 HP DIESEL
.000	.000	.000	.000	.000	.000	.000	.000	4.000	.000	.000	.000	.000	.000	TRACTOR 2WD 160 HP DIESEL
.000	.000	.000	.000	.000	.000	.000	.000	4.000	.000	.000	.000	.000	.000	TRACTOR 2WD 175 HP DIESEL
.000	.000	.000	.000	.000	.000	.000	.000	4.000	.000	.000	.000	.000	.000	TRACTOR 2WD 205 HP DIESEL
.000	.000	.000	.000	.000	.000	.000	.000	4.000	.000	.000	.000	.000	.000	TRACTOR 2WD 225 HP DIESEL
.000	.000	.000	.000	.000	.000	.000	.000	4.000	.000	.000	.000	.000	.000	TRACTOR 2WD 290 HP DIESEL
.000	.000	.000	.000	.000	.000	.000	.000	4.000	.000	.000	.000	.000	.000	TRACTOR 4WD 40 HP DIESEL
.000	.000	.000	.000	.000	.000	.000	.000	4.000	.000	.000	.000	.000	.000	TRACTOR 4WD 55 HP DIESEL
.000	.000	.000	.000	.000	.000	.000	.000	4.000	.000	.000	.000	.000	.000	TRACTOR 4WD 85 HP DIESEL
.000	.000	.000	.000	.000	.000	.000	.000	4.000	.000	.000	.000	.000	.000	TRACTOR 4WD 100 HP DIESEL
.000	.000	.000	.000	.000	.000	.000	.000	4.000	.000	.000	.000	.000	.000	TRACTOR 4WD 135 HP DIESEL
.000	.000	.000	.000	.000	.000	.000	.000	4.000	.000	.000	.000	.000	.000	TRACTOR 4WD 160 HP DIESEL
.000	.000	.000	.000	.000	.000	.000	.000	4.000	.000	.000	.000	.000	.000	TRACTOR 4WD 175 HP DIESEL
.000	.000	.000	.000	.000	.000	.000	.000	4.000	.000	.000	.000	.000	.000	TRACTOR 4WD 205 HP DIESEL
.000	.00													

2.18 THE CROP FILE (CROP****.DAT)

Each crop is characterized with 56 parameters, which are all put in a single line in CROP1501.DAT. The crop-parameters **should not** be changed without consulting the model designers or without solid knowledge of plant growth and development. The first two lines of the CROP1501.DAT are descriptive lines and consist of twelve (12) alpha characters

Field	Variable	Description
LINES 3-N		<i>FORMAT: ONE (1) BLANK COLUMN FOLLOWED BY ONE (1) FIELD OF FOUR (4) COLUMNS (INTEGER) FOLLOWED BY ONE (1) BLANK COLUMN FOLLOWED BY ONE FIELD OF FOUR (4) ALPHA CHARACTERS FOLLOWED BY FIFTY-SIX (56) FIELDS OF EIGHT (8) COLUMNS INCLUDING DECIMAL PLACES (FLOATING)</i>
1	CNUM	Crop Number. (cols. 2-5) For reference purposes only. Crops are accessed by their sequential location in the file. For example, a crop number 9 will access the ninth crop regardless of the setting of this variable.
2	CPNM	Crop Name. (cols. 7-10) A four character name to represent the crop.
3	WA	Biomass-Energy Ratio (CO₂=330ppm). (cols. 11-18) 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. WA is also known as radiation use efficiency.
4	HI	Harvest index. (cols. 19-26) The ratio of economic or harvestable yield to the total biomass of the crop. This crop parameter should be based on experimental data where crop stresses have been minimized to allow the crop to attain its potential. HI is the maximum harvest index that could possibly be attained under nonstressed conditions. APEX adjusts HI as water stress occurs from near flowering to maturity. This HI only pertains to grain and cotton crops. For forage and root crops, the Override Harvest Index (ORHI) should be set in the TILL1501.DAT file for the harvest equipment being used to harvest the crop.

Field	Variable	Description
5	TOP	<p><i>Optimal temperature for plant growth. (cols. 27-34)</i></p> <p>The optimum temperature at which the crop will grow without being physiologically damaged by heat. 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.</p>
6	TBS	<p><i>Minimum temperature for plant growth. (cols. 35-42)</i></p> <p>The minimum (base) temperature at which the crop will grow without being physiologically damaged by cold. 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.</p>
7	DMLA	<p><i>Maximum potential leaf area index. (cols. 43-50)</i></p> <p>Leaf area index refers to the ratio of the surface area of the leaves (one side only) of the crop to the area of the ground covered by the plants. This parameter refers to the greatest leaf area index that the crop is able to attain. The parameters in the CROP1501.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.</p>
8	DLAI	<p><i>Fraction of growing season when leaf area declines. (cols. 51-58)</i></p> <p>Point in the growing season (expressed as a fraction of heat units required for maturation) when the leaf area index begins to decrease due to leaf senescence. The fraction of the growing season in heat units is 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 APEX can be used to estimate the fraction of heat units accumulated. A multi-run APEX 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.</p>

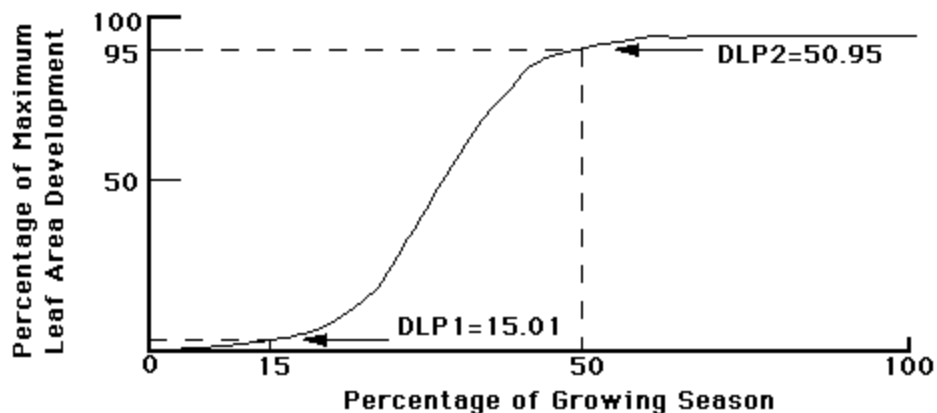
Field	Variable	Description
9	DLAP1	<p><i>First point on optimal leaf area development curve. (cols. 59-66)</i></p> <p>This is the first of two points on the optimal (nonstressed) leaf area development curve. Numbers before decimal are % of growing season. Numbers after decimal are fractions of maximum potential LAI. For example 15.01 states that at 15% of the growing season, 1% of the LAI has developed. 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 APEX 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 APEX 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.</p>
10	DLAP2	<p><i>Second point on optimal leaf area development curve. (cols. 67-74)</i></p> <p>The second of two points on optimal (nonstressed) leaf area development curve. Numbers before decimal are % of growing season. Numbers after decimal are fractions of maximum potential LAI. For example 50.95 states that at 50% of the growing season, 95% of the LAI has developed. 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 APEX 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 APEX 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.</p>

The following graph illustrates how DLPI = 15.01 and DLP2 = 50.95 define the leaf area development of a crop.

Field	Variable	Description
-------	----------	-------------

DLAP2
cont.

Figure 2.23: Leaf area development of crop based on DLAP1 and DLAP2



11 RLAD

Leaf area index decline rate parameter. (cols. 75-82)

For most grain crops, leaf area declines due to leaf senescence as the crop approaches physiological maturity. In most cases, leaf senescence begins with yellowing of the older (lower) leaves and proceeds upward until, in crops like corn, wheat, and soybeans, all leaves senesce and the plant dies. In many grain crops, leaf area index declines linearly with time after grain filling begins. Nutrients and carbohydrates in the senescing leaves are often translocated into the grain. In EPIC the crop parameter DLAI (described above) controls the point in the growing season when leaf area begins to decline. The crop parameter RLAD controls the rate of decline. If RLAD is set to 1.0, the rate of decline is linear. If $RLAD < 1.0$, the rate of decline is initially slow, then increases until all leaves are dead at maturity. If $RLAD > 1.0$, the rate of senescence is initially rapid, then slows as maturity approaches. In all cases, APEX assumes that leaf area begins to decline when the fraction of the growing season equals DLAI, and the leaf area index approaches zero at maturity.

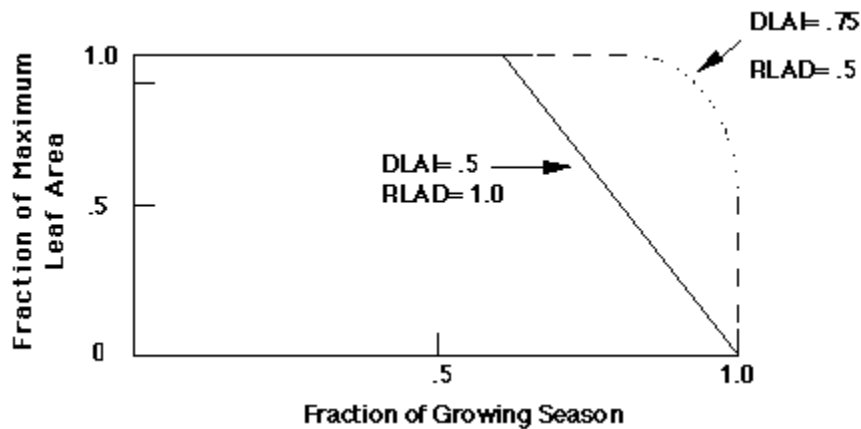
1. 1.0 is linear
2. >1 accelerates decline
3. < 1 retards decline rate.
4. Values range from 0 to 10.

The graph below illustrates how DLAI and RLAD interact to control leaf area decline.

Field	Variable	Description
-------	----------	-------------

RLAD
cont.

Figure 2.24: Leaf area development of crop based on DLAI and RLAD



12 RBMD

Biomass-energy ratio decline rate parameter. (cols. 83-90)

Biomass-energy ratio decline rate parameter for late in the cropping season. This crop parameter functions like the RLAD above for values ranging from 0-10. It reduces the efficiency of conversion of intercepted photosynthetically active radiation to biomass due to production of high energy products like seeds and/or translocation of N from leaves to seeds. In most crops this rate is relatively constant during the vegetative stage of growth, when structural carbohydrates like cellulose are the principal products of growth. However, when grain crops begin to form seeds, the conversion of intercepted solar radiation into biomass begins to decline. That is, less dry matter is formed for each unit of absorbed solar radiation. In addition, as leaf area yellows and begins to senesce, the conversion efficiency declines still more. APEX uses the crop parameter RBMD to reduce the rate of conversion of intercepted solar radiation to biomass as the crop approaches maturity (when the fraction of the growing season is greater than DLAI). Computationally, RBMD reduces WA like RLAD reduces leaf area index (see graph above) For example, RBMD = 1.0 causes a linear decline in WA as the crop matures from DLAI to physiological maturity.

1. 1.0, decline is linear
2. <1.0, the rate of decline is initially slow, then increases until all leaves are dead at maturity.
3. >1.0, the rate of decline is initially rapid, then slows as maturity approaches.
4. Values range from 0 to 10.

Field	Variable	Description
13	ALT	Aluminum tolerance index (cols. 91-98) Index of crop tolerance to aluminum saturation. Ranges from 1 to 5 with 1=sensitive and 5=tolerant.
14	GSI	Maximum Stomatal Conductance. (cols. 99-106) 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. <i>Photosynthetica</i> 13(1): 45-82.)
15	CAF	Critical aeration factor. (cols. 107-114) 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.
16	SDW	Seed weight. (cols. 115-122) It impacts starting crop biomass. A portion of the seed weight is allocated to the initial biomass. This is also used for transplanted crops. Unit of measure is kg/ha.
17	HMX	Maximum crop height (cols. 123-130) The greatest potential height the crop will reach. in m.
18	RDMX	Maximum root depth (cols. 131-138) The greatest depth to which the rooting system will penetrate in m. This effects soil moisture extraction.
19	WAC2	CO₂ Concentration /Resulting WA value (Split Variable). (cols. 139-146) In APEX, 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 than 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 for C4 plants are 1.1 to 1.2; 1.15 is used in crop.dat for crops with the C4 photosynthetic pathway. Typical values of the ratio for C3 plants are 1.3 to 1.4; 1.35 is used in crop.dat for these types of plants. (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).

Field	Variable	Description
20	CNY	<p><i>Fraction of nitrogen in yield. (cols. 147-154)</i> Normal fraction N in yield (g g^{-1}). The amount of nitrogen removed from the plant through the harvesting of the crop. This is the fraction of nitrogen in the yield compared to the entire plant</p> <p>This was estimated from Morrison's Feeds and Feeding and other data sources of plant nutrition. The percentage N in Morrison was adjusted to a dry weight by dividing by the fraction of dry matter to total yield.</p>
21	CPY	<p><i>Fraction of phosphorus in yield. (cols. 155-162)</i> The amount of phosphorus removed from the plant through the harvesting of the crop. This is the fraction of phosphorus in the yield compared to the entire plant. Normal fraction of P in yield (g g^{-1}). Estimated by same procedure as CNY above.</p>
22	CKY	<p><i>Fraction of potassium in yield. (cols. 163-170)</i> Currently Potassium function is not enabled and therefore CKY is not considered in the model</p>
23	WSYF	<p><i>Lower limit of harvest index. (cols. 171-178)</i> 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.</p>
24	PST	<p><i>Pest (insects and disease) factor. (cols. 179-186)</i> Fraction of yield remaining after damage. Usually set at 0.60. APEX has an adjustment process that is a 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.</p>
25	CSTS	<p><i>Seed cost ($\\$ \text{kg}^{-1}$). (cols. 187-194)</i> Cost of seed is used for economic analyses only.</p>
26	PRYG	<p><i>Price for yield ($\\$ \text{t}^{-1}$). (cols. 195-202)</i> Price for grain yield is used for economic analyses only.</p>
27	PRYF	<p><i>Price for forage yield ($\\$ \text{t}^{-1}$). (cols. 203-210)</i> Price for forage yield is used for economic analyses only.</p>
28	WCY	<p><i>Fraction water in yield. (cols. 211-218)</i> The amount of water present in the yield at the time of harvest. Expressed as a fraction. The yields of most grain crops are reported at a standard grain water content; however, for some applications, grain dry weight is appropriate (WCY = 0). APEX yield output is all in dry weight (WCY = 0).</p>

Field	Variable	Description
29	BN1	<i>Nitrogen uptake parameter (N fraction in plant at emergence). (cols. 219-226)</i> 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.
30	BN2	<i>Nitrogen uptake parameter (N fraction in plant at 0.5 maturity). (cols. 227-234)</i> Normal fraction of N in crop biomass at mid-season - Same as BN1.
31	BN3	<i>Nitrogen uptake parameter (N fraction in plant at maturity). (cols. 235-242)</i> Normal fraction of N in crop biomass at maturity - Same as BN1.
32	BP1	<i>Phosphorus uptake parameter (P fraction in plant at emergence). (cols. 243-250)</i> Normal fraction of P in crop biomass at emergence - Same as BN1.
33	BP2	<i>Phosphorus uptake parameter (P fraction in plant at 0.5 maturity). (cols. 251-258)</i> Normal fraction of P in crop biomass at mid-season - Same as BN1.
34	BP3	<i>Phosphorus uptake parameter (P fraction in plant at maturity). (cols. 259-266)</i> Normal fraction of P in crop biomass at maturity - Same as BN1.
35	BK1	<i>Potassium uptake parameter (K fraction in plant at emergence) (cols. 267-274)</i> Currently Potassium function is not enabled and therefore BK1 is not considered in the model
36	BK2	<i>Potassium uptake parameter (K fraction in plant at 0.5 maturity) (cols. 275-282)</i> Currently Potassium function is not enabled and therefore BK2 is not considered in the model
37	BK3	<i>Potassium uptake parameter (K fraction in plant at maturity) (cols. 283-290)</i> Currently Potassium function is not enabled and therefore BK3 is not considered in the model
38	BW1	<i>Wind erosion factor for standing live. (cols. 291-298)</i> 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.
39	BW2	<i>Wind erosion factor for standing dead. (cols. 299-306)</i> Wind erosion factor for standing dead crop residue - Same as BW1.
40	BW3	<i>Wind erosion factor for flat residue. (cols. 307-314)</i> Wind erosion factor for flat residue - Same as BW1.

Field	Variable	Description
41	IDC	<p><i>Crop category number: (cols. 315-322)</i></p> <ol style="list-style-type: none"> 1 Warm season annual legume. 2 Cold season annual legume. 3 Perennial legume. 4 Warm season annual. 5 Cold season annual. 6 Perennial. 7 Evergreen Tree crop 8 Deciduous Tree crop 9 Cotton 10 Leguminous Tree Crop <p>NOTE: Other crop parameters (TB, TG, FRST1, FRST2) also differentiate between cold and warm climate crops.</p>
42	FRST1	<p><i>First point on frost damage curve. (cols. 323-330)</i></p> <p>The first of 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.</p> <p>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 APEX 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.</p>
43	FRST2	<p><i>Second point on frost damage curve. (cols. 331-338)</i></p> <p>Second of 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.</p> <p>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 APEX 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.</p>

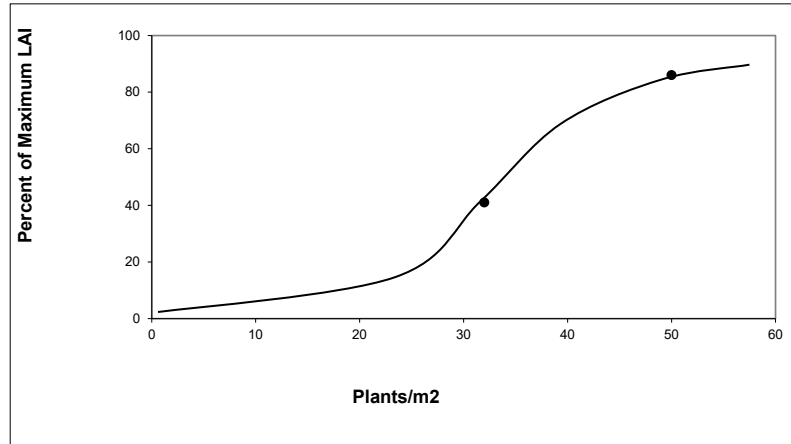
Field	Variable	Description
44	WAVP	<i>Parm relating vapor pressure deficit to WA. (cols. 339-346)</i> In APEX, radiation use efficiency (RUE) is sensitive to vapor pressure deficit (VPD). As VPD increases, RUE decreases. The crop parameter WAVP is the rate of the decline in RUE per unit increase in VPD. The value of WAVP varies among species, but a value of 6 to 8 is suggested as an approximation for most crops.
45	VPTH	<i>Threshold VPD (KPA) (cols. 347-354)</i> In APEX, leaf conductance is insensitive to VPD until VPD (calculated hourly) exceeds the threshold value, VPTH (usually 0.5 to 1.0 kPa).
46	VPD2	<i>VPD value (KPA) (cols. 355-362)</i> In APEX, 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 on the right of the decimal is the corresponding fraction of the maximum leaf conductance at the value of VPD (e.g., 0.7).
47	RWPC1	<i>Fraction of root weight at emergence. (cols. 363-370)</i> This is one of the 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.
48	RWPC2	<i>Fraction of root weight at maturity. (cols. 371-378)</i> This is one of the 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.
49	GMHU	<i>Heat Units required for Germination. (cols. 379-386)</i> This delays germination from the planting date or the date at which the temperature of soil layer 2 exceeds TG. Heat units are accumulated on an annual basis.

Field	Variable	Description
50	PPLP1	<p><i>Plant Population for Crops & Grass-1st Point on curve. (cols. 387-394)</i> First of two points on population curve. Plant Population for crops, grass etc., except trees or plants requiring more than 1 m²/plant. 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 that population. Plant population is expressed as plants per square meter.</p> <p>If the crop is 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.</p> <p>» If entering PLANTS/m² then PPLP1(SMR1)<PPLP2(SMR2) » If entering PLANTS/ha then PPLP1(SMR1)>PPLP2(SMR2)</p>
51	PPLP2	<p><i>Plant Population for Crops & Grass - 2nd Point on curve. (cols. 395-402)</i> Second of two points 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.</p> <p>If the crop is 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.</p> <p>» If entering PLANTS/m² then PPLP1(SMR1)<PPLP2(SMR2) » If entering PLANTS/ha then PPLP1(SMR1)>PPLP2(SMR2)</p> <p>For example, corn has a PPLP1 = 30.43 and PPLP2 = 50.71. This means at 30 plants per square meter 43% of maximum leaf area can be attained which is also the 1st point on the population curve. PPLP2 means at 50 plants per square meter 71% of maximum leaf area can be attained. This is the 2nd point on population curve for corn production. Since PPLP1 is less than PPLP2, it shows the population density of a crop other than trees. 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 indicates the population density is for a tree crop because here PPLP1 is greater than PPLP2.</p>

Field	Variable	Description
-------	----------	-------------

51 PPLP2
cont.

Figure 2.25: Illustration of a plant population curve.



- 52 STX1 **Salinity affect on yield (cols. 403-410)**
This is the yield decrease per increase in salinity. Currently the salinity function is not enabled so the model will not consider STX1 in the simulation. ((t/ha)/(mmho/cm))
- 53 STX2 **Salinity threshold (cols. 411-418)**
The threshold point at which any increase in salinity will cause a decrease in yield. Currently the salinity function is not enabled so the model will not consider STX2 in the simulation. (mmho/cm)
- 54 BLG1 **Lignin fraction in plant at 0.5 maturity (cols. 419-426)**
- 55 BLG2 **Lignin fraction in plant at full maturity (cols. 427-434)**
- 56 WUB **Water use conversion to biomass (t/mm) (cols. 435-442)**
The amount of biomass produced per unit of water applied (irrigation + rainfall).
- 57 FTO **Fraction turnout for cotton (cols. 443-450)**
The fraction of lint present in the total plant material (lint + seed + trash (leaf and stem particles)) harvested. This value is higher for cotton which is picked compared to stripped because less trash is collected along with the lint and seed as it is harvested. A typical value for picker cotton is 0.38 and 0.27 for stripper cotton.

$$\text{Turnout fraction} = (\text{lint weight} / (\text{seed weight} + \text{lint weight} + \text{trash weight}))$$

For DECIDUOUS TREES, FTO represents the percent of biomass lost to leaf fall. Usually set FTO to 0.05 for deciduous trees.

Field	Variable	Description
58	FLT	<i>Fraction lint for cotton (cols. 451-458)</i> The fraction of lint present in the total seedcotton (seed + lint) harvested. This variable differs from FTO in that trash is not included in the total harvested weight. Lint fraction cannot be less than turnout fraction. Lint fraction = (lint weight / (seed weight + lint weight))
59	CCEM	<i>Carbon Emissions (cols. 459-466)</i> Carbon emissions are currently not included in APEX.
60	IPDU	<i>Not used (cols. 466 – 473)</i>
61	TRE1	<i>Not used (cols. 474 – 481)</i>
62	TRE2	<i>Not used (cols. 482 – 489)</i>
63	LAYR	<i>Not used (cols. 490 – 497)</i>
64	WDRM	<i>Not used (cols. 498 – 505)</i>
65	EXTC	<i>Light extinction coefficient. (cols. 506 – 513)</i> Default used if EXTC is not set is 0.65
66	GPAL	<i>Not used (cols. 514 - 521)</i>
67	FNAME	<i>Full name of crop</i>

Figure 2.26: Sample Crop file screen.

CROP	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
# NAME	WA	HI	TOP	TBS	DMLA	DLAI	DLAP1	DLAP2	RLAD	RBM0	ALT	GSI	CAF	SDW	HMX	RDMX
1 SOYB	25.00	0.30	25.00	10.00	5.00	0.90	15.05	50.95	0.10	1.00	3.00	0.0070	0.85	35.00	0.80	2.00
2 CORN	40.00	0.50	25.00	8.00	6.00	0.80	15.05	50.95	1.00	1.00	3.00	0.0070	0.85	20.00	2.00	2.00
3 GRSQ	37.00	0.50	27.50	10.00	5.50	0.80	15.01	50.95	0.50	0.50	2.00	0.0070	0.85	5.00	1.40	2.00
4 COTS	25.00	0.60	27.50	12.50	6.00	0.95	15.01	50.95	0.50	0.50	3.00	0.0200	0.85	25.00	1.00	2.20
5 COTP	25.00	0.40	27.50	12.50	6.00	0.95	15.01	50.95	0.50	0.50	3.00	0.0200	0.85	25.00	1.00	2.20
6 PNUT	30.00	0.00	25.00	9.00	5.00	0.85	15.01	50.95	1.00	0.50	4.00	0.0100	0.85	30.00	0.50	2.00
7 SUNF	49.00	0.30	25.00	10.00	5.00	0.55	15.01	50.95	1.00	2.00	3.00	0.0070	0.85	8.00	2.50	2.20
8 CSUN	60.00	0.25	25.00	6.00	5.00	0.55	15.01	50.95	1.00	2.00	3.00	0.0070	0.85	8.00	2.50	2.20
9 FALW	30.00	0.40	125.00	10.00	0.00	0.55	15.01	50.95	1.00	1.00	3.00	0.0130	0.85	0.01	2.00	10.00
10 WWHY	35.00	0.45	15.00	0.00	6.00	0.60	15.01	50.95	1.00	1.00	2.00	0.0070	0.85	90.00	1.00	2.00
11 SWHT	35.00	0.45	20.00	5.00	6.00	0.60	15.01	50.95	1.00	1.00	2.00	0.0070	0.85	90.00	1.00	2.00
12 CSWH	35.00	0.42	15.00	0.00	5.00	0.60	15.01	45.95	1.00	1.00	2.00	0.0070	0.85	90.00	1.00	2.00
13 DWHT	30.00	0.40	15.00	0.00	5.00	0.60	15.01	50.95	1.00	1.00	2.00	0.0070	0.85	90.00	1.00	2.00
14 EARL	35.00	0.40	15.00	0.00	6.00	0.80	15.01	50.95	1.00	1.00	2.00	0.0060	0.85	90.00	1.00	2.00
15 CBAR	35.00	0.42	15.00	0.00	3.50	0.60	20.10	49.95	1.00	1.00	2.00	0.0070	0.85	90.00	1.20	2.00
16 OATS	35.00	0.42	15.00	0.00	6.00	0.80	15.01	50.95	1.00	1.00	2.00	0.0070	0.85	90.00	1.00	2.00
17 COAT	35.00	0.42	15.00	0.00	5.00	0.60	15.01	45.95	1.00	1.00	2.00	0.0070	0.85	90.00	1.20	2.00
18 RICE	25.00	.2	25.00	10.00	6.00	0.80	15.01	50.95	0.50	0.50	3.00	0.0080	1.00	50.00	0.80	2.00
19 RYE	35.00	0.40	12.50	0.00	6.00	0.80	15.01	50.95	1.00	1.00	2.00	0.0060	0.85	90.00	1.00	2.00
20 WPEA	20.00	0.55	14.00	1.00	4.00	0.90	15.02	50.95	1.00	0.50	2.00	0.0100	0.85	140.00	0.80	2.00
21 LEN1	20.00	0.55	14.00	1.00	5.00	0.90	15.02	50.95	1.00	0.50	3.00	0.0100	0.90	100.00	0.55	2.00
22 LENT	20.00	0.55	14.00	1.00	4.00	0.90	15.02	50.95	1.00	0.50	3.00	0.0100	0.90	100.00	0.55	2.00
23 CANA	34.00	0.30	21.00	5.00	4.50	0.49	15.02	45.95	0.20	0.30	3.00	0.0078	0.90	100.00	1.30	1.40
24 CANP	34.00	0.23	21.00	5.00	3.50	0.50	15.02	45.95	0.20	0.30	3.00	0.0078	0.90	100.00	0.90	0.90
25 FLAX	25.00	0.54	22.50	5.00	2.50	0.90	15.02	50.95	1.00	0.50	3.00	0.0078	0.90	100.00	0.55	2.00
26 FPEA	25.00	0.45	15.00	1.00	5.00	0.75	15.01	50.95	2.00	2.00	2.00	0.0070	0.85	95.00	1.20	2.00
27 MUNG	25.00	0.31	25.00	10.00	5.00	0.90	15.01	50.95	2.00	10.00	3.00	0.0078	0.85	35.00	1.50	2.00
28 SESB	30.00	0.31	25.00	10.00	5.00	0.90	15.01	50.95	2.00	10.00	3.00	0.0078	0.85	35.00	1.50	2.00
29 CSIL	59.00	0.50	25.00	10.00	6.00	0.80	15.05	50.95	1.00	1.00	3.00	0.0070	0.85	20.00	2.00	2.00
30 SHHY	35.00	0.50	27.50	10.00	5.00	0.80	15.01	50.95	0.50	0.50	2.00	0.0070	0.85	90.00	2.00	2.00
31 ALFA	20.00	0.02	25.00	1.00	5.00	0.90	15.01	50.95	0.50	0.50	3.00	0.0100	0.85	15.00	1.25	2.00
32 CLVA	15.00	0.02	15.00	0.00	5.00	0.60	15.01	50.95	2.00	10.00	2.00	0.0070	0.99	35.00	1.20	2.00
33 CLVR	25.00	0.02	25.00	1.00	5.00	0.75	15.01	50.95	2.00	10.00	2.00	0.0070	0.85	35.00	1.20	2.00
34 CLVS	25.00	0.02	25.00	1.00	5.00	0.75	15.01	50.95	2.00	10.00	2.00	0.0070	0.75	35.00	1.20	2.00
35 TIMO	35.00	0.02	25.00	8.00	11.00	0.85	15.01	50.95	2.00	1.00	2.00	0.0070	0.85	5.00	0.80	2.00
36 RNSE	30.00	0.02	25.00	8.00	5.00	0.99	15.01	50.95	1.00	1.00	4.00	0.0050	0.85	5.00	1.00	2.00
37 SPAS	35.00	0.02	25.00	8.00	5.00	0.99	15.01	50.95	1.00	1.00	2.00	0.0070	0.85	5.00	1.00	2.00
38 WPAS	35.00	0.02	15.00	0.00	5.00	0.70	15.05	50.95	1.00	1.00	2.00	0.0070	0.85	5.00	1.00	2.00
39 RYEA	30.00	0.02	15.00	0.00	3.00	0.80	35.01	62.95	1.00	1.00	2.00	0.0070	0.75	90.00	1.10	1.30
40 RYER	30.00	0.02	15.00	0.00	3.00	0.80	35.01	62.95	1.00	1.00	2.00	0.0070	0.75	90.00	1.10	1.30
41 RYEG	30.00	0.02	18.00	0.00	5.00	0.50	15.01	50.95	0.50	1.00	2.00	0.0070	0.85	25.00	0.80	2.00
42 WWGR	35.00	0.02	25.00	8.00	5.00	0.85	50.01	89.95	2.00	1.00	4.00	0.0070	0.85	5.00	0.60	1.30
43 MWGR	35.00	0.02	25.00	8.00	5.00	0.85	15.01	50.95	2.00	1.00	4.00	0.0070	0.85	5.00	0.80	2.00
44 SWGR	35.00	0.02	25.00	8.00	5.00	0.85	15.01	50.95	2.00	1.00	4.00	0.0070	0.85	5.00	0.70	2.00
45 CWGR	35.00	0.02	25.00	6.00	5.00	0.85	35.01	62.95	2.00	1.00	4.00	0.0070	0.85	5.00	0.70	1.30
46 BROM	35.00	0.02	25.00	6.00	5.00	0.85	15.01	50.95	2.00	1.00	4.00	0.0070	0.85	5.00	0.80	2.00
47 BROS	35.00	0.02	25.00	8.00	5.00	0.85	15.01	50.95	2.00	1.00	4.00	0.0070	0.85	5.00	0.80	2.00

17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
WAC2	CNY	CPY	CKY	WSYF	PST	COSD	PRYG	PRYF	WCY	BN1	BN2	BN3	BP1	BP2	BP3	BK1
660.34	0.0699	0.0077	0.0196	0.23	0.60	0.63	198.08	100.00	0.13	0.0524	0.0265	0.0258	0.0074	0.0037	0.0035	0.0120
660.45	.013	0.0025	0.0032	0.40	0.60	3.45	103.16	80.22	0.15	0.0440	.015	.01	0.0062	0.0023	0.0018	0.0150
660.36	0.0199	0.0032	0.0039	0.35	0.60	3.66	92.83	75.00	0.13	0.0440	0.0164	0.0128	0.0060	0.0022	0.0018	0.0270
660.30	0.0140	0.0020	0.0140	0.30	0.60	2.82	1212.75	116.87	0.01	0.0580	0.0190	0.0177	0.0081	0.0027	0.0025	0.0300
660.30	0.0190	0.0029	0.0140	0.30	0.60	2.82	1212.75	116.87	0.01	0.0580	0.0190	0.0177	0.0081	0.0027	0.0025	0.0300
660.25	0.0650	0.0090	0.0060	0.30	0.60	1.80	498.33	551.00	0.06	0.0329	0.0167	0.0162	0.0039	0.0020	0.0019	0.0300
660.66	0.0287	0.0056	0.0071	0.27	0.60	8.71	271.22	5.00	0.06	0.0500	0.0230	0.0146	0.0063	0.0029	0.0023	0.0290
660.81	0.0287	0.0056	0.0071	0.22	0.60	8.71	271.22	5.00	0.06	0.0500	0.0230	0.0146	0.0063	0.0029	0.0023	0.0290
660.35	0.0290	0.0060	0.0070	0.30	0.60	4.41	190.00	5.00	0.06	0.0500	0.0230	0.0150	0.0060	0.0030	0.0020	0.0290
660.47	0.0249	0.0033	0.0042	0.21	0.60	0.26	153.62	20.00	0.12	0.0600	0.0230	0.0134	0.0084	0.0032	0.0019	0.0230
660.41	0.0303	0.0038	0.0039	0.21	0.60	0.22	157.66	20.00	0.12	0.0663	0.0250	0.0148	0.0084	0.0032	0.0019	0.0230
660.47	0.0303	0.0038	0.0039	0.21	0.60	0.26	157.66	20.00	0.12	0.0663	0.0250	0.0148	0.0084	0.0032	0.0019	0.0230
660.41	0.0263	0.0057	0.0048	0.20	0.60	0.26	154.35	20.00	0.12	0.0518	0.0199	0.0116	0.0089	0.0034	0.0020	0.0230
660.45	0.0236	0.0029	0.0060	0.21	0.60	0.27	122.19	20.00	0.12	0.0590	0.0220	0.0131	0.0057	0.0022	0.0013	0.0160
660.47	0.0236	0.0029	0.0050	0.21	0.60	0.27	122.19	20.00	0.12	0.0590	0.0220	0.0131	0.0057	0.0022	0.0013	0.0160
660.47	0.0316	0.0057	0.0047	0.21	0.60	0.03	124.03	20.00	0.10	0.0580	0.0224	0.0130	0.0053	0.0020	0.0012	0.0280
660.47	0.0316	0.0057	0.0047	0.21	0.60	0.03	124.03	20.00	0.10	0.0580	0.0224	0.0130	0.0053	0.0020	0.0012	0.0280
660.34	0.0136	0.0013	0.0013	0.25	0.60	0.85	86.88	20.00	0.14	0.0500	0.0200	0.0100	0.0060	0.0030	0.0018	0.0250
660.47	0.0284	0.0042	0.0030	0.20	0.60	2.38	98.04	75.00	0.12	0.0560	0.0215	0.0125	0.0066	0.0025	0.0015	0.0180
660.27	0.0412	0.0055	0.0114	0.38	0.60	0.69	24.00	75.00	0.12	0.0400	0.0260	0.0232	0.0070	0.0040	0.0030	0.0140
660.27	0.0506	0.0051	0.0102	0.38	0.60	22.40	100.00	5.00	0.12	0.0440	0.0164	0.0128	0.0074	0.0037	0.0023	0.0140
660.27	0.0506	0.0051	0.0102	0.38	0.60	22.40	100.00									

TextPad - [C:\Aggie\MANUALS\APEX, WinAPEX, GIS APEX Manual\APEX 0806 Source Code\CROPCOM.DAT]

