Interactive APEX (i_APEX) USERS GUIDE USING APEX2110 and APEX0806

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Interactive APEX (i_APEX)

Program Objective: To provide a tool for managing large numbers of APEX runs, handling data input and output.

Program Components:

• ACCESS Database: Contains input tables used by I_APEX to construct APEX runs and output tables to organize APEX output.
• Graphical User Interface: Allows for single runs and ranges of runs and permits editing of input data as well as selection of output variables and output files.

Program Operation:

• Fill the ACCESS database with the necessary data.
• Execute I_APEX and bring up the interface.
• Select output variables and output files using the interface.
• Make any necessary edits in the interface.
• Select and execute the runs using the interface.
• Examine the relevant output tables in the ACCESS database.

Output Capabilities:

• General output by APEX run and subarea.
• General output by run, subarea and year.
• Output to the SWAT model.
• Pesticide output by year.
• Yield output by year.
• Organic carbon and nitrogen output by year and soil layer.
• Watershed output by year and month.

Users:

• CEAP National Assessment.

Introduction

The interactive APEX (i_APEX) is a user friendly interface for the physical process and environmental fate model, Agricultural Policy/Environmental eXtender (APEX) (Williams et al., 2006, 2008; Williams and Izaurralde, 2006; Gassman et al., 2010). I_APEX is programmed in C++ and performs automatic management of the input data, execution of each APEX run, and data storage of selected model outputs using a single Microsoft ACCESS database to manage both the input and output data required for APEX simulations. The model provides a well organized easily understood interface with definitions and help assistance for most variables. The greatest advantage of i_APEX is in its ability to perform multiple model runs (over 100,000 runs in a run-set) in "batch" mode for each record selected in the Control Records Table. This provides a tremendous advantage when attempting to model multiple scenario permutations for a single field or small watershed, or in modeling thousands of agricultural fields and other land-uses over a large area such as a river basin or region.

I_APEX is being used by CEAP in a national effort to assess the effectiveness of agricultural conservation practices (Kellogg et al., 2011, 2012a, 2012b, and 2012c). Agricultural regions (based on river basins) of the United States are being modeled that simulate nutrient, pesticide and sediment losses under conditions of agricultural practices based on national farmers' surveys from 2003-2006, and 2011-2013 at over 40,000 selected National Resources Inventory (NRI) sample points. The software has also been used in other studies such as by Yin et al. (2009) in simulations of runoff and sediment yield from field plots in the Upland Huaihe River Watershed, China.

APEX was designed to simulate agricultural management strategies for single field farms containing multiple contiguous fields, grassed waterways, filter strips and buffers, and small watersheds. It can also simulate non-agricultural landscapes including urban settings. The model operates with continuous simulations using a daily time-step with as many years as desired. Weather conditions (precipitation, air temperature, solar radiation , humidity and wind speed and direction), soil conditions, hydrology, erosion/sedimentation, crop growth, weed competition, grazing, irrigation, tillage operations, agricultural management and nutrient and pesticide dynamics are included in the simulations. Hydrology aspects include overland and channel runoff, subsurface flow, deep percolation, field sediment losses and evapotranspiration.

APEX and its field scale model predecessor, the Environmental Policy Impact Climate (EPIC) model (Williams, 1990) have been extensively used to simulate nutrient, pesticide and sediment movement. EPIC has been used under numerous conditions in the U.S. and other countries (Gassman et al., 2005) and even at a global level (Liu at al., 2007). Since its inception in 1996, APEX modeling has been applied in multiple studies to evaluate the impact of agricultural practices (e.g., Ramanarayanan et al., 1997; Gassman et al., 2002; and Williams et al., 2006). APEX has been used as a Best Management Practice (BMP) model by simulating land management scenarios (Borah et al., 2006). The model has been calibrated and validated for hydrology and nutrient and sediment losses (Wang et al., 2006; Ramanarayanan et al., 1998; and Wang et al., 2008) and for pesticide losses (Mudgal et al., 2010; Plotkin et al., 2013).

This user manual provides explanations for i_APEX interface structure, navigating through the i_APEX screens, input and output tables and instruction on how to set up scenarios and perform model Runs. Guidance is provided on design and construction of scenarios and sample set-ups to perform desired simulations of nutrient, pesticide and sediment movement through contiguous fields, channels that drain the fields, field run-on/run-off, and reservoir input-output. A thorough explanation of APEX concepts and equations is provided by Williams et al. (2008) and will only

be addressed in this manual in a general manner to explain i_APEX methods for employing these concepts. Comprehensive variable definitions can be found in the APEX user's manual (Steglich and Williams, 2008). Definitions are also provided for most variables at the bottom of each i_APEX interface screen.

I_APEX Methods

I_APEX ACCESS tables contain the input data that APEX reads and uses to build a complete set of APEX input files. The program executes APEX, reads the APEX output files and fills the appropriate output tables in the ACCESS database (Figure 1). ACCESS input tables are organized by field operations management, soil properties, weather, pesticide properties and fertilizers for each subarea (Table 1). Each input table may be edited directly in ACCESS or edited within the i_APEX editing respective screens. Output tables consist of monthly and annual crop yields, watershed output (except for pesticides) and annual pesticide output (Table 2). ACCESS input table formats are presented in Appendix 1 tables and output table formats are shown in Appendix 2 tables.

Each i_APEX graphical interface screen is organized by aspects of farming categories and correlate with multiple ACCESS tables. i_APEX interface screens, tabs and buttons are organized in the following schema (i_APEX buttons are bracketed and bolded):

- Graphical User Interface
  - Menu selections
    - File –
      - Configuration
    - Edit –
    - View –
    - Window –
    - Select –
    - Run –
    - Record –
    - Help –
  - Tool Bar
  - **[Run Header]**
  - **[Header 1]**
  - **[Header 2]**
  - **[Header 3]**
  - **[Header 4]**
  - **[Header 5]**
  - **[Parameters]**

[Parameters 1]

  - **[Parameters 2]**
  - **[Parameters 3]**
  - **[Parameters 4]**
  - **[Parameters 5]**
  - **[Parameters 6]**
  - **[Parameters 7]**
  - **[Parameters 8]**
  - Weather Station – **[Select] [Edit]**
  - Subareas – 1, 2, 3…

- Soil – **[Select] [Edit]**
- Tillage (suggestion: change name to "Field Operations") – **[Change Operation] [Add Operation] [Delete Operation]**
- **[Miscellaneous]**
- **[Channel]**
- **[Reservoir]**
- **[Lagoon]**
- **[Grazing]**
- **[Routing Reach]**
- **[Auto Fertilization]**
- **[Auto Irrigation]**

Table 1: ACCESS Database Input Tables

Table Name	Corresponding Apex Input Files	Table Contents	Table Structure
Control Records	apexcont.dat iasite.dat	Data general to the run.	One record per execution of APEX
Crops	iacrop.dat	Crop parameters	One record per crop
Fertilizer	iafert.dat	Fertilizer parameters	One record per fertilizer
Field Operations	nnnn.ops	Operation schedule data	One record per operation
Livestock	iasite.dat	Herd data	One record for each of ten possible herds per run
Management	iasub.dat	Management data	One record per subarea
Operations	iatill.dat	Tillage operation parameters	One record per operation
Parameters	iaparm.dat	Coefficients internal to APEX	One record per control record
Pesticide	iapest.dat	pesticide parameters	One record per pesticide
Point Source	iasub.dat	Point source pollution file names	One record per file name
Selected Variables	iaprnt.dat	User selected output variables	One record per variable
Soil Layers	nnnn.sol	Soil layer data	One record per layer per soil
Soils	nnnn.sol	General soil data	One record per soil
Subareas	iasub.dat nnnn.ops	General subarea data	One record per subarea
Weather	iaweath.dat	Weather station data	One record per weather station
Weather by Month	iaweath.dat iawind.dat	Monthly wind and weather data	One record per weather station per month

Figure 1: i_APEX Flow Chart

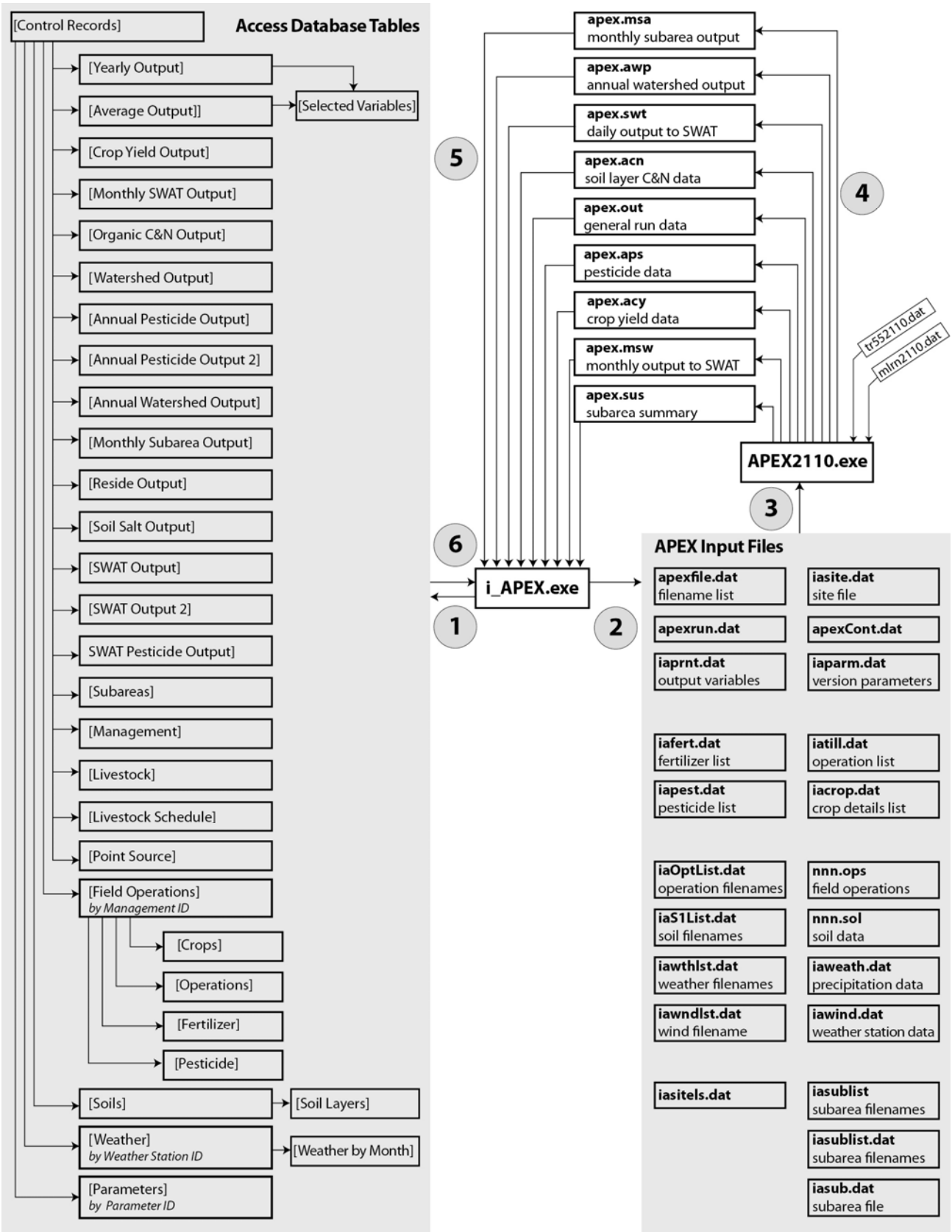


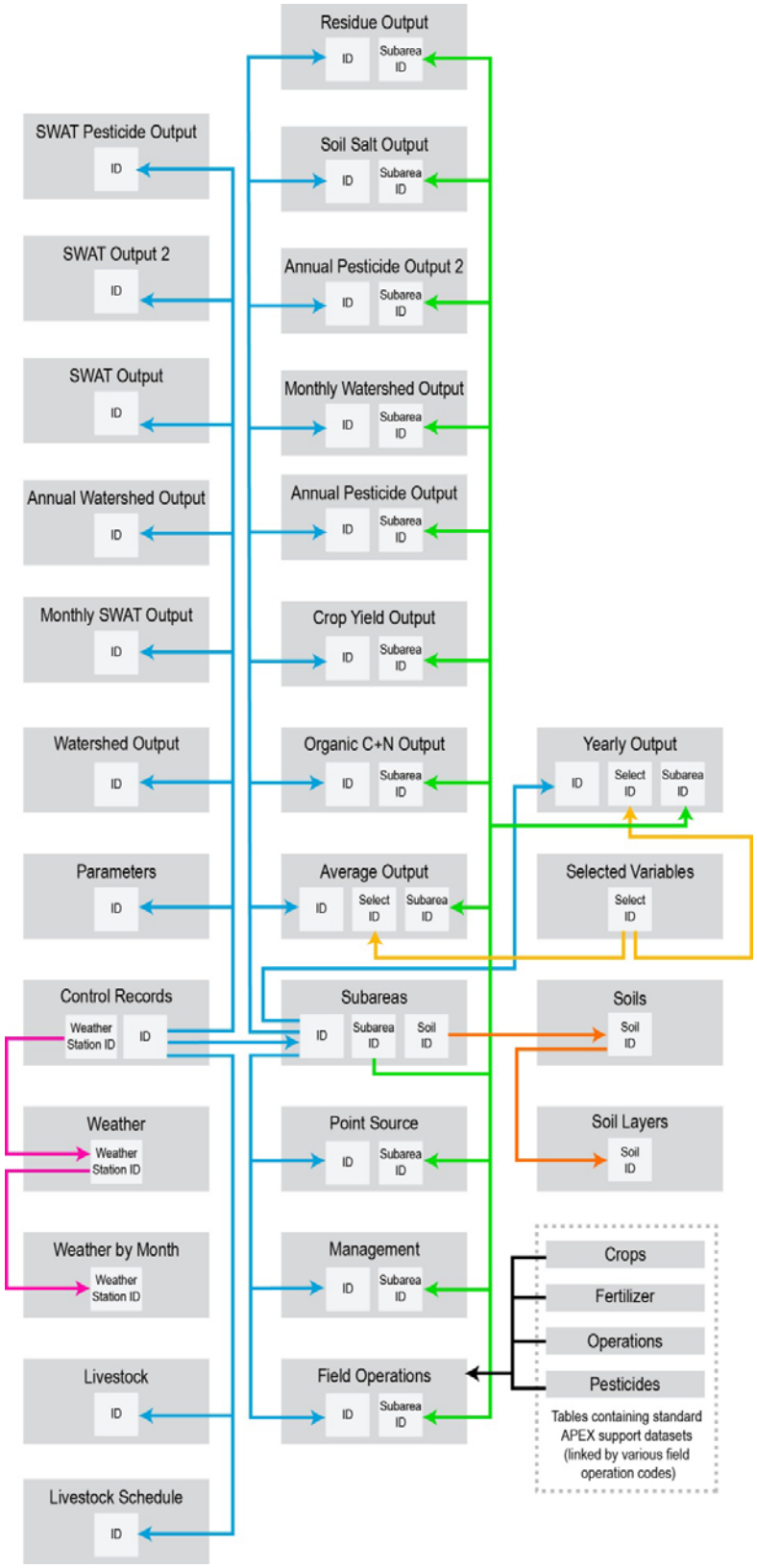
Table 2: ACCESS Database Output Tables

Table Name	Corresponding Apex Output File	Table Contents	Table Structure
Annual Pesticide Output	apex.APS	Hydrology data pertinent to pesticide losses	One record per subarea per year
Annual Pesticide Output 2	apex.APS	Pesticide losses	One record per subarea per year
Average Output	apex.OUT apex.SUS	General run data	One record per run per subarea
Crop Yield Output	apex.ACY	Crop yield data	One record per subarea per year
Monthly SWAT Output	apex.MSW	Monthly output to SWAT model	One record per subarea per month
Organic C and N Output	apex.ACN	Soil layer C and N data	One record per subarea per year
Residue Output	apex.OUT	Crop residue	One record per subarea per month
SWAT Output	apex.SWT	Annual hydrology and dissolved nutrient output to SWAT model	One record per subarea per day of loss
SWAT Output 2	apex.SWT	Annual sediment and nutrient associated with sediment output to SWAT model	One record per subarea per day of loss
SWAT Pesticide Output	apex.SWT	Annual pesticide dissolved and sediment-sorbed output to SWAT model	One record per subarea per day of loss
Watershed Output	apex.OUT	Watershed data	One record per run per month
Yearly Output	apex.OUT apex.SUS	General run data by year	One record per subarea per year

ACCESS Database Links

The i_APEX ACCESS database consists of a series of linked tables that contain input and output data (Figure 2). Four support tables, Crops, Fertilizer, Operations and Pesticide are linked to the Field Operations table and the Selected Variables table which is linked to the Average Output and Yearly Output tables. All other tables are linked to either the Control Records table or the Subarea table which is also linked to the Control Records table. (Note: Selection and data changes to any ACCESS table will not be shown in i_APEX until ACCESS and i_APEX is exited followed by re-executing i_APEX.)