34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	ST
BK2	BK3	BW1	BW2	BW3	IDC	FRST1	FRST2	WAVP	VPTH	VPD2	RWPC1	RWPC2	GMHU	PPLP1	PPLP2	STX1	ST
0.0100	0.0090	1.266	0.633	0.729	1.	5.15	15.95	5.00	0.50	4.75	0.40	0.20	100.00	30.43	50.71	0.20	
0.0120	0.0090	0.433	0.433	0.213	4.	5.15	15.95	8.00	0.50	4.75	0.40	0.20	100.00	4.47	7.77	0.12	
0.0180	0.0130	0.657	0.657	0.320	4.	5.15	15.95	7.00	0.50	4.75	0.40	0.20	100.00	3.20	10.90	0.20	
0.0220	0.0150	1.138	0.603	0.332	9.	5.15	15.95	3.00	1.00	4.30	0.40	0.20	100.00	3.20	10.90	0.05	
0.0220	0.0150	1.138	0.603	0.332	9.	5.15	15.95	3.00	1.00	4.30	0.40	0.20	100.00	3.20	10.90	0.05	
0.0200	0.0090	1.266	0.633	0.729	1.	5.15	15.95	4.00	0.50	4.75	0.40	0.20	100.00	3.10	10.90	0.29	
0.0200	0.0100	3.390	3.390	1.610	4.	5.15	15.95	7.00	0.50	4.75	0.40	0.20	100.00	2.6	6.95	0.05	
0.0200	0.0100	3.390	3.390	1.610	4.	5.15	15.95	7.00	0.50	4.75	0.40	0.20	100.00	2.63	6.99	0.05	
0.0200	0.0100	1.138	0.603	0.332	4.	5.15	15.95	7.00	0.50	4.75	0.40	0.20	0.00	1.10	4.90	0.05	
0.0200	0.0170	3.390	3.390	1.610	5.	5.01	15.10	6.	0.50	4.75	0.40	0.20	100.00	125.60	250.95	0.07	
0.0200	0.0170	3.390	3.390	1.610	5.	5.01	15.10	10.	0.50	4.75	0.40	0.20	0.00	125.60	250.95	0.07	
0.0200	0.0170	3.390	3.390	1.610	5.	5.01	15.10	8.00	0.50	4.75	0.40	0.20	100.00	125.60	250.95	0.07	
0.0200	0.0170	3.390	3.390	1.610	5.	5.01	15.10	7.00	0.50	4.75	0.40	0.20	100.00	125.60	250.95	0.07	
0.0160	0.0150	3.390	3.390	1.610	5.	5.01	15.10	7.00	0.50	4.75	0.40	0.20	100.00	125.60	250.95	0.05	
0.0160	0.0150	3.390	3.390	1.610	5.	5.01	15.10	8.00	0.50	4.75	0.40	0.20	100.00	125.60	250.95	0.05	
0.0200	0.0120	3.390	3.390	1.610	5.	5.01	15.10	7.00	0.50	4.75	0.40	0.20	100.00	125.60	250.95	0.07	
0.0200	0.0120	3.390	3.390	1.610	5.	5.01	15.10	8.00	0.50	4.75	0.40	0.20	100.00	125.60	250.95	0.07	
0.0150	0.0080	3.390	3.390	1.610	4.	5.05	15.95	5.00	0.50	4.75	0.40	0.20	100.00	125.60	250.95	0.12	
0.0150	0.0120	3.390	3.390	1.610	5.	5.01	15.10	7.00	0.50	4.75	0.40	0.20	100.00	125.60	250.95	0.08	
0.0130	0.0120	3.390	3.390	1.610	2.	5.01	15.10	4.00	0.50	4.75	0.40	0.20	100.00	20.20	100.90	0.10	
0.0130	0.0120	1.266	0.633	0.729	1.	5.01	15.10	4.00	0.50	4.75	0.40	0.20	100.00	20.20	100.90	0.10	
0.0130	0.0120	1.266	0.633	0.729	2.	5.01	15.10	4.00	0.50	4.75	0.40	0.20	100.00	20.20	100.90	0.10	
0.0160	0.0130	1.266	0.633	0.729	1.	5.05	15.10	10.00	0.50	4.75	0.40	0.20	100.00	20.20	100.90	0.10	
0.0160	0.0130	1.266	0.633	0.729	1.	5.05	15.10	10.00	0.50	4.75	0.40	0.20	100.00	20.20	100.90	0.10	
0.0130	0.0070	1.266	0.633	0.729	2.	5.05	15.10	10.00	1.00	4.75	0.40	0.20	100.00	20.20	100.90	0.10	
0.0130	0.0120	3.390	3.390	1.610	2.	5.01	15.10	10.00	1.00	4.75	0.40	0.20	100.00	20.20	100.90	0.10	
0.0130	0.0120	1.266	0.633	0.729	1.	5.05	15.95	10.00	1.00	4.75	0.40	0.20	100.00	20.20	100.90	0.10	
0.0140	0.0130	1.266	0.633	0.729	1.	5.05	15.95	10.00	1.00	4.75	0.40	0.20	100.00	20.20	100.90	0.10	
0.0120	0.0090	1.266	0.633	0.729	4.	5.01	15.95	8.00	0.50	4.75	0.40	0.20	100.00	4.47	7.77	0.12	
0.1500	0.1500	3.390	3.390	0.320	4.	5.05	15.95	7.00	0.50	4.75	0.40	0.20	100.00	5.43	15.79	0.20	
0.0180	0.0170	3.390	3.390	3.390	3.	5.01	15.10	4.00	0.50	4.75	0.40	0.20	100.00	22.50	40.71	0.07	
0.0200	0.0180	3.390	3.390	3.390	3.	5.01	15.10	10.00	1.00	4.75	0.40	0.20	100.00	20.20	100.90	0.12	
0.0200	0.0180	3.390	3.390	3.390	2.	5.01	15.10	10.00	1.00	4.75	0.40	0.20	100.00	22.50	40.71	0.12	
0.0230	0.0180	3.390	3.390	3.390	2.	5.01	15.10	10.00	1.00	4.75	0.40	0.20	100.00	22.50	40.71	0.12	
0.0160	0.0150	3.390	3.390	3.390	6.	5.05	15.95	8.00	0.50	4.75	0.40	0.20	100.00	22.50	40.71	0.09	
0.0120	0.0090	3.390	3.390	3.390	6.	1.10	5.95	6.00	0.50	4.75	0.40	0.20	100.00	22.50	40.71	0.09	
0.0157	0.0118	3.390	3.390	3.390	6.	5.05	15.95	7.00	0.50	4.75	0.40	0.20	100.00	22.50	40.71	0.04	
0.0111	0.0083	3.390	3.390	1.610	6.	5.01	15.10	6.00	0.50	4.75	0.40	0.20	100.00	22.50	40.71	0.05	
0.0150	0.0120	3.390	3.390	1.610	6.	5.01	15.10	8.00	0.50	4.75	0.40	0.20	100.00	22.50	40.71	0.07	
0.0150	0.0120	3.390	3.390	1.610	6.	5.01	15.10	8.00	0.50	4.75	0.40	0.20	100.00	22.50	40.71	0.07	
0.0150	0.0110	3.390	3.390	1.610	5.	5.01	15.10	6.00	0.50	4.75	0.40	0.20	100.00	22.50	40.71	0.07	
0.0230	0.0230	3.390	3.390	3.390	6.	5.01	15.95	8.00	0.50	4.75	0.40	0.20	100.00	22.50	40.71	0.07	
0.0230	0.0230	3.390	3.390	3.390	6.	5.01	15.95	8.00	0.50	4.75	0.40	0.20	100.00	22.50	40.71	0.07	
0.0270	0.0270	3.390	3.390	3.390	6.	5.01	15.95	8.00	0.50	4.75	0.40	0.20	100.00	22.50	40.71	0.07	
0.0230	0.0230	3.390	3.390	3.390	6.	5.01	15.95	8.00	0.50	4.75	0.40	0.20	100.00	22.50	40.71	0.07	
0.0240	0.0270	3.390	3.390	3.390	6.	1.01	5.95	8.00	0.50	4.75	0.40	0.20	100.00	10.20	50.90	0.09	
0.0230	0.0270	3.390	3.390	3.390	6.	5.01	15.95	8.00	0.50	4.75	0.40	0.20	100.00	22.50	40.71	0.09	

TextPad - [C:\Aggie\MANUALS\APEX, WinAPEX, GIS APEX Manual\APEX 0806 Source Code\CROPCOM.DAT]

45	46	47	48	49	50	51	52	53	54	55	56	57		
RWPC1	RWPC2	GMHU	PPLP1	PPLP2	STX1	STX2	BLG1	BLG2	WUB	FTO	FLT	CCEM		
5	0.40	0.20	100.00	30.43	50.71	0.20	5.00	0.01	0.10	0.00	0.00	0.00	0.25	15.SOYBEANS
5	0.40	0.20	100.00	4.47	7.77	0.12	1.70	0.01	0.10	10.2	0.00	0.00	1.05	6.CORN
5	0.40	0.20	100.00	3.20	10.90	0.20	4.80	0.01	0.10	0.00	0.00	0.00	0.00	10.GRAIN SORGHUM
5	0.40	0.20	100.00	3.20	10.90	0.05	7.70	0.01	0.10	0.00	0.27	0.38	0.65	7.STRIPPER COTTON
5	0.40	0.20	100.00	3.20	10.90	0.05	7.70	0.01	0.10	0.00	0.38	0.38	0.65	7.PICKER COTTON
5	0.40	0.60	100.00	3.10	10.90	0.29	3.20	0.01	0.10	0.00	0.00	0.00	0.00	15.PEANUTS
5	0.40	0.20	100.00	2.6	6.95	0.05	7.70	0.01	0.10	0.00	0.00	0.00	0.3	3.SUNFLOWERS
5	0.40	0.20	100.00	2.63	6.99	0.05	7.70	0.01	0.10	0.00	0.00	0.00	0.3	3.CAN SUNFLOWERS
5	0.40	0.20	0.00	1.10	4.90	0.05	7.70	0.01	0.10	0.00	0.00	0.00	0.3	0.FALLOW
5	0.40	0.20	100.00	125.60	250.95	0.07	6.00	0.01	0.10	0.00	0.00	0.00	0.11	150.WINTER WHEAT
5	0.40	0.20	0.00	125.60	250.95	0.07	6.00	0.01	0.10	0.00	0.00	0.00	0.13	150.SPRING WHEAT
5	0.40	0.20	100.00	125.60	250.95	0.07	6.00	0.01	0.10	0.00	0.00	0.00	0.13	150.CAN SPRING WHEAT
5	0.40	0.20	100.00	125.60	250.95	0.07	6.00	0.01	0.10	0.00	0.00	0.00	0.3	150.DURAM WHEAT
5	0.40	0.20	100.00	125.60	250.95	0.05	8.00	0.01	0.10	0.00	0.00	0.00	0.11	150.BARLEY
5	0.40	0.20	100.00	125.60	250.95	0.05	8.00	0.01	0.10	0.00	0.00	0.00	0.11	150.CAN BARLEY
5	0.40	0.20	100.00	125.60	250.95	0.07	8.00	0.01	0.10	0.00	0.00	0.00	0.12	150.OATS
5	0.40	0.20	100.00	125.60	250.95	0.07	8.00	0.01	0.10	0.00	0.00	0.00	0.12	150.CAN OATS
5	0.40	0.20	100.00	125.60	250.95	0.12	3.00	0.01	0.10	0.00	0.00	0.00	0.3	150.RICE
5	0.40	0.20	100.00	125.60	250.95	0.08	5.60	0.01	0.10	0.00	0.00	0.00	0.3	150.RYE
5	0.40	0.20	100.00	20.20	100.90	0.10	2.50	0.01	0.10	0.00	0.00	0.00	0.3	70.WINTER PEAS
5	0.40	0.20	100.00	20.20	100.90	0.10	2.50	0.01	0.10	0.00	0.00	0.00	0.3	
5	0.40	0.20	100.00	20.20	100.90	0.10	2.50	0.01	0.10	0.00	0.00	0.00	0.3	
5	0.40	0.20	100.00	20.20	100.90	0.10	2.50	0.01	0.10	0.00	0.00	0.00	0.3	
5	0.40	0.20	100.00	20.20	100.90	0.10	2.50	0.01	0.10	0.00	0.00	0.00	0.3	70.LENTILS
5	0.40	0.20	100.00	20.20	100.90	0.10	2.50	0.01	0.10	0.00	0.00	0.00	0.3	70.CANOLA-ARGENTINE
5	0.40	0.20	100.00											

Table 2.8: Crop name and number included in CROP1501.DAT

Crop No.	Crop Name	Crop No.	Crop Name	Crop No.	Crop Name			
1	SOYB	Soybean	47	BROS	Smooth Brome Grass	93	VELV	Velvetleaf
2	CORN	Corn	48	CWPS	Cow Peas	94	GRFX	Green Foxtail
3	GRSG	Grain Sorghum	49	BERM	Bermuda Grass	95	CEAT	Cheat grass
4	COTS	Stripper Cotton	50	POTA	Potato	96	LBST	Little Bluestem grass
5	COTP	Picker Cotton	51	ASPR	Asparagus	97	GRMA	Gramma grass
6	PNUT	Peanut	52	BROC	Broccoli	98	BUFF	Buffalo grass
7	SUNF	Sunflower	53	CABG	Cabbage	99	SGUM	Sweet Gum tree
8	CSUN	Canadian Sunflower	54	CAUF	Cauliflower	100	CASS	Casava
9	FALW	Fallow	55	CELR	Celery	101	COWP	Cowpea
10	WWHT	Winter Wheat	56	LETT	Lettuce	102	CHKP	Chickpea
11	SWHT	Spring Wheat	57	OLET	Leaf Lettuce	103	BAHG	Bahia grass
12	CSWH	Canadian Spring Wheat	58	SPIN	Spinach	104	BUWH	Buckwheat
13	DWHT	Durum Wheat	59	CRRT	Carrot	105	PRMI	Proso Millet
14	BARL	Barley	60	ONIO	Onion	106	SEBK	Sea buckthorn
15	CBAR	Canadian Barley	61	SGBT	Sugarbeet	107	POAN	Annual Bluegrass (Poa)
16	OATS	Oats	62	GRBN	Green Beans	108	GRAP	Grapes
17	COAT	Canadian Oats	63	LIMA	Lima Beans	109	PTOM	Processing tomatoes
18	RICE	Rice	64	PEAS	Black Eyed Peas	110	BRSB	CRP West Brush
19	RYE	Rye	65	CUCM	Cucumber	111	LESP	Lespedeza grass
20	WPEA	Winter Pea	66	EGGP	Egg plant	112	ORCH	Orchard grass
21	LENW	Lentil	67	CANT	Cantaloupe	113	LOVE	Love grass
22	LENT	Lentil	68	HMEL	Honey Melon	114	ASH	Ash trees
23	CANA	Canola (Argentina)	69	WMEL	Water Melon	115	OAK	Oak trees
24	CANP	Canola (Poland)	70	PEPR	Pepper	116	SHBG	Sherman Bluegrass
25	FLAX	Flax	71	STRW	Strawberry	117	KNAF	Kenaf
26	FPEA	Field Pea	72	TOMA	Tomato	118	INDI	Indian grass
27	MUNG	Mung Bean	73	SPOT	Sweet Potato	119	COFF	Coffee
28	SESB	Sesame Bean	74	SCRN	Sweet Corn	120	MISC	Miscanthus
29	CSIL	Corn Silage	75	TOBC	Tobacco	121	PAVE	Pavement
30	SGHY	Sorghum Hay	76	SUGC	Sugar Cane	122	ORCD	Orchard
31	ALFA	Alfalfa	77	FESC	Fescue grass	123	PAST	Pasture
32	CLVA	Clover (Alsike)	78	PMIL	Pearl Millet	124	AGRL	Agricultural - General
33	CLVR	Clover (Red)	79	PINE	Pine tree	125	AGRR	Agricultural - Row crops
34	CLVS	Clover (Sweet)	80	MESQ	Mesquite tree	126	RNGB	Brush range
35	TIMO	Timothy Hay	81	APPL	Apple tree	127	FRSD	Forest - Deciduous
36	RNGE	Range Grass	82	POPL	Poplar tree	128	FRSE	Forest - Evergreen
37	SPAS	Spring Pasture	83	BLOC	Black Locust Tree	129	WETL	Wetland - General
38	WPAS	Winter Pasture	84	SWCH	Switchgrass	130	WETN	Wetland - Non Forested
39	RYEA	Annual Rye	85	DRYB	Drybeans	131	SWRN	Southwestern range
40	RYER	Perennial Rye	86	FABN	Faba beans	132	HAY	Hay
41	RYEG	Rye Grass	87	SOGR	Sideoats Grama grass	133	FRST	Forest - Mixed
42	WWGR	Western Wheat Grass	88	BBGR	Big Bluestem grass	134	WETF	Wetland - Forested
43	NWGR	Northern Wheat Grass	89	EGGR	Eastern Gama grass	135	AGRC	Agricultural - Close Grown
44	SWGR	Slender Wheat Grass	90	JHGR	Johnsongrass	136	OLIV	Olive Trees
45	CWGR	Crested Wheat Grass	91	GTFX	Giant Foxtail	137	CITR	Citrus Trees
46	BROM	Crested Brome Grass	92	COCB	Cocklebur			

2.19 THE FERTILIZER FILE (FERT****.DAT)

The fertilizer file, **FERTCOM.DAT**, includes most common fertilizers and/or other nutrient materials used in agricultural management, one row per material.

Field	Variable	Description
LINES 1-N	FORMAT:	<i>ONE (1) BLANK COLUMN FOLLOWED BY ONE (1) FIELD OF FOUR (4) COLUMNS (INTEGER) FOLLOWED BY ONE (1) BLANK COLUMN FOLLOWED BY ONE FIELD OF EIGHT (8) ALPHA CHARACTERS FOLLOWED BY TEN (10) FIELDS OF EIGHT (8) COLUMNS INCLUDING UP TO THREE (3) DECIMAL PLACES (FLOATING)</i>
1	I	<i>Fertilizer ID number (cols. 2-5)</i>
2	FTNM	<i>Fertilizer name. (cols. 7-14)</i> A descriptive name that usually includes the N-P-K analysis or the type of manure.
3	FN	<i>Mineral N fraction. (cols. 15-22)</i> Fraction of mineral nitrogen in the bulk fertilizer. (See example)
4	FP	<i>Mineral P fraction (cols. 23-30)</i> Fraction of mineral phosphorus in the bulk fertilizer. This is the fraction of elemental phosphorus, not P ₂ O ₅ . To convert fraction of P ₂ O ₅ to elemental phosphorus, multiply by 0.4366. (See example)
5	FK	<i>Mineral K fraction (cols. 31-38)</i> Fraction of mineral potassium in the bulk fertilizer. This is the fraction of elemental potassium, not K ₂ O. To convert fraction of K ₂ O to elemental potassium, multiply by 0.8301. (See example)
6	FNO	<i>Organic N fraction (cols. 39-46)</i> This applies to organic fertilizers such as manures. This number must be obtained from an analysis test of the product. The amount is reported as a fraction. (See example)
7	FPO	<i>Organic P fraction (cols. 47-54)</i> This applies to organic fertilizers such as manures. This number must be obtained from an analysis test of the product. The amount is reported as a fraction. (See example)
8	FNH3	<i>Ammonium N fraction (cols. 55-62)</i> The fraction of mineral nitrogen in the fertilizer that is in the ammonium (NH ₄) form. (See example)

Field	Variable	Description
9	FOC	Organic C fraction (cols. 63-70) Organic carbon = organic matter / 1.72
10	FSLT	Salt fraction (cols. 71-78) Amount of salt in fertilizer
11	FCST	Cost of Fertilizer (\$/kg) (cols. 79-86) Used for economic analyses only.

Commercial Fertilizer Example 1

If a producer applies a commercially blended fertilizer with an analysis of 20-15-10 the parameters would be set as follows:

FN: 0.20

FP: 0.065

FK: 0.083

FNO: 0.00

FPO: 0.00

FNH3: 0.00

Commercial Fertilizer Example 2

If a producer applies Ammonium nitrate (50% of N is in nitrate form and 50% is in ammonium form) with an analysis of 34-0-0 the parameters would be set as follows:

FN: 0.34

FP: 0.00

FK: 0.00

FNO: 0.00

FPO: 0.00

FNH3: 0.50

Manure Fertilizer Example

A producer applies 1200 pounds of bulk manure that includes 24 pounds of nitrogen which is broken into 6 pounds of mineral nitrogen and 18 pounds of organic nitrogen. The mineral nitrogen includes 5 pounds of ammonia-N and 1 pound of nitrate-N. The bulk manure also includes 30 pounds of potassium and 20 pounds of phosphorus of which 8 pounds is organic phosphorus.

Summary of components

1200 lbs bulk manure fertilizer

-24 lbs nitrogen

-6 lbs mineral nitrogen

-5 lbs ammonia-N

-1 lb nitrate-N

-18 lbs organic nitrogen

- 20 lbs P

-8 lbs organic P

-12 lbs mineral P

- 30 lbs K

The parameters would be set as follows:

FN: 0.005 (6 lbs mineral N/1200 lbs total fertilizer)

FP: 0.01 (12 lbs P/1200 lbs total fertilizer)

FK: 0.025 (30 lbs K/1200 lbs total fertilizer)

FNO: 0.015 (18 lbs organic N/1200 lbs total fertilizer)

FPO: 0.007 (8 lbs P/1200 lbs total fertilizer)

FNH3: 0.83 (5 lbs ammonia-N/6 lbs mineral-N)

Figure 2.27: Sample Fertilizer file screen.

The screenshot shows a TextPad window titled "TextPad - [C:\WinAPEX\APEXPROG\fert.dat]". The window contains a list of fertilizer types and their corresponding nutrient values. The data is organized into columns, with the first column listing fertilizer types and the subsequent columns listing numerical values for various nutrients. The list includes items like "B-FRESH", "B-FDLT-S", "B-FDLT-P", etc., up to "Elem-N".

Fertilizer Type	Col 2	Col 3	Col 4	Col 5	Col 6	Col 7	Col 8	Col 9	Col 10
1 B-FRESH	0.0140	0.0080	0.0000	0.0260	0.0040	0.9900	0.3000	0.0013	0.0122
2 B-FDLT-S	0.0010	0.0030	0.0000	0.0090	0.0020	0.5000	0.3000	0.0094	0.0122
3 B-FDLT-P	0.0300	0.0040	0.0000	0.0200	0.0020	0.9900	0.3000	0.0013	0.0085
4 B-FDLT-C	0.0020	0.0040	0.0000	0.0130	0.0020	0.9900	0.3000	0.0013	0.0122
5 D-FRESH	0.0120	0.0040	0.0000	0.0210	0.0020	0.9900	0.3000	0.0013	0.0122
6 D-1-LAGH	0.6800	0.1700	0.0000	0.0700	0.0800	0.9000	0.3000	0.0013	0.0122
7 D-1-LAGE	0.7000	0.1500	0.0000	0.0800	0.0700	0.9000	0.3000	0.0013	0.0122
8 D-SO-LGN	0.0490	0.0818	0.0000	0.6480	0.2210	0.9720	0.3000	0.0013	0.0122
9 D-LQ-LGN	0.5660	0.0896	0.0000	0.1020	0.2420	0.9870	0.3000	0.0000	0.0122
10 goat-fsh	0.0190	0.0100	0.0000	0.0380	0.0050	0.9900	0.3000	0.0000	0.0122
11 hog-frsh	0.0210	0.0160	0.0000	0.0400	0.0070	0.9900	0.3000	0.0000	0.0122
12 horse-fs	0.0130	0.0060	0.0000	0.0230	0.0030	0.9900	0.3000	0.0000	0.0122
13 P-DPIT-B	0.0100	0.0100	0.0000	0.0100	0.0070	0.9900	0.3000	0.0000	0.0000
14 P-DPIT-L	0.0100	0.0100	0.0000	0.0100	0.0070	0.9900	0.3000	0.0000	0.0122
15 P-FRSH-B	0.0060	0.0100	0.0000	0.0540	0.0070	0.9900	0.3000	0.0000	0.0122
16 P-FRSH-D	0.0030	0.0050	0.0000	0.0270	0.0020	0.9900	0.3000	0.0000	0.0122
17 P-FRSH-G	0.0030	0.0100	0.0000	0.0270	0.0060	0.9900	0.3000	0.0000	0.0122
18 P-FRSH-L	0.0050	0.0100	0.0000	0.0450	0.0070	0.9900	0.3000	0.0000	0.0122
19 P-FRSH-P	0.0030	0.0100	0.0000	0.0270	0.0050	0.9900	0.3000	0.0000	0.0122
20 P-FRSH-T	0.0060	0.0100	0.0000	0.0540	0.0070	0.9900	0.3000	0.0000	0.0122
21 P-LIQ-B	0.0040	0.0100	0.0000	0.0400	0.0070	0.9900	0.3000	0.0000	0.0122
22 P-LIQ-L	0.0040	0.0100	0.0000	0.0400	0.0070	0.9900	0.3000	0.0000	0.0122
23 P-MPIT-B	0.0200	0.0100	0.0000	0.0200	0.0070	0.9900	0.3000	0.0000	0.0122
24 P-MPIT-L	0.0200	0.0100	0.0000	0.0200	0.0070	0.9900	0.3000	0.0000	0.0122
25 sheep-fs	0.0180	0.0070	0.0000	0.0350	0.0030	0.9900	0.3000	0.0000	0.0122
26 veal-fsh	0.0140	0.0080	0.0000	0.0260	0.0040	0.9900	0.3000	0.0013	0.0122
27 10-20-10	0.1000	0.0873	0.0830	0.0000	0.0000	0.0000	0.0000	0.0000	0.2229
28 10-21-00	0.1000	0.0916	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2041
29 10-34-00	0.1000	0.1500	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2912
30 11-46-00	0.1100	0.2007	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.3248
31 14-46-00	0.1400	0.2007	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2977
32 16-00-00	0.1600	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2610
33 16-20-00	0.1600	0.0880	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2755
34 16-20-00	0.1600	0.0880	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2755
35 18-18-00	0.1800	0.0786	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1768
36 18-46-00	0.1800	0.2000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2733
37 19-00-00	0.1900	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0982
38 20-00-00	0.2000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.3001
39 20-00-00	0.2000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2047
40 20-00-00	0.2000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1580
41 20-10-10	0.2000	0.0436	0.0830	0.0000	0.0000	0.0000	0.0000	0.0000	0.2225
42 21-00-00	0.2100	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2537
43 22-00-00	0.2200	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1545
44 23-00-00	0.2300	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1725
45 26-00-00	0.2600	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1537
46 28-00-00	0.2800	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.3623
47 28-00-00	0.2800	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1661
48 28-00-00	0.2800	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1505
49 28-10-10	0.2800	0.1000	0.0830	0.0000	0.0000	0.0000	0.0000	0.0000	0.2689
50 28-14-00	0.2800	0.0611	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2602
51 30-00-00	0.3000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2395
52 Elem-N	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2365

2.20 THE PESTICIDE FILE (PEST****.DAT)

The pesticide file, PESTCOM.DAT, includes most common pesticides in agricultural management.

Field	Variable	Description
LINES 1-N	FORMAT:	ONE(1) FIELD OF FIVE (5) COLUMNS (INTEGER) FOLLOWED BY ONE (1) BLANK COLUMN FOLLOWED BY ONE FIELD OF SIXTEEN (16) ALPHA CHARACTERS FOLLOWED BY SIX (6) FIELDS OF SIXTEEN (16) COLUMNS (EXPONENTIAL) INCLUDING UP TO SIX (6) DECIMAL PLACES (FLOATING)
1	J1	Pesticide ID number (cols. 1-5)
2	PSTN	Pesticide name. (cols. 7-22) Common or brand name of the pesticide.
3	PSOL	Pesticide solubility in ppm. (cols. 23-34) The amount of the pesticide product which can dissolve in water. (ppm)
4	PHLS	Pesticide half life in soil in days. (cols. 35-42) The time that it takes for the pesticide product concentration in the soil to be reduced by half. (days)
5	PHLF	Pesticide half life on foliage in days. (cols. 43-50) The time that it takes for the pesticide product concentration on the foliage to be reduced by half. Degradation occurs through microbial activity and/or sunlight. (days)
6	PWOF	Pesticide wash off fraction. (cols. 51-58) Percentage of the pesticide product that is applied to foliage that is washed off into the soil. (%)
7	PKOC	Pesticide organic C absorption coefficient. (cols. 59-68) Amount of pesticide products attached to the soil divided by the amount of the pesticide product in solution, normalized by organic carbon % in the soil. Refer to Environmental Contaminant Toxicological Reviews 123:1-164.
8	PCST	Pesticide cost in \$/KG. (cols. 69-76) Used for economic analyses only.

Figure 2.28: Sample Pesticide file screen.

Pesticide Name	Col 1	Col 2	Col 3	Col 4	Col 5	Col 6	Col 7	Col 8
1 2, 4-D 4L	0.231800E+05	0.550000E+01	0.900000E+01	0.450000E+00	0.480000E+02	0.686000E+01		
2 2, 4, 5-T Acid	0.150000E+03	0.300000E+02	0.900000E+01	0.450000E+00	0.800000E+02	0.150000E+02		
3 AATREX 4L	0.330000E+02	0.146000E+03	0.500000E+01	0.450000E+00	0.147000E+03	0.700000E+01		
4 Abate	0.000000E+00	0.300000E+02	0.500000E+01	0.650000E+00	0.107000E+04	0.120000E+02		
5 Acaraben	0.130000E+02	0.200000E+02	0.100000E+02	0.500000E-01	0.281000E+04	0.370000E+02		
6 Accelerate	0.100000E+06	0.280000E+01	0.700000E+01	0.900000E+00	0.850000E+02	0.800000E+02		
7 ACCLAIM	0.100000E+01	0.100000E+01	0.500000E+01	0.200000E+00	0.949000E+04	0.671000E+03		
8 ACTELIC	0.900000E+01	0.240000E+02	0.990000E+02	0.900000E+00	0.234020E+05	0.135000E+03		
9 Alanap-L	0.231000E+06	0.245800E+03	0.700000E+01	0.950000E+00	0.221200E+04	0.700000E+01		
10 Alar	0.100000E+06	0.700000E+00	0.400000E+01	0.950000E+00	0.900000E+01	0.800000E+01		
11 Aldrin	0.000000E+00	0.365000E+03	0.200000E+01	0.500000E-01	0.175000E+05	0.490000E+02		
12 Aliette WDG	0.120000E+06	0.100000E+00	0.100000E+00	0.950000E+00	0.166000E+03	0.699000E+01		
13 Ally	0.279000E+04	0.280000E+02	0.250000E+02	0.800000E+00	0.420000E+02	0.558700E+02		
14 AMDRO	0.000000E+00	0.180000E+02	0.990000E+02	0.900000E+00	0.730000E+06	0.270000E+02		
15 AMIBEN 10G	0.700000E+03	0.140000E+02	0.700000E+01	0.950000E+00	0.210000E+02	0.280000E+02		
16 AMID-THIN	0.100000E+03	0.100000E+02	0.500000E+01	0.600000E+00	0.100000E+03	0.343610E+03		
17 AMITROL-T	0.360000E+06	0.100000E+01	0.500000E+01	0.950000E+00	0.930000E+02	0.270000E+02		
18 Ammo	0.000000E+00	0.360000E+02	0.500000E+01	0.400000E+00	0.610000E+05	0.259540E+03		
19 Antor	0.105000E+03	0.900000E+01	0.100000E+02	0.400000E+00	0.100000E+03	0.200000E+02		
20 A-Rest	0.440000E+03	0.150000E+02	0.300000E+02	0.500000E+00	0.830000E+02	0.101000E+04		
21 ARSENAL 2EC	0.500000E+06	0.900000E+02	0.300000E+02	0.800000E+00	0.100000E+03	0.392690E+03		
22 Arsonate	0.140000E+07	0.180000E+03	0.100000E+02	0.100000E+01	0.700000E+04	0.300000E+01		
23 ASANA XL	0.000000E+00	0.108000E+03	0.800000E+01	0.400000E+00	0.527300E+04	0.782400E+02		
24 ASSET 2.5 Gal	0.857000E+03	0.450000E+02	0.180000E+02	0.650000E+00	0.350000E+02	0.500000E+02		
25 ASSET Gal	0.857000E+03	0.450000E+02	0.180000E+02	0.650000E+00	0.350000E+02	0.480000E+02		
26 ASSURE	0.000000E+00	0.600000E+02	0.150000E+02	0.200000E+00	0.540000E+03	0.398530E+03		
27 Asulox	0.550000E+06	0.100000E+02	0.300000E+01	0.950000E+00	0.138000E+03	0.270000E+02		
28 AVENGE	0.817000E+06	0.870000E+02	0.300000E+01	0.950000E+00	0.550000E+05	0.430000E+02		
29 Azodrin	0.100000E+07	0.300000E+02	0.200000E+01	0.950000E+00	0.100000E+01	0.290000E+02		
30 BALAN EC	0.000000E+00	0.510000E+02	0.100000E+02	0.200000E+00	0.824000E+04	0.570000E+02		
31 BANOL	0.100000E+07	0.120000E+02	0.150000E+02	0.950000E+00	0.309000E+03	0.960000E+02		
32 BANVEL	0.360000E+06	0.180000E+02	0.900000E+01	0.650000E+00	0.130000E+02	0.599200E+02		
33 BASAGRAN	0.230000E+07	0.270000E+02	0.200000E+01	0.600000E+00	0.350000E+02	0.528000E+02		
34 Basta	0.137000E+07	0.700000E+01	0.400000E+01	0.950000E+00	0.430000E+03	0.165000E+03		
35 BAYGON EC	0.180000E+04	0.145000E+03	0.990000E+02	0.900000E+00	0.290000E+02	0.106000E+03		
36 BAYLETON 1%	0.720000E+02	0.600000E+01	0.800000E+01	0.300000E+00	0.319000E+03	0.629000E+02		
37 Baytex	0.400000E+01	0.340000E+02	0.200000E+01	0.650000E+00	0.139000E+04	0.244000E+03		
38 BAYTHROID II	0.200000E+03	0.600000E+02	0.500000E+01	0.400000E+00	0.310000E+05	0.200000E+01		
39 BENTAZONE 50WD 2#	0.300000E+01	0.670000E+02	0.600000E+01	0.200000E+00	0.191000E+04	0.138800E+02		

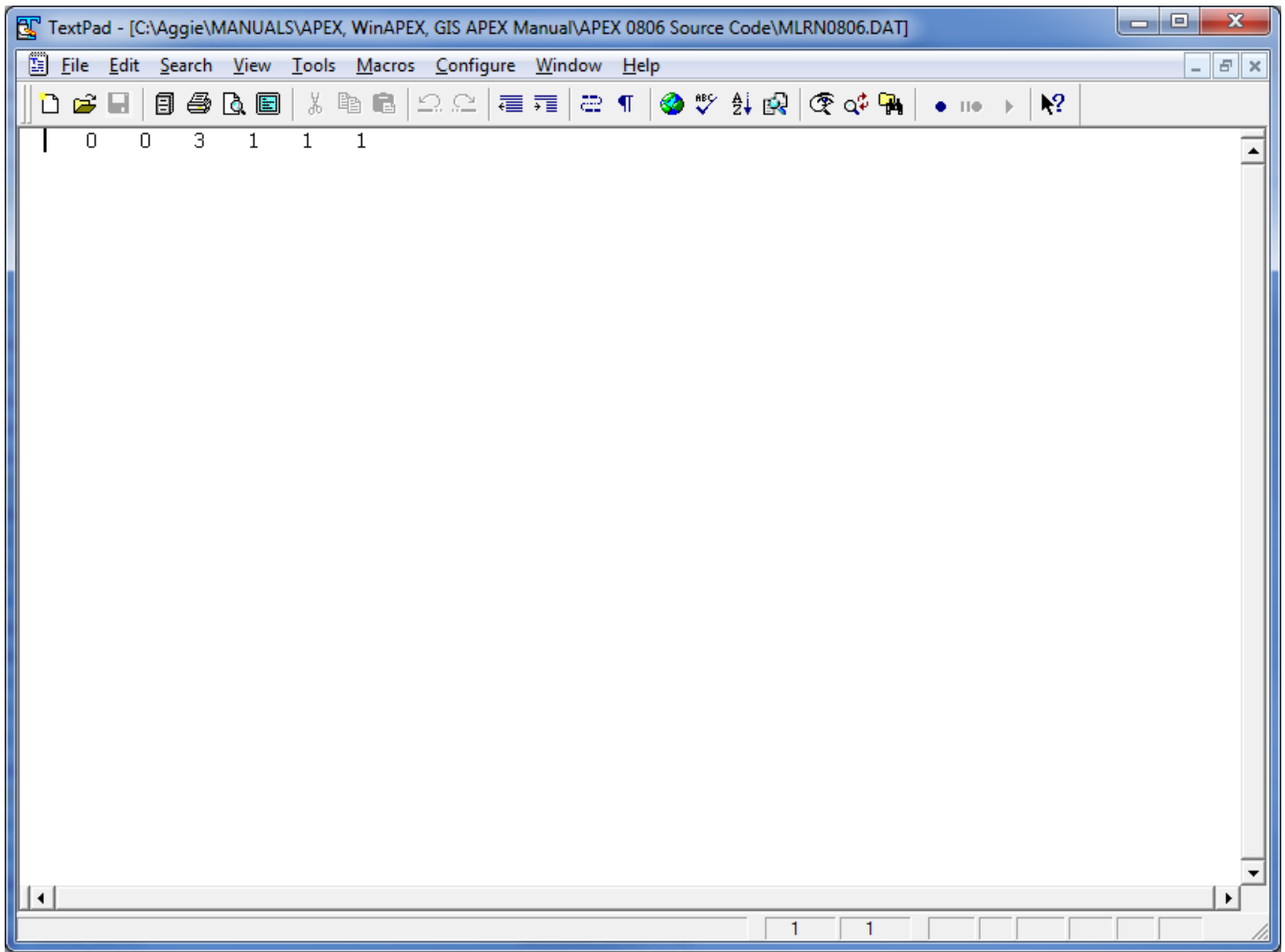
2.21 THE APEX MULTI-RUN FILE (MLRN****.DAT)

An APEX 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 APEX. The simulation continues until a zero NBYR is encountered.

FORMAT: UP TO TWENTY (20) FIELDS OF FOUR (4) COLUMNS PER FIELD (INTEGER)

Field	Variable	Description
1	NX (1)	<i>Number of years for second through the last simulation (cols. 1-4)</i>
2	NX (2)	<i>Normal/Static Soil Erosion (cols. 5-8)</i> 0 Normal erosion of soil profile 1 Static soil profile erosion control practice factor
3	NX(3)	<i>Type of Output (cols. 9-12)</i> 0 Annual watershed output 1 Annual output 2 Annual with soil table 3 Monthly 4 Monthly with soil table 5 Monthly with soil table at harvest 6 N days interval 7 Soil table only n day interval 8 Soil table only during growing season N day interval 9 N day interval during growing season
4	NX(4)	<i>ID number for weather input variables. (cols. 13-16)</i> 1 Precipitation 2 Temperatures 3 Radiation 4 Wind Speed 5 Relative Humidity If any variables are input, precipitation must be included. Therefore, it is not necessary to specify N2 = 1 unless precipitation is the only input variable.
5	NX(5)	<i>Turns on .SAO file (cols. 17-20)</i> .SAO is the subarea output file
6	NX(6)	<i>Turns on .RCH file (cols. 21-24)</i> .RCH is the Reach Watershed output file
7	NX(7)	<i>Turns on .SW1 files (cols. 25-28)</i>

Figure 2.29: Sample Multi-run file screen.



2.22 THE APEX PARM FILE (PARM****.DAT)

The **PARMCOM.DAT** file is a very sensitive part in APEX, because many coefficients of equations are maintained in this file. The equation coefficients **should not** be changed without consulting the model designer first.

This file contains definitions of s-curve and miscellaneous parameters used in APEX1501.

S-CURVE PARAMETERS

An S-shaped curve is used to describe the behavior of many processes in APEX. 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 APEX (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 SCRIP. To illustrate the procedure, consider the two SCRIP values in the first line of the PARM1501.DAT file (90.05,99.95). SCRIP (1,1)=90.05, SCRIP (1,2)=99.95. When split we have x1=90, y1=0.05, x2=99, and y2=0.95. APEX 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 APEX determined parameters.

S-CURVE PARAMETER DEFINITIONS

LINES 1-30 CONSIST OF TWO FIELDS (COLS. 1-8 AND COLS. 9-16) WITH ONE S-CURVE PAIR PER LINE.

FORMAT: TWO (2) FIELDS OF EIGHT (8) COLUMNS PER FIELD INCLUDING UP TO THREE (3) DECIMAL PLACES (FLOATING)

SCRIP1(1)	SCRIP2(1)	Root growth restriction by rock or coarse soil fragments , The number to the left of the decimal is the % coarse fragments, and the number to the right of the decimal is the fraction of root growth restriction. X = % coarse fragment
SCRIP1(2)	SCRIP2(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. X = soil depth (mm)
SCRIP1(3)	SCRIP2(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). X = % of growing season

SCR1(4)	SCR2(4)	<p>Runoff curve number. This is an exception to normal s-curve procedures. 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 SCR(25,n) to match CN2 and CN3 (average and wet condition runoff curve numbers)</p> <p><i>THIS IS ALWAYS LEFT AT 0.0, 0.0. SCR (4) IS CALCULATED BASED ON SCR (25).</i></p>
SCR1(5)	SCR2(5)	<p>Soil Cover Factor. Estimates soil cover factor used in simulating soil temperature. The number to the left of the decimal is the total above ground plant material dead and alive (T/ha) and the number to the right is the soil cover factor (fraction).</p> <p>X = total above ground plant material (dead and live).</p>
SCR1(6)	SCR2(6)	<p>Soil settling rainfall. The # to the left of decimal is rainfall-runoff adjusted for soil texture and depth (mm), and the number to the right of the decimal is soil settling fraction caused by rainfall.</p> <p>X = rainfall (mm) adjusted for soil texture and depth.</p>
SCR1(7)	SCR2(7)	<p>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.</p> <p>X = soil water-critical aeration factor</p>
SCR1(8)	SCR2(8)	<p>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.</p> <p>X = % of optimal N or P content present in plant.</p>
SCR1(9)	SCR2(9)	<p>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 fraction 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. One of several parameters used to regulate pest growth. See also parm 9 and 10, PSTX in the control file, and PST in the crop file.</p> <p>X = sum of daily minimum temperature with rainfall adjustment.</p>
SCR1(10)	SCR2(10)	<p>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.</p> <p>X = plant water use during critical period.</p>
SCR1(11)	SCR2(11)	<p>P plant use – Soil P concentration. The # to the left of the decimal is the soil labile P concentration (PPM) and the number to the right is the P available in (kg/ha). Governs P use by plants as a function of soil P concentration.</p> <p>X = soil labile P concentration.</p>
SCR1(12)	SCR2(12)	<p>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.</p> <p>X = depth at the center of a soil layer (mm).</p>

SCR1(13)	SCR2(13)	Calculates wind erosion vegetative cover factor as a function of above ground plant material. $X = \text{vegetative equivalent} (C1 \cdot \text{BIOM} + C2 \cdot \text{STD} + C3 \cdot \text{RSD})$. 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).
SCR1(14)	SCR2(14)	Calculates soil temperature factor used in regulating microbial processes . $X = \text{soil temperature}(C)$. The # to the left of the decimal is soil temperature and the number to the right is factor (fraction). $X = \text{soil temperature} (C)$
SCR1(15)	SCR2(15)	Plant population in water erosion C-factor . The # to the left is plant population in plants per m ² or plants per ha for trees and the number to the right is the water erosion cover factor (fraction) or the fraction of erosion control. Estimates plant population effect on USLE C-factor. $X = \text{plant population} (\text{plt}/\text{m}^2)$
SCR1(16)	SCR2(16)	Snowmelt function . Increases snow melt as a function of time since the last snowfall. The number to the left of the decimal is the time (days) since the last snowfall, and the number to the right of the decimal is the rate of melt as a function of time. $X = \text{time since the last snowfall} (\text{days})$.
SCR1(17)	SCR2(17)	Component of the plant water stress factor based on soil water content. The number to the left of the decimal is the ratio of root zone soil water content to plant available water storage volume, and the number to the right of the decimal is the fraction of plant stress due to water stress. If Parm 38 = 1 then plant water stress is strictly a function of ET. $X = \text{ratio of root zone soil water content to plant available water storage volume}$.
SCR1(18)	SCR2(18)	Adjusts CN2 as a function of upland slope steepness . The number to the left of the decimal is the upland slope (%), and the number to the right of the decimal is the fraction that the curve number is adjusted. $X = \text{upland slope} (\%)$.
SCR1(19)	SCR2(19)	Regulates feedlot dust emission based on moisture content of litter. The number to the left of the decimal is the water in liter/weight of litter, and the number to the right of the decimal is the fraction of dust emission control $X = \text{water in litter/weight of litter}$.
SCR1(20)	SCR2(20)	Simulates oxygen content of soil as a function of depth. Used in microbial processes of residue decay. The number to the left of the decimal is the depth to center of each soil layer (m) and the number to the right of the decimal is the adjustment to the oxygen content. This parameter works in conjunction with Parm 53. $(1 - \text{Parm } 53) \times \text{SCR20}$ $X = \text{depth to center of each soil layer} (\text{m})$.
SCR1(21)	SCR2(21)	Distance factor in spatial rainfall generator . The number to the left of the decimal is the distance from storm center to subarea centroid (km) and the number to the right of the decimal is the fraction of rainfall received at the storm center given distance X. $X = \text{distance from storm center to subarea centroid} (\text{km})$.
SCR1(22)	SCR2(22)	Plant Water Stress – Soil Water Tension . Governs plant water stress as a function of soil water tension. $X = \text{gravimetric} + \text{osmotic tension}$.

SCR1(23)	SCR2(23)	Estimates plant ground cover as a function of leaf area . The number to the left of the decimal is the leaf area, and the number to the right of the decimal is the fraction of ground cover. X = total LAI of all growing plants.
SCR1(24)	SCR2(24)	Estimates plant ground cover as a function of standing live biomass . The number to the left of the decimal is the standing live biomass (t/ha), and the number to the right of the decimal is the fraction of ground cover. X = standing live biomass (t/ha).
SCR1(25)	SCR2(25)	Simulates O₂ content of the soil as a function of Carbon and Clay content . This S-curve number is used in microbial processes of residue decay. X = F(Carbon/Clay)
SCR1(26)	SCR2(26)	Simulates within-storm rainfall distribution X = time (hour) at user specified time interval
SCR1(27)	SCR2(27)	Increases biological mixing in soil layer 1 as residue increases . X = soil layer 1 residue in t/ha
SCR1(28)	SCR2(28)	Estimates PARM(92) as a function of slope when Parm(92) = 0 . The calculation of Parm 92 will range between 1.0 and 1.7 inversely with slope. The number to the left of the decimal is the slope, and the number to the right of the decimal is the setting for Parm 92 calculated as (2-Y) where Y is the number to the right of the decimal. SCR1 (28) scales the setting of Parm 92 based on slope.
SCR1(29)	SCR2(29)	Phosphorus leaching as a function of soil clay content Increases KD as a function of clay X = soil layer clay content
SCR1(30)	SCR2(30)	Exception to normal S-Curve procedure – sets soil water contents coinciding with CN2 and CN3. X1 = soil water content as % of field capacity – wilting point X2 = soil water content as % of saturation – field capacity. THIS PARAMETER DOES NOT FOLLOW THE SAME X,Y FORMAT AS THE OTHER PARAMETERS. IN THIS CASE Y IS ALWAYS 0. EXAMPLE: X1 = 45.00; this indicates that CN2 is 45% of the volume between field capacity and wilting point → (0.45*(FC-WP) + WP). X2 = 10.00; this indicates that CN3 is 10% of the volume between saturation and field capacity → (0.10*(SAT-FC) + FC).

PARM DEFINITIONS

LINES 31-39 *FORMAT: TEN (10) FIELDS OF EIGHT (8) COLUMNS PER FIELD INCLUDING UP TO TWO (2) DECIMAL PLACES (FLOATING)*

Field	PARM(n)	Definition, units and/or range.
LINE 31		
1	1	Crop canopy-PET (Range is from 1 - 2) factor used to adjust crop canopy resistance in the Penman-Monteith PET equation. (cols. 1-8) Default setting: 1.5
2	2	Root growth-soil strength (Range is from 1 - 2). Normally $1.15 < \text{parm}(2) < 1.2$. Set to 1.5 to minimize soil strength constraint on root growth. Setting $\text{Parm}(2) > 2$ eliminates all root growth stress. (cols. 9-16) Default setting: 2.0
3	3	Water stress-harvest index (Range is from 0 - 1) sets fraction of growing season when water stress starts reducing harvest index. (cols. 17-24) Default setting: 0.75
4	4	Water storage N leaching (Range is from 0 - 1) fraction of soil porosity that interacts with percolating water as nitrogen leaching occurs. (cols. 25-32) Default setting: 0.5
5	5	Soil water lower limit (Range is from 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. (cols. 33-40) Default setting: 0.5
6	6	Winter dormancy (h) (Range is from 0 - 1) causes dormancy in winter grown crops. Growth does not occur when day length is less than annual minimum day length + $\text{parm}(6)$. If the temperature goes below the base temperature of the crop as set in the crop file (crop.dat), the crop goes dormant. Using Parm 6 the crop will go dormant when the day length becomes less than (day length + Parm 6) (cols. 41-48) Default setting: 0.1
7	7	N fixation (Range is from 0 - 1) at 1, fixation is limited by soil water or nitrate content or by crop growth stage. At 0 fixation meets crop nitrogen uptake demand. A combination of the two previously described scenarios is obtained by setting $0 < \text{parm}(7) < 1$. (cols. 49-56) Default setting: 0.99
8	8	Soluble phosphorus runoff coefficient. ($0.1\text{m}^3/\text{t}$), (Range is from 10 - 20). P concentration in sediment divided by that of the water. (cols. 57-64) Default setting: 15.0
9	9	Pest damage moisture threshold , (mm), (Range is from 25 - 150), previous 30-day rainfall minus runoff. One of several parameters used to regulate pest growth. See also parm 10, PSTX in the control file, PST in the crop file and SCRIP (9). (cols. 65-72) Default setting: 25.0
10	10	Pest damage cover threshold , (t/ha), (Range is from 0 - 50), crop residue + above ground biomass. This is the amount of cover required for pests to begin to grow. Setting parm 10 at a large number (50) will result in little or no pest growth because it will be impossible to reach such high levels of cover. One of several parameters used to regulate pest growth. See also parm 9, PSTX in the control file, PST in the crop file and SCRIP (9). (cols. 73-80) Default setting: 1.0

LINE 32		
Field	PARM(n)	Definition, units and/or range.
1	11	Moisture required for seed germination , (fraction), (Range is from 0-1). The amount of moisture in the plow depth layer (set in Parm 43) regulates germination. Parm 11 refers to the fraction of available water in the plow depth that is required for germination. If PDSW/PDAW>Parm 11, germination will occur. PDSW is the soil water content present in the plow depth layer. PDAW is the plant available water (soil water at field capacity – soil water at wilting point) in the plow depth layer. Typical values range from 0.3 to 0.9 for this Parm. Setting the parm value <=0 essentially turns this Parm off and germination will occur regardless of moisture content in the soil. (cols. 1-8) Default setting: -100 (turned off)
2	12	Soil evaporation coefficient , (Range is from 1.5 - 2.5), governs rate of soil evaporation from top 0.2 m of soil. A small value increases soil evaporation. (cols. 9-16) Default setting: 2.5
3	13	Wind erodibility coefficient , (Range is from 0 - 3), adjusts wind soil erodibility factor downward as loose material is eroded. (cols. 17-24) Default setting: 2.0
4	14	Nitrate leaching ratio , (Range is from 0.1 - 1), Ratio of nitrate concentration in surface runoff to nitrate concentration in percolate. A small value reduces nitrate concentration in runoff. (cols. 25-32) Default setting: 1.0
5	15	Runoff CN Residue Adjustment Parameter (Range is from 0.0 - 0.3). Increases runoff for RSD < 1.0 t/ha; Decreases for RSD > 1.0 t/ha. (cols. 33-40) Default setting: 0.0
6	16	Expands CN retention parameter (Range is from 1.0 - 1.5). Values > 1.0 expand CN retention and reduce runoff. (cols. 41-48) Default setting: 1.0
7	17	Soil evaporation – plant cover factor (Range is from 0.00 - 0.5). Reduces effect of plant cover as related to LAI in regulating soil evaporation. (cols. 49-56) Default setting: 0.25
8	18	Sediment routing exponent (Range is from 1.0 – 2.0) exponent of water velocity function for estimating potential sediment concentration. (cols. 57-64) Default setting: 1.5
9	19	Sediment routing coefficient , (t/m ³)(Range is from 0.0001 - 0.05) potential sediment concentration when flow velocity = 1. (m/s). (cols. 65-72) Default setting: 0.005
10	20	Runoff curve number initial abstraction (Range is from 0.05 - 0.4) (cols. 73-80) Default setting: 0.2
LINE 33		
1	21	Soluble Carbon adsorption Coefficient (0.1m ³ /t) (Range is from 10 - 20). Carbon concentration in sediment divided by that in water. (cols. 1-8) Default setting: 10.0
2	22	Reduces NRCS Runoff CN Retention Parameter for Frozen Soil. (Range is from 0.05 – 0.5) Fraction of S (Retention Parameter) Frozen Soil (cols. 9-16) Default setting: 0.05
3	23	Hargreaves PET equation coefficient (Range is from 0.0023 - 0.0032), original value = 0.0023, current value = 0.0032 (cols. 17-24) Default setting: 0.0032
4	24	Pesticide leaching ratio (Range is from 0.1 - 1) Ratio of pesticide concentration in surface runoff to pesticide concentration in percolation. (cols. 25-32) Default setting: 0.1

Field	PARM(n)	Definition, units and/or range.
5	25	Exponential coefficient used to account for rainfall intensity on curve number (Range is from 0.0 – 2.0). Setting this coefficient to 0 causes no effect. SCN = SCN*EXP(Parm 25 * (0.2 - AL5)) (cols. 33-40) Default setting: 0.0
6	26	Fraction of maturity at spring growth initiation (Range is from 0 - 1) allows fall growing crops to reset heat unit index to a value greater than 0 when passing through the minimum temperature month. (cols. 41-48) Default setting: 0.5
7	27	CEC effect on nitrification & volatilization (Range is from 0 - 1) sets lower limit of CEC correction factor in nit/vol function. At 0 CEC should prevent nit/vol process. At 1 CEC has no effect on nit/vol. (cols. 49-56) Default setting: 0.3
8	28	Upper Nitrogen Fixation limit (Range is from 0.1 – 20) This value sets the upper daily limit of nitrogen fixation by legumes. Fixation is for the profile. (kg/ha/day) (cols. 57-64) Default setting: 10.0
9	29	Biological mixing efficiency (Range is from 0.0001 - 0.01) simulates mixing in top soil by earth worms etc. Parm (31) sets depth for this action. (cols. 65-72) Default setting: 0.001
10	30	Heat Effect on Harvest Index (Range is from 0.5 – 10.0) When the heat unit index (HUI) > 0.7, HI development may be reduced DHI = DHI + EXP(Parm(30) * (TOPC – TX)/TOPC); TX>TOPC (cols. 73-80) Default setting: 1.0
LINE 34		
1	31	Maximum depth for biological mixing, (m) , (Range is from 0.1 - 0.3) (cols. 1-8) Default setting: 0.3
2	32	Organic P loss exponent , (Range is from 1 - 1.2) Provides nonlinear effect for organic P loss equation. (cols. 9-16) Default setting: 1.0
3	33	Coefficient in MUST EQ (Range is from 2.0 – 3.0). Original value = 2.5. (cols. 17-24) Default setting: 2.5
4	34	Hargreaves PET equation exponent (Range is from 0.5 - 0.6) original value=0.5. Modified to 0.6 to increase PET. (cols. 25-32) Default setting: 0.5
5	35	Denitrification Rate Adjustment Factor (Range is from 0.25 – 1.0), maximum denitrification rate adjustment factor in Kemanian denitrification component. (cols. 33-40) Default setting: 1.0
6	36	Upper Limit of Daily Denitrification rate (Range is from 0.0001 – 0.5) Maximum fraction of NO ₃ in a soil layer subject to denitrification. (cols. 41-48) Default setting: 0.001
7	37	Exponent in Delivery Ratio for SWAT Output (Range is from 0.1 – 0.6) Transforms APEX small watershed sediment yield to 8-digit basin sediment yield for SWAT input. Normally 0.5—lower values increase sediment yield to SWAT (cols. 49-56) Default setting: 0.2

8	38	Water stress weighting coefficient (Range is from 0 - 1) at 0 plant water stress is strictly a function of soil water content; at 1 plant water stress is strictly a function of actual ET divided by potential ET. $0 < \text{parm } 38 < 1$ considers both approaches. See also SCRP 17. (cols.) (cols. 57-64) Default setting: 1.0
Field	PARM(n)	Definition, units and/or range.
9	39	Puddling Saturated Conductivity (mm/h) (Range is from 0.0001 – 5.0) Simulates puddling in rice paddies by setting second soil layer saturated conductivity to a low value. (cols. 65-72) Default setting: 0.1
10	40	Groundwater storage threshold (Range is from 0.001 - 1.) fraction of groundwater storage that initiates return flow. Return flow will not occur unless the fraction of maximum groundwater storage > Parm 40. (cols. 73-80) Default setting: 0.1
LINE 35		
1	41	Plant root temperature stress exponent (Range is from 0.1 - 2.) exponent of ratio of soil layer temperature to average of plant optimal and base temperatures. (cols. 1-8) Default setting: 0.5
2	42	SCS curve number index coefficient (Range is from 0.3 -2.5) regulates the effect of PET in driving the SCS curve number retention parameter. NVCN in control table = 4. (cols. 9-16) Default setting: 1.0
3	43	Plow layer depth (m) (Range is from 0.05 – 0.2) used to track soluble phosphorus concentration or weight, organic carbon, and soil water content. (cols. 17-24) Default setting: 0.15
4	44	Upper Limit of Curve Number Retention Parameter S (Range is from 1.0 - 2.0) $SUL = \text{PARM}(44) * S1$. Allows CN to go below CN1. (cols. 25-32) Default setting: 1.2
5	45	Sediment routing travel time coefficient , (Range is from 0.5 - 10.) brings inflow sediment concentration to transport capacity concentration as a function of travel time and mean particle size. (cols. 33-40) Default setting: 3.0
6	46	RUSLE C-factor coefficient (Range is from 0.5 - 1.5) coefficient in exponential residue function in residue factor. (cols. 41-48) Default setting: 0.75
7	47	RUSLE C-factor coefficient (Range is from 0.05 – 0.2) coefficient in exponential crop height function in biomass factor. (cols. 49-56) Default setting: 0.1
8	48	Grazing Return Factor (GZRF) (Range is from 1.0 – 5.0) Grazers removed from subarea due to lack of sufficient plant material may not return to the subarea until the amount of above ground plant material is greater than the grazing limit (GZLM) * GZRF. (cols. 57-64) Default setting: 1.0
9	49	Maximum rainfall interception by plant canopy (mm) (Range is from 0.0 - 15.0) (cols. 65-72) Default setting: 7.0
10	50	Rainfall interception coefficient , (Range is from 0.05 - 0.3) (cols. 73-80) Default setting: 0.1
LINE 36		
1	51	Water stored in litter (residue) coefficient (Range is from 0.1 - 0.9). Fraction of litter weight. (cols. 1-8) Default setting: 0.5

2	52	Exponential coefficient in EQUATION expressing tillage effect on residue decay rate (Range is from 5.0 – 15.0) (cols. 9-16) Default setting: 10
Field	PARM(n)	Definition, units and/or range.
3	53	Coefficient in oxygen EQUATION used in modifying microbial activity with soil depth (Range is from 0.8 - 0.95) See also SCRIP 20. (cols. 17-24) Default setting: 0.9
4	54	N enrichment ratio coefficient for routing (Range is from 0.3 - 0.9) GLEAMS equation $ERTO = \min(3.5, \text{Parm } 54 / \text{CIN}^{\text{Parm } 55})$ (cols. 25-32) Default setting: 0.6 ERTO—enrichment ratio CIN—sediment concentration in inflow water
5	55	N enrichment ratio exponent for routing (Range is from 0.1 - 0.3) Used for GLEAMS equation. (cols. 33-40) Default setting: 0.2
6	56	Fraction destroyed by burn operation (Range is from 0.5 -1.0) (cols. 41-48) Default setting: 0.9
7	57	P enrichment ratio coefficient for routing (Range is from 0.05 – 2.0) GLEAMS equation $ERTP = \text{Parm } 57 / (\text{CY})^{\text{Parm } 58}$ (cols. 49-56) Default setting: 0.78 ERTP—P enrichment ratio CY—concentration of sediment
8	58	P enrichment ratio exponent for routing (Range is from 0.3 - 0.9) Used for GLEAMS equation. (cols. 57-64) Default setting: 0.6
9	59	P upward movement by evaporation coefficient (Range is from 1 - 20) (cols. 65-72) Default setting: 10.0
10	60	Maximum number of days a pasture is grazed before rotation (Range is from 1 - 365) (cols. 73-80) Default setting: 7.0
LINE 37		
1	61	Soil water Upward Flow Limit (Range is from 0.05 – 0.95) Limits water tension ratio used to move water from a lower layer to the one above it. $X1 = XX * \min(\text{Parm } 61, (T1-T2) / T1)$ (cols. 1-8) Default setting: 0.2
2	62	Manure erosion equation coefficient , (Range is from 0.1 - 0.5) larger values increase manure erosion. (cols. 9-16) Default setting: 0.25
3	63	N Enrichment Ratio for Delivery to SWAT , (Range is from 0.8 - 1.2) Enrichment ratio for application to 8-digit sediment yield supplied to SWAT. (cols. 17-24) Default setting: 1.0
4	64	Dust distribution coefficient , (Range is from 0.5 - 1.5) affects downwind travel time. (cols. 25-32) Default setting: 1.0
5	65	RUSLE2 transport capacity parameter (Range is from 0.001 - 0.1) Regulates deposition as a function of particle size and flow rate. (cols. 33-40) Default setting: 0.001 7
6	66	RUSLE2 threshold transport capacity coefficient (Range is from 1.0-10.0) Adjusts threshold (FLOW RATE * SLOPE STEEPNESS) (cols. 41-48) Default setting: 3.0

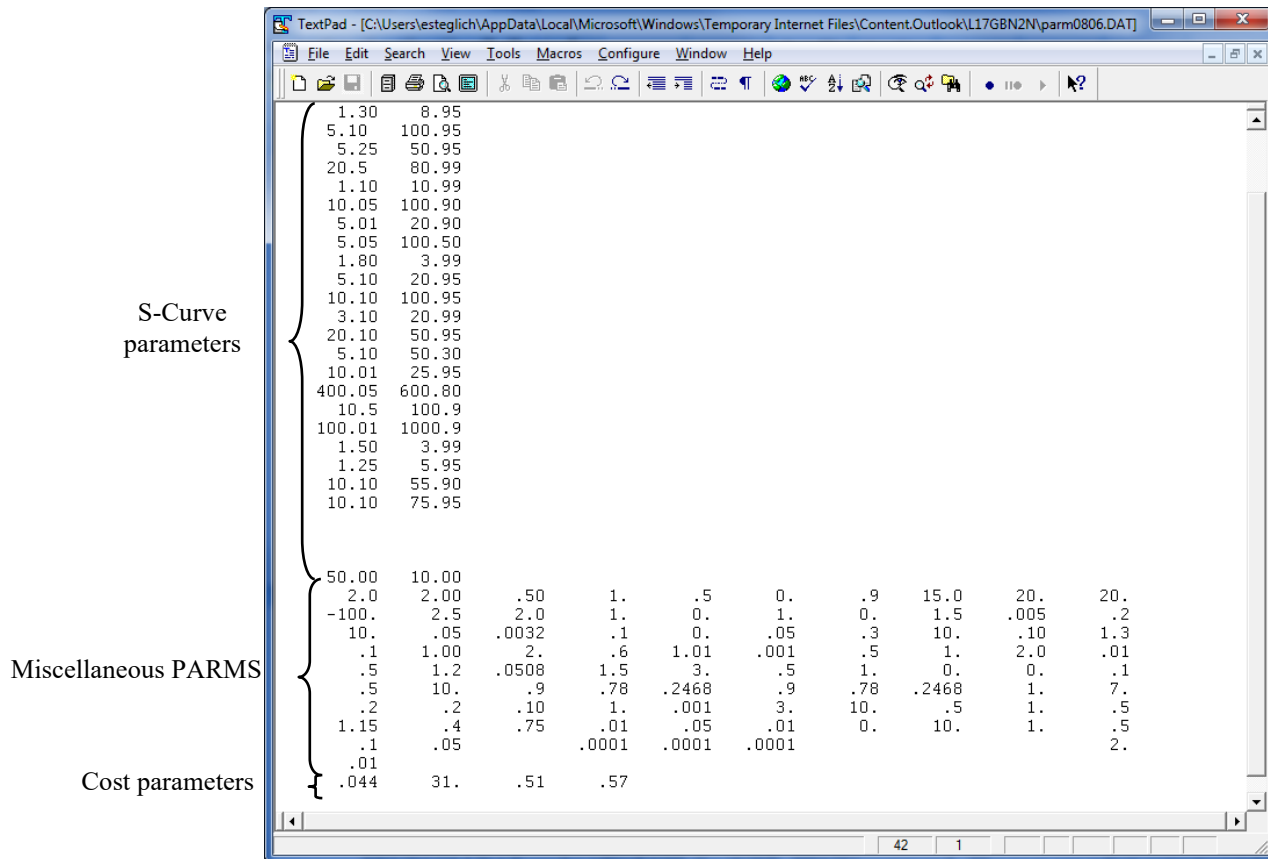
7	67	Dust distribution dispersion exponent (Range is from 5.0 - 15.0) modifies the effect of the angle between the wind direction and the centroid of downwind subareas. (cols. 49-56) Default setting: 10.0
8	68	Manure erosion exponent (Range is from 0.1 - 1.0) modifies equation based on weight of manure on soil surface. (cols. 57-64) Default setting: 0.5
Field	PARM(n)	Definition, units and/or range.
9	69	Coefficient adjusts microbial activity function in the top soil layer , (Range is from 0.1 - 1). (cols. 65-72) Default setting: 0.5
10	70	Microbial decay rate coefficient (Range is from 0.5 - 1.5). Adjusts soil water-temperature-oxygen equation. (cols. 73-80) Default setting: 1.0
LINE 38		
1	71	Manure erosion coefficient (Range is from 1.0 -1.5). Modifies erosion estimate based on above ground plant material. Plant material (live and dead) reduces manure erosion. (cols. 1-8) Default setting: 1.15
2	72	Volatilization/nitrification partitioning coefficient (Range is from 0.05 - 0.5). Fraction of process allocated to volatilization. (cols. 9-16) Default setting: 0.1
3	73	Hydrograph development parameter (Range is from 0.1 - 0.9). Storage depletion routing exponent used to estimate travel time outflow relationship. (cols. 17-24) Default setting: 0.5
4	74	Partitions Nitrogen flow from groundwater (Range is from 0.0 – 20.0) Parm 74 = NCH/NCV. RSFN = RSSF*NCH; DPKN = DPRK*NCV. NCH = horizontal nitrogen concentration; NCV = vertical nitrogen concentration; RSFN = Subarea soluble N yield in return flow ; RSSF = Return subsurface flow ; DPKN = Soluble N in deep percolation; DPRK = Deep percolation. For example, if Parm 74 is set to 5, it means RSFN will be 5 times greater than DPKN. If Parm 74 is set to 0.2, then RSFN is only 0.2 times DPKN. (cols. 25-32) Default setting: 10.0
5	75	P Enrichment Ratio for Delivery to SWAT (Range is from 0.05 - 1.5). Enrichment ratio for application to 8-digit sediment yield supplied to SWAT (cols. 33-40) Default setting: 0.8
6	76	Standing Dead fall rate coefficient (Range is from 0.0001 – 0.1). Governs rate of standing dead conversion to flat residue(cols. 41-48) Default setting: 0.01
7	77	Runoff amount to delay pest application (mm) (Range is from 0.0 – 25.0). Pesticide is not applied on days with runoff greater than Parm 77. (cols. 49-56) Default setting: 0.0 (no delay)
8	78	Soil water value to delay tillage (Range is from 0 – 1) Tillage is delayed when PDSW/FCSW>Parm 78. PDSW = Plow depth soil water content; FCSW = Field capacity soil water content. (cols. 57-64) Default setting: 10.0 (no delay)
9	79	Auto mow lower limit (t/ha) (Range is from 0.2 – 3.0) This parameter will prevent auto mowing by setting the above ground plant material that must be present in order for the model to allow auto mowing to occur. If the amount of above ground plant material is less than or equal the value set for Parm 79, the model will not allow auto mowing to occur until the amount of plant material is greater than Parm 79. (cols. 65-72) Default setting: 1.0

10	80	Upper Limit of Nitrification-Volatilization (Range is from 0.0 – 0.5) Fraction of NH ₃ present. (cols. 73-80) Default setting: 0.5
LINE 39		
1	81	Technology Coefficient (Range is from 0.0 – 0.01) Linear adjustment to harvest index—base year = 2000 (cols. 1-8) Default setting: 0.0 (no improvement in technology)
Field	PARM(n)	Definition, units and/or range.
2	82	Vertical Percolation Exponent (Range is from 1.0 – 6.0) Exponent for calculating vertical percolation in soil layers using the 4mmSlug Method (cols. 9-16) Default setting: 3.0
3	83	Estimates drainage system lateral hydraulic conductivity (Range is from 0.1 – 10.0) Drainage HCL is maximum of Parm 83 * vertical SC and APEX estimate considering drainage time and storage. Default setting: 0.5 HCL = max (Parm 83 * SATC, (PO – S15) / 24 * DRT (cols. 17-24) HCL—lateral hydraulic conductivity SATC—saturated conductivity PO—porosity S15—wilting point DRT—time for drainage to reduce plant stress
4	84	Coefficient regulating P flux between labile and active pool. (Range is from 0.0001 – 0.001) RMN = Parm 84 * WPML – WPMA * RTO (cols. 25-32) Default setting: 0.0001 RMN—N mineralization rate WPML—content of labile P in layer WPMA—weight of active mineral P pool RTO—ratio: PSP/1-PSP PSP—Phosphorus sorption ratio
5	85	Coefficient regulating P flux between active and stable pool. (Range is from 0.0001 – 0.001) ROC = Parm 85 * BK * 4.0 * WPMA – WPMS (cols. 33-40) Default setting: 0.0001 ROC—rate of stable P mineralization pool BK—rate constant that governs flow between active and mineral WPMS—weight of stable P pool
6	86	Nitrogen and Salt Upward movement by evaporation coefficient (Range is from 0.001 – 20.0) (cols. 41-48) Regulates the upward movement of N and salt by evaporation. Increasing Parm 86 increases upward movement. Default setting: 0.01
7	87	Water table recession coefficient (Range is from 0.001 – 1.0) Small values slow the water table recession. (cols. 49-56) Default setting: 0.01
8	88	Limits daily water table movement (Range is from 0.001 – 1.0) Fraction of difference between WTBL and WTMN or WTMX. (cols. 57-64) Default setting: 0.001
9	89	Water table recession exponent (Range is from 0.1 – 0.9) Exponent of day of year/365 (cols. 65-72) Default setting: 0.1
10	90	Subsurface flow factor (Range is from 1.0 – 100.0) Traditional value is 2.0. Larger numbers allocate more flow to SSF and QRF. (cols. 73-80) Default setting: 2.0
LINE 40		
1	91	Flood Evaporation Limit (Range is from 0.001 – 1) Allows for limiting of evaporation of flood waters during flooding. Regulates evaporation from channel and floodplain. Small values reduce channel and floodplain evaporation(cols 1-8) Default setting: 0.1

2	92	Runoff Volume Adjustment for Direct Link (NVCN = 0) (Range is from 0.1 to 2.0) Inversely related to runoff. Used like Parm 42 in CN index method (NVCN = 4). If Parm 92 = 1 (neutral); >1 (decreases runoff); <1 (increases runoff). Typical setting is 1.0. (cols 9-16) Default setting: 1.0
3	93	Water Erosion Threshold (Range is from 0 – 10). (t/ha) This parameter sets a threshold which enables the model to count the number of water erosion events that are greater than the set threshold. (cols. 17-24) Default setting: 0.0
Field	PARM(n)	Definition, units and/or range.
4	94	Wind Erosion Threshold (Range is from 0 – 10). (t/ha) This parameter sets a threshold which enables the model to count the number of wind erosion events that are greater than the set threshold. (cols. 25-32) Default setting: 0.0
5	95	Not Used.
6	96	Soluble Phosphorus Leaching KD value_ (Range is from 1.0 – 15.0) This value is used in the phosphorus leaching equations. Setting this parameter to 1 causes no effect. Default setting: 1.0
7	97	Root Mass Weighting Factor (Range is from 0.00 – 1.00) When Parm(97) = 0.00 root mass is adjusted based on yesterday's value. When Parm(97) = 1.00 root mass is based on today's value. Default setting: 0.9
8	98	Regulates flow between soluble and exchangeable K (potassium) pools (Range is from 0.0001 – 0.001) Default setting: 0.0001
9	99	Regulates flow between exchangeable and fixed K (potassium) pools (Range is from 0.0001 – 0.001) Default setting: 0.0001
10	100	Century Slow Humus Transformation Rate (Range is from 0.00041 – 0.00068) Original value = 0.000548. At this value turnover rate is approximately 5 years. Decreasing this parameter value increases the length of turnover rate. Default setting: 0.000548
LINE 41		
1	101	Century Passive Humus Transformation Rate (Range is from 0.0000082 – 0.000015) Original value = 0.000012. At this value the turnover rate is approximately 228 years. Decreasing this parameter value increases the length of turnover rate. Default setting: 0.000012
2	102	Microbial N:C ratio at which N immobilization is maximum (Range is from 0.025 - 0.075) Default setting: 0.0667
3	103	Microbial N:C ratio at which N immobilization ceases (Range is from 0.04 - 0.2) Default setting: 0.2
4	104	Specific Base Rate for Ammonification (WKA) (1/day) (Range is from 0.2 - 0.4) Default setting: 0.3
5	105	Microbial N:C ratio at which ammonification is maximum (Range is from 0.025-0.075) Default setting: 0.0667
6	106	Microbial N:C ratio at which ammonification ceases (Range is from 0.04 – 0.2) Default setting: 0.2
7	107	Maximum rate of uptake of nitrogen during immobilization (VMU) (gN/gC/day) (Range is from 0.2 – 0.5) Default setting: 0.35
8	108	Half Saturation constant for ammonia immobilization (WKMNH3) (mg N/L) (Range is from 10.0 – 20.0) Default setting: 15.0
9	109	Half Saturation constant for nitrite immobilization (WKMNO2) (mg N/L) (Range is from 5.0 – 15.0) Default setting: 10.0

10	110	Half Saturation constant for nitrate immobilization (WKMNO3) (mg N/L) (Range is from 10.0 – 20.0) Default setting: 15.0
LINE 42: COST PARAMETERS		
1	COIR	Cost of Irrigation Water (\$/mm) (cols. 1-8)
2	COL	Cost of Lime (\$/tonne) (cols. 9-16)
3	FULP	Cost of Fuel (\$/liter) (cols. 17-24)
4	WAGE	Cost of Labor (\$/hour) (cols. 25-32)
LINE 43: IZAURRALDE DENITRIFICATION PARAMETERS		
1	XKN5	Michaelis Menten constant: NO ₃ reduction (Range is from 100.0 – 500.0) (g/m ³) Default setting: 300.0
2	XKN3	Michaelis Menten constant: NO ₂ reduction (Range is from 15.0 – 40.0) (g/m ³) Default setting: 30.0
3	XKN1	Michaelis Menten constant: N ₂ O reduction (Range is from 0.01 – 2.5) (g/m ³) Default setting: 1.0
4	CBVT	Cumulative proportion of the BioVolume of spherical and cylindrical organisms. (Range is from 0.2 – 0.8) (g/m ³) default setting: 0.5

Figure 2.30: Sample PARM file screen



2.23 THE PRINT FILE (PRNT****.DAT)

The file PRNTCOM.DAT controls printing of output (see also IPD in APEXCONT.DAT): The PRNTCOM.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).