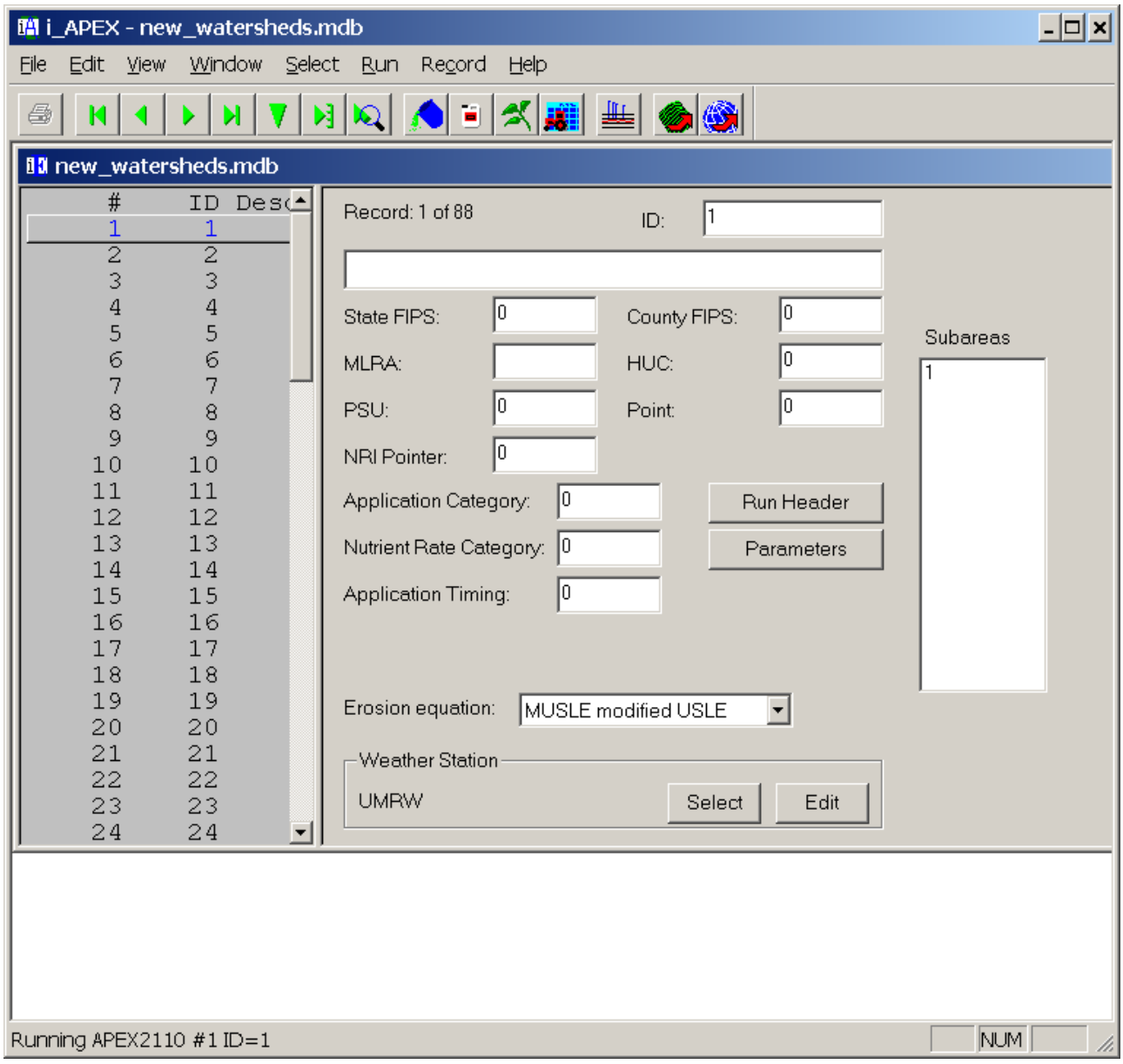
Figure 2: Database Layout



Getting Started: i_APEX Graphical User Interface

1. Executing i_APEX can be achieved by clicking on the i_APEX icon or i_APEX.exe. This will bring up the graphic interface (Figure 3).

Figure 3: Graphical User Interface Window



2. Select "File" after the i_APEX window appears. The user may select a file from the menu and can either create an empty database by selecting "New" or select "Open", and go to the subdirectory containing your i_APEX files and click on the desired i_APEX file such as the example file, new_watersheds.mdb, provided when downloading i_APEX.

Note: If instead of selecting "Open" the user clicks on "File" and selects one of the files from the list of previously used files, a window may appear with the message, "ERROR, unable to open help file "iApexHelp.csv". This will result in definitions of variables not appearing at the bottom of each i_APEX screen.

The execution interface consists of the following four discrete sections:
1) Menu;
2) Tool bar;
3) Control record list on the left below the menu and toolbar; and
4) Edit area to the right of the control record list.

Menu

1) File

New – create an empty database.
Open – open an already existing database.
Close – close the resident database.

Import APEX files – import APEX files into the current database. The user may import APEX input file records and add, delete or edit existing records.

APEXFILE.DAT – imports a complete set of APEX files into the current database. i_APEX determines the file names from the apexfile.dat file.

Pesticide File – imports the APEX pesticide file into the Pesticide table of the current database.

Fertilizer File – imports the APEX fertilizer file into the Fertilizer table of the current database.

Crop File – imports the APEX crop file into the Crop table of the current database.

Operations File – imports the APEX operations file into the Operations table of the current database.

Parameter File-imports the APEX parameter file into the parameter table of the current database.

Import (Area Studies Files) – used to import more APEX files.

Operations File – imports an APEX operations schedule file into the Field Operations table of the current database.

Soil – import**s** an APEX soil file into the Soil and Soil Layer tables of the current database.

Weather **File** – imports an APEX weather file into the Weather table and Weather by Month table of the current database.

Wind File – imports an APEX wind file into the Weather by Month table of the current database.

Export Output – not presently functioning.

Configuration – used to set i_APEX program settings. See Configuration Section.

2) **Edit** command provides the user with an interface to edit i_APEX ACCESS input tables.
   Edit Header Information – edit Control Record information.
   Edit Parameters – edit parameters for this control record.
   All Crops – edit crops.
   All Operations – edit operations.
   All Fertilizers – edit fertilizer entries.
   All Pesticides – edit pesticide entries.

3) **View**
   Toolbar – displays toolbar.
   Status Bar – displays status bar.
   Chart Output – not yet implemented.
   Table Output – not yet implemented.
   Chart All Samples – not yet implemented.

4) **Window** – window options

5) **Select** – inoperative

6) **Run** (Executes i_APEX runs. Output appends to existing ACCESS output tables.
   Deleting of records may be performed in ACCESS)
   This record – run current control record.
   All records – execute multiple runs of APEX
   Run …through… - allows user to set a range of control records to be run.
   Stop if any precheck errors – if precheck indicates errors in data do not run control records.
   Stop if any run errors – stop multiple runs if APEX error is encountered.
   Realtime priority – gives APEX absolute priority over all other processes.
   Save input files – saves the files apexcont.dat, iasub.dat, nnnn.ops, iaparm.dat, and apex.OUT for all runs using the names nn_ia.ext where nn is the control record number and ext is the extension cont, sub, ops, parm, and out respectively.
   Save SWAT files – saves apex.SWAT output files for all runs as swnnnnnn.swat where nnnnnn is the control record number.
   Create Yearly table – fills Yearly table for each APEX run.
   Create Watershed table – fills Watershed table for each APEX run.
   Create Residue Output table – fills Residue Output table.
   Pre-Check All Records – checks all control records for data errors
   Pre-Check This Record – checks the current control record for data errors

7) **Record**
   New – creates new dummy control record.
   Delete – deletes current control record.
   First – makes the first control record the current control record.
   Previous – moves the current control record up one record.
   Next – makes the next control record the current control record.
   Last – makes the last control record the current control record.
   Go To – goes to specified record number
   Search – finds specified record ID

8) **Help**
Help Contents – not yet implemented
Help Search – not yet implemented
About i_APEX

Toolbar

 **1) Print tool** – inoperative

 **2) Select beginning record**

 **3) Select previous record**

 **4) Select next record**

 **5) Select last record**

 **6) Create new record**

 **7) Go to specified record**

 **8) Search for record**

 **9) Edit database Fertilizer table**

 **10) Edit database Pesticide table**

 **11) Edit database Crop table**

 **12) Edit database Operations table**

13) Inoperative

 **14) Run current record**

 **15) Run all records**

Configuration

The configuration window is used to set the i_APEX executable location on your computer, choose the version of APEX to run, select output variables and files and indicate the number of years of output to be saved (Figure 4). These settings are automatically saved when exiting i_APEX.

The top line indicates the location and name of the APEX executable. Located to the right is the [change] button that allows the user to browse to another APEX executable. The executable name must be apex2110v3.exe or apex0806.exe as applicable, to match the name internal to the i_APEX code. By default, the directory containing the APEX executable becomes the run directory for i_APEX and APEX.

Placing a check in the **Prebuild Control Record List** check box tells i_APEX to fill the control record list at the right of the interface based on the Control Record table in the database. Otherwise, the control record list is filled as each control record is run.

A check beside **Prebuild soil list** will tell i_APEX to list soils by name when clicking the soil [select] button in the Subareas Window. The next line selects the version of APEX to run. Each version of APEX requires a different set of parameters in the database parameter table. When the version is changed the Parameter table must also be changed.

Output variables are located in the **Selected Output Variables** box. Thirty-three of these output variables have been preselected in the i_APEX **Selected** box and are always presented in the i_APEX ACCESS output tables. The user is allowed to select an additional 10 output variables from **Selected Output Variables** by clicking the [Select Variable] button. To change a user selected variable, highlight a variable in the **User Selected** box and click the **Remove** button to delete it. Then go to the **Selected Output** Variables box and highlight a variable not already present in the i_APEX **Selected** box and click the **Select Variable** box to add it to the **User Selected** box. A complete list of APEX output variables is presented in the file output variables.csv. This file along with the file IApexHelp.csv must be present in the run directory for i_APEX to function.

A check beside the **Run APEX in visible console** box allows the user to see APEX output to the screen. Otherwise APEX runs will not be shown. To the right is the box that invokes the [**Start with final soil] button**. This button causes i_APEX to rename previously created .SOT soil files present in the run directory as the soil file input to APEX runs.

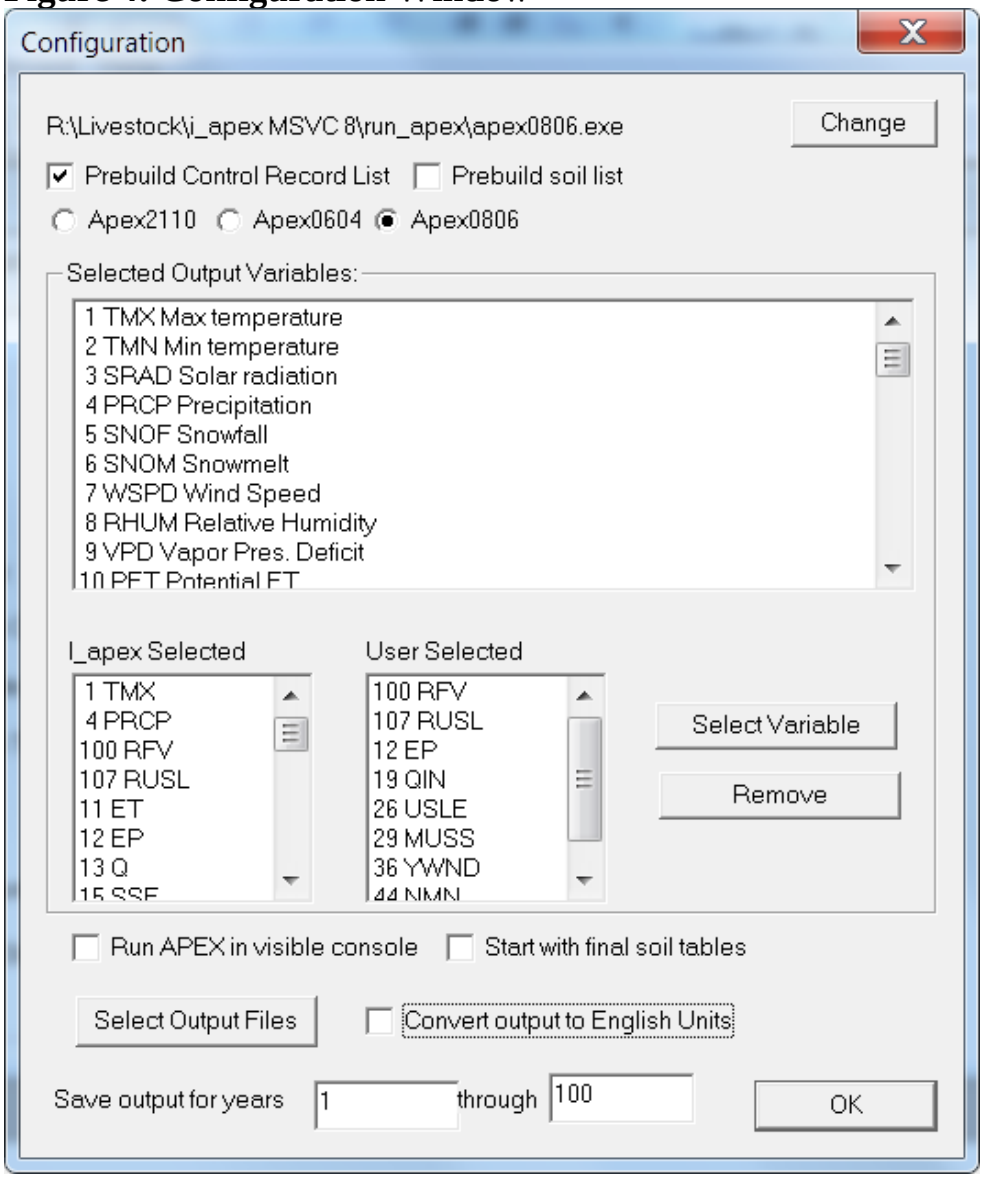
The **[Select Output Files]** button brings up a screen containing check boxes for each possible APEX output file. When a file's box is checked, that file is selected for output by APEX. Output for only six of these files is captured in the database – OUT, ACY, MSW, SUS, APS and ACN. These files must be checked to receive output in their respective database tables.

All output is expressed in metric units by default. Output may be generated in English units by checking the **Convert output to English Unit** box.

The number of years of output can be designated in the last line of C**onfiguration** by typing the beginning and ending years in **Save output for [first year] through [last year]**.

Finally, selecting the **[OK]** button saves all variable designations.

Figure 4: Configuration Window



Control Record List

The control record list from the Control Records table is sequenced starting with the control record # "1"which may or may not be control record ID 1 (Table 3). A Control Record can be created by clicking on an existing sample record and modifying it as desired or generating a new record by using the tool bar controls. A record from the list must be selected before that record in the Control Records table and the linked records in associated tables can be edited.

Edit Area

Edit area fields allow editing of all variables in the current control record. These include:

- Record IDs
- Run Header

- Parameters
- Erosion Equation
- Weather Station
- Subarea variables

Record IDs

Record identifier fields (state, county, etc.) are provided to the right of the control record list. Identifiers are optional and may be left blank.

Run Header

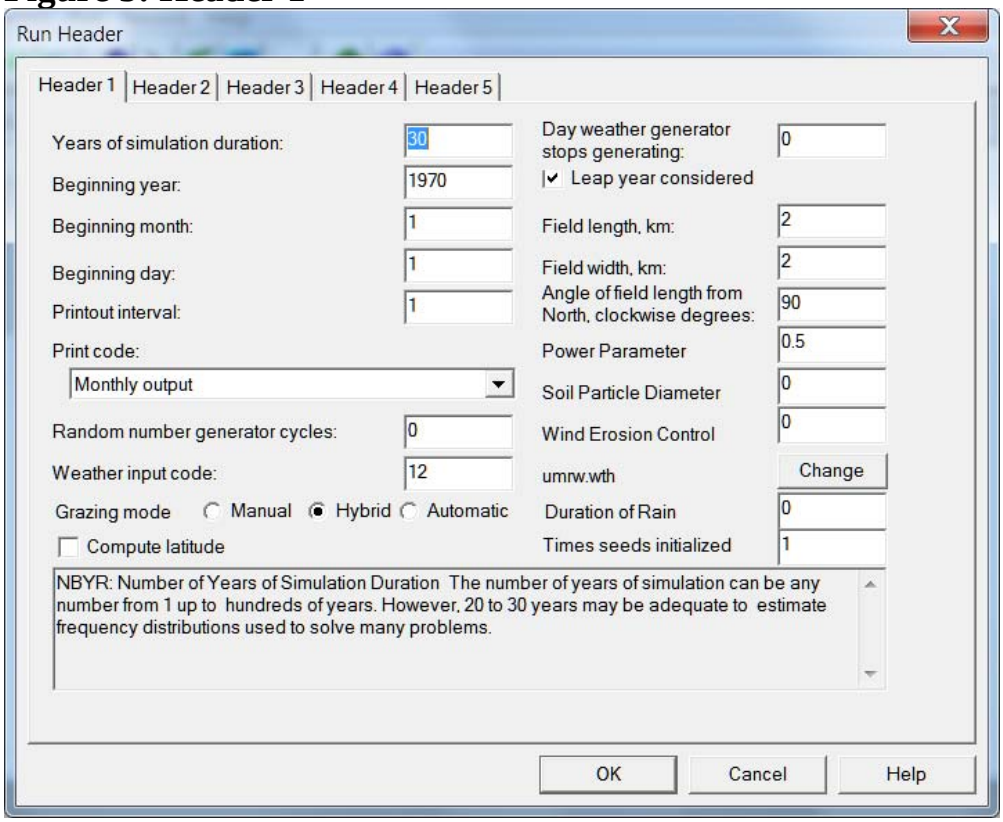
Selecting the **[Run Header]** button brings up the five Header buttons that account for variables contained in the Control Records table (see Appendix 1, Table 1). These variables are written to the iasite.dat and the apexcont.dat files. Placing the cursor on each variable field will display helpful information at the bottom of the Header screens.

Header 1 Window

[Header 1] (Figure 5) includes variables regarding:

- rain duration;
- simulation timing/print criteria;
- random number generator cycles;
- weather input code/day weather generator stops;
- grazing mode/seed initialization;
- field dimensions and angle;
- wind speed (power parameter) and erosion;
- soil particle diameter;
- number of times generator seeds initialized.

Figure 5: Header 1

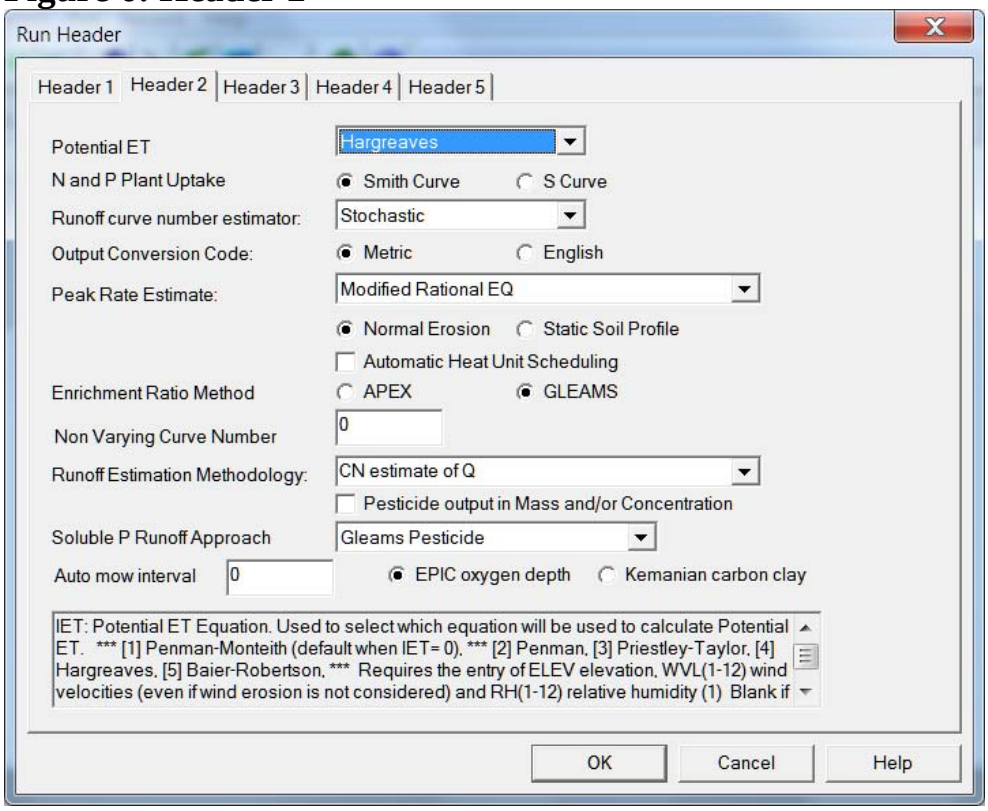


Header 2 Window

[Header 2] (Figure 6) includes variables found in the Control Records table regarding:

- evapotranspiration;
- plant N and P dynamics;
- RCN estimator/methodology/non-varying option;
- output conversion (Metric/English);
- rainfall peak rate;
- enrichment ratio method;
- auto mow minimum interval.
- EPIC oxygen/Kemanian carbon clay.