LINES 1-11 *FORMAT: TWENTY (20) FIELDS OF FOUR (4) COLUMNS PER FIELD (INTEGER)*

LINE 1-5: KA ***Output variable ID number (accumulated and average values).***

Select up to 60 items from Table 2.9 below.

- Right justified
- 4 spaces each
- 20 per line
- Select by number
- Leave blank for standard output
- Enter -1 to omit all accumulated variables

LINE 6: JC ***Output variable ID number (concentration variables).***

Select up to 4 variables from table below, e.g.:

18	QN	N03 loss in runoff
19	SSFN	NO3 in subsurface flow
20	PRKN	NO3 leaching
29	QP	P loss in runoff

- Right justified
- 4 spaces each
- Select by number
- Leave blank for standard output
- Enter -1 to omit all concentration variables

LINE 7: 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	ZQP	Soluble P 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	Initial 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 (sq. ha)
14	SWLT	Water content of surface litter (mm)
15	SNO	Water content of snow (mm)
16	RSDM	Manure present on soil surface (t/ha)
17	GWSN	Nitrogen contained in ground water (kg/ha)

- Right justified
- 4 spaces each
- Select by number
- Leave blank for standard output
- Enter -1 to omit all state variables

LINE 8-9: KD

Output variable ID (daily output variables).

Select variables from Table 2.9 below.

- Leave blank for standard output
- Up to 40 variables
- Right justified
- 4 spaces each
- 20 per row
- Select by number

LINE 10-11: KY

Annual output variable ID (accumulated and average values).

Select variables from the standard table (Table 2.9) below

- Select from KA list above
- Leave blank for standard output
- Enter -1 to omit all accumulated variables
- Up to 40 variables
- Right justified
- 4 spaces each
- 20 per row

Table 2.9: List of Output Variables the User can choose from.

<i>Variable #</i>	<i>Variable Name</i>	<i>Variable Description</i>	<i>Units</i>
1	TMX	Maximum temperature	°C
2	TMN	Minimum temperature	°C
3	SRAD	Solar Radiation	MJ/m ²
4	PRCP	Precipitation	mm
5	SNOF	Snow fall	mm
6	SNOM	Snow melt	mm
7	WSPD	Wind velocity	m/s
8	RHUM	Relative humidity	
9	VPD	Vapor pressure deficit	kPa
10	PET	Potential evaporation	mm
11	ET	Evapotranspiration	mm
12	EP	Transpiration	mm
13	Q	Annual Surface Runoff	mm
14	CN	SCS runoff curve number	
15	SSF	Lateral subsurface flow	m
16	PRK	Percolation below the root zone	mm
17	QDR	Flow from a drainage system	mm
18	IRGA	Irrigation water applied	mm
19	QIN	Inflow to the root zone from the water table	mm
20	TLGE	Lagoon evaporation	mm
21	TLGW	Water wash to lagoon	mm
22	TLGQ	Runoff to lagoon	mm
23	TLGF	Lagoon overflow	mm
24	EI	Rainfall energy factor	
25	C	Average water erosion/crop management factor	
26	USLE	Soil loss from water erosion using USLE	t/ha
27	MUSL	Soil loss from water erosion using MUSLE	t/ha
28	AOF	Soil loss from water erosion using Onstad-Foster	t/ha
29	MUSS	Soil erosion-water	t/ha
30	MUST	Soil loss from water erosion using modified MUSLE	t/ha
31	RUS2	Soil loss from water erosion using RUSLE2	t/ha
32	WK1	Wind erosion soil erodibility factor	
33	RHTT	Ridge Height	mm
34	RRUF	Random roughness of soil	
35	RGRF	Wind erosion ridge roughness factor	
36	YWND	Soil erosion –wind	t/ha
37	YN	Sediment transported N from subarea or reach	kg/ha
38	QN	Nitrogen in runoff	kg/ha
39	SSFN	Amount of mineral nitrogen lost in the horizontal movement of water in the soil from subarea or reach	kg/ha

40	PRKN	Mineral N loss in percolate	kg/ha
41	GMN	Gross amount of nitrogen mineralized	kg/ha
42	DN	N loss by denitrification	kg/ha
43	NFIX	N fixed by leguminous crops	kg/ha
44	NMN	Net amount of nitrogen mineralized; i.e., $NMN = GMN - N$ immobilized	kg/ha
45	NITR	Nitrification	kg/ha
46	AVOL	Nitrogen volatilization	kg/ha
47	QDRN	Soluble N in drainage outflow'	kg/ha
48	YP	P loss with sediment	kg/ha
49	QP	Phosphorus in runoff	kg/ha
50	MNP	P mineralized	kg/ha
51	PRKP	Phosphorus loss in percolate	kg/ha
52	ER	Enrichment ratio	
53	FNO	Organic Nitrogen fertilizer (animal waste)	kg/ha
54	FNMN	Nitrate N fertilizer	kg/ha
55	FNMA	Ammonium N fertilizer	kg/ha
56	FPO	Organic Phosphorus (actual P) of manure	kg/ha
57	FPL	Mineral P fertilizer applied	kg/ha
58	LIME	Limestone applied (CaCO ₃ equivalent)	t/ha
59	TMP	Temperature in second soil layer	°C
60	SW10	Ratio soil water/wilting point in top 10mm	
61	LGMI	Manure input to lagoon	kg/ha
62	LGMO	Manure output from lagoon	kg/ha
63	EPP	Potential plant evaporation	mm
64	RSQI	Reservoir inflow	mm
65	RSQO	Reservoir outflow	mm
66	RSEV	Reservoir volume	mm
67	RSLK	Reservoir leakage (goes into ground water)	mm
68	RSYI	Reservoir sediment inflow	tonne
69	RSYO	Reservoir sediment outflow	tonne
70	RSYD	Reservoir sediment deposition	tonne
71	DPRK	Deep percolation	mm
72	RSSF	Return subsurface flow	mm
73	RSDC	carbon contained in crop residue	kg/ha
74	RSPC	CO ₂ respiration	kg/ha
75	PRKC	Carbon leached from root zone	kg/ha
76	QC	Carbon in runoff	kg/ha
77	YC	Carbon loss with sediment	kg/ha
78	RSDA	Residue added in any form	t/ha
79	QFP	Amount of flow into floodplain	mm
80	RSFN	Subarea soluble N yield in return flow	kg/ha
81	MAP	Manure applied to subarea	kg/ha
82	BUNL	N burn loss	kg/ha
83	QRF	Quick return flow	mm

84	QRFN	Soluble N in quick return flow	kg/ha
85	RFIC	Rainfall interception	mm
86	RSBK	Reservoir back water	mm
87	CPVH	Pipe flow horizontal	mm
88	YMNU	Manure erosion	kg/ha
89	SNOU	N in scraping manure	kg/ha
90	SPOU	P in scraping manure	kg/ha
91	DNMO	Deposition of mineral N at watershed outlet	kg/ha
92	DPMO	Deposition of mineral P at watershed outlet	kg/ha
93	DEMR	Dust emission rate	kg/ha
94	P10D	Dust emission with <10 micron particle size	kg/ha
95	SSF1	Subsurface flow from subarea above	m
96	DPKN	Deep percolation of N out of groundwater	kg/ha
97	CPVV	Pipe flow vertical	mm
98	FPF	Floodplain infiltration	mm/h
99	FOC	Organic C fraction in fertilizer	
100	RFV	Precipitation	mm
101	SCOU	Carbon in manure scraped from feedlot	kg/ha
102	DEPC	Carbon deposited in routing reach	kg/ha
103	DECR	Residue decay	t/ha
104	PSOQ	Point source flow volume	mm
105	PSON	Point source soluble N load	kg/ha
106	PSOP	Point source soluble P load	kg/ha
107	RUSL	Soil erosion by water estimated with RUSLE	t/ha
108	QPU	Soluble P reach outflow of manure	kg/ha
109	FALF	Leaf fall	kg/ha
110	IRDL	Irrigation Distribution loss	mm
111	QRP	Reservoir release rate	mm/day
112	YRP	Sediment outflow from reservoir	t/ha/day
113	YNRP	Particulate N in reservoir outflow	kg/ha
114	YPRP	Particulate P in reservoir outflow	kg/ha
115	QNRP	Soluble N outflow from ponds	kg/ha
116	QPRP	Soluble P outflow from ponds	kg/ha
117	WYLD	Water yield	mm
118	YPM	Total mineral phosphorus loss	kg/ha
119	YPO	Total organic phosphorus loss	kg/ha
120	SW	Soil water in total profile	mm
121	PSOY	Point source sediment pesticide load	t/day
122	PQPS	Point source soluble pesticide load	g/day
123	PYPS	Point source adsorbed pesticide load	g/day
124	MUSI	Soil erosion by water estimated with Modified MUSLE	t/ha
125	QI	Inflow to reservoir	m ³
126	QARS	Reservoir outflow	m ³
127	RFRA	Amount of rainfall that falls on reservoir surface	m ³
128	DN2	Loss of dinitrogen gas	kg/ha

129	SLTI	Salt in irrigation water	kg/ha
130	SLTQ	Salt in runoff	kg/ha
131	SLTS	Salt in lateral subsurface flow	kg/ha
132	SLTF	Salt in fertilizer	kg/ha
133	SLTV	Salt percolated out of root zone	kg/ha
134	YNWN	N loss in wind erosion	kg/ha
135	YPWN	P loss in wind erosion	kg/ha
136	YCWN	Carbon loss in wind erosion	kg/ha
137	PSO3	Nitrate contribution from point source	kg/ha
138	PSSP	Soluble P contribution from point source	kg/ha
139	YWKS	Wind erosion using Manhattan Kansas model	t/ha
140	CBUR	Carbon loss from burning crop residue or forest	kg/ha
141	GRZD	Grazing duration	days
142	QRFP	Phosphorus loss in quick return flow	kg/ha
143	QDRP	Phosphorus loss through drainage system	kg/ha
144	YTHS	Number of days above threshold for water erosion (set in Parm 93)	days
145	YWTH	Number of days above threshold for wind erosion (set in Parm 94)	days

LINE 12- KFL
14:

Output table selection

0 gives no output, KFL > 0 gives output for selected files; there are 43 possible output files, this line has 20 variable fields, 4 columns wide. 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

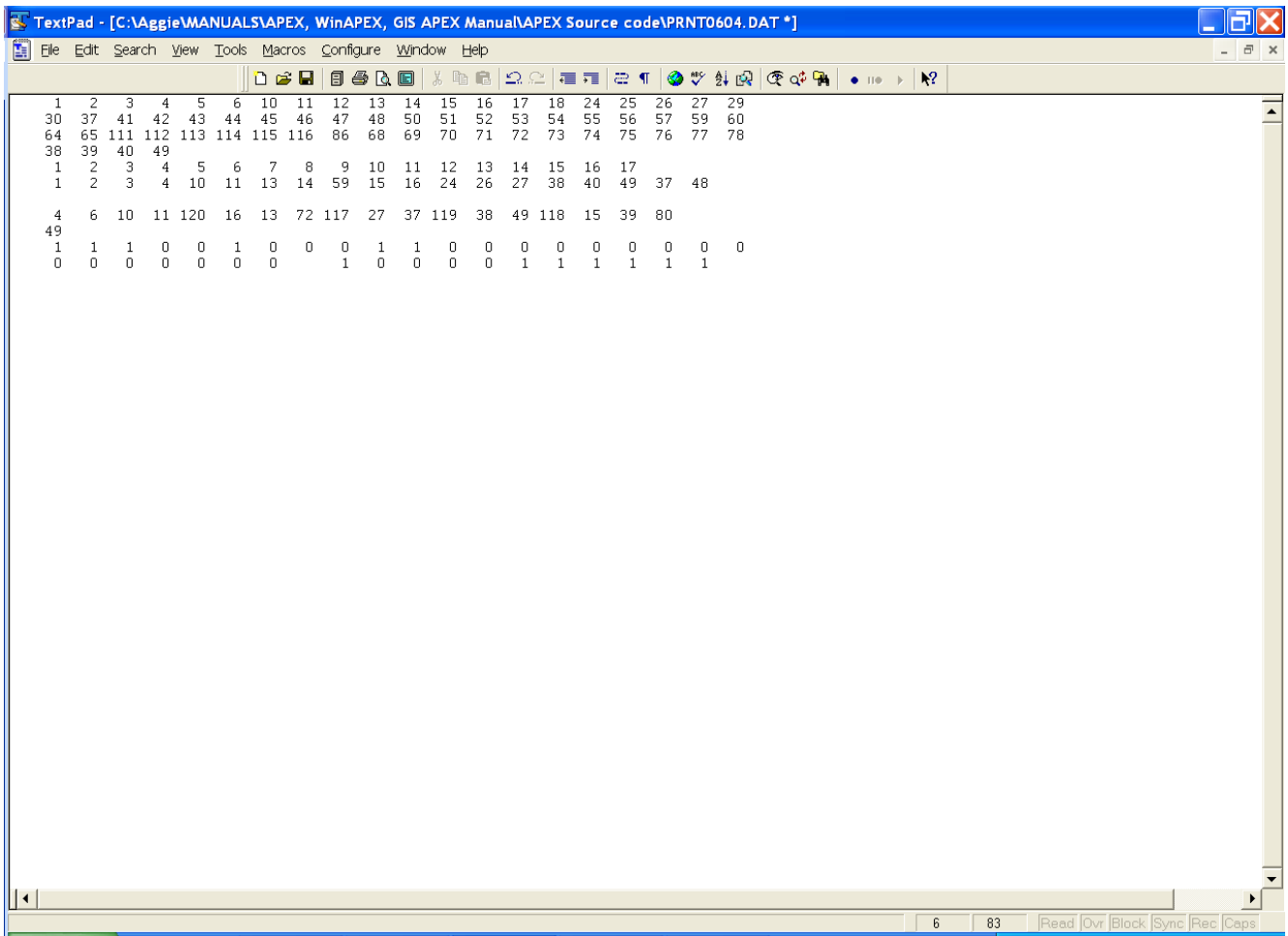
prints file # 1, 9, 16, and 20 from the following file list.

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

1	OUT	STANDARD OUTPUT FILE
2	MAN	SPECIAL MANURE MANAGEMENT SUMMARY FILE
3	SUS	SUBAREA SUMMARY FILE
4	ASA	ANNUAL SUBAREA FILE
5	SWT	WATERSHED OUTPUT TO SWAT
6	DPS	DAILY SUBAREA PESTICIDE FILE
7	MSA	MONTHLY SUBAREA FILE
8	AWP	ANNUAL CEAP FILE
9	DHY	DAILY SUBAREA HYDROLOGY FILE
10	WSS	WATERSHED SUMMARY FILE
11	SAD	DAILY SUBAREA FILE
12	HYC	CONTINUOUS HYDROGRAPHS(DTHY) AT WATERSHED OUTLET
13	DRS	DAILY RESERVOIR FILE
14	APEXBUF.OUT	SPECIAL FILE FOR BUFFER STRIPS
15	MWS	MONTHLY WATERSHED FILE
16	DWS	DAILY WATERSHED OUTLET FILE
17	AWS	ANNUAL WATERSHED OUTLET FILE
18	DGZ	DAILY GRAZING
19	DUX	DAILY MANURE APPLICATION
20	DDD	DAILY DUST DISTRIBUTION
21	ACN	ANNUAL SOIL ORGANIC C & N TABLE
22	DCN	DAILY SOIL ORGANIC C & N TABLE
23	SCX	SUMMARY SOIL ORGANIC C & N TABLE
24	ACY	ANNUAL SUBAREA CROP YIELD
25	EFR	RUNOFF EVENT FLOOD ROUTING
26	EHY	RUNOFF EVENT HYDROGRAPHS
27	APS	ANNUAL SUBAREA/WATERSHED PESTICIDE
28	MSW	MONTHLY OUTPUT TO SWAT
29	DPW	DAILY WATERSHED PESTICIDE FILE
30	SPS	PESTICIDE SUBAREA SUMMARY
31	ACO	ANNUAL COST

32	SWN	SPECIAL WATERSHED SUMMARY FOR NRCS FARM PLANNING
33	Not used	
34	SAO	SPECIAL SUBAREA FILE FOR GIS
35	RCH	SPECIAL REACH FILE FOR GIS
36	ERX	ERROR FILE
37	DMR	DAILY WATERSHED NUTRIENT & SEDIMENT CONC NRCS MRBI
38	STR	SUMMARY OF SUBAREAS & WATERSHED FOR NRCS STAR TOOL
39	MRH	MONTHLY REACH FILE ANNUAL GIS REACH FILE FOR SELECTED COMMAND #'S ICMO (FROM .SIT)
40	MGZ	MONTHLY GRAZING FILE
41	DNC	DAILY NITROGEN/CARBON CESAR IZAURRALDE
42	DHS	DAILY HYDROLOGY/SOIL
43	SW4	DAILY OUTPUT FOR SELECTED COMMAND #'S ICMO (FROM .SIT)
44	DGN	DAILY GENERAL OUTPUT (VAR AFTER COMMAND LOOP IN BSIM)
45	DPD	DAILY PADDY OUTPUT
46	ASL	ANNUAL SOIL TABLE
47	MS5	MONTHLY SOIL PROPERTIES 0 – 0.05m
48	AS5	ANNUAL SOIL PROPERTIES 0 – 0.05m
49		RUN1501.SUM

Figure 2.31: Sample Print file screen.



2.24 THE HERD FILE (HERD****.DAT)

Each herd is identified with a particular owner. Each owner is allowed up to 10 herds. Within HERD1501.DAT each line identifies the characteristics of a particular herd. At the end of the herd file (listing of herds), the user has the option to also identify buy/sell data for particular herds. If animals from herds are not bought/sold, then this information is left blank

The following variables are required for the model. *If grazing is not simulated, add a blank line or a zero line to the top of the HERD1501.DAT file. The model reads each line and looks at the owner to see if it is non-zero. When it comes to a blank or zero line it stops reading.* This allows a user to have a herd file set up, but if the user decides to only simulate crops and not include grazing, he or she can do this without compromising all of the data that has already been entered for the owners and herds in the HERD1501.DAT file. Another option is to use the HERD0.DAT file in place of the HERD1501.DAT file. The HERD0.DAT file only contains a zero line.

FORMAT: ONE (1) FIELD OF FOUR (4) COLUMNS (INTEGER) FOLLOWED BY SIX (6) FIELDS OF EIGHT (8) COLUMNS INCLUDING UP TO THREE (3) DECIMAL PLACES (FLOATING)

Field	Variable	Description
1	IDON	Owner identification number (cols. 1-4)
2	NCOW	Number of Cows in herd (cols. 5-12) This is the number of cows (animal units) in herd N owned by owner N
3	IDMU	Manure ID number from FERTCOM.DAT (cols. 13-20) This number identifies the type of manure being deposited on the soil surface by herd N owned by owner N
4	FFED	Fraction of day (24 hours) that herd is in feeding area (cols. 21-28) This is the fraction of the day that herd N owned by owner N is in the feeding area and not grazing on pasture.
5	GZRT	Daily Grazing rate per animal unit (cols. 29-36) This refers to the amount of forage the animal is capable of grazing in one day. It is expressed in kg per head per day. This number is then multiplied by NCOW to determine the amount the entire herd grazes on a daily basis.
6	DUMP	Daily manure production per animal unit (cols. 37-44) This refers to the amount of manure produced by each animal in the herd each day. It is expressed in kg/hd/d
7	VURN	Daily Urine production per animal unit (cols. 45-52) This refers to the amount of urine produced by each animal in the herd each day. It is expressed in liters per head per day.

The following variables are optional. If animals are bought/sold, then the following variables must be added to the HERD1501.DAT file at the end of the herd listing. Animals of any particular herd may be bought/sold multiple times throughout the year simply by adding multiple lines with the appropriate dates to the following data.

A blank line must be added between the herd data (above variables) and the following data. This indicates to the model that it has reached the end of the herd characteristic data and anything below the blank line indicates buy/sell data.

FORMAT: UP TO TWENTY (20) FIELDS OF FOUR (4) COLUMNS PER FIELD (INTEGER)

Field	Variable	Description
1	IOW	<i>Owner number (cols. 1-4)</i> This is the number that identifies the owner.
2	IHD	<i>Herd number (cols. 5-8)</i> This number identifies the herd. In the listing of the herds above it is assumed that the first herd listed for owner N is identified as herd 1 and the tenth herd listed for owner N is herd 10. (Range: 1-10)
3	I1	<i>Year of buy/sell (cols. 9-12)</i> This is the year the animals were bought or sold.
4	I2	<i>Month of buy/sell (cols. 13-16)</i> This is the month the animals were bought or sold.
5	I3	<i>Day of buy/sell (cols. 17-20)</i> This is the day of the month the animals were bought or sold.
6	I4	<i>Number of animals in herd after buy/sell. (cols. 21-24)</i> The model compares this number to the value of NCOW previously set for the herd and determines if animals were bought or sold. If $I4 > NCOW$, then animals were bought. If $I4 < NCOW$, then animals were sold. NCOW then takes on the value of I4. If animals from a particular herd are bought/sold numerous times per year, each time the animals are bought/sold NCOW increases/decreases to reflect that change.

Figure 2.32: Sample HERD1501 file screen

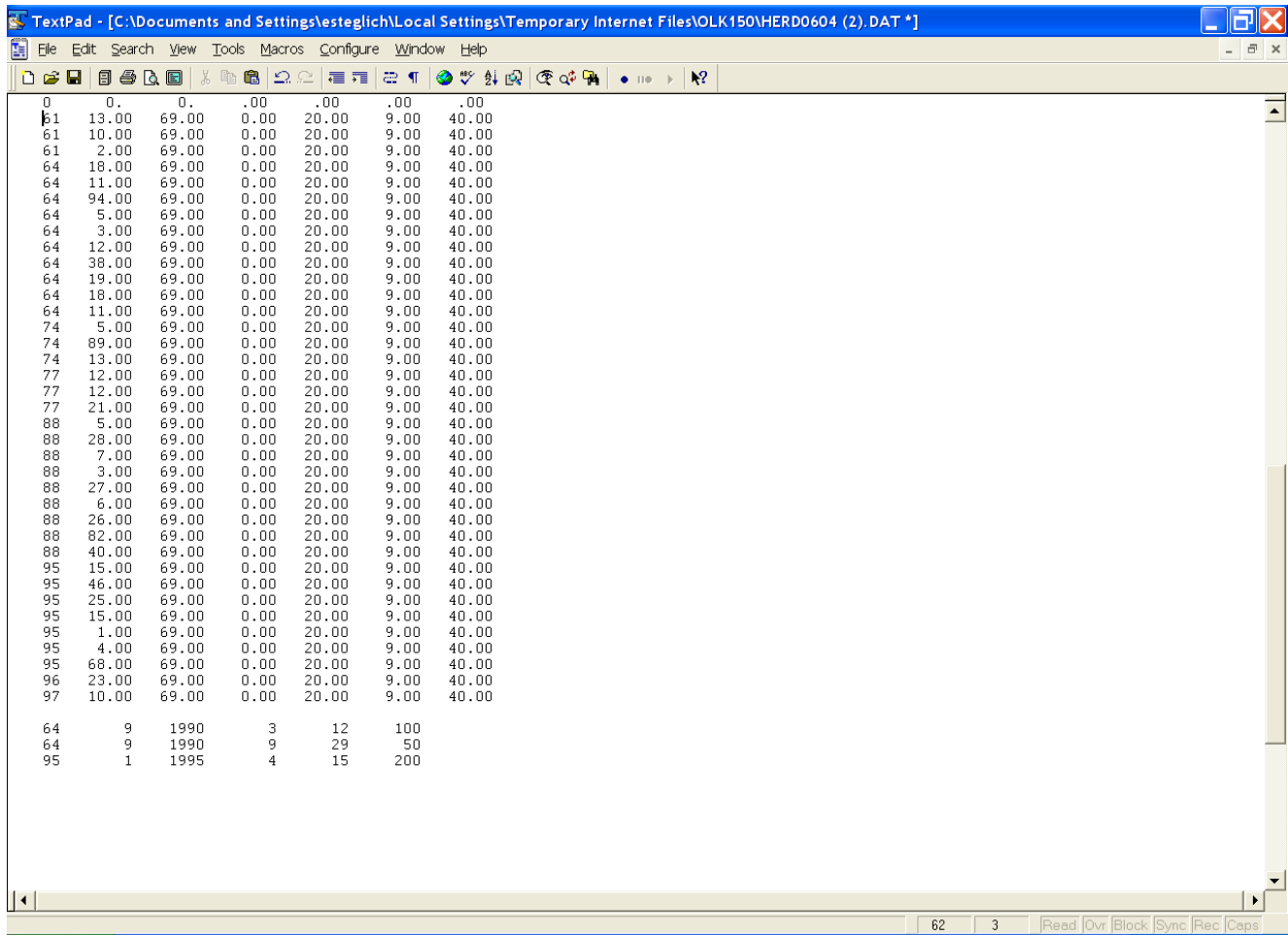
The screenshot shows a TextPad window with a menu bar (File, Edit, Search, View, Tools, Macros, Configure, Window, Help) and a toolbar. The main text area contains a data file with the following content:

61	13.00	69.00	0.00	20.00	9.00	40.00
61	10.00	69.00	0.00	20.00	9.00	40.00
61	2.00	69.00	0.00	20.00	9.00	40.00
64	18.00	69.00	0.00	20.00	9.00	40.00
64	11.00	69.00	0.00	20.00	9.00	40.00
64	94.00	69.00	0.00	20.00	9.00	40.00
64	5.00	69.00	0.00	20.00	9.00	40.00
64	3.00	69.00	0.00	20.00	9.00	40.00
64	12.00	69.00	0.00	20.00	9.00	40.00
64	38.00	69.00	0.00	20.00	9.00	40.00
64	19.00	69.00	0.00	20.00	9.00	40.00
64	18.00	69.00	0.00	20.00	9.00	40.00
64	11.00	69.00	0.00	20.00	9.00	40.00
74	5.00	69.00	0.00	20.00	9.00	40.00
74	89.00	69.00	0.00	20.00	9.00	40.00
74	13.00	69.00	0.00	20.00	9.00	40.00
77	12.00	69.00	0.00	20.00	9.00	40.00
77	12.00	69.00	0.00	20.00	9.00	40.00
77	21.00	69.00	0.00	20.00	9.00	40.00
88	5.00	69.00	0.00	20.00	9.00	40.00
88	28.00	69.00	0.00	20.00	9.00	40.00
88	7.00	69.00	0.00	20.00	9.00	40.00
88	3.00	69.00	0.00	20.00	9.00	40.00
88	27.00	69.00	0.00	20.00	9.00	40.00
88	6.00	69.00	0.00	20.00	9.00	40.00
88	26.00	69.00	0.00	20.00	9.00	40.00
88	82.00	69.00	0.00	20.00	9.00	40.00
88	40.00	69.00	0.00	20.00	9.00	40.00
95	15.00	69.00	0.00	20.00	9.00	40.00
95	46.00	69.00	0.00	20.00	9.00	40.00
95	25.00	69.00	0.00	20.00	9.00	40.00
95	15.00	69.00	0.00	20.00	9.00	40.00
95	1.00	69.00	0.00	20.00	9.00	40.00
95	4.00	69.00	0.00	20.00	9.00	40.00
95	68.00	69.00	0.00	20.00	9.00	40.00
96	23.00	69.00	0.00	20.00	9.00	40.00
97	10.00	69.00	0.00	20.00	9.00	40.00

64	9	1990	3	12	100
64	9	1990	9	29	50
95	1	1995	4	15	200

The status bar at the bottom shows line 101, column 45, and keyboard shortcuts: Read, Ovr, Block, Sync, Rec, Caps.

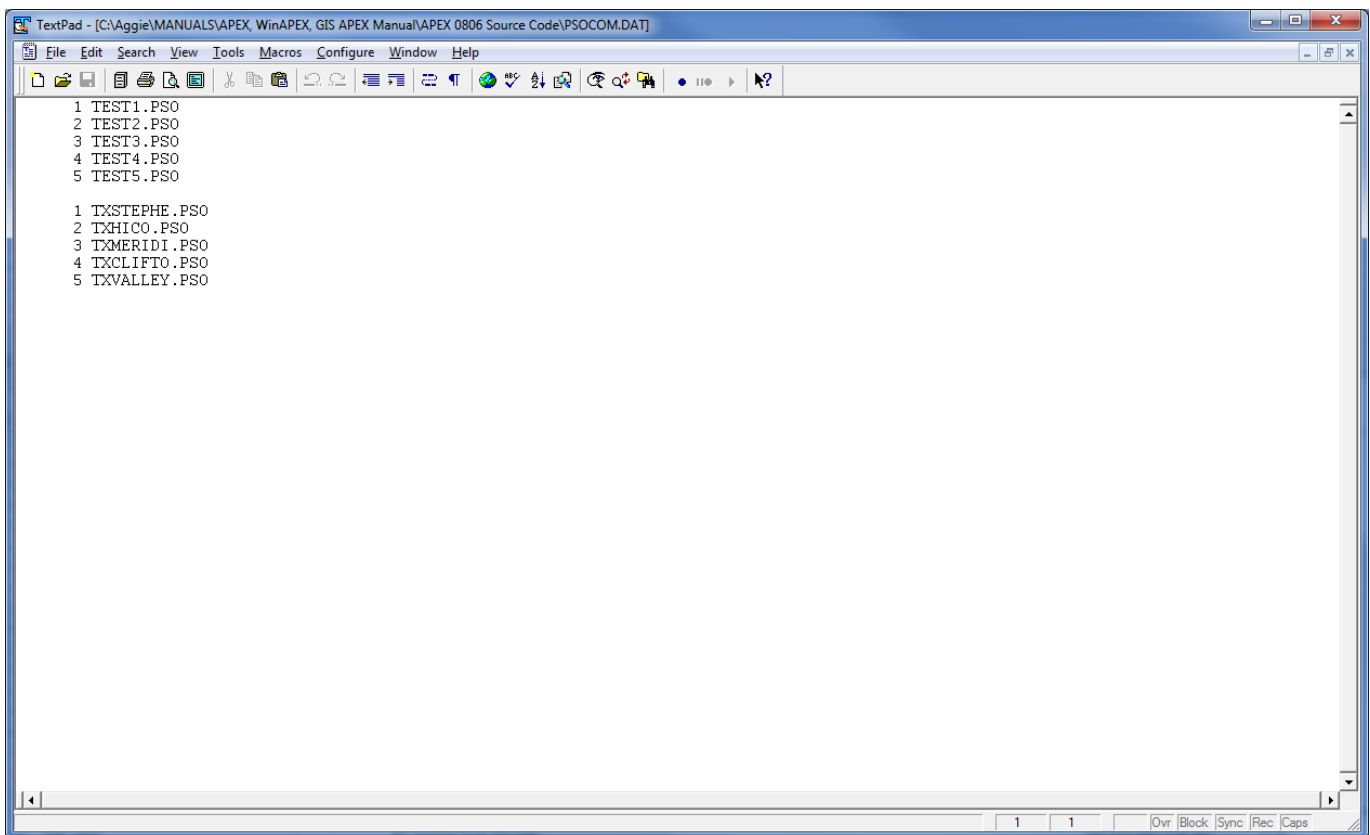
Figure 2.33: Sample HERD1501 file screen with “Zero” line to disable grazing simulation.



2.25 THE POINT SOURCE LIST FILE (PSO****.DAT)

The point source list file consists of a listing of all of the available point source files. The point source list consists of a numbered listing of all point source files which can be referenced by number in the APEX Subarea file. This file is in FREE FORMAT. See Figure 2.33 for an example of the PSOCOM.DAT file. The point source list file name may be user defined; however, it must be properly identified in the APEXFILE.DAT file

Figure 2.34: Sample PSOCOM.DAT file screen.



```
1 TEST1.PSO
2 TEST2.PSO
3 TEST3.PSO
4 TEST4.PSO
5 TEST5.PSO

1 TXSTEPHE.PSO
2 TXHICO.PSO
3 TXMERIDI.PSO
4 TXCLIFTO.PSO
5 TXVALLEY.PSO
```


2.26 THE POINT SOURCE FILE (FILENAME.PSO)

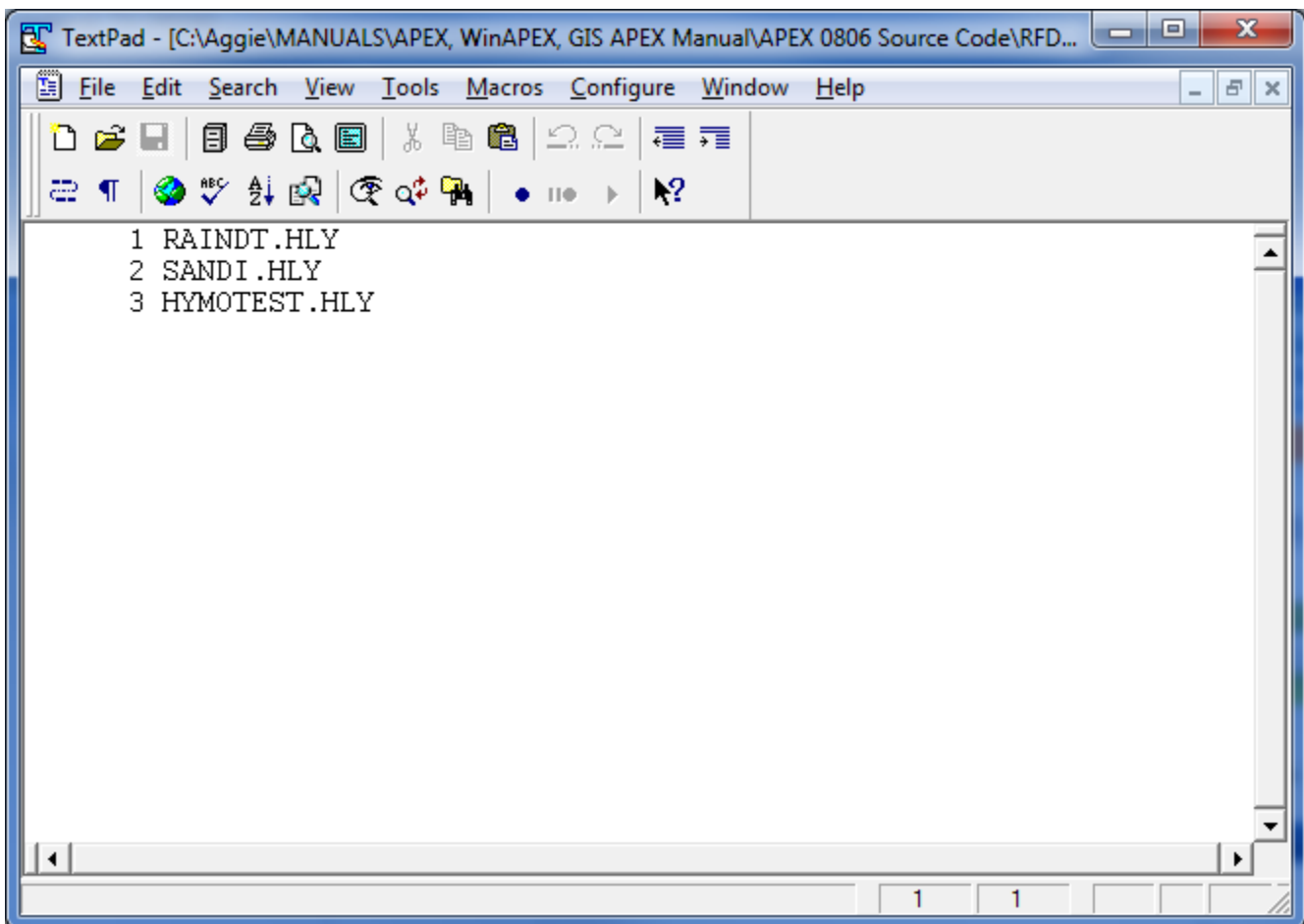
When watersheds have loadings to the stream network from sources not associated with a land area, they are referred to as point sources. The most common point source is a sewage treatment plant. In order to account for loadings from a point source, APEX allows users to add daily loading data for point sources to the main channel network at the outlet of the subarea in which it is located. These loadings are then routed through the channel network along with loadings generated by land areas. The point source file is FREE FORMAT.