Figure 6: Header 2

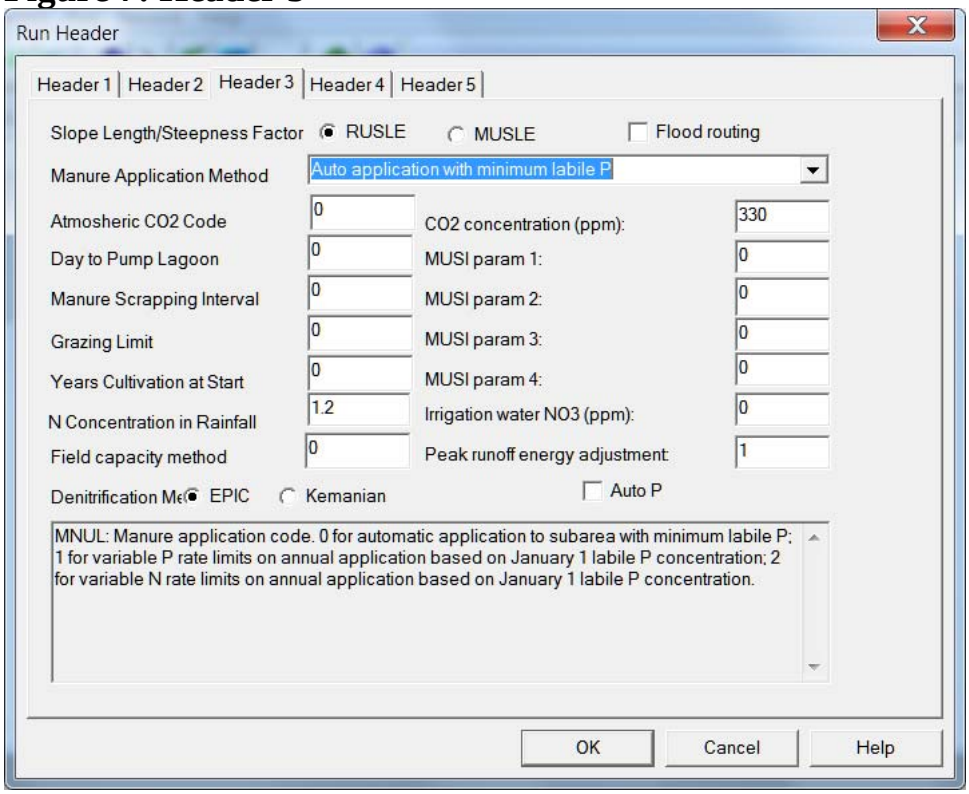


Header 3 Window

[Header 3] (Figure 7) includes variables found in the Control Records table regarding:

- slope length/steepness;
- C, N, P and manure dynamics;
- lagoon pumping day;
- grazing effects;
- cultivation years at start of run;
- field capacity/wilting point estimation method;
- MUSI erosion parameters;
- peak runoff rate-rainfall energy adjustment factor.

Figure 7: Header 3

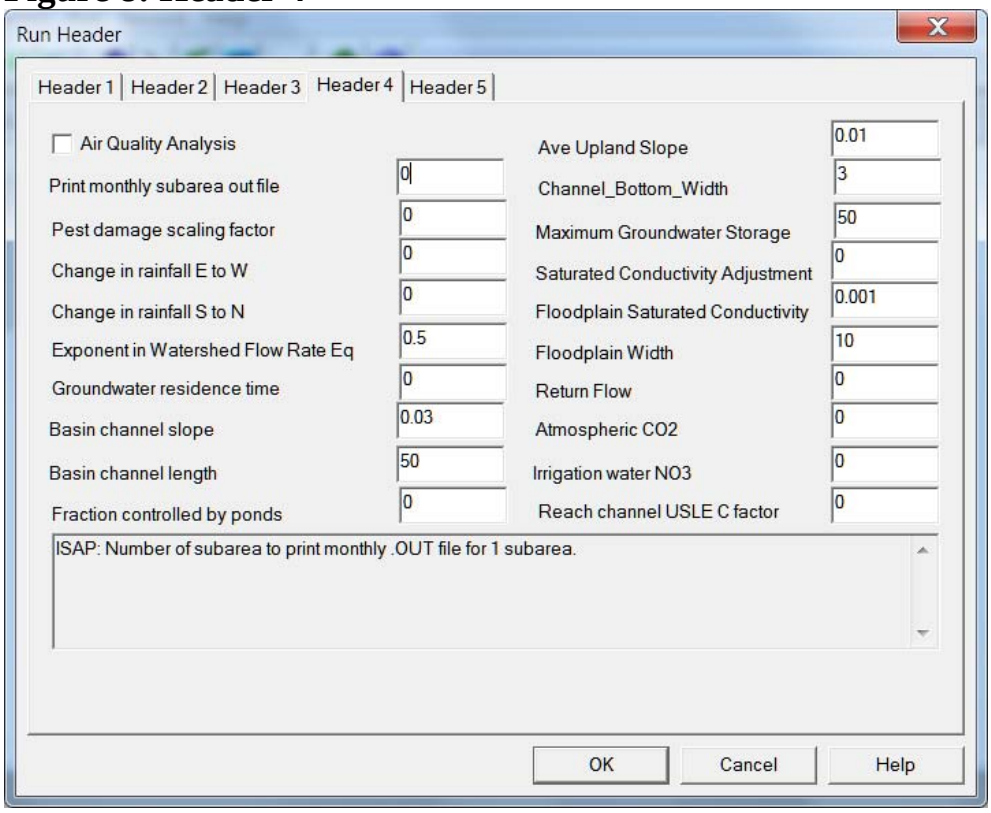


Header 4 Window

[Header 4] (Figure 8) includes miscellaneous variables found in the Control Records table that effect:

- air quality/atmospheric CO2;
- pest damage;
- direction from which precipitation is advancing;
- watershed flow rate exponent;
- groundwater flushing rate/return flow;
- channel dimensions/C factor/pond presence;
- upland slope;
- groundwater storage/floodplain infiltration rate and width used in characterizing field buffers.
- return flow;
- Irrigation water nitrate.

Figure 8: Header 4

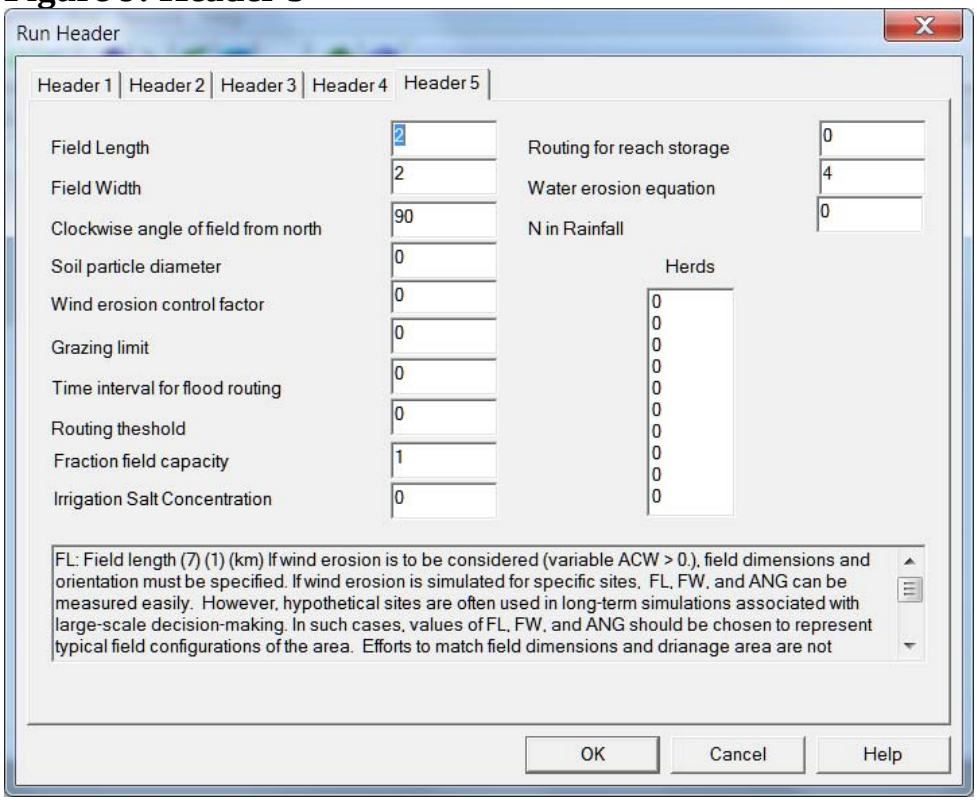


Header 5 Window

[Header 5] (Figure 9) includes variables found in the Control Records table regarding:

- field dimensions and direction;
- soil particle diameter;
- wind erosion control factor/water erosion equation;
- grazing limit/herds;
- routing parameters;
- soil field capacity fraction;
- irrigation salt concentration;
- nitrogen in rainfall.

Figure 9: Header 5



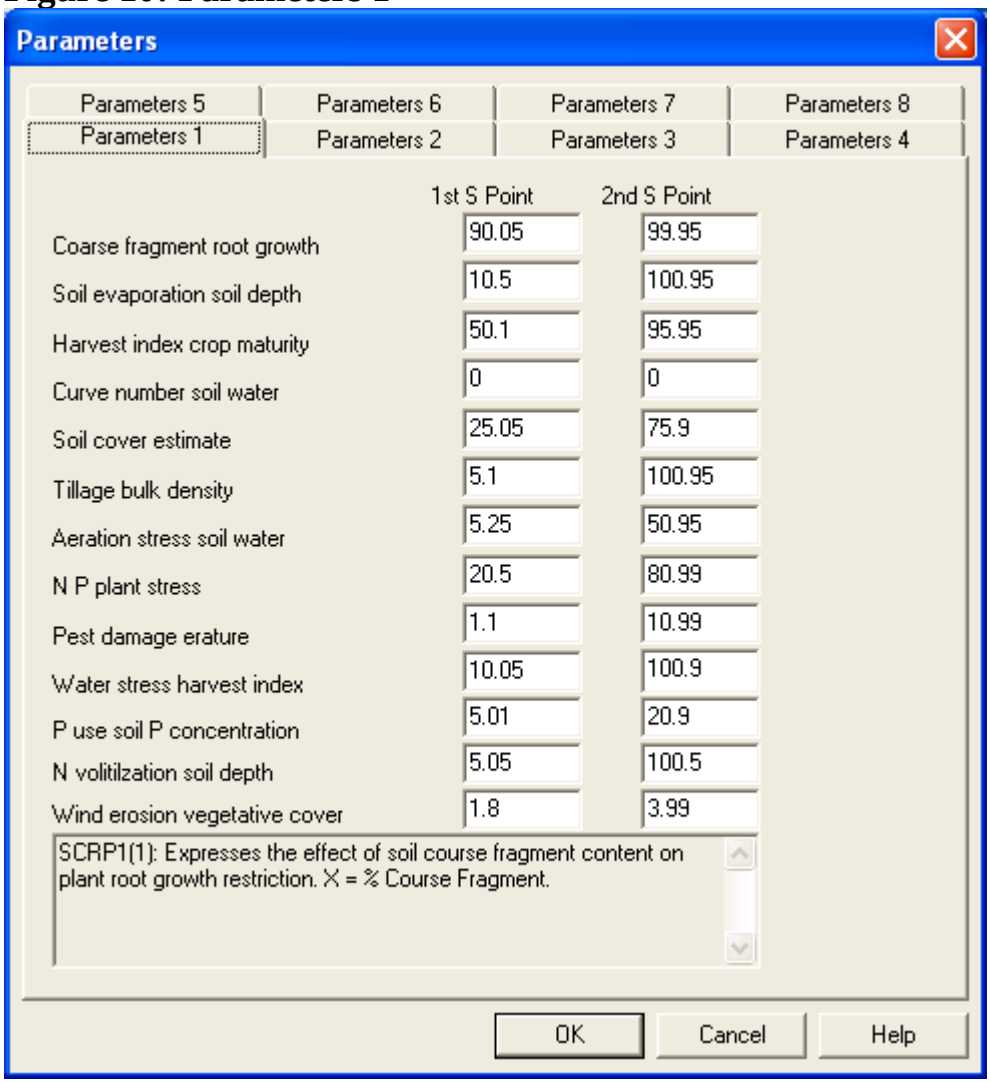
Parameter Windows

Eight parameter windows display supporting variables and coefficients relative to hydrology, crops, soils, nutrients, field operations, erosion and pesticides. All variables have been assigned preexisting defaults. Generally, these defaults may be used in performing runs unless the expert user has more accurate information that is specific to a field, watershed or region. Some of the variables and coefficients are particularly sensitive and are useful during calibration and validation of the model. This will be addressed in the calibration/validation section. The box at the bottom of each parameters window contains the parameter definition for APEX2110. Definitions for APEX0806 may be slightly different (APEX2110 definitions are located in Appendix 1, Table 14; APEX0806 definitions are in Appendix 3).

Parameters 1 Window

See Appendix 1, Table 14 for APEX2110 parameters; Appendix 3 for APEX0806;
[Parameters 1] in Figure 10 includes variables regarding 1st and 2nd S point curve values used estimating Runoff Curve Number.

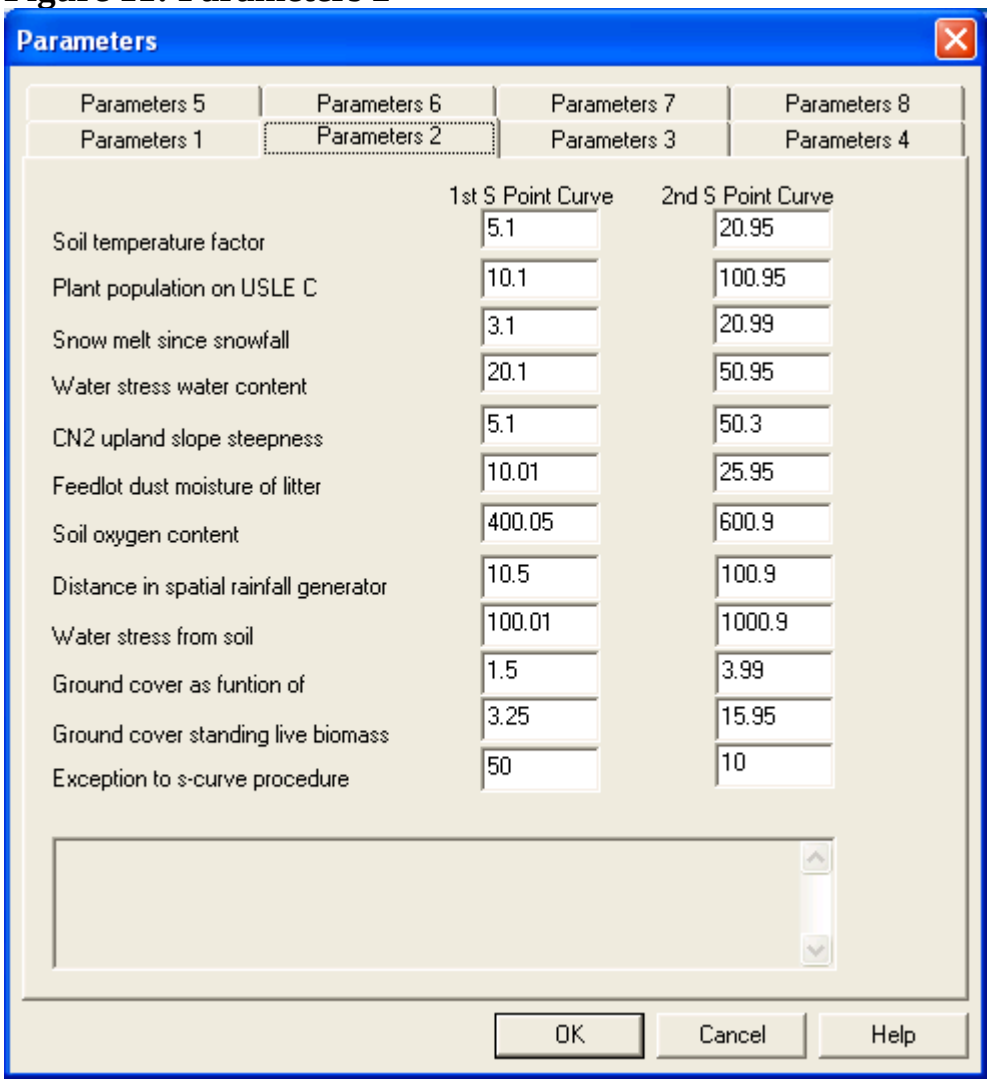
Figure 10: Parameters 1



Parameters 2 Window

See Appendix 1, Table 14 for APEX2110 parameters; Appendix 3 for APEX0806;
[Parameters 2] in Figure 11 includes variables regarding 1st and 2nd S point curve values used estimating Runoff Curve Number.

Figure 11: Parameters 2

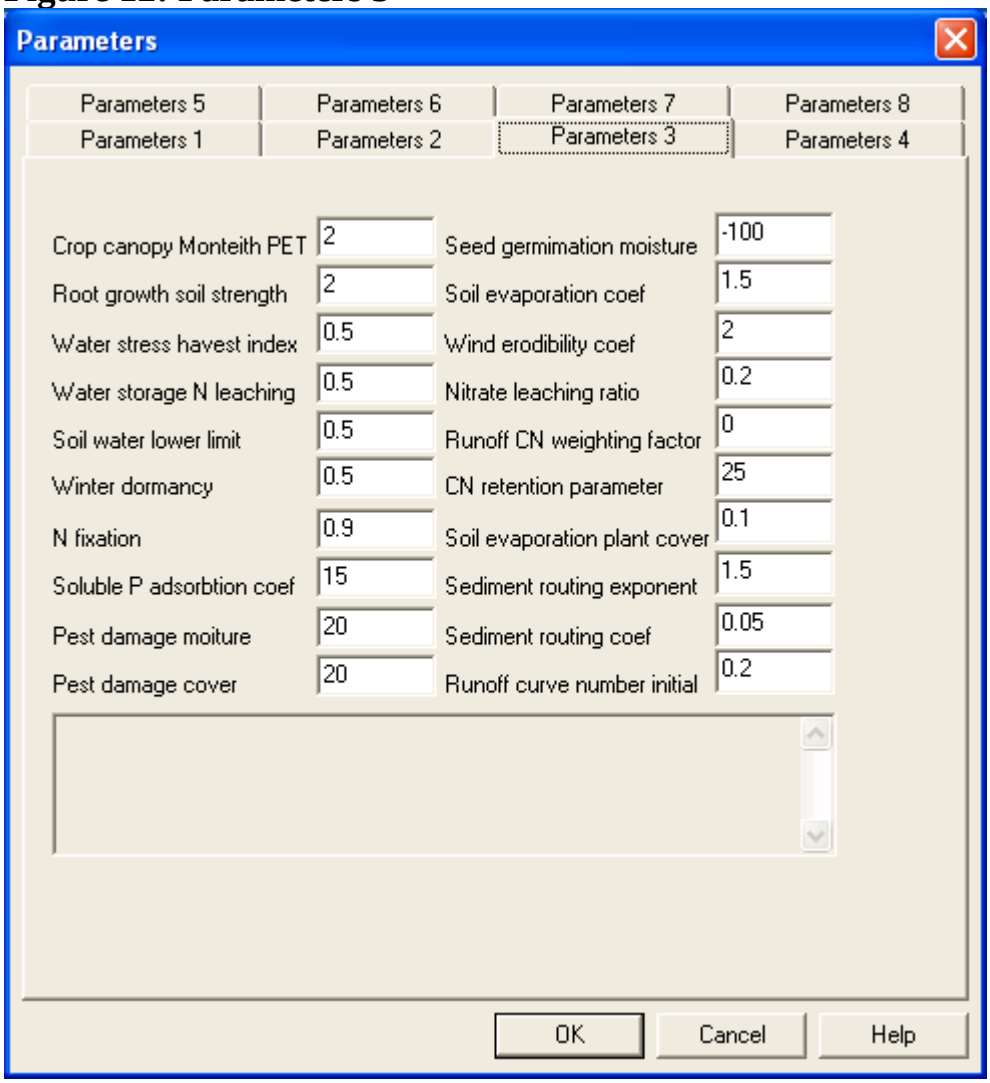


Parameters 3 Window

See Appendix 1, Table 14 for APEX2110 parameters; Appendix 3 for APEX0806 **[Parameters 3**] in Figure 12 includes variables regarding:

- crop and soil effects on hydrologic cycle crop winter dormancy;
- root growth soil strength;
- crop uptake of nitrogen and phosphorus;
- pest effects on crops;
- seed germination moisture;
- wind erodibility coefficient;
- runoff curve number factors/soil water lower limit/water stress harvest index;
- sediment routing exponent/coefficient.

Figure 12: Parameters 3

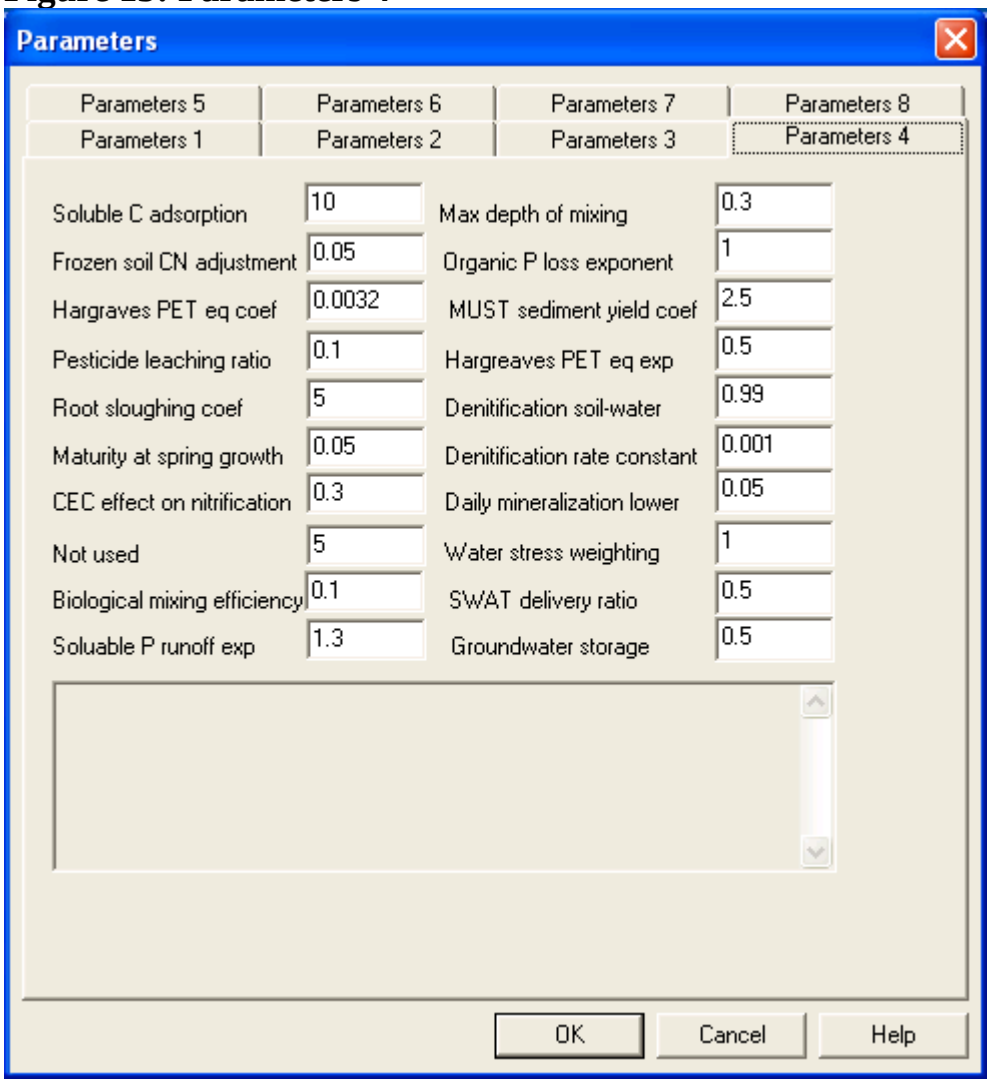


Parameters 4 Window

See Appendix 1, Table 14 for APEX2110 parameters; Appendix 3 for APEX0806; **[Parameters 4]** in Figure 13 includes variables regarding:

- crop carbon uptake/ crop growth variables/water stress/root decay rate;
- frozen soil effect on runoff curve number;
- Hargreaves coefficient/exponent;
- partitioning of pesticides between runoff and leaching;
- mineralization effects;
- biological mixing;
- phosphorus and nitrogen dynamics;
- MUST sediment yield coefficient;
- delivery ratio at edge of field or watershed to SWAT modeling;
- groundwater storage.

Figure 13: Parameters 4

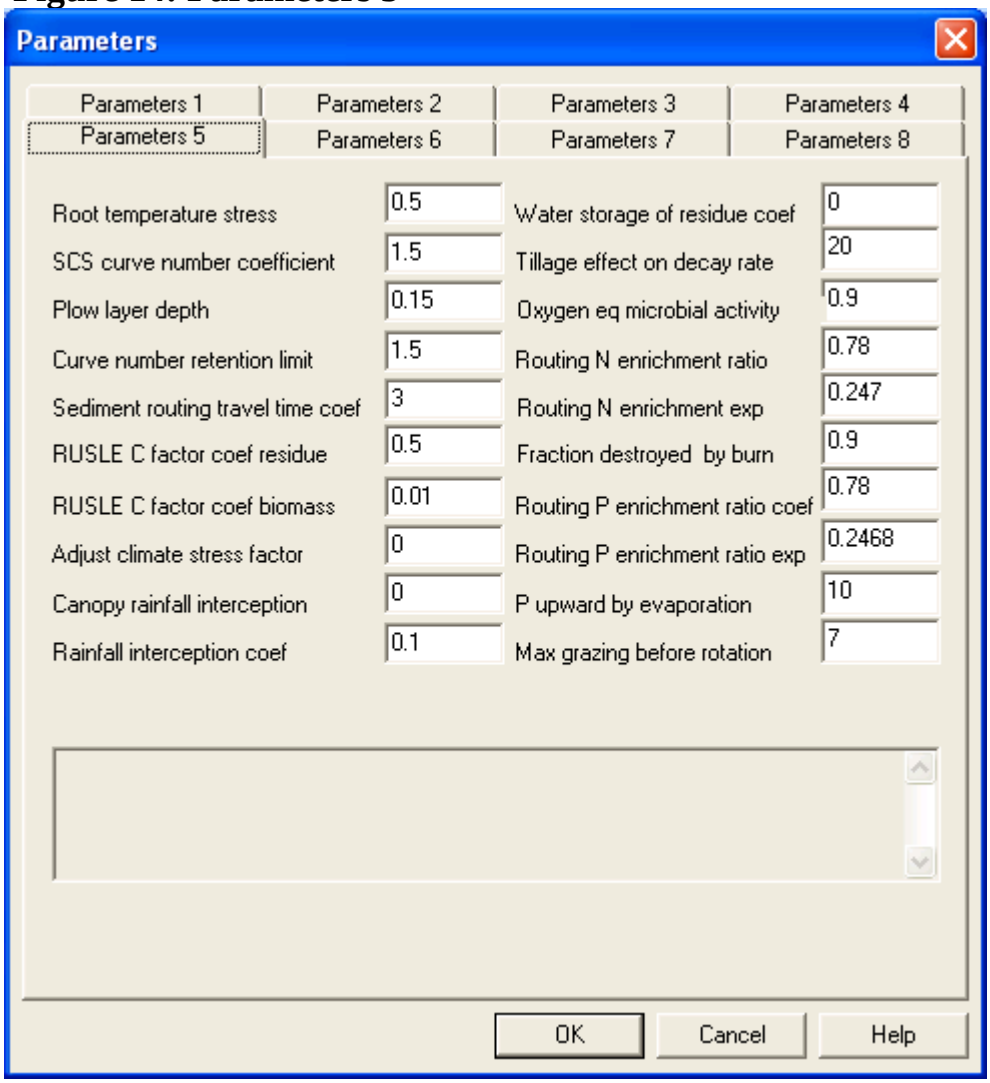


Parameters 5 Window

See Appendix 1, Table 14 for APEX2110 parameters; Appendix 3 for APEX0806; **[Parameters 5]** in Figure 14 includes variables regarding:

- root temperature stress variable;
- runoff curve number variables/flow layer depth;
- sediment routing time;
- C factor variables used in RUSLE erosion calculations;
- rainfall interception and climate stress factors;
- water storage of residue coefficient;
- tillage effect on microbial factors/oxygen equation of microbial activity;
- nitrogen and phosphorus factors;
- fraction burned;
- maximum grazing before rotation.

Figure 14: Parameters 5

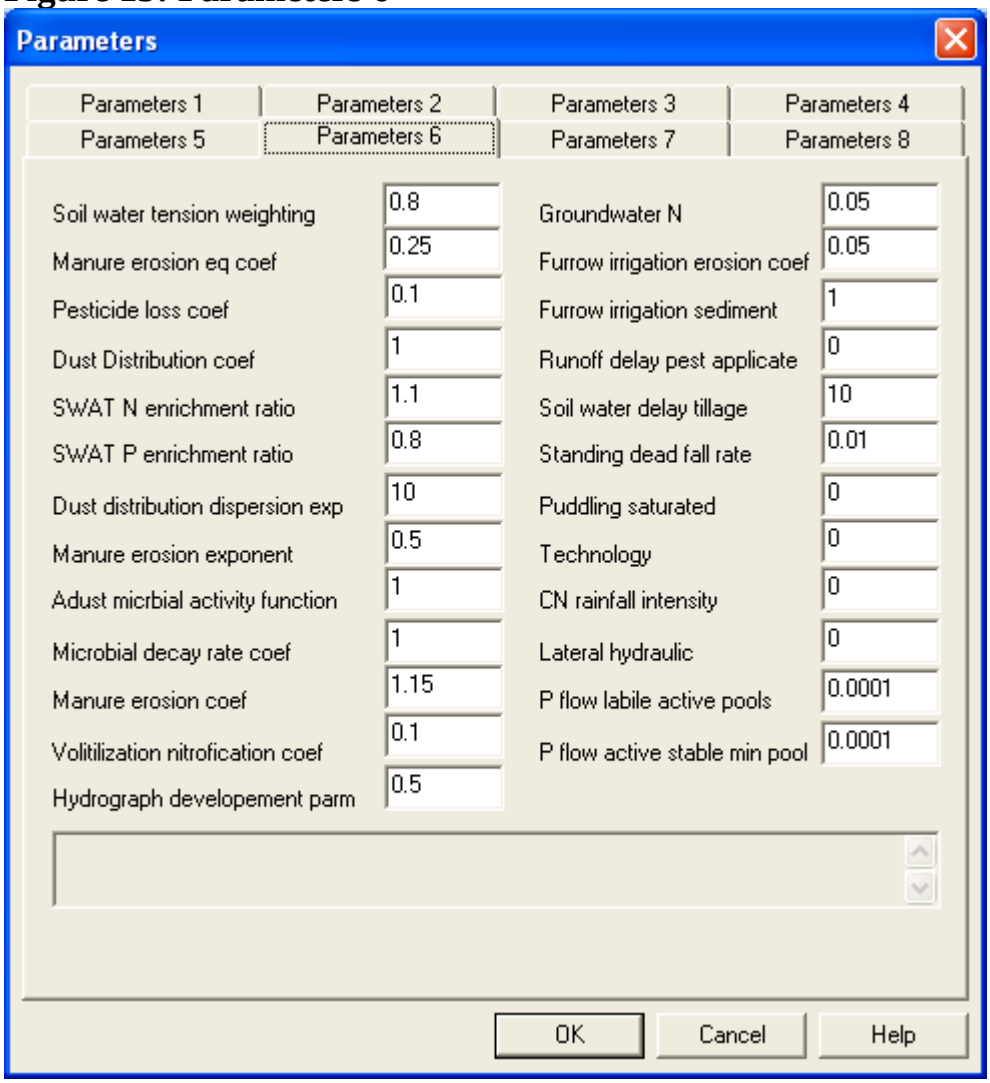


Parameters 6 Window

See Appendix 1, Table 14 for APEX2110 parameters; Appendix 3 for APEX0806;
[Parameters 6] in Figure 15 includes variables regarding:

- soil water variables/puddling;
- nitrogen and phosphorus dynamics/manure erosion/enrichment ratios to SWAT inputs;
- pesticide loss coefficient and delay of application due to soil saturation;
- dust variables;
- microbial activity;
- furrow irrigation variables;
- standing dead fall rate conversion to flat residue coefficient;
- runoff delay pest applicate;
- technology coefficient (harvest index adjustment to year 2000);
- rainfall intensity and lateral hydraulics.

Figure 15: Parameters 6

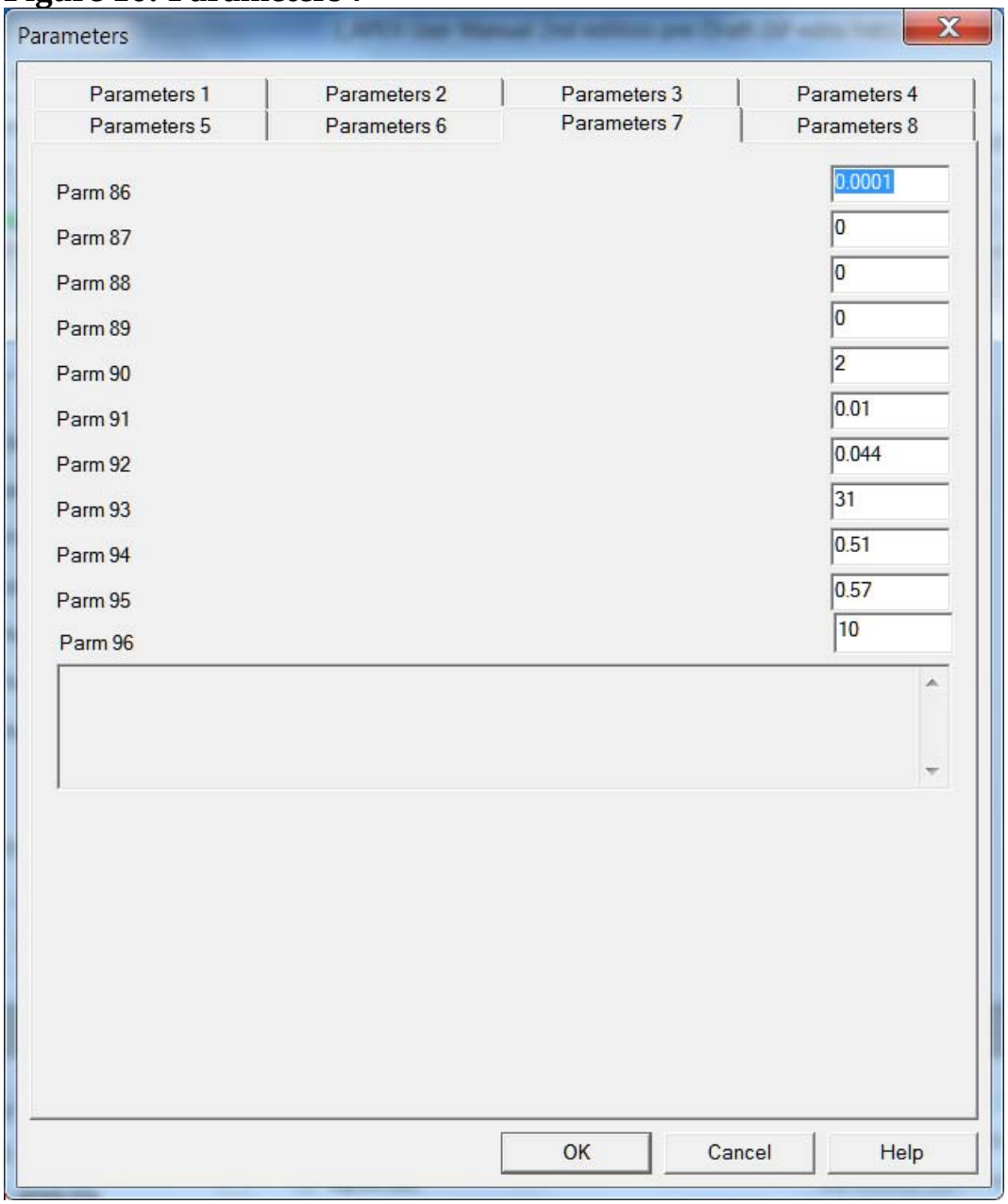


Parameters 7 Window

See Appendix 1, Table 14 for APEX2110 parameters; Appendix 3 for APEX0806; **[Parameters 7]** in Figure 16 includes parameters 86 to 96 regarding:

- nitrogen upward movement from evapotranspiration;
- water table including return flow;
- channel and floodplain evaporation;
- runoff volume adjustment;
- cost parameters.