Variable	Description
DAY	Day of year
YEAR	Year
FLOCNST	Daily water loading (flow) (m ³ /day)
SEDCNST	Daily sediment loading (t/day)
ORGNCNST	Daily organic N loading (kg/day)
ORGPCNST	Daily organic P loading (kg/day)
NO3CNST	Daily nitrate-N loading (kg/day)
NH3CNST	Daily ammonia-N loading (kg/day)
NO2CNST	Daily nitrite-N loading (kg/day)
MINPCNST	Daily mineral (soluble) P loading (kg/day)
CBODCNST	Daily bod loading (kg/day)
DISOXCNST	Daily dissolved oxygen loading (kg/day)
CHLACNST	Daily chlorophyll loading (kg/day)
SOLPSTCNST	Daily soluble pesticide loading (g/day)
SRBPSTCNST	Daily adsorbed pesticide loading (g/day)
BACTPCNST	Daily loading of persistent bacteria (# bacteria/day) SWAT ONLY—NOT USED IN APEX
BACTLPCNST	Daily loading of LESS persistent bacteria (# bacteria/day) SWAT ONLY—NOT USED IN APEX
CMTL1CNST	Daily loading of conservative metal #1 (kg/day) SWAT ONLY—NOT USED IN APEX
CMTL2CNST	Daily loading of conservative metal #2 (kg/day) SWAT ONLY—NOT USED IN APEX
CMTL3CNST	Daily loading of conservative metal #3 (kg/day) SWAT ONLY—NOT USED IN APEX
KSPN	Pesticide # from PESTCOM.DAT

2.27 THE WITHIN-STORM RAINFALL LIST FILE (RFDT****.DAT)

This is a listing of within-storm (more frequent than daily) rainfall. The model references this file to determine which rainfall station (*.HLY) will be used to read the within-storm rainfall data from. The listing consists of the identification number and the within-storm rainfall file name. The file format is FREE FORMAT.

Figure 2.36: Sample *RFDTCOM.DAT* file screen.



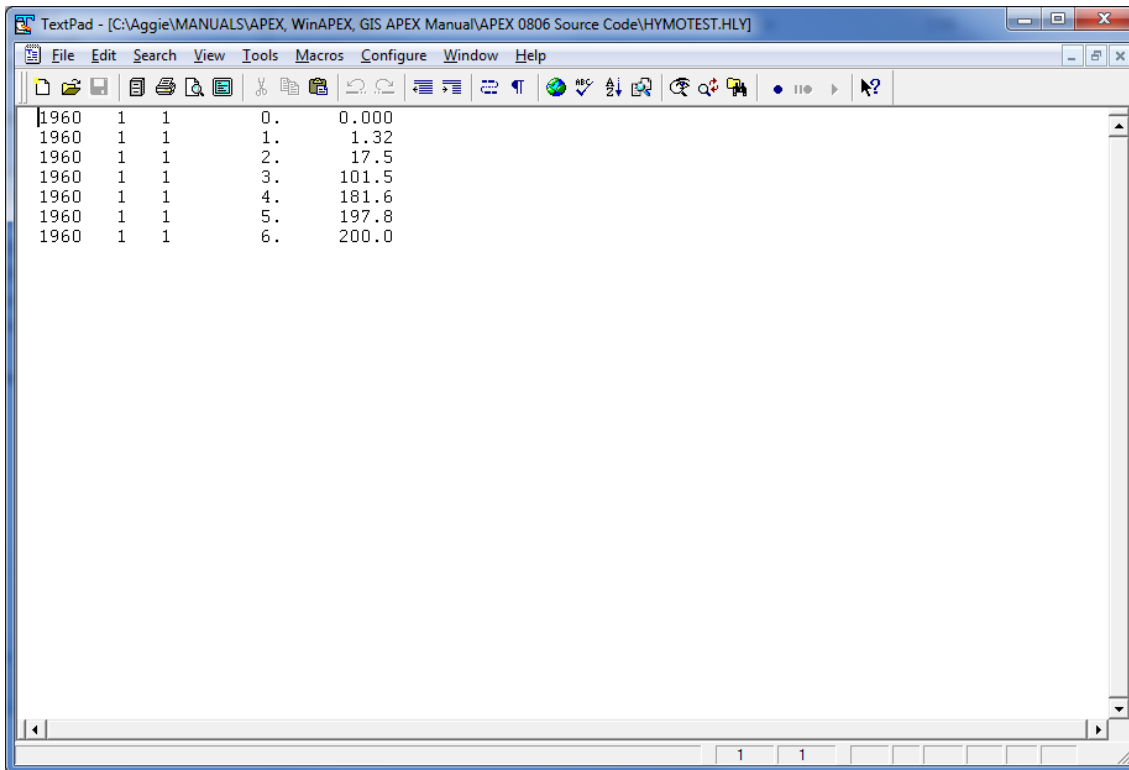
2.28 THE WITHIN-STORM RAINFALL FILE (FILENAME.HLY)

Within-storm rainfall data (sub-daily) is required if the Green and Ampt infiltration method is to be used. IHY in the control table should also be set to 1 for flood routing. DTHY must also be set in the control table to indicate the time interval for flood routing.

FORMAT: : THREE (3) FIELDS OF FOUR (4) COLUMNS (INTEGER) FOLLOWED BY TWO (2) FIELDS OF TEN (10) COLUMNS INCLUDING DECIMAL PLACES (FLOATING)

Field	Variable	Description
1	IYZ	Year (cols. 1-4)
2	MOZ	Month (cols. 5-8)
3	IDZ	Day (cols. 9-12)
4	THZ	Time interval (fraction of an hour) (cols. 10-19)
5	RFDT	Precipitation (mm) (cols. 20-29)

Figure 2.37: Sample FILENAME.HLY file screen.



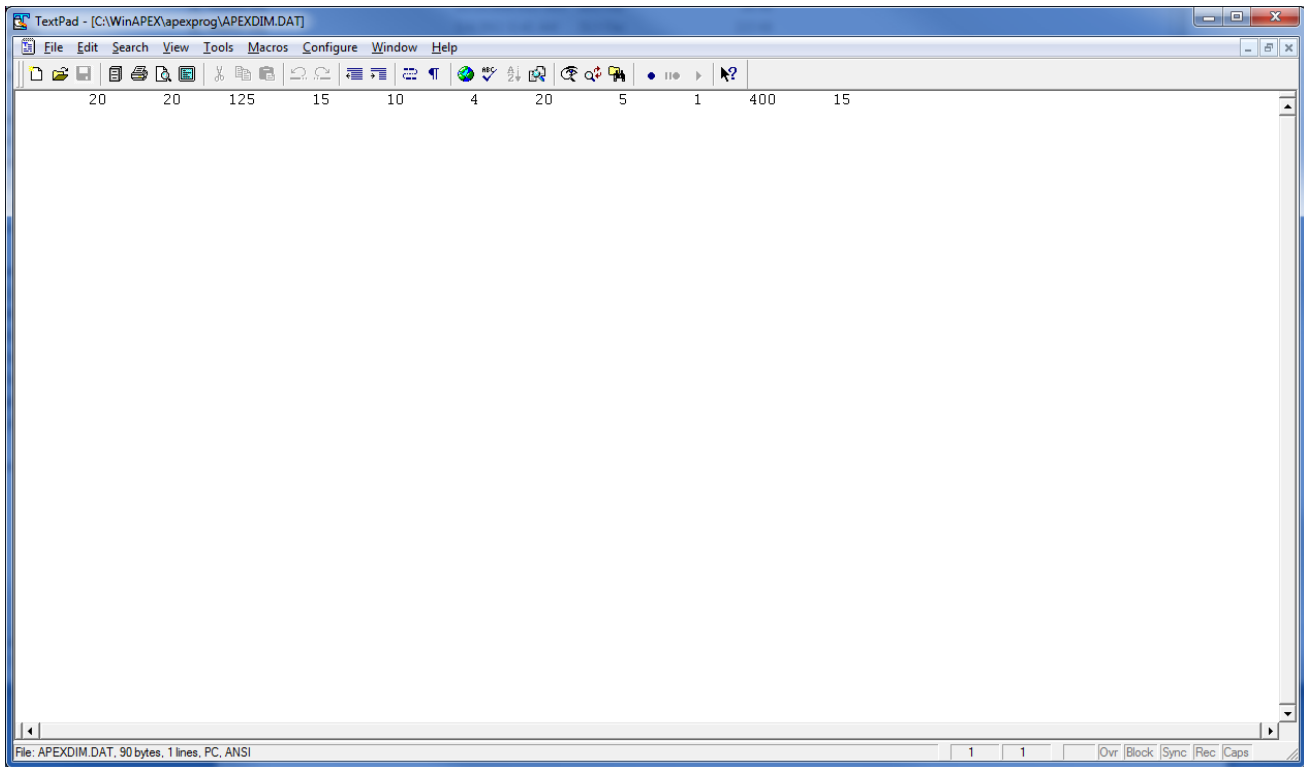
2.29 THE APEX DIMENSION FILE (APEXDIM.DAT)

The APEX dimension file sets limits for various arrays that allow the model to run more efficiently. The user can increase or decrease these limits depending on their scenario.

FORMAT: FREE FORMAT

Field	Variable	Description
1	MPS	Maximum # of pesticides
2	MRO	Maximum # years in crop rotation
3	MNT	Maximum # of tillage operations
4	MNC	Maximum # of crops used
5	MHD	Maximum # animals herds
6	MBS	Maximum # buy/sell livestock transactions
7	MFT	Maximum # fertilizer
8	MPO	Maximum # point sources
9	MHP	Maximum # of hydrograph points
10	MHX	Maximum # of days for storm hydrograph base
11	MSA	Maximum # of subareas
12	MIR	Maximum # of irrigations applications

Figure 2.38: Sample *APEXDIM.DAT* file screen.



CHAPTER 3

OUTPUT DATA VARIABLES

3.1 *.SUS – SUBAREA SUMMARY FILE

SA#	SUBAREA NUMBER ASSIGNED BY COMPUTER
ID#	SUBAREA ID NUMBER INPUT BY USER
WSA	AREA OF SUBAREA OR REACH OUTLET (HA)
CN2	SCS RUNOFF CURVE NUMBER FOR MOISTURE CONDITION 2
YW0	AN APPROXIMATION FOR WIND EROSION BASED ON WEQ (MANHATTEN-KANSAS WIND EROSION FORMAT) (T/HA)
OCPD	ORGANIC CARBON IN PLOW DEPTH (%)
FSFN	FRACTION OF NITROGEN FERTILIZER THAT IS SURFACE APPLIED (KG/HA)
FSFP	FRACTION OF PHOSPHORUS FERTILIZER THAT IS SURFACE APPLIED (KG/HA)
PRB	HIGHEST PEAK RUNOFF RATE (MM/H)
PRAV	AVERAGE PEAK RUNOFF RATE (MM/H)
TCMN	TIME OF MINIMUM CONCENTRATION (H)
CYAV	AVERAGE SEDIMENT CONCENTRATION (PPM)
CYMX	MAXIMUM SEDIMENT CONCENTRATION (PPM)
PRCP	PRECIPITATION (MM)
SNOF	SNOWFALL (MM)
SNOM	SNOWMELT (MM)
IRGA	IRRIGATION WATER APPLIED (MM)
PET	POTENTIAL EVAPOTRANSPIRATION FROM SUBAREA OR SUBBASIN (MM)
ET	EVAPOTRANSPIRATION (MM)
SW	SOIL WATER CONTENT (MM). AMOUNT OF WATER IN THE SOIL PROFILE AT THE END OF THE SIMULATION PERIOD.
PRK	PERCOLATION BELOW THE ROOT ZONE (MM)
DPRK	DEEP PERCOLATION (MM)
Q	ANNUAL SURFACE RUNOFF (MM)

SSF	LATERAL SUBSURFACE FLOW (MM)
RSSF	RETURN SUBSURFACE FLOW (MM)
WYLD	WATER YIELD (MM). THE NET AMOUNT OF WATER THAT LEAVES THE SUBAREA AND CONTRIBUTES TO STREAMFLOW.
CN	SCS RUNOFF CURVE NUMBER
TMX	MAXIMUM TEMPERATURE (°C)
TMN	MINIMUM TEMPERATURE (°C)
TMP	TEMPERATURE IN SECOND SOIL LAYER (°C)
SRAD	SOLAR RADIATION (MJ/M ²)
MUSL	SOIL LOSS FROM WATER EROSION USING MUSLE (T/HA)
RUS2	SOIL EROSION BY WATER ESTIMATED WITH RUSLE2 (T/HA)
FNO	ORGANIC NITROGEN FERTILIZER (ANIMAL WASTE) APPLIED (KG/HA)
FNMN	NITRATE NITROGEN FERTILIZER APPLIED (KG/HA)
FNMA	AMMONIUM NITROGEN FERTILIZER APPLIED (KG/HA)
FPO	ORGANIC PHOSPHORUS FERTILIZER APPLIED (KG/HA)
FPL	MINERAL PHOSPHORUS FERTILIZER APPLIED (KG/HA)
NFIX	NITROGEN FIXED BY LEGUMINOUS CROPS (KG/HA)
DN	NITROGEN LOSS BY DENITRIFICATION (KG/HA)
YN	SEDIMENT TRANSPORTED NITROGEN FROM SUBAREA OR REACH (KG/HA)
YPO	SEDIMENT TRANSPORTED ORGANIC PHOSPHORUS FROM SUBAREA (KG/HA)
QN	SUBAREA SOLUBLE N YIELD CONTAINED IN SURFACE RUNOFF (KG/HA)
QP	SOLUBLE PHOSPHORUS YIELD (KG/HA)
YPM	TOTAL MINERAL PHOSPHORUS LOSS (KG/HA)
SSFN	MINERAL NITROGEN LOSS IN LATERAL SUBSURFACE FLOW FROM SUBAREA OR REACH (KG/HA)
RSFN	SUBAREA SOLUBLE N YIELD IN RETURN FLOW (KG/HA)
MUSL	SOIL EROSION BY WATER USING MUSLE EQUATION (T/HA)

3.2 *.WSS – WATERSHED SUMMARY FILE

PART 1	LAND USE SUMMARY
CROP	CROP CODE
AREA	AREA DEDICATED TO CROP (HA)
FRACTION	FRACTION OF AREA DEDICATED TO CROP
YLD	YIELD OF CROP (T/HA)

PART 2 AVERAGE ANNUAL SUM OF SUBAREA OUTFLOWS/TOTAL WATERSHED OUTFLOW

PRCP	PRECIPITATION (MM)
QSS	WEIGHTED SUM BY AREA OF ALL SUBAREAS OF SURFACE RUNOFF (MM)
QSW	WATERSHED OUTFLOW--SURFACE RUNOFF COMPONENT (MM)
QTS	SUM OF TOTAL FLOW FROM ALL SUBAREAS (MM)
QTW	WATERSHED OUTFLOW (MM)
YS	SUM OF SEDIMENT YIELD FROM ALL SUBAREAS (T/HA)
YW	WATERSHED SEDIMENT YIELD (T/HA)
YNS	SUM OF SEDIMENT TRANSPORTED N FROM ALL SUBAREAS (KG/HA)
YNW	WATERSHED YIELD OF SEDIMENT TRANSPORTED N (KG/HA)
YPS	SUM OF SEDIMENT TRANSPORTED P FROM ALL SUBAREAS (KG/HA)
YPW	WATERSHED YIELD OF SEDIMENT TRANSPORTED P (KG/HA)
QNS	SUM OF SOLUBLE N YIELD FROM ALL SUBAREAS (KG/HA)
QNW	WATERSHED SOLUBLE N YIELD (KG/HA)
QPS	SUM OF SOLUBLE P YIELD FROM ALL SUBAREAS (KG/HA)
QPW	WATERSHED SOLUBLE P YIELD (KG/HA)
YMUS	SUM OF MANURE YIELD FROM ALL SUBAREAS (T/HA)
YMUW	WATERSHED MANURE YIELD (T/HA)
QPUS	SUM OF SUBAREA SOLUBLE PHOSPHORUS IN MANURE (KG/HA)
QPUW	SOLUBLE PHOSPHORUS YIELD IN MANURE FROM WATERSHED (KG/HA)
YCS	CARBON TRANSPORTED BY SEDIMENT (SUM OF SUBAREAS) (KG/HA)
YCW	CARBON TRANSPORTED BY SEDIMENT (FROM WATERSHED OUTLET) (KG/HA)

PART 3 SUBAREA SUMMARY

CMD	ROUTING COMMAND NAME
OUT ID#	ROUTING COMMAND NUMBER
SA#	SUBAREA NUMBER ASSIGNED BY COMPUTER
ID#	SUBAREA ID NUMBER INPUT BY USER
WSA	AREA OF SUBAREA OR REACH OUTLET (HA)
Q	SURFACE RUNOFF FROM SUBAREA OR REACH OUTLET (MM)
SSF	SUBSURFACE FLOW FROM ONE SUBAREA TO ANOTHER (MM)
QRF	QUICK RETURN FLOW (MM)
QDR	FLOW FROM A DRAINAGE SYSTEM (MM)
RTF	RETURN FLOW FROM GROUNDWATER STORAGE (MM)
Y	SEDIMENT YIELD FROM SUBAREA OR REACH OUTLET (T/HA)
DEP	SEDIMENT DEPOSITION WITHIN A REACH (T/HA)
DEG	SEDIMENT DEGRADATION WITHIN A REACH (T/HA)
YMNU	MANURE YIELD FROM SUBAREA OR REACH OUTLET (T/HA)
YC	CARBON LOSS WITH SEDIMENT (T/HA)
YN	SEDIMENT TRANSPORTED N FROM SUBAREA OR REACH (KG/HA)
QN	SOLUBLE N FROM SUBAREA OR REACH (KG/HA)
YP	SEDIMENT TRANSPORTED P FROM SUBAREA OR REACH (KG/HA)
QP	SOLUBLE P FROM SUBAREA OR REACH (KG/HA)
SSFN	SOLUBLE N FROM SUBAREA OR REACH (KG/HA)

QRFN	SOLUBLE N IN QUICK RETURN FLOW (KG/HA)
QDRN	SOLUBLE N FROM A DRAINAGE SYSTEM (KG/HA)
RTFN	SOLUBLE N IN RETURN FLOW (KG/HA)

3.3 *.SPS – PESTICIDE SUBAREA SUMMARY FILE

This file may include data for up to 10 pesticides

SA#	SUBAREA NUMBER
ID	SUBAREA ID
PDRN	PESTICIDE IN DRAINAGE SYSTEM (G/HA)
PRSF	PESTICIDE IN SUBSURFACE FLOW (G/HA)
PDPK	PESTICIDE IN DEEP PERCOLATION (G/HA)
PSIN	PESTICIDE INFLOW FROM ANOTHER SUBAREA (G/HA)

3.4 *.SWN – SPECIAL WATERSHED SUMMARY FOR NRCS FARM PLANNING FILE

QS	SURFACE RUNOFF (MM)
Y	SEDIMENT YIELD (T/HA)
QN	SOLUBLE NITROGEN IN SURFACE RUNOFF(KG/HA)
SSQN	SOLUBLE NITROGEN IN SUBSURFACE FLOW (KG/HA)
YN	AVERAGE ANNUAL SEDIMENT TRANSPORTED NITROGEN FROM SUBAREA OR REACH (KG/HA)
DWOC	CHANGE IN ORGANIC CARBON DURING SIMULATION (T/HA)

3.5 *.SCX – SUMMARY SOIL ORGANIC CARBON AND NITROGEN FILE

A column for each soil layer (soil profile is divided into 10 layers; however, the layers are identified with the original layer number). This file also includes a total across layers.

(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	CHANGE IN MINERAL N
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
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

3.6 *.STR – SUMMARY OF SUBAREAS AND WATERSHED FOR NRCS STAR TOOL

SA#	SUBAREA NUMBER ASSIGNED BY COMPUTER
SAID	SUBAREA ID NUMBER INPUT BY USER
RF	RAINFALL (MM)
Q	SURFACE RUNOFF (MM)
WYLD	WATER YIELD (MM)
RUS2	SOIL EROSION BY WATER USING RUSLE2 METHOD (T/HA)

Y	SEDIMENT YIELD (T/HA)
YWWD	SOIL EROSION BY WIND (T/HA)
YLDG	GRAIN YIELD (T/HA)
YLDF	FORAGE YIELD (T/HA)
WS	WATER STRESS (DROUGHT) (D)
NS	NITROGEN STRESS (D)
PS	PHOSPHORUS STRESS (D)
TS	LOW TEMPERATURE STRESS (D)
AS	AERATION STRESS (D)
SS	SALT STRESS (D)
FN	TOTAL ANNUAL NITROGEN FERTILIZER RATE (KG/HA)
FP	TOTAL ANNUAL PHOSPHORUS FERTILIZER RATE (KG/HA)
IRGA	IRRIGATION APPLIED (MM)
STIR	SOIL TILLAGE INTENSITY RATING
FULU1	FUEL USE (L/HA)
DWOC	CHANGE IN ORGANIC MATTER DURING SIMULATION (T/HA)
QN	SOLUBLE NITROGEN IN SURFACE RUNOFF (KG/HA)
SSFN	SOLUBLE NITROGEN IN SUBSURFACE FLOW (KG/HA)
QRFN	SOLUBLE NITROGEN IN QUICK RETURN FLOW (KG/HA)
QDRN	SOLUBLE NITROGEN IN DRAINAGE SYSTEM (KG/HA)
RTFN	SOLUBLE NITROGEN IN RETURN FLOW (KG/HA)
DPKN	DEEP PERCOLATION OF NITROGEN OUT OF GROUND WATER (KG/HA)
YN	SEDIMENT TRANSPORTED NITROGEN (KG/HA)
YNWN	NITROGEN LOSS IN WIND EROSION (KG/HA)
NVOL	NITROGEN VOLATILIZATION (KG/HA)
DNIT	DENITRIFICATION (KG/HA)
NFIX	NITROGEN FIXED BY LEGUMINOUS CROP (KG/HA)
QP	SOLUBLE PHOSPHORUS IN SURFACE RUNOFF (KG/HA)
SSFP	SOLUBLE PHOSPHORUS IN SUBSURFACE FLOW (KG/HA)
QDRP	SOLUBLE PHOSPHORUS IN DRAINAGE SYSTEM (KG/HA)
PRKP	PHOSPHORUS LOSS IN PERCOLATE (KG/HA)
YPWN	PHOSPHORUS LOSS IN WIND EROSION (KG/HA)
QPST	PESTICIDE IN SURFACE RUNOFF (G/HA)
LPST	LEACHED PESTICIDE (G/HA)
YPST	PESTICIDE IN SEDIMENT (G/HA)

3.7 *.SAO – SPECIAL SUBAREA FILE FOR GIS

SAID	SUBAREA ID
GIS	GIS CODE
TIME	<ul style="list-style-type: none"> • DAILY TIME STEP: THE JULIAN DATE • MONTHLY TIME STEP: THE MONTH (1-12) • ANNUAL TIME STEP: 4-DIGIT YEAR • AVERAGE ANNUAL SUMMARY LINES: NUMBER OF YEARS AVERAGED TOGETHER

NOTE: The time step is determined from IPD in the Control Table.

If IPD = 0 – 2, then time step is annual

If IPD = 3 – 5, then time step is monthly

If IPD = 6 – 9, then time step is daily

WSA	AREA OF SUBAREA OR SUBBASIN (HA)
PRCP	PRECIPITATION (MM)
SNOF	SNOWFALL (MM)
SNOM	SNOWMELT (MM)
IRGA	IRRIGATION APPLIED (MM)
PET	POTENTIAL EVAPOTRANSPIRATION FROM SUBAREA OR SUBBASIN (MM)
ET	ACTUAL EVAPOTRANSPIRATION FROM SUBAREA OR SUBBASIN (MM)
SW	SOIL WATER CONTENT (MM). AMOUNT OF WATER IN THE SOIL PROFILE AT THE END OF THE SIMULATION PERIOD.
PRK	WATER THAT PERCOLATES THROUGH THE ROOT ZONE DURING THE SIMULATION PERIOD (MM). THERE IS POTENTIALLY A LAG BETWEEN THE TIME THE WATER LEAVES THE BOTTOM OF THE ROOT ZONE AND REACHES THE SHALLOW AQUIFER. OVER A LONG PERIOD OF TIME, THIS VARIABLE SHOULD EQUAL GROUNDWATER PERCOLATION.
DPRK	DEEP PERCOLATION (MM)
QSUR	SURFACE RUNOFF CONTRIBUTION TO STREAMFLOW DURING SIMULATION PERIOD (MM)
SSF	LATERAL SUBSURFACE FLOW (MM)
RSSF	RETURN SUBSURFACE FLOW (MM)
WYLD	WATER YIELD (MM). THE NET AMOUNT OF WATER THAT LEAVES THE SUBAREA AND CONTRIBUTES TO STREAMFLOW.
CN	SCS RUNOFF CURVE NUMBER
TMX	MAXIMUM TEMPERATURE (°C)
TMN	MINIMUM TEMPERATURE (°C)
TMP	TEMPERATURE IN SECOND SOIL LAYER (°C)
SRAD	SOLAR RADIATION (MJ/M ²)
MUSL	SOIL LOSS FROM WATER EROSION USING MUSLE (T/HA)
RUS2	SOIL EROSION BY WATER ESTIMATED WITH RUSLE2 (T/HA)
FNO	ORGANIC NITROGEN FERTILIZER (ANIMAL WASTE) APPLIED (KG/HA)
FNMN	NITRATE NITROGEN FERTILIZER APPLIED (KG/HA)
FNMA	AMMONIUM NITROGEN FERTILIZER APPLIED (KG/HA)
FPO	ORGANIC PHOSPHORUS FERTILIZER APPLIED (KG/HA)
FPL	MINERAL PHOSPHORUS FERTILIZER APPLIED (KG/HA)
NFIX	NITROGEN FIXED BY LEGUMINOUS CROPS (KG/HA)
DN	NITROGEN LOSS BY DENITRIFICATION (KG/HA)
YN	SEDIMENT TRANSPORTED NITROGEN FROM SUBAREA OR REACH (KG/HA)
YPO	SEDIMENT TRANSPORTED ORGANIC PHOSPHORUS FROM SUBAREA (KG/HA)

QN	SUBAREA SOLUBLE N YIELD CONTAINED IN SURFACE RUNOFF (KG/HA)
QP	SOLUBLE PHOSPHORUS YIELD (KG/HA)
YPM	TOTAL MINERAL PHOSPHORUS LOSS (KG/HA)
SSFN	MINERAL NITROGEN LOSS IN LATERAL SUBSURFACE FLOW FROM SUBAREA OR REACH (KG/HA)
RSFN	SUBAREA SOLUBLE N YIELD IN RETURN FLOW (KG/HA)
WOC	TOTAL ORGANIC CARBON (T/HA)
PCTI200UM	PARTICLES (<200 MICRONS) TRANSPORTED WITH WATER INTO SUBAREA (KG/HA)
PCTI10UM	PARTICLES (<10 MICRONS) TRANSPORTED WITH WATER INTO SUBAREA (KG/HA)
PCTI2UM	PARTICLES (<2 MICRONS) TRANSPORTED WITH WATER INTO SUBAREA (KG/HA)
PCTO200UM	PARTICLES (<200 MICRONS) TRANSPORTED WITH WATER OUT OF SUBAREA (KG/HA)
PCTO10UM	PARTICLES (<10 MICRONS) TRANSPORTED WITH WATER OUT OF SUBAREA (KG/HA)
PCTO2UM	PARTICLES (<2 MICRONS) TRANSPORTED WITH WATER OUT OF SUBAREA (KG/HA)

THE FOLLOWING VARIABLES ARE DISPLAYED FOR UP TO 5 CROPS

YLDG	GRAIN YIELD (T/HA)
YLDF	FORAGE YIELD (T/HA)
HUI	HEAT UNIT INDEX
LAI	LEAF AREA INDEX (M ² /M ²)
RD	ROOTING DEPTH (M)
RW	ROOT WEIGHT (T/HA)
BIOM	CROP BIOMASS – INCLUDES ROOTS AND ABOVE GROUND PLANT MATERIAL(T/HA)
STL	STANDING LIVE PLANT BIOMASS (T/HA)
CPHT	CROP HEIGHT (M)
STD	STANDING DEAD CROP RESIDUE (T/HA)
STDL	STANDING DEAD LIGNIN (T/HA)
WS	DROUGHT STRESS (DAYS)
NS	NITROGEN STRESS (DAYS)
PS	PHOSPHORUS STRESS (DAYS)
TS	TEMPERATURE STRESS (DAYS)
AS	AERATION STRESS (DAYS)
SALT	SALT STRESS (DAYS)
REG	CROP GROWTH REGULATOR (MINIMUM STRESS FACTOR)
CPNM	CROP NAME

3.8 *.RCH – SPECIAL REACH FILE FOR GIS

RCID	REACH ID
GIS	GIS CODE
TIME	<ul style="list-style-type: none"> • DAILY TIME STEP: THE JULIAN DATE • MONTHLY TIME STEP: THE MONTH (1-12) • ANNUAL TIME STEP: 4-DIGIT YEAR • AVERAGE ANNUAL SUMMARY LINES: NUMBER OF YEARS AVERAGED TOGETHER

NOTE: The time step is determined from IPD in the Control Table.

If IPD = 0 – 2, then time step is annual

If IPD = 3 – 5, then time step is monthly

If IPD = 6 – 9, then time step is daily

WSA	AREA OF SUBAREA OR REACH OUTLET (HA)
QI	AVERAGE STREAMFLOW (SURFACE RUNOFF) INTO REACH (M ³ /S)
QO	AVERAGE STREAMFLOW (SURFACE RUNOFF) OUT OF REACH (M ³ /S)
WYLI	WATER YIELD INFLOW (M ³ /S)
WYLO	WATER YIELD OUTFLOW (M ³ /S)
ET	EVAPOTRANSPIRATION (M ³ /S)
FPF	WATER LOSS FROM REACH THROUGH INFILTRATION INTO STREAMBED OR FLOODPLAIN. (M ³ /S)
YI	SEDIMENT TRANSPORTED WITH WATER INTO REACH (TOTAL TONS)
YO	SEDIMENT TRANSPORTED WITH WATER OUT OF REACH (TOTAL TONS)
CY	SEDIMENT CONCENTRATION IN REACH (PPM)
YONI	ORGANIC NITROGEN TRANSPORTED WITH WATER INTO REACH (TOTAL KG)
YONO	ORGANIC NITROGEN TRANSPORTED WITH WATER OUT OF REACH (TOTAL KG)
YOPI	ORGANIC PHOSPHORUS TRANSPORTED WITH WATER INTO REACH (TOTAL KG)
YOPO	ORGANIC PHOSPHORUS TRANSPORTED WITH WATER OUT OF REACH (TOTAL KG)
NO3I	NITRATE TRANSPORTED WITH WATER INTO REACH (TOTAL KG)
NO3O	NITRATE TRANSPORTED WITH WATER OUT OF REACH (TOTAL KG)
NH4I	AMMONIUM TRANSPORTED WITH WATER INTO REACH (TOTAL KG)
NH4O	AMMONIUM TRANSPORTED WITH WATER OUT OF REACH (TOTAL KG)
NO2I	NITRITE TRANSPORTED WITH WATER INTO REACH (TOTAL KG)
NO2O	NITRITE TRANSPORTED WITH WATER OUT OF REACH (TOTAL KG)
QPI	MINERAL PHOSPHORUS TRANSPORTED WITH WATER INTO REACH (TOTAL KG)
QPO	MINERAL PHOSPHORUS TRANSPORTED WITH WATER OUT OF REACH (TOTAL KG)

ALGI	ALGAL BIOMASS TRANSPORTED WITH WATER INTO REACH (TOTAL KG)
ALGO	ALGAL BIOMASS TRANSPORTED WITH WATER OUT OF REACH (TOTAL KG)
BODI	CARBONACEOUS BIOCHEMICAL OXYGEN DEMAND OF MATERIAL TRANSPORTED INTO REACH (TOTAL KG)
BODO	CARBONACEOUS BIOCHEMICAL OXYGEN DEMAND OF MATERIAL TRANSPORTED OUT OF REACH (TOTAL KG)
DO2I	AMOUNT OF DISSOLVED OXYGEN TRANSPORTED INTO REACH (TOTAL KG)
DO2O	AMOUNT OF DISSOLVED OXYGEN TRANSPORTED OUT OF REACH (TOTAL KG)
QPSI	SOLUBLE PESTICIDE TRANSPORTED WITH WATER INTO REACH (TOTAL G)
QPSO	SOLUBLE PESTICIDE TRANSPORTED WITH WATER OUT OF REACH (TOTAL G)
YPSI	PESTICIDE SORBED TO SEDIMENT TRANSPORTED WITH WATER INTO REACH (TOTAL G)
YPSO	PESTICIDE SORBED TO SEDIMENT TRANSPORTED WITH WATER OUT OF REACH (TOTAL G)
RPST	LOSS OF PESTICIDE FROM WATER BY REACTION (TOTAL G)
VPST	LOSS OF PESTICIDE FROM WATER BY VOLATILIZATION (TOTAL G)
DPST	TRANSFER OF PESTICIDE FROM WATER TO STREAM OR FLOODPLAIN SEDIMENT BY SETTLING (TOTAL G)

3.9 *.ASA – ANNUAL SUBAREA FILE

SA#	SUBAREA NUMBER ASSIGNED BY COMPUTER
ID#	SUBAREA ID NUMBER INPUT BY USER
YR	YEAR DATE
YR#	YEAR NUMBER(1-NBYR)
PRCP	PRECIPITATION (MM)
SNOF	SNOWFALL (MM)
SNOM	SNOWMELT (MM)
IRGA	IRRIGATION WATER APPLIED (MM)
PET	POTENTIAL EVAPOTRANSPIRATION (MM)
ET	EVAPOTRANSPIRATION (MM)
SW	SOIL WATER CONTENT (
PRK	PERCOLATION BELOW THE ROOT ZONE (MM)
DPRK	DEEP PERCOLATION (MM)
Q	ANNUAL SURFACE RUNOFF (MM)
SSF	LATERAL SUBSURFACE FLOW (MM)
RSSF	RETURN SUBSURFACE FLOW (MM)
WYLD	WATER YIELD (MM). THE NET AMOUNT OF WATER THAT LEAVES THE SUBAREA AND CONTRIBUTES TO STREAMFLOW.
CN	SCS RUNOFF CURVE NUMBER
TMX	MAXIMUM TEMPERATURE (°C)
TMN	MINIMUM TEMPERATURE (°C)
TMP	TEMPERATURE IN SECOND SOIL LAYER (°C)
SRAD	SOLAR RADIATION (MJ/M ²)
MUSL	SOIL LOSS FROM WATER EROSION USING MUSLE (T/HA)
RUS2	SOIL EROSION BY WATER ESTIMATED WITH RUSLE2 (T/HA)
FNO	ORGANIC NITROGEN FERTILIZER (ANIMAL WASTE) APPLIED (KG/HA)
FNMN	NITRATE NITROGEN FERTILIZER APPLIED (KG/HA)
FNMA	AMMONIUM NITROGEN FERTILIZER APPLIED (KG/HA)
FPO	ORGANIC PHOSPHORUS FERTILIZER APPLIED (KG/HA)
FPL	MINERAL PHOSPHORUS FERTILIZER APPLIED (KG/HA)
NFIX	NITROGEN FIXED BY LEGUMINOUS CROPS (KG/HA)
DN	NITROGEN LOSS BY DENITRIFICATION (KG/HA)
YN	SEDIMENT TRANSPORTED NITROGEN FROM SUBAREA OR REACH (KG/HA)
YPO	SEDIMENT TRANSPORTED ORGANIC PHOSPHORUS FROM SUBAREA (KG/HA)
QN	SOLUBLE NITROGEN YIELD (KG/HA)
QP	SOLUBLE PHOSPHORUS YIELD (KG/HA)
YPM	TOTAL MINERAL PHOSPHORUS LOSS (KG/HA)
SSFN	MINERAL NITROGEN LOSS IN LATERAL SUBSURFACE FLOW FROM SUBAREA OR REACH (KG/HA)
RSFN	SUBAREA SOLUBLE N YIELD IN RETURN FLOW (KG/HA)