Figure 16: Parameters 7

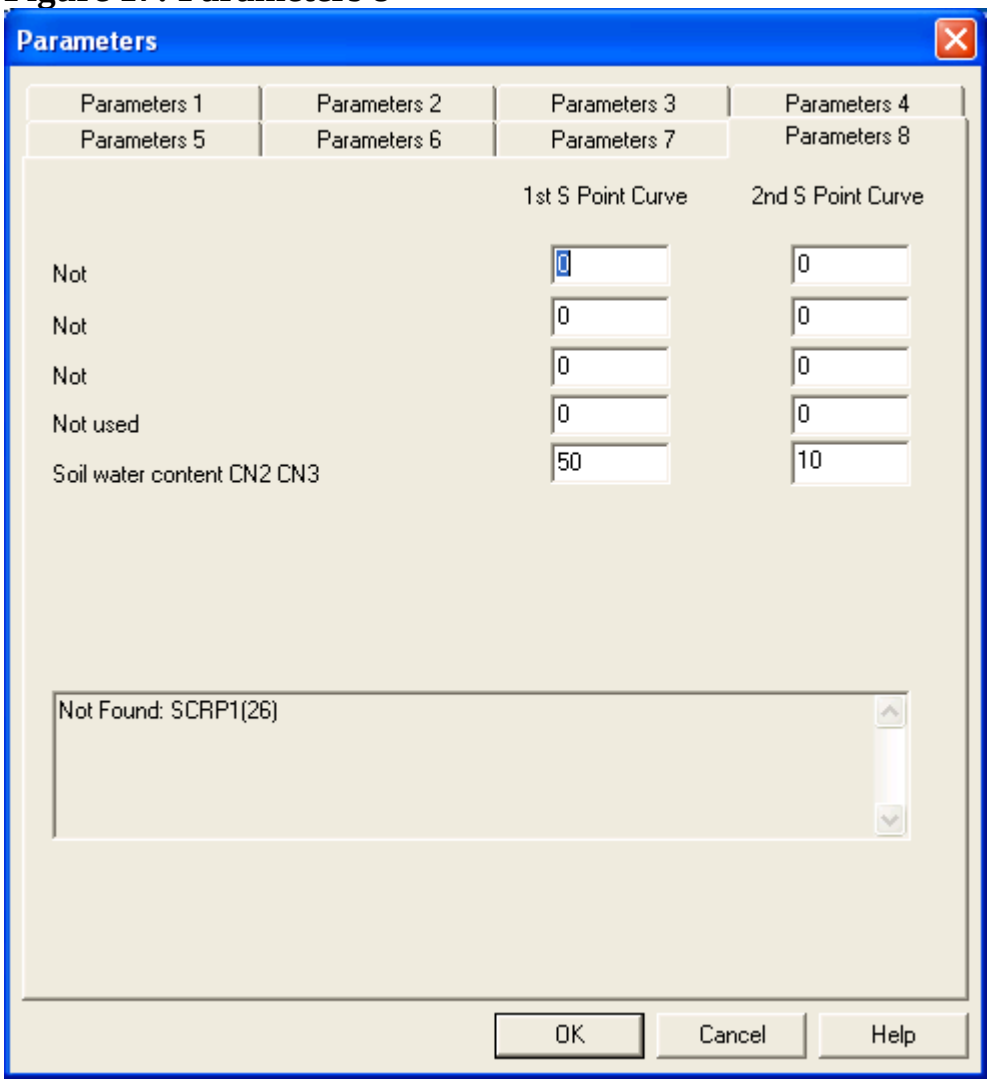


Parameters 8 Window

See Appendix 1, Table 14 for APEX2110 parameters; Appendix 3 for APEX0806

[Parameters 8] in Figure 17 only includes the two remaining curve number variables that affect soil water content and calculation of the runoff curve number. All other runoff curve number S Point Curve variables are addressed in the [Parameters 1] and [Parameters 2] windows in Figure 10 and 11, respectively.

Figure 17: Parameters 8



Weather

A weather station may be selected from the list that is resident in the ACCESS Weather and Weather by Month tables (Graphical User Interface Window, Figure 3). Measured daily weather data can be used in the simulations including:

1. Precipitation;
2. Maximum and minimum temperatures;
3. Solar radiation;
4. Average wind speed;
5. Average relative humidity.

If none of the daily weather parameters are available, the Weather input code = [0] (Header 1, Figure 5), and all five weather parameters will be simulated by the APEX climate generator based on the selected weather station (Header 1, Figure 5). Parameters that are used by the climate generator may be edited by selecting the **[Edit]** button in the Graphical user interface window

(Figure 3). Availability of other measured parameters can be assigned to the Weather input code based on the designations above. For example, if only precipitation is available and the user needs other daily parameters to be generated, the Weather input code = [1]. Measured precipitation must be available if daily temperatures and other measured parameters are to be used in the simulations. When other measured data are available, a "1" designation does not need to be input. For example, if all 5 parameters have measured values available the Weather input code = [2345]. In all simulations, mean monthly weather data must be input into the ACCESS table, **Weather by Month** (Appendix 1, Table 9).

Soils

A soil may be selected by clicking **[Select]** in the upper right section of the Subarea window (Figure 18). Selecting the **Soil** [**Edit]** button brings up the soil edit window, and double clicking on the entries in the soil layer list box brings up an edit window for a particular soil layer. A layer may be added by selecting the [**Add Layer]** button and editing values using the **[Edit Layer]** button. To delete a layer, click on the layer in the list box and select the **[Delete Layer]** button. Alternatively, soil may be added or altered using the **Soils** (Appendix 1, Table 6) and **Soil Layers** (Appendix 1, Table 7) ACCESS tables.

The USDA Natural Resources Conservation Service has sampling data for many of the soil inputs. Soil water holding capacity parameters required by the model including bulk density, field capacity, wilting point and saturated conductivity. When measured field capacity and wilting point are unavailable the values may be estimated from bulk density texture, organic carbon content and soil fragments using soil equations calculated by the model and designated in of the Control Records Table (Appendix 1, Table 1) for the Field Capacity Method (variable ISW):

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 pointed inputted (static);

Alternatively, these soil parameters and saturated conductivity may be calculated external to the model (e.g., Saxton and Rawls, 2006) and input into the soils tables by the user.

Erosion/Sediment

APEX allows six different methods that can be used to estimate soil erosion depending upon availability of field soil, crop and rainfall intensity information (Graphical user interface, Figure 3) as defined by Steglich and Williams (2011). These include:

- MUST - Modified MUSLE theoretical based equation;
- AOF - Onstad-Foster;
- USLE - Universal Soil loss Equation;
- MUSS - Small Watershed MUSLE;
- MUSLE - Modified USLE;
- MUSI - Modified MUSLE with input parameters (see BUS(1));
- RUSLE - Revised Universal Soil Loss Equation; and
- RUSLE2 - Modified RUSLE.

Hydrology

Components of APEX that most affect hydrology include simulation of:

Runoff, percolation and subsurface flow;
Irrigation;
Evapotranspiration.

Runoff

There are four methods that can be used to model runoff and percolation by selecting the Runoff Estimation Methodology options (Header 2, Figure 6):

Curve number estimate of Q

Runoff Curve Number estimator – select either Stochastic or Rigid;
Green and Ampt Q: Exponential rainfall simulation – Peak rainfall rate simulated;
Green and Ampt Q: Exponential rainfall, Input peak – Peak rain input;
Green and Ampt Q: Uniform rainfall – Uniformly distributed, peak rainfall input.

Using sensitivity analysis of APEX hydrologic variables, Wang et al. (2006) determined that the NRCS Runoff Curve Number index coefficient (CNIC) and CN2 variables were particularly influential in the effects of runoff and percolation. Curve number may be input manually in field operations or the model can automatically determine the values over the simulation period as crops, cover crops, tillage and hydrologic soil conditions change. Manual input of CN2 will remain unchanged throughout the model run unless a new value is input in a subsequent field operation.

Irrigation

Two irrigation modes are available:

Automatic – Specifications of automatic irrigation may be input by selecting the [Auto Irrigation] button in the Subarea Edit Window (Figure 18);

Manual – Irrigation is applied as a field operation with depth and date applied input in the Subarea Edit Window in the Operations section (Figure 18).

Six irrigation types are available by assigning the Irrigation code (IRR) in the Auto Irrigation window one of the following options:

0: Dryland;
1: Sprinkler irrigation;
2: Furrow/flood irrigation;
3: Fertigation;
4: Lagoon; and
5: Drip irrigation.

Irrigation may be partitioned between runoff and infiltration using the Irrigation Runoff Ratio (EFI) in the Auto irrigation window to designate the volume fraction that may run off (Figure 18). The manual irrigation type and EFI can be assigned in the field operations section of the Subarea window.

Evapotranspiration

Evapotranspiration can be modeled in APEX using one of five alternative methods (Header 2, Figure 6):

- Penman (1948) – requires daily recorded values for maximum and minimum air temperatures, precipitation, solar radiation, average wind speed and relative humidity;
- Penman-Monteith (Monteith, 1965) - requires daily recorded values for maximum and minimum air temperatures, precipitation, solar radiation, average wind speed and relative humidity;
- Priestly-Taylor (1972) - requires daily recorded values for maximum and minimum air temperatures, precipitation and solar radiation;
- Hargreaves and Samani (1985) - requires daily recorded values for maximum and minimum air temperatures, precipitation;
- Baier-Robertson (1965) - requires daily recorded values for maximum and minimum air temperatures and precipitation (appropriate for cold climates).

APEX computes evaporation from plants and soils separately (Ritchie, 1972). Additional variables associated with these methods can be found in **[Parameters 3]** (Figure 12) and **[Parameters 4]** (Figure 13). The Hargreaves PET equation exponent is particularly influential in its effect on evapotranspiration (Wang et al., 2006).

Fertilization

Like irrigation, fertilization may be applied in two ways:

Automatic – Specifications of automatic fertilization may be input by selecting the [Auto Fertilization] button in the Subarea Edit Window (Figure 18);

Manual – Fertilization is applied as a field operation with depth and date applied input in the Subarea Edit Window in the Operations section (Figure 18) by selecting an ID from the ACCESS Fertilizer table.

Fertilizer may be applied in many different forms such as:

- Poultry manure;
- Cattle manure;
- Mineral phosphorus
- Anhydrous ammonia;
- Mineral nitrogen;
- N-P-K 28-10-10.

Carbon, nitrogen, phosphorus and other nutrients enable the crop to grow. Rate of crop growth is dependent upon nutrient availability, chemical form and application method. Initial soil nutrient levels should be input in the ACCESS Soils table (Appendix 1, Table 6). The model performs chemical and biochemical reactions that affect the nutrient bioavailability as well as nutrients runoff and infiltration. Carbon dynamics and level of soil organic carbon are simulated throughout a model run. Nitrification and denitrification dynamics are estimated by the model as well as nitrogen forms such as ammonium, nitrate, nitrite and labile and nonlabile forms of organic nitrogen. Phosphorus chemistry is also determined by the model to estimate inorganic and organic forms utilized by the crop and leaving the field in runoff and percolation. The user can manipulate nutrient chemistry and budgets by altering numerous variables found in [Header 2] (Figure 6), [Header 3] (Figure 7), [Header 4] (Figure 8) and [Header 5] (Figure 9), as well as

[Parameter 1] (Figure 10), [Parameter 3] (Figure 12), [Parameter 4] (Figure 13), [Parameter 5] (Figure 14) and [Parameter 6] (Figure 15).

Runoff Curve Number greatly influences the partitioning of nitrogen and phosphorus between runoff (soluble and associated with detritus and sediment losses) and subsurface flow.

Pesticides

Application of pesticides may result in losses in runoff, percolation (including subsurface lateral flow) and absorbed to sediment particles. Pesticides and their properties are found in the Pesticides ACCESS table. Formatting for this table is shown in Appendix 1, Table 12. Pesticides may be applied by any method desired that have a populated record in the ACCESS Operations table (e.g., spraying, incorporation and knifing). Incorporation and knifing can be indicated in the Operations table by providing a depth in millimeters to the variable labeled "Tillage Depth". Pesticide properties and application method affect pesticide losses as does application timing and are all indicated in the subarea operations (Figure 18). Greater water runoff will enable increased pesticide runoff (soluble and associated with sediment) and is inversely proportional to soluble pesticide infiltration. Pesticides with a Koc > 5000 will have little or no infiltration when there is significant organic matter present except through macropores, cracks and holes. An APEX variable that impacts pesticide losses is the Pesticide Leaching Ratio in the [Parameters 4] window (Figure 13) which affects partitioning of the pesticide runoff to leaching ratio. The Pesticide Leaching Ratio is typically set at 0.1 unless more specific information is available. Another APEX variable that affects losses, the Pesticide Loss Coefficient in the i_APEX [Parameters 6] Window (Figure 15), represents the fraction of porosity that interacts with a pesticide as it leaches through the soil layer (typically set at 0.1 unless more field specific information is available). Pesticide drift losses during application can be estimated by the user by providing an application fraction to the variable, Harvest Pesticide Efficiency Ratio (Appendix 1, Table 13). When performing modeling studies, the USEPA assumes a default value of 5% drift and 95% reaching soil and plant surfaces (Harvest Pesticide Efficiency Ratio = 0.95). Pesticide applications have a "Code" variable value of 7, unless the application is by chemigation in which case the "Code" would be 8.

Subareas

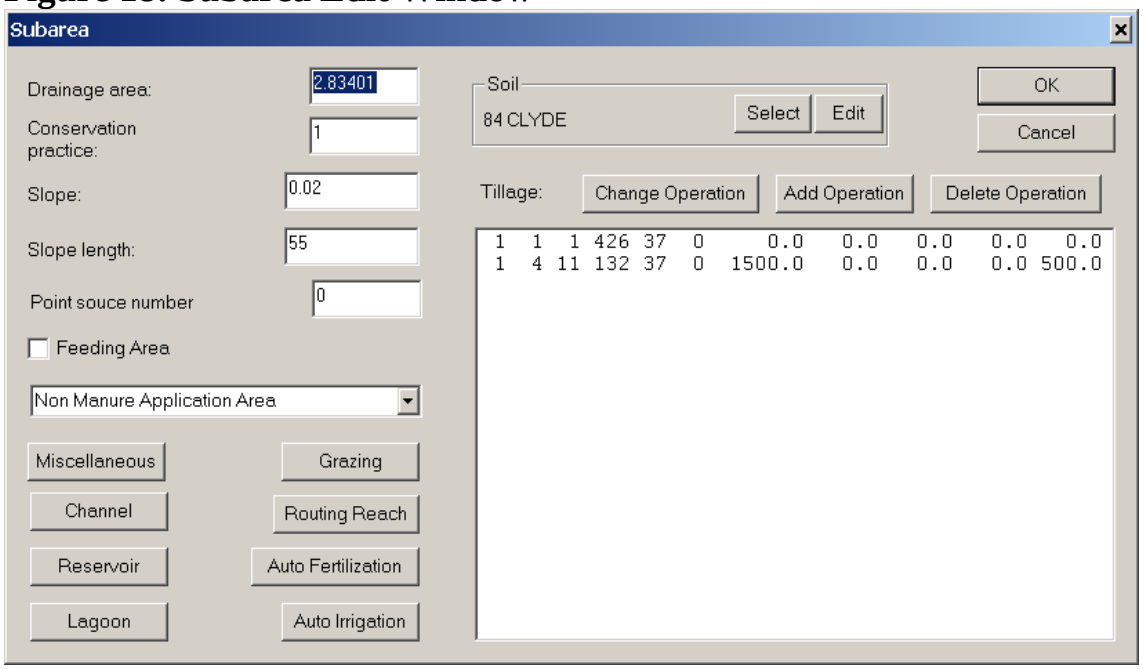
The subarea edit window can be shown by double clicking on a subarea number entry in the Subarea list box (Figure 18). It is used to edit variables found in the Subareas and Management tables of the database. Variable fields in the upper left quadrant include subarea size, conservation practice (also known as P factor which indicates direction of tilling and cropping relative to field slope), slope (decimal fraction), slope length (distance in meters of subarea slope), feeding area (if pasture land being used by livestock) and manure type (manure application option as **Non Manure Application Area**, **Liquid Manure Application Area** or **Solid Manure Application Area.**

In the lower left quadrant of this window, are six buttons that describe aspects of the subarea being addressed including:

- **[Miscellaneous**] - various subarea variables that don't fit in with the other seven categories;
- **[Grazing]** – number of animals and grazing limit for up to ten herds;
- **[Channel]** – characteristics of channel (see routing);
- **[Routing Reach]** – characteristics of routing reach (see routing);
- **[Reservoir]** – design characteristics of reservoir (all zeroes if no reservoir);
- **[Auto Fertilization]** – variables for the automatic application of fertilizer;

- **[Lagoon**] – variables describing lagoon characteristics;
- **[Auto Irrigation]** – variables for automatic irrigation.

Figure 18: Subarea Edit Window



Note: None of the edit changes are written to the database until another control record is selected from the control record list.

Subareas: Routing

APEX allows up to four contiguous homogenous land use units or subareas. Each subarea represents a landuse partitioning and runs off to the watershed channel (stream). Ultimately, subsurface lateral return flow combines with runoff at the watershed outlet. A complete set of input variables must be independently populated for each subarea including Field operations (Subarea edit window, Figure 18). Buffers may be simulated by treating them as floodplains. Floodplain modeling enables run-on of runoff from the upslope subarea that borders on the floodplain. Water and associated nutrients, pesticides and sediment are drained onto the buffer (floodplain) soil surface.

Channel length (CHL) (**[Channel]** window in the **Subarea** window, Figure 18), **Channel length of routing reach** (RCHL) (**[Routing Reach]** window in the Subarea window, Figure 18) and **Watershed area** (WSA) (WSA = **Drainage area** for each Subarea; Figure18) must be specified in order to lay out the routing schema for the watershed. Extreme areas in a watershed (furthest from the watershed outlet), should make CHL = RCHL. A CHL > RCHL indicates to the model that it is a downstream subarea. A negative watershed area (-WSA) indicates that the area of the subarea is added to another subarea(s) before reaching the downstream subarea. Figure 19 shows routing for a watershed with four subareas from Steglich and Williams (2008):

Subarea 1 (extreme area, cotton peanut rotation); WSA = 50 ha;
Subarea 2 (extreme area, Pasture); WSA = - 45 ha;
Subarea 3 (downstream area, Corn-soy rotation); WSA = 70 ha;
Subarea 4 (downstream area); WSA = 30 ha.