3.10 *.AWS – ANNUAL WATERSHED OUTLET FILE

YR	YEAR DATE
PRCP	PRECIPITATION (MM)
QSS	SUM OF SURFACE RUNOFF FROM ALL SUBAREAS (MM)
QSW	WATERSHED OUTFLOW--SURFACE RUNOFF COMPONENT (MM)
QTS	SUM OF TOTAL FLOW FROM ALL SUBAREAS (MM)
QTW	WATERSHED OUTFLOW (MM)
YS	SUM OF SEDIMENT YIELD FROM ALL SUBAREAS (T/HA)
YW	WATERSHED SEDIMENT YIELD (T/HA)
YNS	SUM OF SEDIMENT TRANSPORTED N FROM ALL SUBAREAS (KG/HA)
YNW	WATERSHED YIELD OF SEDIMENT TRANSPORTED N (KG/HA)
YPS	SUM OF SEDIMENT TRANSPORTED P FROM ALL SUBAREAS (KG/HA)
YPW	WATERSHED YIELD OF SEDIMENT TRANSPORTED P (KG/HA)
QNS	SUM OF SOLUBLE N YIELD FROM ALL SUBAREAS (KG/HA)
QNW	WATERSHED SOLUBLE N YIELD (KG/HA)
QPS	SUM OF SOLUBLE P YIELD FROM ALL SUBAREAS (KG/HA)
QPW	WATERSHED SOLUBLE P YIELD (KG/HA)
YMUS	SUM OF MANURE YIELD FROM ALL SUBAREAS (T/HA)
YMUW	WATERSHED MANURE YIELD (T/HA)
QPUS	SUM OF SUBAREA SOLUBLE PHOSPHORUS IN MANURE (KG/HA)
QPUW	SOLUBLE PHOSPHORUS YIELD IN MANURE FROM WATERSHED (KG/HA)
YCS	CARBON TRANSPORTED BY SEDIMENT (SUM OF SUBAREAS) (KG/HA)
YCW	CARBON TRANSPORTED BY SEDIMENT (FROM WATERSHED OUTLET) (KG/HA)

3.11 *.ACY – ANNUAL SUBAREA CROP YIELD FILE

SA#	SUBAREA NUMBER ASSIGNED BY COMPUTER
ID#	SUBAREA ID NUMBER INPUT BY USER
YR	YEAR
YR#	RUN YEAR NUMBER
CPNM	CROP NAME
YLDG	GRAIN, FIBER, ETC CROP YIELD (T/HA)
YLDF	FORAGE CROP YIELD (T/HA)
BIOM	CROP BIOMASS (T/HA)
WS	DROUGHT STRESS (DAYS)
NS	NITROGEN STRESS (DAYS)
PS	PHOSPHORUS STRESS (DAYS)
TS	TEMPERATURE STRESS (DAYS)
AS	EXCESS WATER STRESS (DAYS)
SS	SALT STRESS (DAYS)
ZNMN	MINERAL NITROGEN IN NITRATE FORM IN THE ROOT ZONE (KG/HA)
ZQP	SOLUBLE PHOSPHORUS IN THE ROOT ZONE (KG/HA)

AP15	PLOW DEPTH SOLUBLE PHOSPHORUS CONCENTRATION (G/T)
ZOC	ORGANIC CARBON IN THE ROOT ZONE (T/HA)
OCPD	ORGANIC CARBON IN PLOW DEPTH (%)
RSDP	CROP RESIDUE PRESENT (T/HA)
ARSD	ADDED CROP RESIDUE (T/HA)
IRGA	IRRIGATION APPLIED (MM)
FN	TOTAL ANNUAL NITROGEN FERTILIZER RATE (KG/HA)
FP	TOTAL ANNUAL PHOSPHORUS FERTILIZER RATE (KG/HA)
FNMN	NITRATE NITROGEN FERTILIZER APPLIED (KG/HA)
FNMA	AMMONIUM NITROGEN FERTILIZER APPLIED (KG/HA)
FNO	ORGANIC NITROGEN FERTILIZER (ANIMAL WASTE) APPLIED (KG/HA)
FPL	MINERAL PHOSPHORUS FERTILIZER APPLIED (KG/HA)
FPO	ORGANIC PHOSPHORUS FERTILIZER APPLIED (KG/HA)

3.12 *.MAN – SPECIAL MANURE MANAGEMENT SUMMARY FILE

PART 1	AVERAGE ANNUAL VALUES
SA#	SUBAREA NUMBER ASSIGNED BY COMPUTER
ID#	SUBAREA ID NUMBER INPUT BY USER
OWN#	SUBAREA OWNER NUMBER
CROP	CROP NAME
YLD1	GRAIN, FIBER, ETC CROP YIELD (T/HA)
YLD2	FORAGE CROP YIELD (T/HA)
YLN	N HARVESTED WITH CROP (KG/HA)
YLP	P HARVESTED WITH CROP (KG/HA)
COW	NUMBER OF COWS RESIDING ON THIS SUBAREA (HEAD)
WSA	AREA OF SUBAREA (HA)
Q	SURFACE RUNOFF FROM SUBAREA (MM)
Y	SEDIMENT YIELD FROM SUBAREA (T/HA)
QP	SOLUBLE P YIELD FROM SUBAREA (KG/HA)
YP	SUBAREA SEDIMENT TRANSPORTED P YIELD (KG/HA)
QN	SUBAREA SOLUBLE N YIELD CONTAINED IN SURFACE RUNOFF (KG/HA)
SSFN	SUBAREA SOLUBLE N YIELD IN SUBSURFACE FLOW (KG/HA)
RSFN	SUBAREA SOLUBLE N YIELD IN RETURN FLOW (KG/HA)
PRKN	SUBAERA SOLUBLE N LEACHED FROM SOIL PROFILE (KG/HA)
YN	SUBAREA SEDIMENT TRANSPORTED N YIELD (KG/HA)
FP	P FERTILIZER APPLIED TO SUBAREA (KG/HA)
FN	N FERTILIZER APPLIED TO SUBAREA (KG/HA)
MAP	MANURE APPLIED TO SUBAREA (T/HA)
AP0	INITIAL PLOW DEPTH(PARM(43) SOLUBLE P CONCENTRATION (G/T)

APF	FINAL PLOW DEPTH(PARM(43) SOLUBLE P CONC (G/T)
CSP	AVERAGE CONC OF SOLUBLE P IN SURFACE (G/M ³)

PART 2

OWN ID	OWNER ID NUMBER
AREA	AREA OWNED BY OWNER(HA)
MAP	MANURE APPLIED (T/HA/YR)

PART 3

MANURE BALANCE

BALANCE	MANURE BALANCE (T)
PER	PERCENT ERROR IN BALANCE
DF	ERROR IN THE BALANCE
TMPD	TOTAL MANURE PRODUCED BY ANIMALS (T/HA)
TWMB	BEGINNING MANUE CONTENT OF LAGOONS (T/HA)
TWMF	FINAL MANURE CONTENT OF LAGOONS (T/HA)
TSMU	SOLID MANURE STORED AT THE END OF THE RUN (T/HA)
RSDM	FINAL MANURE PRESENT IN THE SOIL AND ON THE SURFACE (T/HA)
YMNU	TOTAL MANURE EROSION (T)
MNMU	MINERLIZED MANURE (T/HA)

PART 4

MANURE APPLICATION BALANCE

PER	PERCENT ERROR IN BALANCE
DF	ERROR IN THE BALANCE
TWMP	TOTAL MANURE PRODUCED (T/HA)
TMAP	TOTAL MANURE APPLIED TO SUBAREA (T)
TWMB	BEGINNING MANUE CONTENT OF LAGOONS (T/HA)
TWMF	FINAL MANURE CONTENT OF LAGOONS (T/HA)
TSMU	SOLID MANURE STORED AT THE END OF THE RUN (T/HA)
YMFA	MANURE ERODED FROM FEED AREAS (T/HA)
LGOF	MANURE LOST IN LAGOON OVERFLOW (T/HA)
MNFA	MANURE MINERALIZED IN FEED AREA (T/HA)
RSFA	FINAL MANURE PRESENT IN FEED AREA (T/HA)

LIQ MAN APPL	TOTAL LIQUID MANURE APPLIED (T)
--------------	---------------------------------

COMM FERT APPL N	TOTAL COMMERCIAL NITROGEN FERTILIZER APPLIED (T)
COMM FERT APPL P	TOTAL COMMERCIAL PHOSPHORUS FERTILIZER APPLIED (T)

3.13 *.ACN - ANNUAL SOIL ORGANIC CARBON AND NITROGEN FILE

A column for each soil layer (soil profile is divided into 10 layers; however, the layers are identified with the original layer number). This file also includes a total across layers.
(units are kg/ha unless otherwise designated)

DEPTH	DEPTH OF SOIL LAYER (M)
BD 33KPA	BULK DENSITY AT FIELD CAPACITY (T/M3)
SAND(%)	PERCENT SAND IN SOIL (%)
SILT(%)	PERCENT SILT IN SOIL (%)
CLAY(%)	PERCENT CLAY IN SOIL (%)
ROCK(%)	PERCENT ROCK FRAGMENTS IN SOIL (%)
WLS	WEIGHT OF STRUCTURAL LITTER (KG/HA)
WLM	WEIGHT OF METABOLIC LITTER (KG/HA)
WLSL	WEIGHT OF LIGNIN CONTENT IN STRUCTURAL LITTER (KG/HA)
WLSC	WEIGHT OF STRUCTURAL LITTER C POOL (KG/HA)
WLMC	WEIGHT OF METABOLIC LITTER C POOL (KG/HA)
WLSLC	WEIGHT C CONTENT OF LIGNIN IN STRUCTURAL LITTER (KG/HA)
WLSLNC	WEIGHT NON-C CONTENT OF LIGNIN IN STRUCTURAL LITTER (KG/HA)
WBMC	BIOMASS C POOL (KG/HA)
WHSC	SLOW HUMUS C POOL (KG/HA)
WHPC	PASSIVE HUMUS C POOL (KG/HA)
WOC	TOTAL C POOL (KG/HA)
WLSN	STRUCTURAL LITTER N (KG/HA)
WLMN	METABOLIC LITTER N (KG/HA)
WBMN	BIOMASS N POOL (KG/HA)
WHSN	SLOW HUMUS N POOL (KG/HA)
WHPN	PASSIVE HUMUS N POOL (KG/HA)
WON	TOTAL N POOL (KG/HA)
ECND	ELECTRICAL CONDUCTIVITY (MMHO/CM)
WSLT	WEIGHT OF SALT (KG/HA)

3.14 *.SWT – WATERSHED OUTPUT TO SWAT

JDA	JULIAN DATE
YR	YEAR
WYLD	WATER YIELD (MM). THE NET AMOUNT OF WATER THAT LEAVES THE SUBAREA AND CONTRIBUTES TO STREAMFLOW.
Y	SEDIMENT YIELD (T/HA)
YN	SEDIMENT TRANSPORTED NITROGEN FROM SUBAREA OR REACH (KG/HA)
YP	SEDIMENT TRANSPORTED PHOSPHORUS FROM SUBAREA OR REACH (KG/HA)
QN	SOLUBLE N YIELD CONTAINED IN SURFACE RUNOFF (KG/HA)
QP	SOLUBLE PHOSPHORUS YIELD FROM SUBAREA OR REACH (KG/HA)
QPST	PESTICIDE IN SURFACE RUNOFF (G/HA)
YPST	PESTICIDE IN SEDIMENT (G/HA)

3.15 *.AWP – ANNUAL CEAP FILE

YR	YEAR
PRCP	PRECIPITATION MM
ET	EVAPOTRANSPIRATION (MM)
Q	ANNUAL SURFACE RUNOFF (MM)
SSF	LATERAL SUBSURFACE FLOW (MM)
RSSF	RETURN SUBSURFACE FLOW (MM)
QRF	QUICK RETURN FLOW (MM)
QDR	FLOW FROM A DRAINAGE SYSTEM (MM)
PRK	PERCOLATION BELOW THE ROOT ZONE (MM)
IRGA	IRRIGATION WATER APPLIED (MM)
WY	WATER YIELD (MM)
Y	SEDIMENT YIELD FROM SUBAREA OR REACH OUTLET (T/HA)
YWND	SEDIMENT LOST THROUGH WIND EROSION (T/HA)
QN	SOLUBLE NITROGEN IN RUNOFF (KG/HA)
SSFN	SOLUBLE NITROGEN IN SUBSURFACE FLOW (KG/HA)
QRFN	SOLUBLE NITROGEN IN QUICK RETURN FLOW (KG/HA)
RSFN	SOLUBLE NITROGEN IN RETURN FLOW (KG/HA)
YN	SEDIMENT TRANSPORTED NITROGEN (KG/HA)
YNWN	ORGANIC NITROGEN TRANSPORTED BY WIND EROSION (KG/HA)
QDRN	SOLUBLE NITROGEN FROM A DRAINAGE SYSTEM (KG/HA)
PRKN	MINERAL NITROGEN LOSS IN PERCOLATE (KG/HA)
DN	NITROGEN LOSS THROUGH DENITRIFICATION (KG/HA)
AVOL	NITROGEN VOLATILIZATION (KG/HA)
NFIX	NITROGEN FIXED BY LEGUMINOUS CROPS (KG/HA)
FNO	ORGANIC NITROGEN FERTILIZER APPLIED (ANIMAL WASTE) (KG/HA)
FNMN	NITRATE-N FERTILIZER APPLIED (KG/HA)
FNMA	AMMONIUM-N FERTILIZER APPLIED (KG/HA)
QP	SOLUBLE P YIELD FROM SUBAREA (KG/HA)
YP	SUBAREA SEDIMENT TRANSPORTED P YIELD (KG/HA)

YPWN	PHOSPHORUS LOSS IN WIND EROSION (KG/HA)
PRKP	PHOSPHORUS LOSS IN PERCOLATE (KG/HA)
FPO	ORGANIC PHOSPHORUS (ACTUAL P) IN MANURE (KG/HA)
FPL	MINERAL PHOSPHORUS FERTILIZER APPLIED (KG/HA)
QC	CARBON IN RUNOFF (KG/HA)
YC	CARBON LOSS WITH SEDIMENT (KG/HA)
YCWN	CARBON LOSS IN WIND EROSION (KG/HA)
RFN	NITROGEN IN RAINFALL (KG/HA)
YLN	N HARVESTED WITH CROP (KG/HA)
YLP	P HARVESTED WITH CROP (KG/HA)
BTN	BEGINNING TOTAL NITROGEN (KG/HA)
BTP	BEGINNING TOTAL PHOSPHORUS (KG/HA)
FTN	FINAL TOTAL NITROGEN (KG/HA)
FTP	FINAL TOTAL PHOSPHORUS (KG/HA)
BTC	BEGINNING TOTAL CARBON (KG/HA)
FTC	FINAL TOTAL CARBON (KG/HA)
BPDP	BEGINNING PHOSPHORUS IN PLOW LAYER (KG/HA)
FPDP	FINAL PHOSPHORUS IN PLOW LAYER (KG/HA)
BSLT	BEGINNING SALT CONTENT IN SOIL (KG/HA)
FSLT	FINAL SALT CONTENT IN SOIL (KG/HA)
BTC1	BEGINNING TOTAL CARBON IN SUBAREA 1(KG/HA)
FTC1	FINAL TOTAL CARBON IN SUBAREA 1 (KG/HA)
RUS2A1	SOIL LOSS IN SUBAREA 1 FROM WATER EROSION USING RUSLE2 EQ(T/HA)
YTHS	NUMBER OF DAYS WATER EROSION IS GREATER THAN THE THRESHOLD FOR WATER EROSION AS SET IN PARM 93 (DAYS)
YWTH	NUMBER OF DAYS WIND EROSION IS GREATER THAN THE THRESHOLD FOR WIND EROSION AS SET IN PARM 94 (DAYS)

3.16 *.APS – ANNUAL PESTICIDE FILE

This file may include data for up to 10 pesticides

SA#	SUBAREA NUMBER
SAID	SUBAREA ID
YR	YEAR
YR#	RUN YEAR NUMBER
Q	ANNUAL SURFACE RUNOFF (MM)
SSF	LATERAL SUBSURFACE FLOW (MM)
PRK	PERCOLATION BELOW THE ROOT ZONE (MM)
QDRN	DRAIN TILE FLOW (MM)
Y	SEDIMENT YIELD FROM SUBAREA OR REACH OUTLET (T/HA)
YOC	ORGANIC CARBON LOST WITH SEDIMENT (KG/HA)
PSTN	PESTICIDE NAME
PAPL	PESTICIDE APPLIED (G/HA)
PSRO	PESTICIDE IN RUNOFF (G/HA)

PLCH	PESTICIDE LEACHED (G/HA)
PSSF	PESTICIDE IN SUBSURFACE FLOW (G/HA)
PSED	PESTICIDE IN SEDIMENT (G/HA)
PDGF	PESTICIDE BIODEGRADED ON FOLIAGE (G/HA)
PDGS	PESTICIDE BIODEGRADED IN THE SOIL (G/HA)
PDRN	PESTICIDE IN DRAINAGE SYSTEM (G/HA)
PRSF	4-DAY PESTICIDE CONCENTRATION IN RUNOFF (PPB)

3.17 *.ACO – ANNUAL COST FILE

SA#	SUBAREA NUMBER
ID	SUBAREA ID
Y	YEAR
M	MONTH
D	DAY
OP	OPERATION NAME OR DESCRIPTION
CROP	CROP NUMBER (REFER TO CROP.DAT)
MT#	NUMBER OF MATERIAL FROM FERT OR PEST FILES
HC	IHC CODE (REFER TO TILL.DAT)
EQ	OPERATION OR EQUIPMENT CODE (REFER TO TILL.DAT)
TR	TRACTOR (REFER TO TILL.DAT)
COTL	TOTAL COST (\$/HA)
COOP	OPERATION COST (\$/HA)
MTCO	MATERIAL COST (\$/HA)
MASS	AMOUNT APPLIED (KG/HA)
FUEL	FUEL USAGE (L/HA)

3.18 APEXBUF.OUT – SPECIAL FILE FOR BUFFER STRIPS

WSA	WATERSHED AREA (HA)
CHL	CHANNEL LENGTH (KM)
CHS	CHANNEL SLOPE (M/M)
FPL	FLOW LENGTH ACROSS BUFFER (TYPICALLY ABOUT 0.01 KM) (KM)
Q	SURFACE RUNOFF FROM BUFFER STRIP (MM)
Y	SEDIMENT YIELD FROM BUFFER STRIP (T/HA)
YN	SEDIMENT TRANSPORTED NITROGEN (KG/HA)
YP	SEDIMENT TRANSPORTED PHOSPHORUS (KG/HA)
QN	SOLUBLE NITROGEN IN SURFACE RUNOFF (KG/HA)
QP	SOLUBLE PHOSPHORUS IN SURFACE RUNOFF (KG/HA)

3.19 *.MSA – MONTHLY SUBAREA FILE

This file contains data by month for numerous variables

SA #	SUBAREA NUMBER
ID	SUBAREA ID
YR	YEAR
YR#	YEAR NUMBER(1-NBYR)
TMX	MAXIMUM TEMPERATURE (°C)
TMN	MINIMUM TEMPERATURE (°C)
SRAD	SOLAR RADIATION (MJ/M ²)
PRCP	PRECIPITATION (MM)
SNOF	SNOWFALL (MM)
SNOM	SNOWMELT (MM)
VPD	VAPOR PRESSURE DEFICIT (KPA)
PET	POTENTIAL EVAPOTRANSPIRATION (MM)
ET	EVAPOTRANSPIRATION (MM)
EP	TRANSPIRATION (MM)
Q	SURFACE RUNOFF (MM)
CN	NRCS RUNOFF CURVE NUMBR
SSF	LATERAL SUBSURFACE FLOW (MM)
PRK	PERCOLATION BELOW THE ROOT ZONE (MM)
IRGA	IRRIGATION APPLIED (MM)
EI	RAINFALL ENERGY FACTOR
C	CROP MANAGEMENT FACTOR
USLE	SOIL LOSS FROM WATER EROSION USING USLE (T/HA)
MUSL	SOIL LOSS FROM WATER EROSION USING MUSLE (T/HA)
MUSS	SOIL EROSION-WATER (T/HA)
MUST	SOIL LOSS FROM WATER EROSION USING MODIFIED MUSLE (T/HA)
RUS2	SOIL LOSS FROM WATER EROSION USING RUSLE2 (T/HA)
YWND	SEDIMENT LOST THROUGH WIND EROSION (T/HA)
YN	SEDIMENT TRANSPORTED NITROGEN FROM SUBAREA OR REACH (KG/HA)
GMN	GROSS AMOUNT OF NITROGEN MINERALIZED (KG/HA)
DN	NITROGEN LOSS BY DENITRIFICATION (KG/HA)
NFIX	NITROGEN FIXED BY LEGUMINOUS CROPS (KG/HA)
NMN	NET AMOUNT OF NITROGEN MINERALIZED; I.E., NMN = GMN – N IMMOBILIZED (KG/HA)
NITR	NITRIFICATION (KG/HA)
AVOL	NITROGEN VOLATILIZATION (KG/HA)
QDRN	SOLUBLE NITROGEN FROM A DRAINAGE SYSTEM (KG/HA)
YP	PHOSPHORUS LOSS WITH SEDIMENT (KG/HA)
MNP	PHOSPHORUS MINERALIZED (KG/HA)
PRKP	PHOSPHORUS LOSS IN PERCOLATE (KG/HA)
ER	ENRICHMENT RATIO
FNO	ORGANIC NITROGEN FERTILIZER (ANIMAL WASTE) (KG/HA)
FNMN	NITRATE-N FERTILIZER (KG/HA)
FNMA	AMMONIUM-N FERTILIZER (KG/HA)

FPO	ORGANIC PHOSPHORUS (ACTUAL P) IN MANURE (KG/HA)
FPL	MINERAL PHOSPHORUS FERTILIZER APPLIED (KG/HA)
TMP	TEMPERATURE IN SECOND SOIL LAYER (°C)
SW10	SOIL WATER CONTENT IN TOP 10 MM
RSQI	RESERVOIR INFLOW (MM)
RSQO	RESERVOIR OUTFLOW (MM)
RSEV	RESERVOIR VOLUME (MM)
RSLK	RESERVOIR LEAKAGE WHICH GOES INTO GROUND WATER (MM)
DPRK	DEEP PERCOLATION (MM)
RSSF	RETURN SUBSURFACE FLOW (MM)
RSDC	CARBON CONTAINED IN CROP RESIDUE (KG/HA)
RSPC	CO ² RESPIRATION (KG/HA)
PRKC	CARBON LEACHED FROM ROOT ZONE (KG/HA)
QC	CARBON IN RUNOFF (KG/HA)
YC	CARBON LOSS WITH SEDIMENT (KG/HA)
RSDA	CROP RESIDUE ADDED AT HARVEST (KG/HA)
MAP	MANURE APPLIED TO SUBAREA (KG/HA)
QRF	QUICK RETURN FLOW (MM)
QRFN	SOLUBLE NITROGEN IN QUICK RETURN FLOW (KG/HA)
RFIC	RAINFALL INTERCEPTION (MM)
RSBK	RESERVOIR BACK WATER (MM)
YMNU	MANURE EROSION (KG/HA)
DEMR	DUST EMISSION RATE
P10D	DUST EMISSION WITH <10 MICRON PARTICLE SIZE (KG/HA)
DPKN	DEEP PERCOLATION OF NITROGEN OUT OF GROUNDWATER (KG/HA)
FPF	FLOODPLAIN INFILTRATION (MM)
FOC	ORGANIC CARBON FRACTION IN FERTILIZER
DEPC	CARBON DEPOSITED IN ROUTING REACH (KG/HA)
DECR	RESIDUE DECAY (T/HA)
PSOQ	POINT SOURCE FLOW VOLUME (MM)
PSON	POINT SOURCE SOLUBLE NITROGEN LOAD (KG/HA)
PSOP	POINT SOURCE SOLUBLE PHOSPHORUS LOAD (KG/HA)
RUSL	SOIL EROSION BY WATER ESTIMATED WITH RUSLE (T/HA)
QPU	SOLUBLE P REACH OUTFLOW OF MANURE
IRDL	IRRIGATION DISTRIBUTION LOSS
WYLD	WATER YIELD (MM). THE NET AMOUNT OF WATER THAT LEAVES THE SUBAREA AND CONTRIBUTES TO STREAMFLOW.
QI	AVERAGE STREAMFLOW (SURFACE RUNOFF) INTO REACH (M ³ /S)
QARS	RESERVOIR OUTFLOW (M ³)
RFRA	AMOUNT OF RAINFALL THAT FALLS ON RESERVOIR SURFACE (M ³)
DN2	LOSS OF DINITROGEN GAS (KG/HA)
YNWN	NITROGEN IN SEDIMENT DUE TO WIND EROSION
ZNMA	MINERAL NITROGEN IN AMMONIUM FORM IN ROOT ZONE (KG/HA)
ZNMN	MINERAL NITROGEN IN NITRATE FORM IN ROOT ZONE (KG/HA)
ZPML	MINERAL PHOSPHORUS IN LABILE FORM IN ROOT ZONE (KG/HA)
UNM	PLANT NITROGEN UPTAKE (KG/HA)
UPM	PLANT PHOSPHORUS UPTAKE (KG/HA)
RZSW	ROOT ZONE SOIL WATER (MM)

WTBL	INITIAL WATER TABLE HEIGHT (M)
GWST	GROUNDWATER STORAGE (MM)
STDO	STANDING DEAD CROP RESIDUE (T/HA)
RSD	CROP RESIDUE ON SOIL SURFACE (T/HA)
RSVQ	RESERVOIR STORAGE (MM)
RSVY	SEDIMENT CONTAINED IN RESERVOIR (T/HA)
RSSA	RESERVOIR SURFACE AREA (SQ. HA)
SWLT	WATER CONTENT OF SURFACE LITTER (MM)
SNO	WATER CONTENT OF SNOW (MM)
RSDM	MANURE PRESENT ON SOIL SURFACE (T/HA)
GWSN	NITROGEN CONTAINED IN GROUND WATER (KG/HA)

3.20 *.MWS – MONTHLY WATERSHED FILE

This file contains data by month and year for numerous variables

QSW	WATERSHED OUTFLOW-SURFACE RUNOFF COMPONENT (MM)
QTW	WATERSHED OUTFLOW (MM)
YW	SOIL LOSS FROM WIND EROSION (T/HA)
YNW	WATERSHED YIELD OF SEDIMENT TRANSPORTED NITROGEN (KG/HA)
YPW	WATERSHED YIELD OF SEDIMENT TRANSPORTED PHOSPHORUS (KG/HA)
QNW	WATERSHED SOLUBLE NITROGEN YIELD (KG/HA)
QPW	WATERSHED SOLUBLE PHOSPHORUS YIELD (KG/HA)
YMUW	MANURE YIELD FROM SUBAREA OR REACH OUTLET (T/HA)
QPUW	SOLUBLE PHOSPHORUS YIELD IN MANURE FROM WATERSHED (KG/HA)
YCW	CARBON TRANSPORTED BY SEDIMENT (FROM WATERSHED OUTLET) (KG/HA)

3.21 *.MSW – MONTHLY OUTPUT TO SWAT

AREA	WATERSHED AREA (HA)
YEAR	YEAR
MONTH	MONTH
WYLD	WATER YIELD (MM). THE NET AMOUNT OF WATER THAT LEAVES THE SUBAREA AND CONTRIBUTES TO STREAMFLOW.
Y	SEDIMENT YIELD FROM SUBAREA OR REACH OUTLET (T/HA)
YN	SEDIMENT TRANSPORTED NITROGEN FROM SUBAREA OR REACH (KG/HA)
YP	SEDIMENT TRANSPORTED PHOSPHORUS FROM SUBAREA OR REACH (KG/HA)
QN	SOLUBLE NITROGEN YIELD CONTAINED IN SURFACE RUNOFF FROM SUBAREA OR REACH (KG/HA)
QP	SOLUBLE PHOSPHORUS YIELD CONTAINED IN SURFACE RUNOFF FROM SUBAREA OR REACH (KG/HA)
QPST	PESTICIDE IN RUNOFF (G/HA)
YPST	PESTICIDE IN SEDIMENT (G/HA)

3.22 *.DPS – DAILY SUBAREA PESTICIDE FILE

SA#	SUBAREA NUMBER
SA ID	SUBAREA ID
Y	YEAR DATE
M	MONTH DATE
D	DAY DATE
RFV	PRECIPITATION (MM)
Q	SURFACE RUNOFF (MM)
SSF	TOTAL SUBSURFACE FLOW (MM)
YSD	SEDIMENT YIELD (T/HA)
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)
PSED	PESTICIDE TRANSPORTED BY SEDIMENT (G/HA)
PDGF	PESTICIDE DEGRADATION FROM FOLIAGE (G/HA)
PDGS	PESTICIDE DEGRADATION FROM SOIL (G/HA)
PFOL	PESTICIDE BIODEGRADED ON FOLIAGE SURFACE (END OF MONTH) (G/HA)
PSOL	PESTICIDE BIODEGRADED IN SOIL (END OF MONTH) (G/HA)
PDRN	PESTICIDE IN DRAINAGE SYSTEM OUTFLOW (G/HA)
PRSF	PESTICIDE IN SUBSURFACE FLOW (G/HA)
PDPK	PESTICIDE LOST IN DEEP PERCOLATION (G/HA)

3.23 *.SAD – DAILY SUBAREA FILE

SA#	SUBAREA NUMBER
ID	SUBAREA ID
Y	YEAR
M	MONTH
D	DAY
CPNM	CROP NAME
HUI	HEAT UNIT INDEX
LAI	LEAF AREA INDEX
RD	ROOTING DEPTH (M)
RW	ROOT WEIGHT (T/HA)
BIOM	CROP BIOMASS – INCLUDES ROOTS & ABOVE GROUND PLANT MATERIAL (T/HA)
STL	STANDING LIVE PLANT BIOMASS (T/HA)
CPHT	CROP HEIGHT (M)
STD	STANDING DEAD CROP RESIDUE (T/HA)
STDL	STANDING DEAD LIGNIN (T/HA)
WS	WATER STRESS (DROUGHT) (D)
NS	NITROGEN STRESS (D)
PS	PHOSPHORUS STRESS (D)
TS	LOW TEMPERATURE STRESS (D)
AS	AERATION STRESS (D)
SALT	SALT STRESS (D)
REG	CROP GROWTH REGULATOR (MINIMUM STRESS FACTOR)
TMX	MAXIMUM TEMPERATURE (°C)
TMN	MINIMUM TEMPERATURE (°C)
SRAD	SOLAR RADIATION (MJ/M ²)
PRCP	PRECIPITATION (MM)
RHUM	RELATIVE HUMIDITY
VPD	VAPOR PRESSURE DEFICIT (KPA)
PET	POTENTIAL EVAPOTRANSPIRATION (MM)
ET	EVAPOTRANSPIRATION (MM)
EP	TRANSPIRATION (MM)
ZNMA	MINERAL NITROGEN IN AMMONIUM FORM IN ROOT ZONE (KG/HA)
ZNMN	MINERAL NITROGEN IN NITRATE FORM IN ROOT ZONE (KG/HA)
ZPML	MINERAL PHOSPHORUS IN LABILE FORM IN ROOT ZONE (KG/HA)
UMN	PLANT NITROGEN UPTAKE (KG/HA)
UPM	PLANT PHOSPHORUS UPTAKE (KG/HA)
RZSW	ROOT ZONE SOIL WATER (MM)
WTBL	INITIAL WATER TABLE HEIGHT (M)
GWST	GROUNDWATER STORAGE (MM)
STDO	INITIAL STANDING DEAD CROP RESIDUE FROM OLD CROPS(T/HA)
RSD	CROP RESIDUE ON SOIL SURFACE (T/HA)
RSVQ	RESERVOIR STORAGE (MM)
RSVY	SEDIMENT CONTAINED IN RESERVOIR (T/HA)
SWLT	WATER CONTENT OF SURFACE LITTER (MM)

SNO	WATER CONTENT OF SNOW (MM)
RSDM	MANURE PRESENT ON SOIL SURFACE (T/HA)
GWSN	NITROGEN CONTAINED IN GROUND WATER (KG/HA)

3.24 *.DRS – DAILY RESERVOIR FILE

SA#	SUBAREA NUMBER
ID	SUBAREA ID
Y	YEAR
M	MONTH
D	DAY
PRCP	PRECIPITATION (M ³)
QI	INFLOW HYDROGRAPH RATE (M ³)
EV	EVAPORATION (M ³)
SP	SEEPAGE (M ³)
QO	OUTFLOW HYDROGRAPH RATE (M ³)
RSV	INITIAL RESERVOIR VOLUME (M ³)
RSVP	VOLUME AT PRINCIPAL SPILLWAY ELEVATION (M ³)
RSVE	VOLUME AT EMERGENCY SPILLWAY ELEVATION (M ³)
YI	SEDIMENT INFLOW (T/HA)
YO	SEDIMENT OUTFLOW (T/HA)
DEP	SEDIMENT DEPOSITION WITHIN A REACH (T/HA)
RSSA	RESERVOIR SURFACE AREA (HA)

3.25 *.DWS – DAILY WATERSHED OUTLET FILE

Y	YEAR
M	MONTH
D	DAY
RFV	PRECIPITATION (MM)
TMX	MAXIMUM TEMPERATURE (°C)
TMN	MINIMUM TEMPERATURE (°C)
SRAD	SOLAR RADIATION (MJ/M ²)
PRCP	PRECIPITATION (MM)
RHUM	RELATIVE HUMIDITY
VPD	VAPOR PRESSURE DEFICIT (KPA)
PET	POTENTIAL EVAPOTRANSPIRATION (MM)
ET	EVAPOTRANSPIRATION (MM)
EP	TRANSPIRATION (MM)

3.26 *.DGZ – DAILY GRAZING FILE

SA#	SUBAREA NUMBER
ID	SUBAREA ID
Y	YEAR DATE
M	MONTH DATE
D	DAY DATE
Y#	RUN YEAR NUMBER
ON#	OWNER NUMBER
HD#	HERD NUMBER
OPER	OPERATION
CROP	CROPPING SYSTEM NAME
YLD	CROP YIELD (KG/HA)
YSD	SEDIMENT YIELD (KG/HA)
AGPM	ABOVE GROUND PLANT MATERIAL (T/HA)
STL	STANDING LIVE PLANT BIOMASS (T/HA)
STD	STANDING DEAD CROP RESIDUE (T/HA)
CNLV	NITROGEN CONCENTRATION IN STANDING LIVE VEGETATION (G/G)
CNDD	NITROGEN CONCENTRATION IN STANDING DEAD VEGETATION(G/G)

3.27 *.DUX – DAILY MANURE APPLICATION FILE

SA#	SUBAREA NUMBER
ID	SUBAREA ID
Y	YEAR DATE
M	MONTH DATE
D	DAY DATE
Y#	RUN YEAR NUMBER
ON#	OWNER NUMBER
HD#	HERD NUMBER
FERT	FERTILIZER TYPE
AP RATE	FERTILIZER APPLICATION RATE (KG/HA)
MN	MINERAL NITROGEN APPLIED (KG/HA)
NH3	AMMONIA NITROGEN APPLIED (KG/HA)
ON	ORGANIC NITROGEN APPLIED (KG/HA)
MP	MINERAL PHOSPHORUS APPLIED (KG/HA)
OP	ORGANIC PHOSPHORUS APPLIED (KG/HA)

3.28 *.DDD – DAILY DUST DISTRIBUTION

ORDER #	ORDER OF SUBAREA FROM GREATEST TO LEAST DUST DISTRIBUTION
SA#	SUBAREA NUMBER
ID	SUBAREA ID
DP10	DUST DEPOSITION WITH <10 MICRON PARTICLE SIZE (KG/HA)
FRACT	FRACTION OF DUST EMISSION WHICH IS DEPOSITED IN THE SUBAREA
ACCUM	SUM OF THE FRACTION OF DUST EMISSION. THIS SHOULD BE NEAR 1