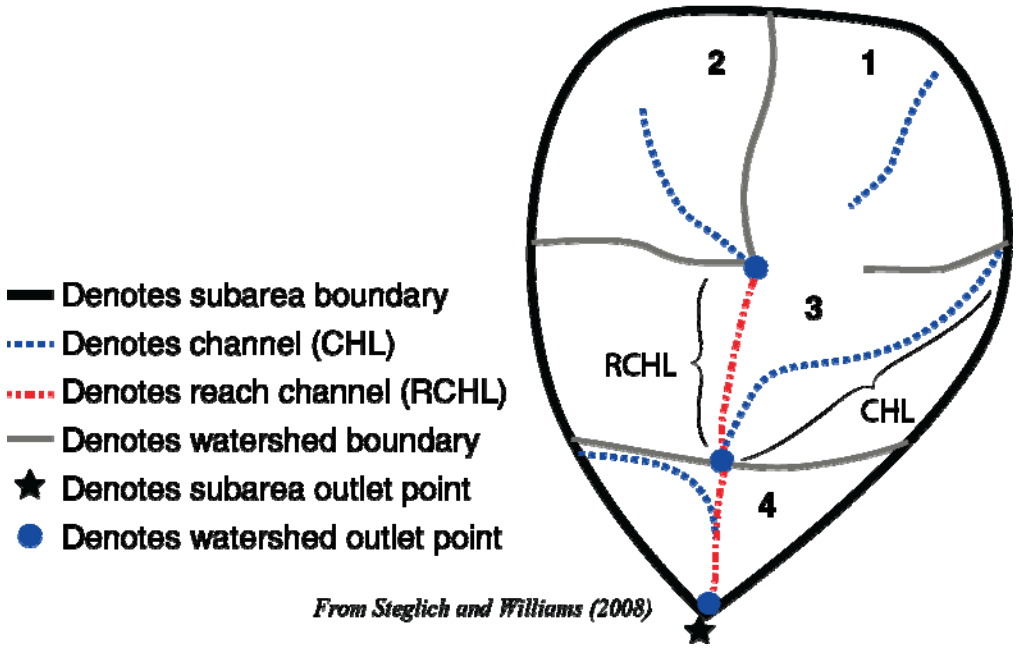
- CHL = RCHL

Extreme area (headwaters); CHL = distance from subarea outlet to farthest point in subarea. The distance is equal to the RCHL if the length of the routing reach is the same as the CHL length. As shown in the diagram, an extreme subarea drains to the headwaters of the water reach. Therefore, a true routing reach has not yet been established in these subareas. In subarea 3, a routing reach has been defined since water moves through the subarea from the upper end of the subarea (point at which water from the upstream subarea(s) enter the subarea) to the subarea outlet.

- CHL > RCHL
  In subarea 3, the distance from subarea outlet to the farthest point in the subarea is greater than the routing reach length through the subarea.

- –WSA
  A negative watershed area (WSA) causes summation of subarea areas. In Figure 19, subarea 2 is added to subarea 1 before being routed through 3).

Figure 19: Example of Watershed and APEX Routing Method



Subareas: Floodplains and Filter Strips

Floodplains and filter strips must be set up as a routing subarea that routes runoff from the upslope subarea to the floodplain or filter strip. If the Subarea is a filter strip (buffer), the Filter Strip variable should be checked off in the [Channel] window located in the Subarea edit window (Figure 18). The Filter Strip Flow Fraction in the [Channel] window must be input that determined the partitioning of flow through the filter strip or floodplain. Typical values for the Filter Strip Flow Fraction are in the range from 0.87 to 0.98 (Wang, personal communication, January, 2013). Other physical values that characterize the filter strip or floodplain are located in the [Channel] window. The Floodplain Saturated Conductivity and Floodplain Width in Header

4, Figure 8, can be adjusted to determine the extent of filtration that occurs in the filter strip or floodplain.

Subarea Field Operations

The **Field operations** edit window is located in the lower right section of the Subarea window. This area has three buttons, **[Change Operation]**, **[Add Operation]** and **[Delete Operation]** and a list box below of the operations. Field operations are the "drivers" of APEX modeling that includes all aspects of field management:

- Conservation Practices;
- Tillage;
- Planting;
- Fertilization;
- Chemical Applications (e.g., liming and ammonium);
- Pesticide application;
- Irrigation;
- Harvest;
- Killing the Crop;
- Cover Crop.

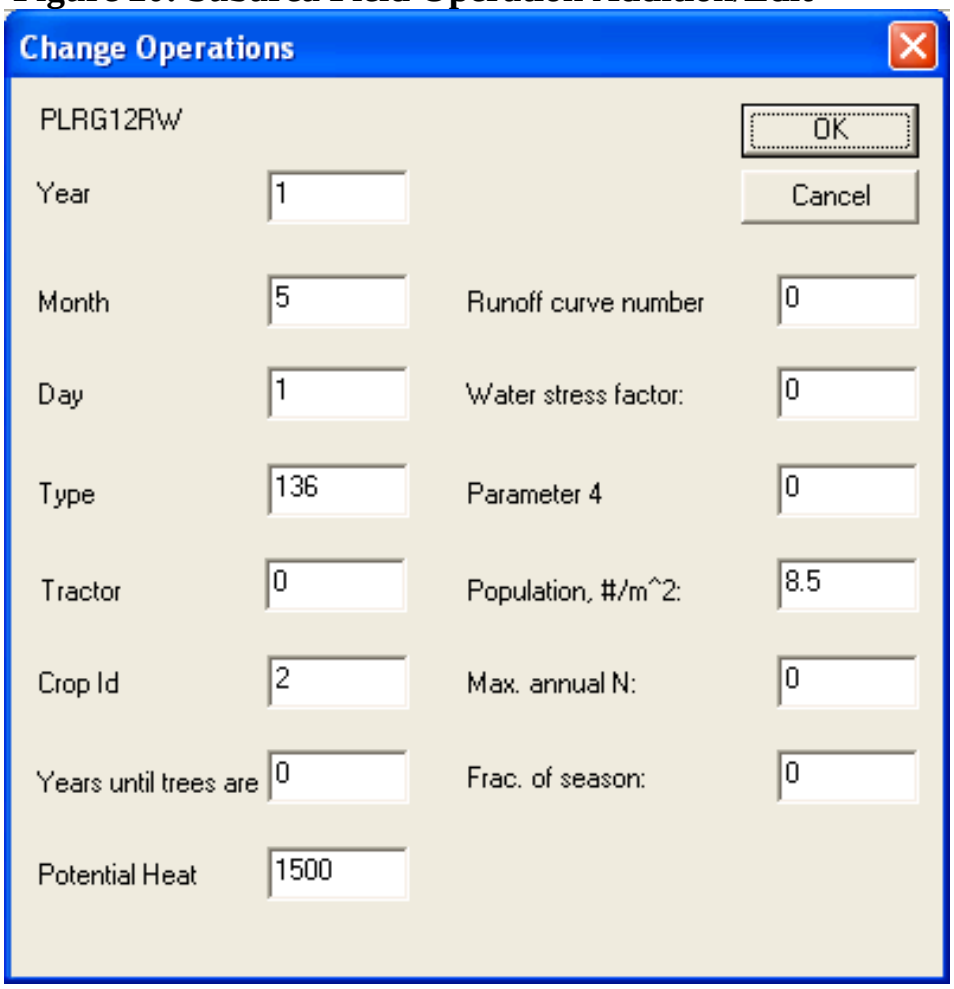
All subareas where a crop is grown must have a planting record, a harvest record and a kill record to end the crop. A crop will continue to grow even after harvest, mowing and being turned under if a "Kill" record is not used to end the crop. Pasture land of course does need to be killed.

A field operation record consists of sixteen variable fields, nine integer fields followed by seven real fields called parameter fields. The first eight integer fields include ID, Subarea Id, Year, Month, Day, Type, Tractor, and Crop Id. The last integer field and the seven parameter fields change their definition depending on the type of the field operation indicated by the **Type field** (Figure 20). The **Type field** links to the entries in the ACCESS Operations table which contains the operation name among other variables. A set of field operations make up a crop rotation for each subarea within a run. The field operations within the rotation are ordered by date with the Year, Month, and Day.

To edit an operation, click on the field operation in the list box and select **[Change Operation]**. To add a field operation, select **[Add Operation]** and to delete a field operation, click on the field operation in the list box and select **[Delete Operation]**.

Adding or editing a field operation can be performed using the **Subarea Field Operation Addition/Edit Change** window (Figure 20). To edit an existing field operation record, click directly on the record to be changed in the **Field operations** window. The operation shown in Figure 20 is for planting. The field operation name will appear in the upper left section of the window after identifying the **Type** ID number from the ACCESS Field Operations table, identifying **Year**, **Month** and **DAY**, selecting **[OK]** (which saves a field operation and exits the window) followed by clicking on the new field operation to re-invoke the window. Other variables pertinent to the particular field operation may then be input. Selecting **[Cancel]** in the Subarea Edit Window cancels all previous field operation edits.

Figure 20: Subarea Field Operation Addition/Edit



Calibration and Validation of APEX Using i_APEX

Calibration and validation of APEX with measured data can significantly increase the accuracy of modeling results. Methods for performing model calibration and validation are described in the APEX manual (Steglich and Williams, 2008), APEX documentation (Williams et al., 2008) and the conservation modeling guidance report by Waidler et al. (2011).

Calibration adjustments of i_APEX variables are typically based on time periods (days, months or years) that encompass several years of measured data. Variable adjustments are made until model results optimally correlate with measured results based on statistical performance. Adjustments of variables during the validation period are based on calibration results. Model calibrations and validations are most often performed by adjusting parameters that effect:

Hydrology:
Runoff Curve number CNIC and CN2;
Irrigation partitioning;

Evapotranspiration;
Erosion and sedimentation:
RUSLE C Factor;
Soils:
Soil water holding capacity parameters;
Nutrients:
Hydrology parameters;
Application timing;
Application method;
Fertilizer type;
Nitrogen and phosphorus chemical and biological dynamic variables;
Pesticides:
Hydrology parameters;
Application timing;
Application method;
Pesticide properties;
Pesticide loss coefficient;
Pesticide Leaching Ratio;
Crop yield and heat units:
Simulated crop yields should be within 10% of measured yields (Steglich and Williams, 2008).

References

Baier, W. and G. W. Robertson. 1965. Estimation of latent evaporation from simple weather observations. *Canadian J. Plant Sci*. 45: 276-284.

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.

Gassman, P. W., E. Osei, A. Saleh, and L. M. Hauck. 2002. Application of an environmental and economic modeling system for watershed assessments. *J. American Water Resour. Assoc.* 38(2): 423-438.

Gassman P. W., J. R. Williams, V. W. Benson, R. C. Izaurralde, L. M. Hauck, C. A. Jones, J. D. Atwood, J. Kiniry, and J. D. Flowers. 2005. Historical development and applications of the EPIC and APEX models. Working Paper 05 WP-397. Center for Agricultural and Rural Development, Iowa State University, Ames, Iowa. Available at: http://www. Card. Iastate. Edu/publications/synopsis. Aspx?id=763.

Gassman, P. W., J. R. Williams, X. Wang, A. Saleh, E. Osei, L. M. Hauck, R. C. Izaurralde, J. D. Flowers. 2010. The agricultural policy/environmental extender (APEX) model: an emerging tool for landscape and watershed environmental analyses. *Trans. ASABE* 53(3): 711-740.

Hargreaves, G. H., and Z. A. Samani. 1985. Reference crop evapotranspiration from temperature. *Applied Engr. Agric.* 1: 96-99.

Kellogg, R. L., et al. 2011. Assessment of the effects of conservation practices on cultivated cropland in the Chesapeake Bay Region. Released February, 2011. Conservation Effects Assessment Project. USDA, Natural Resources Conservation Service. Washington D. C. Website: http://www.nrcs.usda.gov/technical/nri/ceap/.

Kellogg, R. L., et al. 2012a. Assessment of the Effects of Conservation Practices on Cultivated Cropland in the Ohio-Tennessee River Basin. Released February 09, 2012. Conservation Effects Assessment Project. USDA, Natural Resources Conservation Service. Washington D. C. Website: http://www.nrcs.usda.gov/technical/nri/ceap/.

Kellogg, R. L., et al. 2012b. Assessment of the effects of conservation practices on cultivated cropland in the Upper Mississippi River Basin. Revised July, 2012. Conservation Effects Assessment Project. USDA, Natural Resources Conservation Service. Washington D. C. Website: http://www.nrcs.usda.gov/technical/nri/ceap/.

Kellogg, R. L., et al. 2012c. Assessment of the Effects of Conservation Practices on Cultivated Cropland in the Missouri River Basin. Released August 30, 2012. Conservation Effects Assessment Project. USDA, Natural Resources Conservation Service. Washington D. C. Website: http://www.nrcs.usda.gov/technical/nri/ceap/.

Monteith, J. L. 1965. Evaporation and environment. *Symp. Soc. Exp. Biol.* 19: 205-234.

Mudgal, A., C. Baffaut, S. H. Anderson, E. J. Sadler, and A. L. Thompson. 2010. APEX model assessment of variable landscapes on runoff and dissolved herbicides. *Trans. ASABE* 53(4): 1047-1058.

Penman, H. L. 1948. Natural evaporation from open, bare soil and grass. *Proc. Soc. London Ser.* A193: 120-145.

Plotkin, S., X. Wang, T. L. Potter, D. D. Bosch, J. R. Williams, E. S. Hesketh and J. K. Bagdon. 2013. APEX Calibration and Validation of Water and Herbicide Transport under Southern Atlantic Coastal Plain (USA) Conditions. Anticipated publication in: *Trans.ASABE* 56(1): Not yet available.

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.

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 1(55):76-88.

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, Minneapolis, MN, August 10-14.

Ritchie, J. T. 1972. Model for predicting evaporation from a row crop with incomplete cover. *Water Resour. Res*. 8(5): 1204-1213.

Saxton, K. E. and W. J. Rawls. 2006. Soil water characteristic estimates by texture and organic matter for hydrologic solutions. *Soil Sci. Soc. Am. J.* 70: 1569–1578.

Steglich, E. M. and J.W. Williams. 2008. Agricultural Policy/Environmental eXtender Model User's Manual. Version 0604. BREC Report # 2008-16. AgriLIFE Research, Blackland Research and Extension Center, 720 East Blackland Road, Temple, Texas.

Steglich, E. M. and J.W. Williams. Draft 2011. Agricultural Policy/Environmental eXtender Model User's Manual. Version 0806. BREC Report. AgriLIFE Research, Blackland Research and Extension Center, 720 East Blackland Road, Temple, Texas.

Waidler, D., M. White, E. M. Steglich, X. Wang, J.W. Williams, C.A. Jones and R.Srinivasan. June, 2011. Conservation Practice Modeling Guide for SWAT and APEX. AgriLIFE Research & Extension, Texas A&M System. Texas Water Resources Institute Technical Report No. 399, Texas A&M University System, College Station, Texas.

Wang, X. January 2013. Personal communication. AgriLIFE Research & Extension, Texas A&M System. Temple, Texas.

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 Tillage Res.* 101: 78-88.

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.

Williams, J. R. 1990. The erosion−productivity impact calculator (EPIC) model: A case history. *Philosophical Trans.: BiologicalScience* 329(1255): 421−428.

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. ASABE* 49(1): 61-73.

Williams, J.W., R.C. Izauralde, and E.M. Steglich, 2008. Agricultural Policy/Environment eXtender Model Theoretical Documentation. Version 0604, BREC Report # 2008-17

Williams, J. R., E. Wang, A. Meinardus, W. L. Harman, M. Siemers, and J. D. Atwood. 2006. *APEX users guide*. V.2110. Temple, TX: Texas A&M University, Texas Agricultural Extension Service, Texas Agricultural Experiment Station, Blackland Research Center.

Yin, L., X. Wang, J. Pan, and P. W. Gassman. 2009. Evaluation of APEX for daily runoff and sediment yield from three plots in the Upland Huaihe River watershed, China. *Trans. ASABE* 52(6):1833-1845.

Appendix A – ACCESS i_APEX Input Tables

Table A.1: Control Records

ID	Long Integer	None	none	apexcont.dat
Description	Text	none	none	apexcont.dat
State FIPS	Long Integer	none	none	apexcont.dat
County FIPS	Long Integer	none	none	apexcont.dat
SWAT Subbasin	Long Integer	none	none	apexcont.dat
NRIPTR	Long Integer	none	none	apexcont.dat
PSU	Long Integer	none	none	apexcont.dat
Point	Integer	none	none	apexcont.dat
HUC	Long Integer	none	none	apexcont.dat
MLRA	Text	none	none	apexcont.dat
Application Category	Integer	none	none	apexcont.dat
Nutrient Rate Category	Integer	none	none	apexcont.dat
Application Timing	Integer	none	none	apexcont.dat
Number Subareas	Long Integer	none	none	apexcont.dat
Weather Station Id	Long Integer	none	none	apexcont.dat
Simulation Length	Long Integer	none	nybr	apexcont.dat
Beginning Year	Long Integer	none	iyr	apexcont.dat
Beginning Month	Long Integer	none	imo	apexcont.dat
Beginning Dat	Long Integer	none	ida	apexcont.dat
Printout Interval	Byte	none		apexcont.dat
Print Code	Byte	none	idp	apexcont.dat
Weather Input Code	Integer	none	ngn	apexcont.dat
Weather Random Cycles	Byte	none	ign	apexcont.dat
Weather Generator Stop Day	Byte	none	igsd	apexcont.dat
Leap Year Considered	Integer	none	lpyr	apexcont.dat
Potential ET	Long Integer	none	iet	apexcont.dat
Stochastic Curve Number	Long Integer	none	iscn	apexcont.dat
Peak Rate Estimate	Long Integer	none	ityp	iasite.dat
Soil Profile	Long Integer	none	ista	apexcont.dat
Automatic Heat Unit Scheduling	Long Integer	none	ihus	apexcont.dat
Non Varying Curve Number	Integer	none	nvcn0	apexcont.dat
Runoff Estimation Methodology	Long Integer	none	infl	apexcont.dat
Pesticide Mass and Concentration	Integer	none	masp	apexcont.dat
Daily Output to SWAT	Integer	none	iswt	apexcont.dat
Enrichment Method	Integer	none	iert	apexcont.dat
Soluble P Runoff Approach	Byte	none	ibp	apexcont.dat
NP Uptake Code	Integer	none	nupc	apexcont.dat
Manure Application Code	Integer	none	mnul	apexcont.dat
Lagoon Pump Trigger	Long Integer	none	ipd	apexcont.dat
Manure Scrapping Interval	Long Integer	none	mscp	apexcont.dat
Steepness Factor Code	Integer	none	islf	apexcont.dat