3.29 *.DCN – DAILY SOIL ORGANIC CARBON AND NITROGEN FILE

A column for each soil layer (soil profile is divided into 10 layers; however, the layers are identified with the original layer number). This file also includes a total across layers.
(C and N units are kg/ha unless otherwise designated)

YEAR	YEAR
MONTH	MONTH OF YEAR
DAY	DAY OF MONTH
SA#	SUBAREA NUMBER
ID	SUBAREA ID
DEPTH	SOIL DEPTH (M)
SW	SOIL WATER CONTENT (M/M)
TEMP	SOIL TEMPERATURE (°C)
RSD	CROP RESIDUE ON SOIL SURFACE (T/HA)
CO2 LOSS	CO ₂ LOST TO THE ATMOSPHERE FROM RESPIRATION (KG/HA)
NET MN	NET NITROGEN MINERALIZATION FROM LITTER, HUMUS, AND BIOMASS (KG/HA)
FOP	FRESH ORGANIC PHOSPHORUS (KG/HA)
TOTAL	TOTAL (FOR EACH APPROPRIATE VARIABLE) FOR ENTIRE SOIL PROFILE

3.30 *.EFR – RUNOFF EVENT FLOOD ROUTING FILE

CMD	COMMAND
IDO	OUTFLOW ID
ID	SUBAREA ID
Y	YEAR
M	MONTH
D	DAY
QP	PEAK FLOW RATE (M ³ /S)
TP	TIME TO PEAK (HR)
Q	RUNOFF VOLUME (MM)
SMQ	SUM OF RAINFALL EXCESS (MM)
SMH	SUM OF RUNOFF VOLUME IN HYDROGRAPH (MM)

3.31 *.EHY – RUNOFF EVENT HYDROGRAPHS FILE

SA	SUBAREA NUMBER
ID	SUBAREA ID
CMD	COMMAND
IDO	OUTFLOW ID
Y	YEAR
M	MONTH
D	DAY
T	TIME (HR)
WSAH	WATERSHED AREA (HA)
SCN	CN RETENTION PARMETER (MM)
QVOL	RUNOFF VOLUME (MM)
HYD	HYDROGRAPH STORAGE (MM)
TC	TIME OF CONCENTRATION (HR)
XKDT	RECESSION CONSTANT/TIME TO PEAK (HR)
RF	RAINFALL (MM)
QV	RUNOFF (MM)
DQ	CHANGE IN RUNOFF (M ³ /S)
ST	STORAGE (M ³ /S)
QHYP	OUTFLOW RATE (M ³ /S)
HYDVOL	TOTAL RUNOFF VOLUME (MM)
HYDST	TOTAL STORAGE (MM)
PEAKRATE	TOTAL PEAK RATE (M ³ /S)
TP	TOTAL TIME OF CONCENTRATION (HR)
WSAS	WATERSHED AREA (HA)
HYDV	RUNOFF (MM)
YI	INFLOW SEDIMENT (T/HA)
STY	STORAGE SEDIMENT (T/HA)

QHYS	OUTFLOW RATE (M ³ /S)
CY	SEDIMENT CONCENTRATION (PPM)
YHY	OUTFLOW SEDIMENT RATE (T/S)
YITOTAL	TOTAL INFLOW SEDIMENT (T/HA)
YIS	SEDIMENT INFLOW STORED FROM PREVIOUS DAY (T/HA)
YO	SEDIMENT OUTFLOW (T/HA)
YOS	SEDIMENT OUTFLOW STORED AT THE END OF THE DAY (T/HA)
IDN1	ROUTE INFLOW ID
WSAA	WATERSHED AREA (HA)
WSA (IDN1)	ROUTE INFLOW AREA (HA)
HYDVOLR	ROUTE INFLOW RUNOFF VOLUME (MM)
HYDSTRR	ROUTE INFLOW TOTAL STORAGE (MM)
QCAP	ROUTE CHANNEL FLOW CAPACITY (M ³ /S)
IT	ROUTE NUMBER OF ITERATIONS TO CONVERGING SOLUTION
RFR	ROUTE RAINFALL (MM)
QI	ROUTE REACH INFLOW HYDROGRAPH RATE (M ³ /S)
V	ROUTE FLOW VELOCITY (M/S)
TT	ROUTE TRAVEL TIME (HR)
C	ROUTE VARIABLE STORAGE COEFFICIENT
QIST	ROUTE QI PLUS STR
STR	ROUTE STORAGE (M ³ /S)
QOR	ROUTE OUTFLOW HYDROGRAPH REATE QI1 + QI2 (M ³ /S)
HYDVOLTOTR	ROUTE OUTFLOW RUNOFF VOLUME (MM)
HYDSTTOTR	ROUTE OUTFLOW TOTAL STORAGE (MM)
PEAKRATERT	ROUTE TOTAL PEAK RATE (M ³ /S)
TPR	ROUTE TOTAL TIME OF CONCENTRATION (HR)
AVE IT	ROUTE AVERAGE NUMBER OF ITERATIONS REQUIRED FOR COMPLETE SOLUTION OF ROUTING EQUATIONS
IDN1A	ADD HYD INFLOW ID
IDN2	ADD HYD ROUTE REACH ID
QI1	ADD HYD INFLOW RATE FOR SA1 (M ³ /S)
QI2	ADD HYD INFLOW RATE FOR SA2 (M ³ /S)
QO	ADD HYD OUTFLOW HYDROGRAPH RATE QI1 +QI2 (M ³ /S)
WSA (IDN1)A	ADD HYD INFLOW REACH AREA (HA)
WSA (IDN2)	ADD HYD REACH AREA (HA)
WSA (IDO)	ADD HYD OUTFLOW AREA (HA)
ADD VOLA	ADD HYD RUNOFF VOLUME (MM)
PEAK RATE A	ADD HYD TOTAL PEAK RATE (M ³ /S)
TPRA	ADD HYD TOTAL TIME OF CONCENTRATION (HR)
SA	SUBAREA NUMBER
ID	SUBAREA ID
CMD	COMMAND
IDO	OUTFLOW ID
Y	YEAR
M	MONTH
D	DAY
T	TIME (HR)
WSAH	WATERSHED AREA (HA)

SCN	CN RETENTION PARMETER (MM)
QVOL	RUNOFF VOLUME (MM)
HYD	HYDROGRAPH STORAGE (MM)
TC	TIME OF CONCENTRATION (HR)
XKDT	RECESSION CONSTANT/TIME TO PEAK (HR)
RF	RAINFALL (MM)
QV	RUNOFF (MM)
DQ	CHANGE IN RUNOFF (M ³ /S)
ST	STORAGE (M ³ /S)
QHYH	OUTFLOW RATE (M ³ /S)
HYDVOL	TOTAL RUNOFF VOLUME (MM)
HYDST	TOTAL STORAGE (MM)
PEAKRATE	TOTAL PEAK RATE (M ³ /S)
TP	TOTAL TIME OF CONCENTRATION (HR)
WSAS	WATERSHED AREA (HA)
HYDV	RUNOFF (MM)
YI	INFLOW SEDIMENT (T/HA)
STY	STORAGE SEDIMENT (T/HA)
QHYS	OUTFLOW RATE (M ³ /S)
CY	SEDIMENT CONCENTRATION (PPM)
YHY	OUTFLOW SEDIMENT RATE (T/S)
YITOTAL	TOTAL INFLOW SEDIMENT (T/HA)
YIS	SEDIMENT INFLOW STORED FROM PREVIOUS DAY (T/HA)
YO	SEDIMENT OUTFLOW (T/HA)
YOS	SEDIMENT OUTFLOW STORED AT THE END OF THE DAY (T/HA)
IDN1	ROUTE INFLOW ID
WSAA	WATERSHED AREA (HA)
WSA (IDN1)	ROUTE INFLOW AREA (HA)
HYDVOLR	ROUTE INFLOW RUNOFF VOLUME (MM)
HYDSTRR	ROUTE INFLOW TOTAL STORAGE (MM)
QCAP	ROUTE CHANNEL FLOW CAPACITY (M ³ /S)
IT	ROUTE NUMBER OF ITERATIONS TO CONVERGING SOLUTION
RFR	ROUTE RAINFALL (MM)
QI	ROUTE REACH INFLOW HYDROGRAPH RATE (M ³ /S)
V	ROUTE FLOW VELOCITY (M/S)
TT	ROUTE TRAVEL TIME (HR)
C	ROUTE VARIABLE STORAGE COEFFICIENT
QIST	ROUTE QI PLUS STR
STR	ROUTE STORAGE (M ³ /S)
QOR	ROUTE OUTFLOW HYDROGRAPH REATE QI1 + QI2 (M ³ /S)
HYDVOLTOTR	ROUTE OUTFLOW RUNOFF VOLUME (MM)
HYDSTTOTR	ROUTE OUTFLOW TOTAL STORAGE (MM)
PEAKRATERT	ROUTE TOTAL PEAK RATE (M ³ /S)
TPR	ROUTE TOTAL TIME OF CONCENTRATION (HR)
AVE IT	ROUTE AVERAGE NUMBER OF ITERATIONS REQUIRED FOR COMPLETE SOLUTION OF ROUTING EQUATIONS
IDN1A	ADD HYD INFLOW ID
IDN2	ADD HYD ROUTE REACH ID

QI1	ADD HYD INFLOW RATE FOR SA1 (M ³ /S)
QI2	ADD HYD INFLOW RATE FOR SA2 (M ³ /S)
QO	ADD HYD OUTFLOW HYDROGRAPH RATE QI1 +QI2 (M ³ /S)
WSA (IDN1)A	ADD HYD INFLOW REACH AREA (HA)
WSA (IDN2)	ADD HYD REACH AREA (HA)
WSA (IDO)	ADD HYD OUTFLOW AREA (HA)
ADD VOLA	ADD HYD RUNOFF VOLUME (MM)
PEAK RATE A	ADD HYD TOTAL PEAK RATE (M ³ /S)
TPRA	ADD HYD TOTAL TIME OF CONCENTRATION (HR)

3.32 *.DPW – DAILY WATERSHED PESTICIDE FILE

This file may include data for up to 10 pesticides

SA#	SUBAREA NUMBER
ID	SUBAREA ID
Y	YEAR
M	MONTH
D	DAY
RFV	PRECIPITATION (MM)
Q	ANNUAL SURFACE RUNOFF (MM)
SSF	LATERAL SUBSURFACE FLOW (MM)
YSD	SEDIMENT YIELD (T/HA)
PSTN	PESTICIDE NAME
PSRO	PESTICIDE IN RUNOFF (G/HA)
PSSF	PESTICIDE IN SUBSURFACE FLOW (G/HA)
PSED	PESTICIDE IN SEDIMENT (G/HA)

3.33 *.DHY – DAILY SUBAREA HYDROLOGY FILE

ISA	SUBAREA ID
NBSA	SUBAREA NUMBER
Y	YEAR
M	MONTH
D	DAY
CN	SCS RUNOFF CURVE NUMBER
SCI	RETENTION PARAMETER IN NRCS CN INDEX METHOD
RFV	PRECIPITATION (MM)
STMP2	SOIL TEMPERATURE IN SOIL LAYER 2(C°)
SML	SNOW MELT (MM)
Q	SURFACE RUNOFF (MM)
SSF	SUBSURFACE FLOW(MM)
QRF	QUICK RETURN FLOW (MM)
RSSF	RETURN SUBSURFACE FLOW (MM)
WYLD	WATER YIELD (MM)
QRB	PEAK FLOW RATE (MM/H)
TC	TIME OF CONCENTRATION (H)
DUR	DURATION (H)
ALTC	ALPHA
AL5	HALF-HOUR ALPHA
REP	PEAK RAINFALL INTENSITY (MM/H)
RZSW	ROOT ZONE SOIL WATER (MM)
GWST	GROUND WATER STORAGE (MM)

3.34 *.DMR – DAILY WATERSHED NUTRIENT AND SEDIMENT CONCENTRATION

JDA	JULIAN DATE
YR	YEAR
WYLD	WATER YIELD (MM)
Y	SEDIMENT CONCENTRATION (PPM)
YN	NITROGEN CONCENTRATION IN SEDIMENT (PPM)
YP	PHOSPHORUS CONCENTRATION IN SEDIMENT (PPM)
QN	SOLUBLE NITROGEN CONCENTRATION IN SURFACE RUNOFF (PPM)
QP	SOLUBLE PHOSPHORUS CONCENTRATION IN SURFACE RUNOFF (PPM)

3.35 *.MRH – MONTHLY REACH FILE (ANNUAL GIS REACH FILE FOR SELECTED COMMAND #'S ICMO (FROM .SIT))

3.36 *.MGZ – MONTHLY GRAZING FILE

3.37 *.DNC – DAILY NITROGEN/CARBON CESAR IZAURRALDE

3.38 *.DHS – DAILY HYDROLOGY/SOIL

3.39 *.SW4 – DAILY OUTPUT FOR SELECTED COMMAND #'S (FROM .SIT)

**3.40 *.DGN – DAILY GENERAL OUTPUT (VAR
AFTER COMMAND LOOP IN BSIM)**

3.41 *.DPD – DAILY PADDY OUTPUT

3.42 *.ASL – ANNUAL SOIL TABLE

**3.43 *.MS5 – MONTHLY SOIL PROPERTIES 0 –
0.05M**

3.44 *.AS5 – ANNUAL SOIL PROPERTIES 0 – 0.05M

3.45 RUN1501.SUM

CHAPTER 4

APEX OUTPUT ANALYZER

4.1 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. **Improperly constructed subarea file (*.SUB):**
Incorrect routing instructions.
4. **When daily weather is input:**
Incorrect format.

4.2 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.

4.3 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)

4.4 GENERAL PROBLEMS

1. Working files don't match those contained in APEXFILE.DAT
For example you are working with CROP1501.DAT and APEXFILE.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 APEXCONT.DAT must be equal or greater than the one appearing on line one of the weather file (*.WTH).

4.5 COMPLETED RUNS--EXAMINE *.OUT FILES

Select monthly output in APEXCONT.DAT (IPD = 3).

PRELIMINARY INVESTIGATION

1. Check nutrient and water balances for each subarea (look for BALANCE). They should be near 0.
2. Check water balance for the entire watershed (TOTAL WATER BALANCE).
3. Check total watershed area--if it is not correct there is an error in the routing instructions (last line of last table --AVERAGE ANNUAL DATA).
4. Check average annual surface runoff, water yield, and sediment and nutrient yields (same line as in 3.).
5. If results in line 4 are not reasonable check individual subarea contributions (use last table or for more detail see SUMMARY TABLE).

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 PARM1501.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 PARM1501.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) (PARM1501.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. **Routing:**

Considerable runoff can be infiltrated into floodplains depending on travel time and floodplain saturated conductivity (minimum of FPS0 input in APEXCONT.DAT or floodplain second soil layer SC).

Flow through a routing reach can be increased by return flow from groundwater and quick return flow. Maximum groundwater storage, groundwater residence time, and ratio of return flow to return flow + deep percolation can be set in APEXCONT.DAT. These values are overridden by values >0. on line 2 of *.SOL. Groundwater storage must exceed a threshold value (PARM(40) PARM1501.DAT) before return flow occurs.

5. **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 km². The USLE is an erosion equation that is useful in studies like assessing the effect of erosion on productivity.

6. **Slope length and steepness factor:**

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

7. **Routing:**

Net deposition or degradation can occur as sediment is transported through a routing reach. Values of deposition and degradation are shown for each reach in the last table in *.OUT (AVERAGE ANNUAL DATA). The delivery ratio of the channel/floodplain system is obtained by dividing YO by YI (WATERSHED SUMMARY TABLE). This is not a true watershed delivery ratio because deposition occurs within the subareas. Thus, YO/YI should generally range from 0.5 to 0.95.

Problems:

(1) Channel and floodplain geometry not well defined. Under estimating channel capacity causes excessive floodplain flow and thus deposition and floodplain scour. Over estimating channel capacity may cause large erroneous delivery ratios. Valley section surveys are desirable but almost never available. GIS lacks detail particularly for channel dimensions. In the absence of good data it is best to let the model estimate channel and floodplain dimensions. Values of channel capacity flow rate (QG in mm/h), bottom width/depth (BWD), and floodplain width/channel width (FCW) can be input in APEXCONT.DAT. Many natural channels can accommodate a 2 year frequency flow rate.

(2) The channel cover and soil erodibility factors poorly estimated. The USLE C (RCHC) and K (RCHK) factors are input on the fifth line of each subarea in *.SUB. If the product of these factors is extremely low (0.001) very little channel erosion will occur regardless of flow conditions. If the product is large (0.3) severe channel erosion may result.

(3) The sediment concentration at a 1.0 m/s velocity (PARM(19)) in PARM1501.DAT may not be appropriate for the watershed. The concentration in t/m³ should normally range from 0.05 to 0.25. This is the base concentration used in the routing equation. High values cause over estimation of sediment transport.

8. **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.

4.6 APEX****.OUT (THE DETAILED SIMULATOR OUTPUT FILE)

The APEX****.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
 - APEXfile.DAT listing
 - Run #
 - Weather data
 - Management data
 - Crop
 - Subarea
 - Soil
 - Routing Reach
 - Reservoir
 - Routing Scheme

2. Output
 - Simulation results
 - Summary

CHAPTER 5

VALIDATION

5.1 VALIDATION OF CROP YIELDS

USER NOTE OF CAUTION: If a multiple-run has been executed (denoted by a value greater than zero in col. 4 in MLRN1501.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 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 AVERAGE CROP YIELDS OVER ALL YEARS AND SUBAREAS IN A WATERSHED, open the *.man file. Read below the columns “YLD1” and “YLD2”; the first number is the average grain yield and the second, the average forage yield over the number of years simulated. Copy this file to EXCEL or ACCESS to average the yields for each crop across subareas. Then compare the average watershed yield with the historical yield reported in the watershed. (If historical yields are available for specific years, make the APEX run using a daily weather file for the years in question specified in line 13 of the *.sit file). If one or more crop yields are not accurate, follow the list of instructions below to produce more accurate yields:

- **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 *.man file where both grain and forage yields (YLD1 and YLD2) are listed by crop and subarea. Unusually low yielding soils can be identified by referring to the specific subarea number in the *.sub file. 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 APEXCONT.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 (decrease) the simulated 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.

- **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 CROP1501.DAT file for the appropriate crop. In the Crop Parameters table each row with the same parameter name a different subarea. If the two leaf area indices are near equal and the crop yield is low, increase the index value in CROP1501.DAT.

- **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 CROP1501.DAT, the harvest index (HI) relates to the grain yield only as a ratio of the above-ground biomass. The higher (lower) the ratio, the more (less) grain yield reported for a given level of biomass. Similarly, the biomass to energy ratio (WA) increases (decreases) yields through biomass changes and, therefore, both grain and forage yields increase (decrease).

5.2 MODEL ADJUSTMENT FOR VALIDATING RUNOFF AND SEDIMENT LOSSES

METHOD 1: FOR THE LAYMAN USER

USER NOTE OF CAUTION: If a multiple-run has been executed (denoted by a value greater than zero in col. 4 in MLRN1501.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 APEX1501 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 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.

- **Fourth, check the subarea and watershed size-**

Correct runoff/sediment losses by checking the number of watersheds and their areas for accuracy. Open the *.wss file and check the accumulated area in the last line of the WSA column and then each subarea above.

- **Fifth, 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.

- **Sixth, check the saturated conductivity values for soils-**

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

- **Seventh, 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.
- **Eighth, 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).
- **Ninth, 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.
- **Tenth, 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.
- **Eleventh, revise the value of Parm (42)-**
Revise the value of Parm(42) which has a range of 0.5 to 1.5. Higher values increase runoff/sediment losses and vice versa.

METHOD 2: FOR THE TECHNICAL USER

USER NOTE OF CAUTION: If a multiple-run has been executed (denoted by a value greater than zero in col. 4 in MLRN1501.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 APEX1501 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 \surd 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 the subarea and watershed size-**
Correct runoff/sediment losses by checking the number of watersheds and their areas for accuracy. Open the *.wss file and again go to the second set of results to check the accumulated area in the last line of the WSA column and then each subarea above.
- **Sixth, 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”.
- **Seventh, 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.
- **Eighth, check the choice of water erosion equation-**
For watershed analyses, open APEXCONT.DAT, line 5 (DRV), where sediment losses need to be indicated with the recommended choices of #3 (MUSS) or #0 (MUST).
- **Ninth, 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”.
- **Tenth, 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.

- **Eleventh, 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.

- **Twelfth, revise the value of Parm (42)-**

Revise the value of Parm(42) which has a range of 0.5 to 1.5. Higher values increase runoff/sediment losses and vice versa.

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

- Open APEXCONT.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 19 for a more accurate simulation of MUST/MUSS.

APPENDICES

APPENDIX A—MANNING’S N SURFACE ROUGHNESS (UPN)

Surface Roughness Manning’s N for Upland; the surface roughness factor is Manning’s N.

Values of Manning’s N for various conditions:

Overland flow	Value chosen	Range
Fallow, no residue	[.0100]	0.008-0.012
Conventional tillage, no residue	[.0900]	0.06-0.12
Conventional tillage, residue	[.1900]	0.16-0.22
Chisel plow, no residue	[.0900]	0.06-0.12
Chisel plow, residue	[.1300]	0.10-0.16
Fall disking, residue	[.4000]	0.30-0.50
No till, no residue	[.0700]	0.04-0.10
No till (0.5-1.0 t/ha)	[.1200]	0.07-0.17
No till (2.0-9.0 t/ha)	[.3000]	0.17-0.47
Rangeland (20% cover)	[.6000]	
Short grass prairie	[.1500]	0.10-0.20
Dense grass	[.2400]	0.17-0.30
Bermuda grass	[.4100]	0.30-0.48

(1) Blank if unknown (enter zero) [.0000]

APPENDIX B—ROUTING REACH & CHANNEL MANNING’S N (RCHN & CHN)

Reach Channel Manning’s N (RCHN); if set to 0 will be calculated.

Type of Channel	Value	Chosen Range
A. Excavated or dredged		
1. Earth, straight and uniform	.0250	.016-.033
2. Earth, winding and sluggish	.0350	.023-.050
3. Not maintained, weeds and brush	.0750	.040-.140
B. Natural Streams		
1. Few trees, stones or brush	.0500	.025-.065
2. Heavy timber and brush	.1000	.050-.150

If the channel conducting runoff to the edge of the field is winding and/or contains obstructions, water flow rates will be reduced, and sediment will have an opportunity to settle. The channel roughness factor is referred to as the Manning's N value. The table contains suggested values of Manning's N for various conditions of channel flow.

APPENDIX C—APEX PUBLICATIONS

APEX Journal Article References

1. Azevedo, J.C., J.R. Williams, M.G. Messina, and R.F. Fisher. 2005. Impacts of the sustainable forestry initiative landscape level measures on hydrological processes. *Water Resour. Manage.* 19: 95
2. Azevedo, J.C., X.B. Wu, M.G. Messina, and R.F. Fisher. 2005. Assessment of sustainability in intensively managed forested landscapes: A case study in eastern Texas. *Soc. Amer. Foresters* 51(4): 321-333.
3. Chen, X., W. L. Harman, M. Magre, E. Wang, R. Srinivasan, J. R. Williams. 2000. "Water quality assessment with agro-environmental indexing of non-point sources, Trinity River Basin." *Applied Engineering in Agriculture* 16(4):405-417.
4. Fox, Garey A. 1998. "Investigation of High Plains Management Practices with the APEX Modeling System." *Texas A&M Undergraduate Journal of Science*, Vol. 2 (1):9-16, Spring issue.
5. Gassman, P.W., E. Osei, A. Saleh, and L.M. Hauck. 2002. Application of an environmental and economic modeling system for watershed assessments. *J. Amer. Water Res. Assoc.* 38(2): 423-438.
6. Gassman, P.W., E. Osei, A. Saleh, J. Rodecap, S. Norvell, and J.R. Williams. 2006. Alternative practices for sediment and nutrient loss control on livestock farms. *Agric., Ecosys. & Environ.* 17(2-3): 135-144.
7. Harman, W.L., E. Wang, and J.R. Williams. 2004. Reducing atrazine losses: water quality implications of alternative runoff control practices. *J. Environ. Qual.* 33: 7-12.
8. J.R. Williams, W.L. Harman, M. Magre, U. Kizil, J. A. Lindley, G. Padmanabhan and E. Wang. 2006. APEX feedlot water quality simulation. *Trans. of the ASABE.* 49(1):61-73.
9. Paudel, K.P., D. Hite, W. Intarapong, and D. Susanto. 2003. A watershed-based economic model of alternative management practices in southern agricultural systems. *J. Agric. Applied Econ.* 35(2): 381-389.
10. Osei, E., B. Du, A. Bekele, L. Hauck, A. Saleh, and A. Tanter. 2008. Impacts of alternative manure application rates on Texas animal feeding operations: A macro level analysis. *J. Amer. Water Res. Assoc.* 44(3) (on-line; in press).
11. Osei, E., P.W. Gassman, R. Jones, S. Pratt, L. Hauck, L. Beran, W. Rosenthal, and J.R. Williams. 2000a. Economic and Environmental Impacts of Alternative Practices on Dairy Farms in an Agricultural Watershed. *J. Soil Water Cons.* 55(4): 466-472.
12. Osei, E., P.W. Gassman, L.M. Hauck, S. Neitsch, R.D. Jones, J. Mcnitt, and H. Jones. 2003a. Using Nutrient Management to Control Nutrient Losses from Dairy Pastures. *J. Range Manage.* 56: 218-226.
13. Osei, E., P.W. Gassman, L.M. Hauck, R. Jones, L. Beran, P.T. Dyke, D.W. Goss, J.D. Flowers, and A.M.S. McFarland. 2003b. Economic Costs and Environmental Benefits of Manure Incorporation on Dairy Waste Application Fields. *J. Environ. Manage.* 68(1): 1-11.
14. Qiu, Z., T. Prato, L. Godsey, and V. Benson. 2002. Integrated assessment of uses of woody draws in agricultural landscapes. *J. Amer. Water Resour. Assoc.* 38(5): 1255-1269.
15. Ramanarayanan, Tharacad S., M. V. Padmanabhan, G. N. Gajanan, Jimmy Williams. 1998. "Comparison of simulated and observed runoff and soil loss on three small United States watersheds." *NATO ASI Series I*(55):76-88.
16. Saleh, A., J.G. Arnold, P.W. Gassman, L.W. Hauck, W.D. Rosenthal, J.R. Williams, and A.M.S. McFarland. 2000. Application of SWAT for the Upper North Bosque watershed. *Trans. ASAE* 43(5): 1077-1087.
17. Saleh, A. and O. Gallego. 2007. Application of SWAT and APEX using the SWAPP (SWAT-APEX) program for the Upper North Bosque River Watershed in Texas. *Trans. ASABE* 50(4): 1177-1187.
18. Saleh, A. J.R. Williams, J.C. Wood, L.M. Hauck, and W.H. Blackburn. 2004. Application of APEX for forestry. *Trans. ASAE* 47(3): 751-765.
19. Wang, E., C. Xin, J.R. Williams, and C. Xu. 2006. Predicting soil erosion for alternative land uses. *J. Environ. Qual.* 35: 459-467.
20. Wang, E., W. L. Harman, J. R. Williams, and J. M. Sweeten. 2002. "Profitability and nutrient losses of alternative manure application strategies with conservation tillage." *J. Soil and Water Conservation* 57(4):221-228.

21. Wang, X., W.E. Fox, J.R. Williams, P. Tuppad, D. Hoffman, J. Wolfe. 2008. Impact of watershed subdivision on APEX runoff and sediment load predictions. *J. Hydrol* (in review).
22. Wang, X., P.W. Gassman, J.R. Williams, S. Potter, and A.R. Kemanian. 2008. Modeling the impacts of soil management practices on runoff, sediment yield, maize productivity, and soil organic carbon using APEX. *Soil Till. Res.* (in review).
23. Wang, X., S.R. Potter, J.R. Williams, J.D. Atwood, and T. Pitts. 2006. Sensitivity analysis of APEX for national assessment. *Trans. ASABE* 49(3): 679-688.
24. Wang, X., A. Saleh, M.W. McBroom, J.R. Williams, and L. Yin. 2007. Test of APEX for nine forested watersheds in east Texas. *J. Environ. Qual.* 36: 983-995.
25. Williams, J.R., W.L. Harman, M. Magre, U. Kizil, J.A. Lindley, G. Padmanabhan, and E. Wang. 2006. APEX feedlot water quality simulation. *Trans. ASAE* 49(1): 61-73.
26. Yin, L., X. Wang, J. Pan, and P.W. Gassman. 2007. Evaluation of APEX for daily runoff and sediment yield from three plots in the Upland Huaihe River watershed, China. *Trans. ASABE* (in review).

Model Review Journal Articles that include discussion about APEX

27. Borah, D.K., G. Yagow, A. Saleh, P.L. Barnes, W. Rosenthal, E.C. Krug, and L.M. Hauck. 2006. Sediment and nutrient modeling for TMDL development and implementation. *Trans. ASABE* 49(4): 967-986.
28. Srivastava, P., K.W. Migliaccio, and J. Šimůnek. 2007. Landscape models for simulating water quality at point, field, and watershed scales. *Trans. ASABE* 50(5): 1683-1693.
29. Williams, J.R., J.G. Arnold, J.R. Kiniry, P.W. Gassman, and C.H. Green. 2007. History of model development at Temple, Texas. *Hydrological Sciences Journal* (in review).

APEX book Chapters

30. Williams, J.R., J.G. Arnold, R. Srinivasan, and T.S. Ramanarayanan. 1998. APEX: A new tool for predicting the effects of climate and CO₂ changes on erosion and water quality. In: *Modelling Soil Erosion by Water*, 441-449. J. Boardman, J. and D. Favis-Mortlock, eds. NATO ASI Series / Global Environmental Change, Vol. I 55. Berlin, Germany: Springer-Verlag.
31. Williams, J.R. and R.C. Izaurralde. 2006. The APEX model. In *Watershed Models*, 437-482. Singh, V.P. and D.K. Frevert, eds. Boca Raton, Florida: CRC Press, Taylor & Francis.

Conference/Proceedings Papers that describe APEX applications

32. Gassman, P.W., J. Abraham, L. Hauck, A. Saleh, and K. Keplinger. 2001. Simulation of nutrient losses from chicken litter applications in east central Texas with APEX and SWAT. Presented at the 2001 ASAE Annual International Meeting, July 30-Aug. 1, Sacramento, CA. ASAE Paper No. 01-2004, St. Joseph, MI: American Society of Agricultural Engineers.
33. Gassman, P.W., A. Saleh, E. Osei, J. Abraham, and J. Rodecap. 2003. Environmental and economic impacts of alternative management scenarios for the Mineral Creek Watershed. In: *Proceedings of the Total maximum Daily Load (TMDL) Environmental Regulations II*, 323-331, Nov. 8-12, Albuquerque, NM. St. Joseph, MI: American Society of Agricultural Engineers.
34. Harman, Wyatt L., E. Wang, and J. R. Williams. 2002. "Herbicide remediation to protect water quality: Simulation results of APEX." Presented at the International Conference on Environmentally Sustainable Agriculture for Dry Areas for the 3rd Millennium, Shijiazhuang, Hebei, Peoples Republic of China, Sept. 15-19.
35. Harman, W. L., J. R. Williams, M. Magre, and E. Wang. 2003. "Reducing nutrient losses from CAFOs: A simulation analysis of feedlot management options and filter strip characteristics." Presented at the International Conference on Agriculture and Science Technology, Houston, Texas, Oct. 12 – 15.
36. Hauck, L.M., G. Ice, and A. Tanter. 2005. Challenges to and opportunities for applying the Comprehensive Economic and Environmental Optimization (CEEOT) Tool to forestry activities. In: *Watershed Management to Meet Water Quality Standards and Emerging TMDL (Total Maximum Daily Load)*, Proceedings of the Third Conference, pp. 533-542, March 5-9, Atlanta, GA. American Society of Agricultural Engineers, St. Joseph, MI.

37. Intarapapong, W. and D. Hite. 2003. Watershed-level policies to implement best management practices under environmental risk. Presented at the Southern Agricultural Economics Association Annual Meeting, Feb. 1-5, Mobile, AL.
38. Intarapapong, W., D. Hite, and A. Renck. 2002. Environmental risk assessment under environmental standard and safety-first constraints. Presented at the Western Agricultural Economics Association Annual Meeting, July 28-31, Long Beach, CA.
39. Izaurralde, R. C., J. R. Williams, W. B. McGill, and N. J. Rosenberg. 2001. "Simulating Soil Carbon Dynamics, Erosion, and Tillage with EPIC." Paper presented at the First National Conference on Carbon Sequestration, Washington DC, May 14 – 17.
40. Osei, E., B. Du, and L.M. Hauck. 2007. Impacts of changing herd sizes on the effects of manure application rates. In: Watershed Management to Meet Water Quality Standards and TMDLs: 4th Conference Proceedings, March 10-14, San Antonio, TX, 59-66. A. McFarland and A. Saleh, eds. American Society of Agricultural and Biological Engineers, St. Joseph, MI.
41. Osei, E., B. Du, L.M. Hauck, A. Saleh, and A. Tanter. 2008. Macro-level analysis of CNMPs in the Ohio River Basin. In: Proceedings of the 21st Century Watershed Technology: Improving Water Quality and Environment Conference, March 29-April 3, Concepción, Chile. E.W. Tollner and A. Saleh, eds. St. Joseph, MI: American Society of Agricultural and Biological Engineers.
42. Osei, E., J. McNitt, P. Gassman, W. Rosenthal, and H. Jones. 1998. An economic and environmental appraisal of selected manure management practices in agricultural watersheds. In: Watershed Management: Moving from Theory to Implementation, March 3-6, Denver, CO, 1295-1302. Alexandria, VA: Water Environment Federation.
43. Ramanarayanan, T.S., J.R. Williams, W.A. Dugas, L.M. Hauck, and A.M.S. McFarland. 1997. Using APEX to identify alternative practices for animal waste management. Presented at the ASAE International Meeting, 10-14 August, Minneapolis, Minnesota. ASAE Paper No. 97-2209. St. Joseph, MI: American Society of Agricultural Engineers.
44. Saleh, A. and O. Gallego. 2007. Application of SWAT and APEX models using SWAPP (SWAT/APEX program) for the Upper North Bosque River watershed in Texas. In: Watershed Management to Meet Water Quality Standards and TMDLs: 4th Conference Proceedings, March 10-14, San Antonio, TX, 458-468. A. McFarland and A. Saleh, eds. American Society of Agricultural and Biological Engineers, St. Joseph, MI.
45. Saleh, A., P.W. Gassman, J. Abraham, and J. Rodecap. 2003. Application of SWAT and APEX models for Upper Maquoketa River watershed in northeast Iowa. Presented at the 2003 ASAE Annual International Meeting, July 27-30, Las Vegas, NV. ASAE Paper No. 032063, St. Joseph, MI: American Society of Agricultural Engineers.
46. Saleh, A., E. Osei, and O. Gallego. 2008. Use of CEEOT-SWAPP modeling system for targeting and evaluating environmental pollutants. In: Proceedings of the 21st Century Watershed Technology: Improving Water Quality and Environment Conference, March 29-April 3, Concepción, Chile. E.W. Tollner and A. Saleh, eds. St. Joseph, MI: American Society of Agricultural and Biological Engineers.
47. Saleh, A., J.R. Williams, J.C. Wood, L. Hauck, and W.H. Blackburn. 2001. Application of APEX for forestry. Presented at the 2005 ASAE International Meeting, July 17-20, Sacramento, CA. ASAE Paper No. 018004, St. Joseph, MI: American Society of Agricultural Engineers.
48. Saleh, A., J.R. Williams, J.C. Wood, L. Hauck, and W.H. Blackburn. 2003. Application of APEX for forestry. In: Proceedings of the Total Maximum Daily Load (TMDL) Environmental Regulations, March 11-13, Forth Worth, TX, 595-605. A. Saleh, ed. St. Joseph, MI: American Society of Agricultural Engineers.
49. Sanabria, Joaquin, Jay D Atwood, Paul T. Dyke, Jimmy R. Williams, and Andrew. P. Manale. 2000. "Precipitation Extreme Events and Land Management Practices for Flood Mitigation." In Proceedings of American Water Resources Association Conference on Water Resources in Extreme Environments, Editor Douglas L. Kane. May 1 – 3. Anchorage, AK.
50. Schilling, E., G. Ice, B. Wigley, M. Miwa, A. Saleh. 2007. Water quality issues facing the forest products industry: Current research focus and future research needs. In: Watershed Management to Meet Water Quality Standards and TMDLs: 4th Conference Proceedings, March 10-14, San Antonio, TX, 294-300. A. McFarland and A. Saleh, eds. American Society of Agricultural and Biological Engineers, St. Joseph, MI.
51. Williams, J.R. 2002. The APEX manure management component. In: Proceedings of the Total Maximum Daily Load (TMDL) Environmental Regulations, March 11-13, Forth Worth, TX, 44-51. A. Saleh, ed. St. Joseph, MI: American Society of Agricultural Engineers.

52. Williams, J.R., C.A. Jones, P.W. Gassman, and L.M. Hauck. 1995. Simulation of Animal Waste Management with APEX. In: *Innovations and New Horizons in Livestock and Poultry Manure Management*, pp. 22-26, September 6-7, Austin, TX.
53. Williams, J.R., S. Srinivasan, J.G. Arnold, and L.M. Hauck. 2000. Agricultural runoff modeling. In: *Proceedings of the Workshop on Watershed Modeling, Watershed 2000*, July 9, Vancouver, Canada. Alexandria, VA: Water Environment Federation.

Conference/Proceedings Papers that describe use of APEX within the National CEAP project

54. Kannan, N., C. Santhi, M. Di Luzio, S. Potter, and J.G. Arnold. 2005. Measuring environmental benefits of conservation practices: The Conservation Effects Assessment Project (CEAP)-a model calibration approach at the national level. Presented at the 2005 ASAE Annual International Meeting, Tampa, FL. ASAE Paper No. 05-2131. St. Joseph, MI: American Society of Agricultural Engineers.
55. Lemunyon, J.L. and R.L. Kellogg. 2008. Assessment of conservation benefits derived from conservation practices in the United States. In: *Proceedings of the 21st Century Watershed Technology: Improving Water Quality and Environment Conference*, March 29-April 3, Concepción, Chile. E.W. Tollner and A. Saleh, eds. St. Joseph, MI: American Society of Agricultural and Biological Engineers.
56. Santhi, C., N. Kannan, M. Di Luzio, S.R. Potter, J.G. Arnold, J.D. Atwood, and R.L. Kellogg. 2005. An approach for estimating water quality benefits of conservation practices at the national level. Presented at the 2005 ASAE International Meeting, July 17-20, Tampa, FL. ASAE Paper No. 052043, St. Joseph, MI: American Society of Agricultural Engineers.

Conference/Proceedings Papers that describe adaptations of APEX components

57. Houser, J.B., A. Saleh, and L.M. Hauck. 2003. Development and testing of dynamic fertilizer model to assess the effect of CNMPs in the North Bosque watershed. In: *Proceedings of the Total maximum Daily Load (TMDL) Environmental Regulations II*, November 8-12, Albuquerque, NM, 323-331. St. Joseph, MI: American Society of Agricultural Engineers.
58. Houser, J.B., A. Saleh, and L.M. Hauck. 2004. Calibration and verification of dynamic fertilizer model to assess the effect of CNMPs. Presented at the 2004 ASAE/CSAE Annual International Meeting, August 1-4, Ottawa, Canada. ASAE Paper No. 042258, St. Joseph, MI: American Society of Agricultural Engineers.
59. Houser, J.B., A. Saleh, and L.M. Hauck. 2005. Application of dynamic fertilizer model for assessment of CNMPs. In: *Watershed Management to Meet Water Quality Standards and Emerging TMDL (Total Maximum Daily Load)*, Proceedings of the Third Conference, 320-329, March 5-9, Atlanta, GA. American Society of Agricultural Engineers, St. Joseph, MI.
60. Zhai, T. and R.H. Mohtar. 2004. Rangeland modeling – Forage, water, and nutrients: Species competition and tree effects. Presented at the 2004 ASAE/CSAE Annual International Meeting, 1-4 August, Ottawa, Ontario, Canada. ASAE Paper 043039. St. Joseph, MI: American Society of Agricultural Engineers.

Other APEX Documents

61. Benson, Verel W., D. Todd Rarrand, Robert E. Young III and Peter Zimmell. Estimated Nutrient Movement with Alternative Poultry Litter Application rates on various soils, using different management systems. 2000.
62. Benson, V.W., P.T. Zimmel, A. Bross, D.L. Schuster, and J. Trujillo. 200. Newton and McDonald Counties contract broiler representative farm. FAPRI-UMC Report #08-00. Columbia, MO: Food and Agricultural Policy Research Institute, University of Missouri.
63. Dybala, T.J. 1998. Lake Aquilla – Brazos River Authority Part I: Farm scale modeling using the Agricultural Policy Environmental Extender (APEX). Temple, TX: U.S. Department of Agriculture, Natural Resources Conservation Service, Water Resources Assessment Team. Available at: <http://www.tx.nrcs.usda.gov/technical/wrat/projects/aquilla.html>.
64. FAPRI. 2006. Missouri watershed water quality initiative. FAPRI-UMC Report #22-06. Columbia, MO: Food and Agricultural Policy Research Institute, University of Missouri. Available at: http://www.fapri.missouri.edu/outreach/publications/2006/FAPRI_UMC_Report_22_06.pdf.

65. FAPRI. 2007. Estimating water quality, air quality, and soil carbon benefits of the Conservation Reserve Program. FAPRI-UMC Report #01-07. Columbia, MO: Food and Agricultural Policy Research Institute, University of Missouri. Available at: http://www.fapri.missouri.edu/outreach/publications/2007/FAPRI_UMC_Report_01_07.pdf.
66. Flowers, J.D., J.R. Williams, and L.M. Hauck. 1996. NPP integrated modeling system: calibration of the APEX model for dairy waste application fields in Erath County, Texas. PR 96-07. Stephenville, Texas: TIAER, Tarleton State University.
67. Gassman, P.W. 1997. The National Pilot Program integrated modeling system: Environmental baseline assumptions and results for the APEX model. Livestock Series Report 9. Staff Report 97-SR 85. CARD, Iowa State Univ., Ames, IA.
68. Gassman, P.W. and L. Hauck. 1996. The environmental component of the National Pilot Project integrated modeling system. Livestock Series Report 8. Staff Report 96-SR 84. CARD, Iowa State Univ., Ames, IA.
69. Gassman, P.W., J.R. Williams, V.R. Benson, R.C. Izaurralde, L.M. Hauck, C.A. Jones, J.D. Atwood, J.R. Kiniry, and J.D. Flowers. 2005. Historical Development and Applications of the EPIC and APEX models. Working paper 05-WP 397. Ames, Iowa: Center for Agricultural and Rural Development, Iowa State University. Available at: <http://www.card.iastate.edu/publications/DBS/PDFFiles/05wp397.pdf>.
70. Harman, Wyatt L., Ranjan Muttiah, J. R. Williams, and Melanie Magre. 1998. Sedimentation of Lake Meredith: An Investigation of Water and Wind Deposition. BRC Report No. 01-25, Texas A & M University, Blackland Research Center, Temple.
71. Keith, G., S. Norvell, R. Jones, C. Maguire, E. Osei, A. Saleh, P. Gassman, and John Rodecap. 2000. Livestock and the environment: a national pilot project: CEEOT-LP modeling for the Upper Maquoketa River Watershed, Iowa: final report. Report No. PR0003. Stephenville, TX: Texas Institute for Applied Environmental Research, Tarleton State Univ. Available at: <http://tiaer.tarleton.edu/library/library.cfm>.
72. McNitt, J., R. Jones, E. Osei, L. Hauck, and H. Jones. 1999. Livestock on the environment: Precedents for runoff policy: Policy options CEEOT-LP. PR 9909. Stephenville, TX: Texas Institute for Applied Environmental Research, Tarleton State Univ. Available at: <http://tiaer.tarleton.edu/library/library.cfm>.
73. Osei, E., B. Du, A. Bekele, L. Hauck, A. Saleh, and A. Tanter. 2004. CEEOT-MMS: A macro modeling system for environmental assessment. TR0409. Stephenville, TX: Texas Institute for Applied Environmental Research, Tarleton State Univ.
74. Osei, E., P. Gassman, and A. Saleh. 2002. Livestock and the Environment: Economic and Environmental Modeling Using CEEOT. Report No. PR0002. Stephenville, TX: Texas Institute for Applied Environmental Research, Tarleton State Univ. Available at: <http://tiaer.tarleton.edu/library/library.cfm>.
75. Plotkin, S. 2007. I_APEX Calibration Using Research Plots in Tifton, Georgia. Amherst, MA: USDA-NRCS, National Agricultural Pesticide Risk Analysis (NAPRA) Project Team.
76. Pratt, S., R. Jones, and C.A. Jones. 1997. Livestock and the environment: Expanding the focus: Policy options CEEOT-LP. PR 96-03. Stephenville, TX: Texas Institute for Applied Environmental Research, Tarleton State Univ. Available at: <http://tiaer.tarleton.edu/library/library.cfm>.
77. Rosenthal, Wesley, Wyatt L. Harman, Erda Wang, and Benjamin Sheng. 2001. Arroyo Colorado River Nutrient Losses: An Investigation of Residue Management Through Conservation Tillage to Reduce Nutrient Losses. BRC Report No. 01-32. Texas A & M University, Blackland Research Center, Temple.
78. Rosenthal, Wesley, Wyatt L. Harman, J. R. Williams, and Melanie Magre. 1999. White River Lake Sedimentation: An Investigation of Range and Cropland Management Practices to Reduce Erosion. BRC Report NO. 01-26, Texas A & M University, Blackland Research Center, Temple.
79. Rosenthal, Wesley, Wyatt L. Harman, J. R. Williams, and Melanie Magre. 2000a. Lower Leon River Sedimentation: An Investigation of Range and Cropland Management Practices to Reduce Erosion. BRC Report No. 01-28, Texas A & M University, Blackland Research Center, Temple.
80. Rosenthal, Wesley, Wyatt L. Harman, J. R. Williams, and Melanie Magre. 2000b. Upper Leon River Sedimentation: An Investigation of Range and Cropland Management Practices to Reduce Erosion. BRC Report No. 01-29, Texas A & M University, Blackland Research Center, Temple.
81. Steglich, E. and J.R. Williams. 2008. APEX Users Manual. BREC Report # 2008-16. Temple, TX: Blackland Research & Extension Center. Texas AgriLIFE Research.
82. Williams, J. R., C. A. Jones, P. W. Gassman and L. M. Hauck. Simulation of Animal Waste Management with APEX. ABSTRACT.

83. Williams, J.R. and C. Izaurralde. 2005. The APEX Model. BRC Report No. 2005-02. Temple, TX: Texas A&M University, Texas Agricultural Extension Service, Texas Agricultural Experiment Station.

APPENDIX D—APEX BALANCES VARIABLE DEFINITIONS

These variables can be found in the *.OUT file

Variables common to all balances:

- PER = percent error in the balance
- DF = error in the balance (should be near 0.0)

Soil Water Balance (m³)

- BSW = beginning soil water content
- PCP = precipitation
- Q = surface runoff
- ET = evapotranspiration
- PRK = percolation
- SSF = lateral subsurface outflow
- IRG = irrigation
- SNO = initial water content of snow cover
- QIN = inflow from external source to maintain water table
- SSFI= subsurface inflow from upstream subarea
- FPF = floodplain infiltration
- QDR = flow from drainage system
- QRF = quick return flow
- RBK = back water from a reservoir
- CPVH= lateral pipe outflow
- PSOQ= inflow from a point source
- RGDL=irrigation delivery loss
- FSW = final soil water content

N Balance (kg/ha)

- BTOT= beginning total N
- RFN = rainfall N
- Y = N loss with sediment
- Q = soluble N loss in surface runoff
- SSF = soluble N loss in lateral subsurface outflow
- PRK = soluble N leaching loss
- QRF = soluble N loss with quick return flow
- DR = soluble N loss from drainage system
- SSFI= soluble N inflow from upstream subsurface inflow
- DN = denitrification loss
- VOL = volatilization loss
- BURN= N loss from burning crop residue or forest
- YLD = N loss in crop yield
- FIX = N fixation by legumes
- FNMN= nitrate N fertilizer
- FNMA= ammonia N fertilizer

FNO = organic N fertilizer
SNOU= N loss when manure is removed from feedlots
DEP = organic N loss or gain resulting from floodplain scour/deposition
PSON= N contributed by point source
ETOT= final total N
ENMN=
ENMA=
EON=
ESDN=
ESON=
EUNM=

C Balance (kg/ha)

BTOT= beginning total C
Y = C loss with sediment
PRK = C leaching loss
Q = C loss in surface runoff
RSPC= C loss from crop residue respiration
RSDC= C added with crop residue
TFOC= C added with organic fertilizer
SCOU= C loss when manure is removed from feedlots
DEP = C loss or gain resulting from floodplain scour/deposition
FTOT= final total C
ELSC=
ELMC=
EBMC=
EHSC=
EHPC=

P Balance (kg/ha)

BTOT= beginning total P
Y = P loss with sediment
Q = soluble P loss in surface runoff
PRK = soluble P leaching loss
YLD = P loss in crop yield
FPML= labile P fertilizer
FPO = organic P fertilizer
SPOU= P loss when manure is removed from feedlots
DEP = organic P loss or gain resulting from floodplain scour/deposition
PSOP= P contributed by point source
ETOT= final total P
EPML=
EPMA=
EPMS=
EPO=
EFOP=
ESDP=
ESOP=

EUPM=
EPMU=
EPOU=

APPENDIX E—RICE PADDY SIMULATION USING APEX

Setting crop parameters

1. Update crop parameters for RICE in Crop.dat file.
 - a. HI=50
 - b. DLAP1=10.001 and DLAP2=40.95
 - c. RWPC1=0.47 and RWPC2=0.05
 - d. SWD=100kg/ha sets the beginning amount of biomass
 - e. HMX=1.2m; maximum height
 - f. PPLP1=20.2 and PPLP2=120.95

Setting seepage rate of paddy soils

1. Update PARM(39) to 0.5 (or an appropriate value) in the Parm.dat file.

Creating management schedules

1. Tillage (plowing) operation
 - a. Selecting a tillage implement such as a field cultivator or disk plow to simulate tillage in preparation for the rice crop; this sets a plowing depth of 100mm.
2. Set paddy embankment
 - a. Set embankment (Puddle)
 - i. Select a Puddling operation such as Puddle Rice Paddy
 - ii. Set OPV(1) : Weir height (mm)
 - iii. Make sure PARM(39) is set to reduce infiltration rate as directed previously
3. Irrigation
 - a. Auto Irrigation for paddies
 - i. Select and setup an irrigation operation such as Gated Pipe
 - ii. OPV(1): Enter the target water depth (mm)
 - iii. OPV(3) = 9999; this sets up paddy irrigation with a target ponding depth
 - iv. OPV(6): Enter the minimum water depth (mm) at which auto irrigation is triggered
 - v. NIRR = 2 (in *.SUB file (subarea file))
 - vi. IRR = 2 (in *.SUB file (subarea file))
4. Transplanting
 - a. Select a planting operation such as Transplanter, 4 Row
 - b. OPV(1)=1950: Potential Heat Units
 - c. OPV(2)=12; Land Use Number after transplanting (Contoured & terraced)
 - d. OPV(3): LAI at the time of transplanting = 0.1

5. Fertilizer application
 - a. Select a fertilizer operation such as Fertilizer Application Aerial
 - b. JX (7): Select a Fertilizer ID from FERT.DAT
 - c. OPV(1): Enter the Application amount (kg/ha)

6. Pesticide application
 - a. Select a pesticide operation such as Chemical Application Aerial
 - b. JX (7): Select a Pesticide ID from PEST.DAT
 - c. OPV(1): Enter the application amount (kg/ha)
 - d. OPV(2): Enter the fraction of pest controlled by the operation (e.g. 0.99)

7. Destroy puddle
 - a. Select a operation such as Puddle, Stop to destroy the embankment (dike)
 - b. Set OPV(1)=0;
 - c. Set OPV(2)=0
 - d. Infiltration rate is recovered to SATK automatically

8. Harvest/Kill
 - e. Select a harvesting operation such as Combine, 4WD
 - f. Select the Kill operation to end the growth of the crop.

REFERENCES

- Abruna, F., J. Rodriguez, and S. Silva. 1982. Crop response to soil acidity factors in Ultisols and Oxisols in Puerto Rico. VI. Grain sorghum. *J. Agric. Univ. P.R.* 61:28-38.
- Acevedo, E., T.C. Hsiao, and D.W. Henderson. 1971. Immediate and subsequent growth responses of maize leaves to changes in water status. *Plant Physiol.* 48:631-636.
- Adams, W.A., 1973. The effect of organic matter on the bulk and true densities of some uncultivated podzolic soils. *J. Soil Sci.* 24, 10-17.
- Albrecht, S.L., S.M. Bennett, and K.J. Boote. 1984. Relationship of nitrogenase activity to plant water stress in field-grown soybeans. *Field Crops Res.* 8:61-71.
- Andrews, R.E. and E.I. Newman. 1970. Root density and competition for nutrients. *Oecol. Plant.* 5:319-334.
- Arnold, J.G., J. D. Atwood, V. W. Benson, R. Srinivasan, and J. R. Williams. 1998. Potential Environmental and Economic Impacts of Implementing National Conservation Buffer Initiative Sedimentation Control Measures. USDA, NRCS Staff paper.
- Bagnold, R.A., 1977. Bed-load transport by natural rivers. *Water Resources Research*, 13(2): 303-312.
- Baier W., Robertson, Geo. W., 1965. Estimation of Latent Evaporation from Simple Weather Observations. *Can. J. Plant Sci.* Vol. 45 Pp. 276-284.
- Begg, J.E., J.F. Bierhuizen, E.R. Lemon, D.K. Misra, R.O. Slatyer, and W.R. Stern. 1964. Diurnal energy and water exchanges in bulrush millet in an area of high solar radiation. *Agric. Meteorol.* 1:294-312.
- Bonhomme, R., F. Ruget, M. Derieux, and P. Vincourt. 1982. Relations entre production de matiere seche aeriene et energie interceptee chez differents genotypes de mais. *C.R. Adad. Sci. Paris* 294:393-398.

- Borg, H. and D.V. Grimes. 1986. Depth development of roots with time: An empirical description. *Trans. ASAE* 29:194-197.
- Bouinols, A., M. Cabelguenne, C.A. Jones, A. Chalamet, J.L. Charpentreau, and J.R. Marty. 1991. Simulation of soybean nitrogen nutrition for a silty clay soil in southern France. *Field Crops Res.* 26:19-34.
- Brenes, E. and R.W. Pearson. 1973. Root responses of three Gramineae species to soil acidity in an Oxisol and an Ultisol. *Soil Sci.* 116:295-302.
- Chepil, W.S. 1956. Influence of moisture on erodibility of soil by wind. *Soil Sci. Soc. Am. Proc.* 20:288-292.
- Cole, G.W., L. Lyles, and L.J. Hagen. 1982. A simulation model of daily wind erosion soil loss. 1982 ASAE Winter Meeting, Paper No. 82-2575.
- DeJager, A. 1979. Localized stimulation of root growth and phosphate uptake in *Zea mays* L. resulting from restricted phosphate supply. pp. 391-403 In J.L. Harley and R. S. Russell (eds.) *The Soil-Root Interface*. Academic Press, New York.
- Doorenbos, J. and A.H. Kassam. 1979. Yield response to water. *Irrigation and Drainage Paper 33*. Food Agric. Org. United Nations, Rome.
- Eavis, B.W. 1972. Soil physical conditions affecting seedling root growth. I. Mechanical impedance, aeration, and moisture availability as influenced by bulk density and moisture levels in a sandy loam soil. *Plant Soil* 36:613-622.
- Eik, K. and J.J. Hanway. 1965. Some factors affecting development and longevity of leaves of corn. *Agron. J.* 57:7-12.
- Flowers, J. D., J. R. Williams, L. M. Hauck, 1996. Livestock and the Environment: A National Pilot Project NPP Integrated Modeling system: Calibration of the APEX Model for Dairy Waste Application Fields in Erath County, Texas. TIAER pr 96-07.
- Foy, C.D., H.N. Lafever, J.W. Scuartz, and A.L. Fleming. 1974. Aluminum tolerance of wheat cultivars related to region of origin. *Agron. J.* 66:751-758.
- Godwin, D.C., C.A. Jones, J.T. Ritchie, P.L.G. Vlek, and L.G. Youngdahl. 1984. The water and nitrogen components of the CERES models. pp. 95-100 In *Proc. Intl. Symp. on Minimum Data Sets for Agrotechnology Transfer*, March 1983, Patancheru, India. Intl. Crops Research Institute for the Semi-Arid Tropics.
- Green, W. H. and G. A. Ampt. 1911. *Studies on Soil Physics: 1. Flow of Air and Water Through Soils.* *Journal Agricultural Science* 4:1-24.

- Grossman, R.B., V.D. Nettleton, and B.R. Brasher. 1985. Application of pedology to plant response prediction for tropical vertisols. In Proc. Fifth Intl. Soil Classification Workshop, Sudan, November 1982.
- Hagen, L.J., E. L. Skidmore, and J.B. Layton. 1988. Wind erosion abrasion: Effects of aggregate moisture. *Trans. ASAE* 31:725-728.
- Hanks, R.J. 1983. Yield and water-use relationships: An overview. pp. 393-411 In H.M. Taylor, W.R. Jordan, and T.R. Sinclair, eds., *Limitations to Efficient Water Use in Crop Production*. Am. Soc. Agron., Crop Sci. Soc. Am., Soil Sci. Soc. Am., Madison, WI.
- Hargreaves, G.H. and Z.A. Samani. 1985. Reference crop evapotranspiration from temperature. *Applied Engr. Agric.* 1:96-99.
- Harper, J.E. 1976. Contribution of dinitrogen and soil or fertilizer nitrogen to soybean production. pp. 101-107 In L.D. Hill (ed.) *Proc. World Soybean Research Conf.*
- Hazen, Allen. 1930. *Flood Flows, A Study of Frequencies and Magnitudes*. John Wiley & Sons, Inc., New York.
- Hershfield, D.M. 1961. Rainfall frequency atlas of the United States for durations from 30 minutes to 24 hours and return periods from 1 to 100 years. U.S. Dept. Commerce Tech. Paper No. 40.
- Izaurrealde, R.C., J.R. Williams, W.B. McGill, N.J. Rosenberg, and M.C. Quiroga Jakas. 2004. Simulating soil C dynamics with EPIC: Model description and testing against long-term data. Submitted to *Ecol. Modell.*
- Jarvis, S.C. and A.D. Robson. 1983. The effect of nitrogen nutrition of plants on the development of acidity in western Australian soils. I. Effects with subterranean clover grown under leaching conditions. *Aust. J. Agric. Res.* 34:341-353.
- Jones, C.A. 1983a. A survey of the variability in tissue nitrogen and phosphorus concentrations in maize and grain sorghum. *Field Crops Res.* 6:133-147.
- Jones, C.A. 1983b. Effect of soil texture on critical bulk densities for root growth. *Soil Sci. Soc. Am. J.* 47:1208-1211.
- Jones, C.A. 1984. Estimation of percent aluminum saturation from soil chemical data. *Commun. Soil Sci. Plant Anal.* 15:327-335.
- Jones, C.A. 1985. *C-4 Grasses and Cereals*. John Wiley & Sons, Inc., New York.
- Jones, C.A., C.V. Cole, A.N. Sharpley, and J.R. Williams. 1984. A simplified soil and plant phosphorus model. I. Documentation. *Soil Sci. Soc. Am. J.* 48(4):800-805.
- Jungk, A. and S.A. Barber. 1974. Phosphate uptake rate of corn roots as related to the proportion of the roots exposed to phosphate. *Agron. J.* 66:554-557.

- Kamprath, E.J. 1970. Exchangeable aluminum as a criterion for liming leached mineral soils. *Soil Sci. Soc. Am. Proc.* 34:252-254.
- Kiniry, J.R., J.R. Williams, P.W. Gassman, and P. Debaeke. 1992. A general, process-Oriented model for two competing plant species. *Trans ASAE.* Vol.35(3):801-810.
- Kletke, D.D. 1979. Operation of the enterprise budget generator. Oklahoma State Univ., Agric. Exp. Sta. Res. Rept. P-790.
- Knisel, W.G. 1980. CREAMS, A field scale model for chemicals, runoff, and erosion from agricultural management systems. U.S. Dept. Agric. Conserv. Res. Rept. No. 26.
- Leonard, R.A., W.G. Knisel, and D.A. Still. 1987. GLEAMS: Groundwater loading effects on agricultural management systems. *Trans. ASAE* 30(5):1403-1428.
- McElroy, A.D., S.Y. Chiu, J.W. Nebgen, and others. 1976. Loading functions for assessment of water pollution from nonpoint sources. *Environ. Prot. Tech. Serv., EPA* 600/2-76-151.
- McGrann, J.M., K.D. Olson, T.A. Powell, and T.R. Nelson. 1986. Microcomputer budget management system user manual. Dept. Agric. Econ., Texas A&M Univ., College Station.
- Menzel, R.G. 1980. Enrichment ratios for water quality modeling. pp. 486-492 In W.G. Knisel, ed., CREAMS, A field scale model for chemicals, runoff, and erosion from agricultural management systems. U.S. Dept. Agric. Conserv. Res. Rept. No. 26.
- Monteith, J.L. 1965. Evaporation and environment. *Symp. Soc. Exp. Biol.* 19:205-234.
- Monteith, J.L. 1973. *Principles of Environmental Physics.* Edward Arnold, London.
- Monteith, J.L. 1977. Climate and the efficiency of crop production in Britain. *Phil. Trans. Res. Soc. London Ser. B.* 281:277-329.
- Monteith, N.H. and C.L. Banath. 1965. The effect of soil strength on sugarcane growth. *Trop. Agric.* 42:293-296.
- Muchow, R.C., D.B. Coates, G.L. Wilson, and M.A. Foale. 1982. Growth and productivity of irrigated *Sorghum bicolor* (L. Moench) in Northern Australia. I. Plant density and arrangement effects on light interception and distribution, and grain yield, in the hybrid Texas 610SR in low and medium latitudes. *Aust. J. Agric. Res.* 33:773-784.
- Mugwira, L.M., S.J. Patel, and A.L. Fleming. 1980. Aluminum effects on growth and Al, Ca, Mg, K, and P levels in triticale, wheat, and rye. *Plant Soil* 57:467-470.
- Nicks, A.D. 1974. Stochastic generation of the occurrence, pattern, and location of maximum amount of daily rainfall. pp. 154-171 In *Proc. Symp. Statistical Hydrology, Aug.-Sept. 1971, Tucson, AZ.* U.S. Dept. Agric., Misc. Publ. No. 1275.

- Nicks, A.D., L.J. Lane. 1989. Chapter 2. Weather Generator. Pp. 2.1-2.19. Profile Model Documentation. USDA-Water Erosion Prediction Project: Hillslope Profile Version. NSERL Report No. 2, USDA-ARS National Soil Erosion Research Lab., West Lafayette, Indiana 47907.
- Nyatsanga, T. and W.H. Pierre. 1973. Effect of nitrogen fixation by legumes on soil acidity. *Agron. J.* 65:936-940.
- Onstad, C.A. and G.R. Foster. 1975. Erosion modeling on a watershed. *Trans. ASAE* 18(2):288-292.
- Parton, W.J., Schimel, D.S., Cole, C.V. and Ojima, D.S., 1987. Analysis of factors controlling soil organic matter levels in Great Plains grasslands. *Soil Sci. Soc. Am. J.* 51, 1173-1179.
- Parton, W.J., Scurlock, J.M.O., Ojima, D.S., Gilmanov, T.G., Scholes, R.J., Schimel, D.S., Kirchner, T., Menaut, J-C, Seastedt, T., Garcia Moya, E., Kamnalrut, A. and Kinyamario, J.I., 1993. Observations and modelling of biomass and soil organic matter dynamics for the grassland biome worldwide. *Global Biogeochemical Cycles* 7, 785-809.
- Parton, W.J., Ojima, D.S., Cole, C.V. and Schimel, D.S., 1994. A general model for soil organic matter dynamics: Sensitivity to litter chemistry, texture and management. In: *Quantitative Modeling of Soil Forming Processes*, SSSA Spec. Public. No. 39, Madison, WI, pp. 147-167.
- Patterson, T.G. and T.A. Larue. 1983. Nitrogen fixation (C_2H_2) by soybeans: Cultivars and seasonal effects and comparison of estimates. *Crop. Sci.* 23:488-492.
- Pavan, M.A., F.T. Bingham, and P.F. Pratt. 1982. Toxicity of aluminum to coffee in Ultisols and Oxisols amended with $CaCO_3$, $MgCO_3$, and $CaSO_4/2H_2O$. *Soil Sci. Soc. Am. J.* 46:1201-1207.
- Peech, M. 1965. Lime requirement. *Agronomy* 9:927-932.
- Penman, H.L. 1948. Natural evaporation from open, bare soil and grass. *Proc. Soc. London Ser. A*193:120-145.
- Pesek, J., G. Stanford, and N.L. Case. 1971. Nitrogen production and use. pp. 217-269 In R.A. Olson, ed., *Fertilizer Technology and Use*. Soil Sci. Soc. Am., Madison, WI.
- Pierre, W.H., J.R. Webb, and W.D. Shrader. 1971. Quantitative effects of nitrogen fertilizer on the development and downward movement of soil acidity in relation to level of fertilization and crop removal in a continuous corn cropping system. *Agron. J.* 63:291-297.
- Potter, K.N. and T.M. Zobeck. 1990. Estimation of soil microrelief. *Trans. ASAE* 33(1):156-161.
- Potter, K.N., T.M. Zobeck, and L.J. Hagen. 1990. A microrelief index to estimate soil erodibility by wind. *Trans. ASAE* 33(1):151-155.
- Priestley, C.H.B. and R.J. Taylor. 1972. On the assessment of surface heat flux and evaporation using large-scale parameters. *Mon. Weather Rev.* 100:81-92.

- Putman, J., J. Williams, and D. Sawyer. 1988. Using the erosion productivity calculator (EPIC) model to estimate the impact of soil erosion for the 1985 RCA appraisal. *J. Soil Water Conserv.* 43(4):321-326.
- Reddy, K.R., R. Khaleel, M.R. Overcash, and P.W. Westerman. 1979. A nonpoint source model for land areas receiving animal wastes: II. Ammonia volatilization. *Trans. ASAE* 22(6):1398-1404.
- Renard, K. G., G. R. Foster, G. A. Weesies, D. K. McCool, and D. C. Yoder. 1997. Predicting soil erosion by water: A guide to conservation planning with the revised universal soil loss equation (RUSLE). U. S. Dept. Agric., Agric. Res. Ser., Agriculture Handbook Number 703
- Richardson, C.W. 1981. Stochastic simulation of daily precipitation, temperature, and solar radiation. *Water Resources Res.* 17(1):182-190.
- Richardson, C.W. 1982. Dependence structure of daily temperature and solar radiation. *Trans. ASAE* 25(3):735-739.
- Richardson, C.W. and D.A. Wright. 1984. WGEN: A model for generating daily weather variables. U.S. Dept. Agric., Agric. Res. Ser., ARS-8.
- Ritchie, J.T. 1972. A model for predicting evaporation from a row crop with incomplete cover. *Water Resources Res.* 8:1204-1213.
- Seligman, N.G. and H. van Keulen. 1981. PAPRAN: A simulation model of annual pasture production limited by rainfall and nitrogen. pp. 192-221 In M.J. Frissel and J.A. van Veen, eds., *Simulation of Nitrogen Behaviour of Soil-Plant Systems*, Proc. Workshop, Wageningen, Jan.-Feb. 1980.
- Sharpley, A.N., C.A. Jones, and J.R. Williams. 1990. The nutrient component of EPIC. Chapter 7, pp. 152-166 In A.N. Sharpley and J.R. Williams (eds.) *EPIC--Erosion/Productivity Impact Calculator: 1. Model Documentation*. U.S. Dept. Agric. Tech. Bull. No. 1768.
- Sharpley, A.N., C.A. Jones, C. Gray, and C.V. Cole. 1984. A simplified soil and plant phosphorus model: II. Prediction of labile, organic, and sorbed phosphorus. *Soil Sci. Soc. Am. J.* 48:800-805.
- Sharpley, A.N., C.A. Jones, C. Gray, and others. 1985. A detailed phosphorus characterization of seventy-eight soils. U.S. Dept. Agric., Agric. Res. Ser., ARS-31.
- Sharpley, A.N. and J.R. Williams, eds. 1990. *EPIC--Erosion/Productivity Impact Calculator: 1. Model Documentation*. U.S. Dept. Agric. Tech. Bull. No. 1768.
- Simanton, J.R., E. Rawitz, and E.D. Shirley. 1984. Effects of rock fragments on erosion of semiarid rangeland soils. Chapter 7, pp. 65-72 In *Erosion and Productivity of Soils Containing Rock Fragments*. Soil Sci. Soc. Am., Madison, WI.
- Skidmore, E.L. 1986. Wind-erosion climatic erosivity. *Climate Change* 9:195-208.

- Soil Survey Staff. 1982. Procedures for collecting soil samples and methods of analysis for soil survey. U.S. Dept. Agric., Soil Conserv. Ser., Soil Survey Investigations Rept. No. 1 (revised August 1982). Washington, DC.
- Stockle, C.O., J.R. Williams, N.J. Rosenberg, and C.A. Jones. 1992. A method for estimating the direct and climatic effects of rising atmospheric carbon dioxide on growth and yield of crops: Part I--Modification of the EPIC model for climate change analysis. *Agric. Systems* 38:225-238.
- Stout, J.E. 1990. Wind erosion with a simple field. *Trans. ASAE* 33:1597-1600.
- Taylor, H.M. 1983. A program to increase plant available water through rooting modification. pp. 463-472 In *Root Ecology and Its Practical Application*. Intl. Symp., Gumpenstein, September 1982. Bundesanstalt fur alpenlandische Landwirtschaft, A-8952 Irding.
- Taylor, H.M., G.M. Robertson, and J.J. Parker, Jr. 1966. Soil strength--root penetration relations for medium to coarse-textured soil materials. *Soil Sci.* 102:18-22.
- Tollenaar, M., T.B. Daynard, and R.B. Hunter. 1979. Effect of temperature on rate of leaf appearance and flowering date of maize. *Crop Sci.* 19:363-366.
- Thornley, J.H.M. 1976. *Mathematical Models in Plant Physiology*. Academic Press, New York.
- Uchijima, Z., T. Udagawa, T. Horie, and K. Kobayashi. 1968. The penetration of direct solar radiation into corn canopy and the intensity of direct radiation on the foliage surface. *J. Agron. Meteorol.* Tokyo 3:141-151.
- U.S. Department of Agriculture, Soil Conservation Service. 1972. *National Engineering Handbook*, Hydrology Section 4, Chapters 4-10.
- U.S. Department of Agriculture, Soil Conservation Service. 1986. *Urban hydrology for small watersheds*. Tech. Release 55.
- U.S. Department of Commerce. 1968. *Climatic Atlas of the United States*. Environmental Science Services Administration, Environmental Data Service.
- U.S. Department of Commerce. 1979. *Maximum short duration rainfall*. National Summary, Climatic Data.
- Vitousek, P.M., Turner, D.R., Parton, W.J. and Sanford, R.L., 1994. Litter decomposition on the Mauna Loa environmental matrix, Hawaii: Patterns, mechanisms, and models. *Ecology* 75, 418-429.
- Watts, W.R. 1972. Leaf extension in *Zea mays*. II. Leaf extension in response to independent variation of the temperature of the apical meristem, of the air around the leaves, and of the rootzone. *J. Exp. Bot.* 23:713-721.
- Williams, J.R. 1975a. HYMO flood routing, *J. Hydrology*, 26, 17-27.

Williams, J.R. 1975b. Sediment yield prediction with universal equation using runoff energy factor. U.S. Dept. Agric., Agric. Res. Serv., ARS-S-40.

Williams, J.R. 1995. The EPIC Model. pp 909-1000 In V. P. Singh, Computer models of watershed hydrology, Water Resources Publications, Highlands Ranch, CO.

Williams, J.R. and R.W. Hann. 1978. Optimal operation of large agricultural watersheds with water quality constraints. Texas Water Resources Institute, Texas A&M Univ., Tech. Rept. No. 96.

Williams, J.R., C.A. Jones, and P.T. Dyke. 1984. A modeling approach to determining the relationship between erosion and soil productivity. Trans. ASAE 27:129-144.

Williams, J.R., A.D. Nicks, and J.G. Arnold. 1985. SWRRB, a simulator for water resources in rural basins. ASCE Hydr. J., 111(6): 970-986.

Williams, J.R., J. G. Arnold, and R. Srinivasan. 2000. The APEX Model. Texas A&M Blackland Research Center Temple, BRC Report No. 00-06.

Wischmeier, W.H. and D.D. Smith. 1978. Predicting rainfall erosion losses, a guide to conservation planning. U.S. Dept. Agric., Agric. Handbook No. 537.

Woodruff, N.P. and F.H. Siddoway. 1965. A wind erosion equation. Soil Sci. Soc. Am. Proc. 29(5):602-608.