Table A.1 continued

Air Quality Analysis	Integer	none	naq	apexcont.dat
Flood Routing	Integer	none	ihy	apexcont.dat
Atmospheric CO2 Code	Integer	none	ico2	apexcont.dat
Field Capacity Method	Integer	none	isw	apexcont.dat
Subarea Print Code	Integer	none	isap	apexcont.dat
Peak Runoff	Single	none	apm	apexcont.dat
Rainfall Nitrogen Concentration	Single	none	rfnc	apexcont.dat
CO2 Concentration	Single	none	co2	apexcont.dat
Irrigation NO3 Concentration	Single	none	cqni	apexcont.dat
Pest Damage Factor	Single	none	pstx	apexcont.dat
Grazing Limit	Single	none	gzl0	apexcont.dat
Years Cultivation at Start	Single	none	rtn0	apexcont.dat
Erosion Equation	Single	none	drv	apexcont.dat
MUSI Parameter 1	Single	none	bus(1)	apexcont.dat
MUSI Parameter 2	Single	none	bus(2)	apexcont.dat
MUSI Parameter 3	Single	none	bus(3)	apexcont.dat
MUSI Parameter 4	Single	none	bus(4)	apexcont.dat
Manure Rate for P Uptake	Single	none	upr	iasite.dat
Manure Rate for N Uptake	Single	none	unr	iasite.dat
Channel Cap Flow Rate	Single	none	qg	apexcont.dat
Exponent in Flow Rate Eq	Single	none	qcf	apexcont.dat
Ave Upland Slope	Single	none	chs0	apexcont.dat
Channel Bottom Width	Single	none	bwd	apexcont.dat
Floodplain Width	Single	none	fcw	apexcont.dat
Floodplain Saturated Conductivity	Single	none	fpsc	apexcont.dat
Maximum Groundwater Storage	Single	none	gws0	apexcont.dat
Return Flow Days	Single	none	rft0	apexcont.dat
Return Flow Ratio	Single	none	rfp0	apexcont.dat
Saturated Conductivity Adjustment	Single	none	sat0	apexcont.dat
Field Width	Single	none	fw	apexcont.dat
Field Length	Single	none	fl	apexcont.dat
Field Angle	Single	none	ang	apexcont.dat
Power Parameter	Single	none	uxp	apexcont.dat
Soil Particle Diameter	Single	none	diam	apexcont.dat
Wind Erosion Control Factor	Single	none	acw	apexcont.dat
Rainfall Change E to W	Single	none	bxct	apexcont.dat
Rainfall Change S to N	Single	none	byct	apexcont.dat
Flood Routing Time	Single	none	dthy	apexcont.dat
Routing Threshold	Single	none	qth	apexcont.dat
Routing when Reach Storage	Single	none	stnd	apexcont.dat
Basin Channel Length	Single	none	bchl	iasite.dat
Basin Channel Slope	Single	none	bchs	iasite.dat
Atmospheric CO2	Single	none	co2x	iasite.dat

Table A.1 continued

Irrigation Water NO3	Single	none	cqnx	iasite.dat
N in Rainfall	Single	none	rfnx	iasite.dat
Weather 1	Integer	none	impw(2)	iasite.dat
Weather 2	Integer	none	impw(3)	iasite.dat
Weather 3	Integer	none	impw(4)	iasite.dat
Weather 4	Integer	none	impw(5)	iasite.dat
Weather 5	Integer	none	impw(6)	iasite.dat
Weather 6	Integer	none	impw(7)	iasite.dat
Weather 7	Integer	none	impw(8)	iasite.dat
Weather 8	Integer	none	impw(9)	iasite.dat
Weather 9	Integer	none	impw(10)	iasite.dat
Fraction of Area by Weather 1	Single	none	fwxp(1)	iasite.dat
Fraction of Area by Weather 2	Single	none	fwxp(2)	iasite.dat
Fraction of Area by Weather 3	Single	none	fwxp(3)	iasite.dat
Fraction of Area by Weather 4	Single	none	fwxp(4)	iasite.dat
Fraction of Area by Weather 5	Single	none	fwxp(5)	iasite.dat
Fraction of Area by Weather 6	Single	none	fwxp(6)	iasite.dat
Fraction of Area by Weather 7	Single	none	fwxp(7)	iasite.dat
Fraction of Area by Weather 8	Single	none	fwxp(8)	iasite.dat
Fraction of Area by Weather 9	Single	none	fwxp(9)	iasite.dat
Weather Input File Name	Single	none	fwth	iasite.dat

Table A.2: Livestock

ID	**Long Integer**	**none**		**iasite.dat**
Owner Id	Long Integer	none		iasite.dat
Herd Id	Integer	none		iasite.dat
Number of Animals	Integer	none	ncow	iasite.dat
Fraction Herd in Feeding Area	Single	none	ffed	iasite.dat
Grazing Rate	Single	kg/hd/d	gzrt	iasite.dat
Daily Manure Dump	Single	kg/hd/d	dump	iasite.dat
Manure Id	Integer	none	idmu	iasite.dat
Urine Volume	Single	l/hd/d	vurn	iasite.dat

Table A.3: Subarea

ID	**Long Integer**	**none**		**iasub.dat**
Subarea Id	Long Integer	none		iasub.dat
Soil Id	Long Integer	none	inps	iasub.dat
Operation Schedule Id	Lone Integer	none	iops	iasub.dat
Owner Id	Long Integer	none	iow	iasub.dat
Feeding Area	Long Integer	none	ii	iasub.dat
Manure App Area	Long Integer	none	iapl	iasub.dat
Curve Number Type	Integer	none	nvcn	iasub.dat

Table A.3 continued

Daily Weather Station Number	Integer	none	iwth	iasub.dat
Point Source Number	Integer	none	ipts	iasub.dat
Water Content of Snow Cover	Single	mm	sno	iasub.dat
Standing Dead Crop Residue	Single	t/ha	stdo	iasub.dat
Subarea X Centroid	Single	none	xct	iasub.dat
Subarea Y Centroid	Single	none	yct	iasub.dat
Drainage Area	Single	ha	wsa	iasub.dat
Channel Length	Single	km	chl	iasub.dat
Channel Depth	Single	m	chd	iasub.dat
Manning N for Channel	Single	none	chn	iasub.dat
Slope	Single	m/m	stp	iasub.dat
Slope Length	Single	m	splg	iasub.dat
Manning N for Upland	Single	none	upn	iasub.dat
Filter Strip Flow Fraction	Single	none	ffpq	iasub.dat
RR Channel Length of Routing	Single	km	rchl	iasub.dat
RR Routing Reach Channel Depth	Single	m	rchd	iasub.dat
RR Bottom Width of Channel	Single	m	rcbw	iasub.dat
RR Top Width of Channel	Single	m	rctw	iasub.dat
RR Slope	Single	m/m	rchs	iasub.dat
RR Mannings N for Channel	Single	none	rchn	iasub.dat
RR USLE C for Channel	Single	none	rchc	iasub.dat
RR USLE K for Channel	Single	none	rchk	iasub.dat
RR Floodplain Width	Single	m	rfpw	iasub.dat
RR Floodplain Length	Single	km	rfpl	iasub.dat
RS Surface Area at Emergency Spillway	Single	ha	rsae	iasub.dat
RS Volume at Emergency Spillway Elev	Single	mm	rsve	iasub.dat
RS Initital Volume	Single	mm	rsv	iasub.dat
RS Principle Spillway Release Rate	Single	mm/h	rsrr	iasub.dat
RS Initial Sediment Concentration	Single	ppm	rsys	iasub.dat
RS Normal Sediment Concentration	Single	ppm	rsyn	iasub.dat
RS Bottom Hydraulic Conductivity	Single	mm/h	rshc	iasub.dat
RS Time Required to Return to Normal Sediment Conc	Single	days	rsdp	iasub.dat
RS Bulk Density	Single	t/m^3	rsbd	iasub.dat
Land Use Number	Integer	none	lun	nnnn.ops
Hydraulic Condition	Integer	none		nnnn.ops*
Autoirrigation Number	Long Integer	none	iaua	iasub.dat

*used to calculate curve number for plant operation

Table A.4: Management

ID	Long Integer	none		iasub.dat
Subarea Id	Long Integer	none		iasub.dat
Irrigation Rigidity	Integer	none	irr	iasub.dat
Irrigation	Long Integer	none	irr	iasub.dat
Minimum Auto Irrigation Interval	Long Integer	days	iri	iasub.dat
Minimum Auto Fertilizer Interval	Long Integer	days	ifa	iasub.dat
Liming Code	Long Integer	none	lm	nnnn.ops
Furrow Dike Code	Long Integer	none	ifd	nnnn.ops*
Drainage Code	Long Integer	none	idr	iasub.dat
Lagoon Fertigation Code	Integer	none	idf1	iasub.dat
Feeding Area Manure Code	Integer	none	idf2	iasub.dat
Daily Manure Application Code	Integer	none	idf3	iasub.dat
Auto Commercial N Code	Integer	none	idf4	iasub.dat
Auto Solid Manure Code	Integer	none	idf5	iasub.dat
Irrigation Trigger	Single	none	bir	iasub.dat
Irrigation Runoff Ratio	Single	Variable	efi	iasub.dat
Maximum Annual Irrigation Volume	Single	mm	vimx	iasub.dat
Minimum Single Irrigation Volume	Single	mm	armn	iasub.dat
Maximum Single Irrigation Volume	Single	mm	armx	iasub.dat
Auto Fertilizer Trigger	Single	Variable	bft	iasub.dat
Fertilizer Auto Rate Depth	Single	Variable	fnp4	iasub.dat
Maximum Annual N	Single	kg/ha	fmx	iasub.dat
Drainage End Stress	Single	days	drt	iasub.dat
Furrow Dike Safety Factor	Single	none	fdsf	iasub.dat
Conservation Practice Factor	Single	none	pec	iasub.dat
Lagoon Control Fraction	Single	none	dalg	iasub.dat
Lagoon Volume Ratio	Single	none	vglm	iasub.dat
Lagoon Input from Wash	Single	m^3/cow/dat	coww	iasub.dat
Lagoon Time from Max	Single	days	ddlg	iasub.dat
Liquid to Total Manure Ratio	Single	none	solq	iasub.dat
Auto Manure Application Rate	Single	kg/ha	fnp5	iasub.dat
Lagoon Safety Factor	Single	none	sflg	iasub.dat
Herd 1 Id	Integer	none	ny(1)	iasub.dat
Herd 2 Id	Integer	none	ny(2)	iasub.dat
Herd 3 Id	Integer	none	ny(3)	iasub.dat
Herd 4 Id	Integer	none	ny(4)	iasub.dat
Herd 5 Id	Integer	none	ny(5)	iasub.dat
Herd 6 Id	Integer	none	ny(6)	iasub.dat
Herd 7 Id	Integer	none	ny(7)	iasub.dat
Herd 8 Id	Integer	none	ny(8)	iasub.dat

Table A.4 continued

Herd 9 Id	Integer	none	ny(9)	iasub.dat
Herd 10 Id	Integer	none	ny(10)	iasub.dat
Grazing Limit for Herd 1	Single	t/ha	xtp(1)	iasub.dat
Grazing Limit for Herd 2	Single	t/ha	xtp(2)	iasub.dat
Grazing Limit for Herd 3	Single	t/ha	xtp(3)	iasub.dat
Grazing Limit for Herd 4	Single	t/ha	xtp(4)	iasub.dat
Grazing Limit for Herd 5	Single	t/ha	xtp(5)	iasub.dat
Grazing Limit for Herd 6	Single	t/ha	xtp(6)	iasub.dat
Grazing Limit for Herd 7	Single	t/ha	xtp(7)	iasub.dat
Grazing Limit for Herd 8	Single	t/ha	xtp(8)	iasub.dat
Grazing Limit for Herd 9	Single	t/ha	xtp(9)	iasub.dat
Grazing Limit for Herd 10	Single	t/ha	xtp(10)	iasub.dat

Table A.5: Field Operations

ID	**Long Integer**	**none**		**nnnn.ops**
Subarea Id	Long Integer	none		nnnn.ops
Year	Long Integer	none	jx(1)	nnnn.ops
Month	Integer	none	jx(2)	nnnn.ops
Day	Integer	none	jx(3)	nnnn.ops
Type	Integer	none	jx(4)	nnnn.ops
Tractor	Long Integer	none	jx(5)	nnnn.ops
Crop Id	Integer	none	jx(6)	nnnn.ops
Int Variable	Integer	none	jx(7)	nnnn.ops
Parameter 1	Single	Variable	opv1	nnnn.ops
Parameter 2	Single	Variable	opv2	nnnn.ops
Parameter 3	Single	Variable	opv3	nnnn.ops
Parameter 4	Single	Variable	opv4	nnnn.ops
Parameter 5	Single	Variable	opv5	nnnn.ops
Parameter 6	Single	Variable	opv6	nnnn.ops
Parameter 7	Single	Variable	opv7	nnnn.ops

Table A.6: Soils

Soil Id	Long Integer	none	none	nnnn.sol
Name	Text	none	afx	nnnn.sol
Soils 5 Id	Text	none	none	nnnn.sol
Hydrologic Group	Single	none	hsg	nnnn.sol
Number of Layers	Integer	none	none	nnnn.sol
Weathering Code	Integer	none	xids	nnnn.sol
Albedo	Single	none	salb	nnnn.sol
Initial Water Content	Single	none	ffc	nnnn.sol
Minimum Water Table Depth	Single	m	wtmn	nnnn.sol
Maximum Water Table Depth	Single	m	wtmx	nnnn.sol
Initial Water Table Depth	Single	m	wtbl	nnnn.sol
Subsurface Flow Travel Time	Single	days	rftt	nnnn.sol
Initial Groundwater Storage	Single	mm	gwst	nnnn.sol
Maximum Groundwater Storage	Single	mm	gwmx	nnnn.sol
Return Flow Root Zone	Single		rfpk	nnnn.sol
Maximum Layers	Single	none	tsla	nnnn.sol
Previous Years Cultivation	Single	years	rtn1	nnnn.sol
Soil Group Type	Single	none	xids	nnnn.sol
Minimum Thickness of Maximum Layer	Single	m	zqt	nnnn.sol
Minimum Profile Thickness	Single	m	zf	nnnn.sol
Minimum Beginning Layer Thickness	Single	m	ztk	nnnn.sol
Fraction of Org C in Biomass	Single	none	fbm	nnnn.sol
Fraction of Humus in Passive	Single	none	fhp	nnnn.sol

Table A.7: Soil Layers

Soil Id	Long Integer	none	none	nnnn.sol
Layer Number	Integer	none	none	nnnn.sol
Layer Depth	Single	m	z	nnnn.sol
Bulk Density	Single	t/m^3	bd	nnnn.sol
Wilting Point	Single	none	none	nnnn.sol
Field Capacity	Integer	none	xids	nnnn.sol
Albedo	Single	none	salb	nnnn.sol
Initial Water Content	Single	none	ffc	nnnn.sol
Minimum Water Table Depth	Single	m	wtmn	nnnn.sol
Maximum Water Table Depth	Single	m	wtmx	nnnn.sol
Initial Water Table Depth	Single	m	wtbl	nnnn.sol
Subsurface Flow Travel Time	Single	days	rftt	nnnn.sol
Initial Groundwater Storage	Single	mm	gwst	nnnn.sol
Maximum Groundwater Storage	Single	mm	gwmx	nnnn.sol
Return Flow Root Zone	Single		rfpk	nnnn.sol

Table A.7 continued

Maximum Layers	Single	none	tsla	nnnn.sol
Previous Years Cultivation	Single	years	rtn1	nnnn.sol
Soil Group Type	Single	none	xids	nnnn.sol
Minimum Thickness of Maximum Layer	Single	m	zqt	nnnn.sol
Minimum Profile Thickness	Single	m	zf	nnnn.sol
Minimum Beginning Layer Thickness	Single	m	ztk	nnnn.sol
Fraction of Org C in Biomass	Single	none	fbm	nnnn.sol
Fraction of Humus in Passive	Single	none	fhp	nnnn.sol

Table A.8: Weather

ID	**Long Integer**	**none**		**iaweath.dat**
Name	Text	none		iaweath.dat
Latitude	Single	degrees	xlat	iaweath.dat
Longitude	Single	degrees	xlog	iaweath.dat
Elevation	Single	m	elev	iaweath.dat
Years Max Month Records	Single	years	ywi	iaweath.dat
Wet Dry Probability Coefficient	Single	none	bta	iaweath.dat
Rain Distribution	Single	none	expk	iaweath.dat
Two Year 24 Hour Rainfall	Single	mm	qg	iaweath.dat

Table A.9: Weather by Month

ID	**Long Integer**	**none**		**iaweath.dat**
Month	Integer	none		iaweath.dat
Air Temperature Average Max	Single	c	obmx	iaweath.dat
Air Temperature Average Min	Single	c	obmn	iaweath.dat
Air Temperature Std Max	Single	c	stmx	iaweath.dat
Air Temperature Std Min	Single	c	stmn	iaweath.dat
Precipitation Average	Single	mm	rmo	iaweath.dat
Precipitation Std	Single	mm	rst(2)	iaweath.dat
Precipitation Skew Coefficient	Single	none	rst(3)	iaweath.dat
Probability Dry Wet	Single	none	prw(1)	iaweath.dat
Probability Wet Wet	Single	none	prw(2)	iaweath.dat
Rain Days Average	Single	days	uavm	iaweath.dat
Rain Half Max	Single	none	wi	iaweath.dat
Solar Radiation	Single	mj/ly	obsl	iaweath.dat
Relative Humidity	Single	none	rh	iaweath.dat
Average Velocity	Single	m/s	uavm	iaweath.dat
Wind Velocity N	Single	none	dir(1)	iaweath.dat
Wind Velocity NNE	Single	none	dir(2)	iaweath.dat

Table A.9 continued

Wind Velocity NE	Single	none	dir(3)	iaweath.dat
Wind Velocity ENE	Single	none	dir(4)	iaweath.dat
Wind Velocity E	Single	none	dir(5)	iaweath.dat
Wind Velocity SE	Single	none	dir(6)	iaweath.dat
Wind Velocity ESE	Single	none	dir(7)	iaweath.dat
Wind Velocity SSE	Single	none	dir(8)	iaweath.dat
Wind Velocity S	Single	none	dir(9)	iaweath.dat
Wind Velocity SSW	Single	none	dir(10)	iaweath.dat
Wind Velocity SW	Single	none	dir(11)	iaweath.dat
Wind Velocity WSW	Single	none	dir(12)	iaweath.dat
Wind Velocity W	Single	none	dir(13)	iaweath.dat
Wind Velocity WNW	Single	none	dir(14)	iaweath.dat
Wind Velocity NW	Single	none	dir(15)	iaweath.dat
Wind Velocity NNW	Single	none	dir(16)	iaweath.dat

Table A.10: Crops

ID	**Long Integer**	**none**		**iacrop.dat**
Name	Text	none	cpnm	iacrop.dat
Category	Integer	none	idc	iacrop.dat
Biomass Energy Ratio	Single	none	wa	iacrop.dat
Harvest Index	Single	none	hi	iacrop.dat
Optimal Temperature	Single	c	tb	iacrop.dat
Minimum Temperature	Single	c	tg	iacrop.dat
Maximum Leaf Area Index	Single	none	dmla	iacrop.dat
Growing Season Leaf Decline	Single	none	dlai	iacrop.dat
Leaf Development First Point	Single	none	dlap1	iacrop.dat
Leaf Development Second Point	Single	none	dlap2	iacrop.dat
Leaf Area Decline Rate	Single	none	rlad	iacrop.dat
Biomass Energy Decline Rate	Single	none	rbmd	iacrop.dat
Aluminum Tolerance	Single	none	alt	iacrop.dat
Maximum Stomatal Conductance	Single	none	gsi	iacrop.dat
Critical Aeration Factor	Single	none	caf	iacrop.dat
Seeding Rate	Single	none	sdw	iacrop.dat
Maximum Crop Height	Single	m	hmx	iacrop.dat
Maximum Root Depth	Single	m	rdmx	iacrop.dat
CO2 Concentration	Single	ppm	wac2	iacrop.dat
Nitrogen in Yield	Single	none	cny	iacrop.dat
Phosphorus in Yield	Single	none	cpy	iacrop.dat
Cky	Single	none	cky	iacrop.dat
Minimum Harvest Index	Single	none	wsyf	iacrop.dat
Pest Factor	Single	none	pst	iacrop.dat
Seed Cost	Single	$/kg	cosd	iacrop.dat

Table A.10 continued

Price for Yield	Single	$/t	pryg	iacrop.dat
Water in Yield	Single	none	wcy	iacrop.dat
Nitrogen Uptake Emergence	Single	none	bn1	iacrop.dat
Nitrogen Uptake Midseason	Single	none	bn2	iacrop.dat
Nitrogen Uptake Maturity	Single	none	bn3	iacrop.dat
Phosphorus Uptake Emergence	Single	none	bp1	iacrop.dat
Phosphorus Uptake Midseason	Single	none	bp2	iacrop.dat
Phosphorus Uptake Maturity	Single	none	bp3	iacrop.dat
Wind Erosion Factor Live	Single	none	bw1	iacrop.dat
Wind Erosion Factor Dead	Single	none	bw2	iacrop.dat
Wind Erosion Factor Flat	Single	none	bw3	iacrop.dat
Frost Damage First Point	Single	none	frst1	iacrop.dat
Frost Damage Second Point	Single	none	frst2	iacrop.dat
Vapor Pressure Deficit	Single	none	vpth	iacrop.dat
VPD Threshold	Single	none	vpd1	iacrop.dat
VPD	Single	none	vdp2	iacrop.dat
Root Weight Emergence	Single	none	rwpc1	iacrop.dat
Root Weight Maturity	Single	none	rwpc2	iacrop.dat
Germination Heat Units	Single	none	gmhu	iacrop.dat
Price for Yield Forage	Single	$/t	pryf	iacrop.dat
Plant Population Point 1	Single	none	smr1	iacrop.dat
Plant Population Point 2	Single	none	smr2	iacrop.dat
Lignin at Half Maturity	Single	none	blg1	iacrop.dat
Lignin at Full Maturity	Single	none	blg2	iacrop.dat
Bk1	Single	none	bk1	iacrop.dat
Bk2	Single	none	bk2	iacrop.dat
Bk3	Single	none	bk3	iacrop.dat
Stx1	Single	none	stx1	iacrop.dat
Stx2	Single	none	stx2	iacrop.dat
Wub	Single	none	wub	iacrop.dat
Fto	Single	none	fto	iacrop.dat
Flt	Single	none	flt	iacrop.dat

Table A.11: Fertilizer

ID	**Long Integer**	**none**		**iafert.dat**
Name	Text	none	ftnm	iafert.dat
Mineral Nitrogen	Single	none	fn	iafert.dat
Mineral Phosphorus	Single	none	fp	iafert.dat
Mineral Potassium	Single	none	fk	iafert.dat
Organic Nitrogen	Single	none	fno	iafert.dat
Organic Phosphorus	Single	none	fpo	iafert.dat
Ammonium Nitrogen	Single	none	fnh3	iafert.dat
Organic Carbon	Single	none	foc	iafert.dat

Table A.12: Pesticide

ID	Long Integer	none		iapest.dat
Name	Text	none	pstn	iapest.dat
Solubility	Single	none	psol	iapest.dat
Half Life Soil	Single	none	phls	iapest.dat
Half Life Foliage	Single	none	phlf	iapest.dat
Wash Off Fraction	Single	none	pwof	iapest.dat
Organic Carbon Absorption	Single	none	pkoc	iapest.dat
Cost	Single	none	pcst	iapest.dat

Table A.13: Operations

ID	Long Integer	none		iatill.dat
Name	Text	none	til	iatill.dat
Code	Integer	none	ihc	iatill.dat
Cost	Single	none	colt	iatill.dat
Mixing Efficiency	Single	None	emx	iatill.dat
Surface Random Roughness	Single	none	rr	iatill.dat
Tillage Depth	Single	none	tld	iatill.dat
Ridge Height	Single	none	rht	iatill.dat
Ridge Interval	Single	none	rin	iatill.dat
Furrow Dike Height	Single	none	dkh	iatill.dat
Furrow Dike Interval	Single	none	dki	iatill.dat
Harvest Pesticide Efficiency Ratio	Single	none	he	iatill.dat
Override Harvest Index	Single	none	orhi	iatill.dat
Fraction of Soil Compacted	Single	none	frcp	iatill.dat
Fraction of Population Reduced	Single	none	fpop	iatill.dat
Pcd	Single	none	pcd	iatill.dat
Pric	Single	none	pric	iatill.dat
Plst	Single	none	plst	iatill.dat
Hry	Single	none	hry	iatill.dat
Hrl	Single	none	hrl	iatill.dat
Pwr	Single	none	pwr	iatill.dat
Wdt	Single	none	wdt	iatill.dat
Spd	Single	none	spd	iatill.dat
Rc1	Single	none	rcl	iatill.dat
Rc2	Single	none	rc2	iatill.dat
Xlb	Single	none	xlb	iatill.dat
Fcm	Single	none	fcm	iatill.dat
Vr1	Single	none	vrl	iatill.dat
Vr2	Single	none	vr2	iatill.dat
Efm	Single	none	efm	iatill.dat
Rti	Single	none	rti	iatill.dat

Table A.14: Miscellaneous Parameters (for APEX2110; see Appendix 3 for APEX0604 and APEX0806)

ID	Long Integer	none	none	iaparm.dat
S Curve 1 1	Single	none	Coarse fragment root growth 1	iaparm.dat
S Curve 1 2	Single	none	Coarse fragment root growth 2	iaparm.dat
S Curve 2 1	Single	none	Soil evaporation soil depth 1	iaparm.dat
S Curve 2 2	Single	none	Soil evaporation soil depth 2	iaparm.dat
S Curve 3 1	Single	none	Harvest index crop maturity 1	iaparm.dat
S Curve 3 2	Single	none	Harvest index crop maturity 2	iaparm.dat
S Curve 4 1	Single	none	Curve number soil water 1	iaparm.dat
S Curve 4 2	Single	none	Curve number soil water 2	iaparm.dat
S Curve 5 1	Single	none	Water table ground water storage 1	iaparm.dat
S Curve 5 2	Single	none	Water table ground water storage 2	iaparm.dat
S Curve 6 1	Single	none	Tillage Bulk Density 1	iaparm.dat
S Curve 6 2	Single	none	Tillage Bulk Density 2	iaparm.dat
S Curve 7 1	Single	none	Aeration Stress Soil Water 1	iaparm.dat
S Curve 7 2	Single	none	Aeration Stress Soil Water 2	iaparm.dat
S Curve 8 1	Single	none	N P plant stress 1	iaparm.dat
S Curve 8 2	Single	none	N P plant stress 2	iaparm.dat
S Curve 9 1	Single	none	Pest damage erature 1	iaparm.dat
S Curve 9 2	Single	none	Pest damage erature 2	iaparm.dat
S Curve 10 1	Single	none	Water stress harvest index 1	iaparm.dat
S Curve 10 2	Single	none	Water stress harvest index2	iaparm.dat
S Curve 11 1	Single	none	P use soil P concentration 1	iaparm.dat
S Curve 11 2	Single	none	P use soil P concentration 2	iaparm.dat
S Curve 12 1	Single	none	N volatilization soil depth 1	iaparm.dat
S Curve 12 2	Single	none	N volatilization soil depth 2	iaparm.dat
S Curve 13 1	Single	none	Wind erosion vegetative cover 1	iaparm.dat
S Curve 13 2	Single	none	Wind erosion vegetative cover 2	iaparm.dat
S Curve 14 1	Single	none	Soil temperature factor 1	iaparm.dat
S Curve 14 2	Single	none	Soil temperature factor 2	iaparm.dat
S Curve 15 1	Single	none	Snow melt from snow fall 1	iaparm.dat
S Curve 15 2	Single	none	Snow melt from snow fall 2	iaparm.dat
S Curve 16 1	Single	none	Soil cover soil erature 1	iaparm.dat
S Curve 16 2	Single	none	Soil cover soil erature 1	iaparm.dat
S Curve 17 1	Single	none	Water stress water content 1	iaparm.dat
S Curve 17 2	Single	none	Water stress water content 2	iaparm.dat
S Curve 18 1	Single	none	CN2 upland slope steepness 1	iaparm.dat
S Curve 18 2	Single	none	CN2 upland slope steepness 2	iaparm.dat
S Curve 19 1	Single	none	Feedlot dust moisture of filter 1	iaparm.dat
S Curve 19 2	Single	none	Feedlot dust moisture of filter 2	iaparm.dat
S Curve 20 1	Single	none	Soil oxygen content 1	iaparm.dat
S Curve 20 2	Single	none	Soil oxygen content 2	iaparm.dat
S Curve 21 1	Single	none	Distance in spatial rainfall generator 1	iaparm.dat

Table A.14 continued

S Curve 21 2	Single	none	Distance in spatial rainfall generator 2	iaparm.dat
S Curve 22 1	Single	none	Not used	iaparm.dat
S Curve 22 2	Single	none	Not used	iaparm.dat
S Curve 23 1	Single	none	ground cover standing live biomass 1	iaparm.dat
S Curve 23 2	Single	none	ground cover standing live biomass 2	iaparm.dat
S Curve 24 1	Single	none	Not used	iaparm.dat
S Curve 24 2	Single	none	Not used	iaparm.dat
S Curve 25 1	Single	none	Water content CN2 CN3 1	iaparm.dat
S Curve 25 2	Single	none	Water content CN2 CN3 2	iaparm.dat
Parm1	Single	none	Crop canopy Monteith PET	iaparm.dat
Parm2	Single	none	Root growth soil strength	iaparm.dat
Parm3	Single	none	Water stress harvest index	iaparm.dat
Parm4	Single	none	Water storage N leaching	iaparm.dat
Parm5	Single	none	Soil water lower limit	iaparm.dat
Parm6	Single	none	Winter dormancy	iaparm.dat
Parm7	Single	none	N fixation	iaparm.dat
Parm8	Single	none	Soluble P adsorption coefficient	iaparm.dat
Parm9	Single	none	Pest damage moisture	iaparm.dat
Parm10	Single	none	Pest damage cover	iaparm.dat
Parm11	Single	none	Seed germination	iaparm.dat
Parm12	Single	none	Soil evaporation coefficient	iaparm.dat
Parm13	Single	none	Wind erodibility coefficient	iaparm.dat
Parm14	Single	none	Nitrate leaching ratio	iaparm.dat
Parm15	Single	none	Runoff CN weighting factor	iaparm.dat
Parm16	Single	none	CN retention parameter	iaparm.dat
Parm17	Single	none	Soil evaporation plant cover	iaparm.dat
Parm18	Single	none	Sediment routing exponent	iaparm.dat
Parm19	Single	none	Sediment routing coefficient	iaparm.dat
Parm20	Single	none	Runoff curve number initial	iaparm.dat
Parm21	Single	none	Soluble C adsorption	iaparm.dat
Parm22	Single	none	Not used	iaparm.dat
Parm23	Single	none	Hargreaves PET equation coefficient	iaparm.dat
Parm24	Single	none	Pesticide leaching ratio	iaparm.dat
Parm25	Single	none	Not used	iaparm.dat
Parm26	Single	none	Maturity at spring growth	iaparm.dat
Parm27	Single	none	CEC effect on nitrification	iaparm.dat
Parm28	Single	none	Not used	iaparm.dat
Parm29	Single	none	Biological mixing efficiency	iaparm.dat
Parm30	Single	none	Soluble P runoff exponent	iaparm.dat
Parm31	Single	none	Maximum depth of mixing	iaparm.dat
Parm32	Single	none	Organic P loss exponent	iaparm.dat
Parm33	Single	none	Not used	iaparm.dat
Parm34	Single	none	Hargreaves PET equation exponent	iaparm.dat

Table A.14 continued

Parm35	Single	none	Denitrification soil water	iaparm.dat
Parm36	Single	none	Denitrification rate constant	iaparm.dat
Parm37	Single	none	Not used	iaparm.dat
Parm38	Single	none	Water stress weighting	iaparm.dat
Parm39	Single	none		iaparm.dat
Parm40	Single	none	Ground water storage	iaparm.dat
Parm41	Single	none	Root temperature stress	iaparm.dat
Parm42	Single	none	SCS curve number coefficient	iaparm.dat
Parm43	Single	none	Plow layer depth	iaparm.dat
Parm44	Single	none	Not used	iaparm.dat
Parm45	Single	none	Sediment routing travel time coefficient	iaparm.dat
Parm46	Single	none	RUSLE C factor coefficient residue	iaparm.dat
Parm47	Single	none	RUSLE C factor coefficient biomass	iaparm.dat
Parm48	Single	none	Adjust climate stress factor	iaparm.dat
Parm49	Single	none	Canopy rainfall interception	iaparm.dat
Parm50	Single	none	Rainfall interception coefficient	iaparm.dat
Parm51	Single	none	Water storage of residue coefficient	iaparm.dat
Parm52	Single	none	Till effect on decay rate	iaparm.dat
Parm53	Single	none	Oxygen coefficient microbial activity	iaparm.dat
Parm54	Single	none	Routing N enrichment coefficient	iaparm.dat
Parm55	Single	none	Routing N enrichment exponent	iaparm.dat
Parm56	Single	none	Fraction destroyed by burn	iaparm.dat
Parm57	Single	none	Routing P enrichment ratio coefficient	iaparm.dat
Parm58	Single	none	Routing P enrichment ratio exponent	iaparm.dat
Parm59	Single	none	P upward by evaporation	iaparm.dat
Parm60	Single	none	Maximum grazing before rotation	iaparm.dat
Parm61	Single	none	Soil water tension weighting	iaparm.dat
Parm62	Single	none	Manure erosion equation coefficient	iaparm.dat
Parm63	Single	none	Pesticide loss coefficient	iaparm.dat
Parm64	Single	none	Dust distribution coefficient	iaparm.dat
Parm65	Single	none	Not used	iaparm.dat
Parm66	Single	none	Not used	iaparm.dat
Parm67	Single	none	Dust distribution dispersion exponent	iaparm.dat
Parm68	Single	none	Manure erosion exponent	iaparm.dat
Parm69	Single	none	Adjust microbial activity function	iaparm.dat
Parm70	Single	none	Microbial decay rate coefficient	iaparm.dat
Parm71	Single	none	Manure erosion coefficient	iaparm.dat
Parm72	Single	none	Volatilization nitrification coefficient	iaparm.dat
Parm73	Single	none	Hydrograph development parameter	iaparm.dat
Parm74	Single	none	Not used	iaparm.dat
Parm75	Single	none	Furrow irrigation erosion coefficient	iaparm.dat
Parm76	Single	none	Furrow irrigation sediment	iaparm.dat

Table A.14 continued

Parm77	Single	none	Runoff delay pest application	iaparm.dat
Parm78	Single	none	Soil water delay tillage	iaparm.dat
Parm79	Single	none	Standing dead fall rate coefficient	iaparm.dat
Parm80	Single	none	Puddling saturated conductivity	iaparm.dat
Parm81	Single	none	Technology coefficient	iaparm.dat
Parm82	Single	none	Runoff CN rainfall intensity coefficient	iaparm.dat
Parm83	Single	none	Regulates lateral hydrologic conductivity	iaparm.dat
Parm84	Single	none	P flux between labile & active pool coef	iaparm.dat
Parm85	Single	none	P flux between active & stable pool coef	iaparm.dat
Parm86	Single	none	N upward by evaporation coefficient	iaparm.dat
Parm87	Single	none	Not used	iaparm.dat
Parm88	Single	none	Not used	iaparm.dat
Parm89	Single	none	Not used	iaparm.dat
Parm90	Single	none	Not used	iaparm.dat
Parm91	Single	none	Cost 1	iaparm.dat
Parm92	Single	none	Cost 2	iaparm.dat
Parm93	Single	none	Cost 3	iaparm.dat
Parm94	Single	none	Cost 4	iaparm.dat
Parm95	Single	none	Cost 5	iaparm.dat
Parm96	Single	none	Not used	iaparm.dat

Table A.15: Selected Variables

Select Id	**Long Integer**	**none**	**none**	**iaprnt.dat**
Selected Variable	Text	none	none	iaprnt.dat
Variable Definition	Text	none	none	iaprnt.dat

Appendix B – ACCESS I_APEX Output Tables

Table B.1: Average Output

Select Id	Long Integer	none	none	apex.OUT
Farm Id	Long Integer	none	none	apex.OUT
Subarea	Integer	none	none	apex.OUT
Area by Field	Single	ha		apex.OUT
Tmx	Single	mm	Maximum Temperature	apex.OUT
Prcp	Single	mm	Precipitation	apex.OUT
Q	Single	mm	Runoff	apex.OUT
Prk	Single	mm	Percolation	apex.OUT
Yp	Single	kg/ha	Phosphorus loss with sediment	apex.OUT
Ssf	Single	mm	Subsurface flow	apex.OUT
Rssf	Single	mm	Subsurface flow that returns to surface stream	apex.OUT
Yn	Single	kg/ha	Organic nitrogen loss with sediment	apex.OUT
Qn	Single	kg/ha	NO3 loss in runoff	apex.OUT
Ssfn	Single	kg/ha	Mineral nitrogen loss in subsurface flow	apex.OUT
Prkn	Single	kg/ha	Mineral nitrogen loss in percolate	apex.OUT
Gmn	Single	kg/ha	Gross nitrogen mineralized	apex.OUT
Dn	Single	kg/ha	Nitrogen loss by denitification	apex.OUT
Dprk	Single	mm	Deep percolation	apex.OUT
Nfix	Single	kg/ha	Nitrogen fixed by leguminous crops	apex.OUT
Et	Single	mm	Evapotransporation	apex.OUT
Qp	Single	kg/ha	Soluble phosphorus loss in runoff	apex.OUT
Mnp	Single	kg/ha	Phosphorus mineralized	apex.OUT
Avol	Single	kg/ha	NH3 nitrogen volatilization	apex.OUT
Nitr	Single	kg/ha	Nitrification NH3 conversion to NO3	apex.OUT
Musl	Single	t/ha	Soil loss from water erosion using modified MUSLE equation	apex.OUT
Fnmn	Single	kg/ha	Fertilizer application of nitrate	apex.OUT
Fnma	Single	kg/ha	Fertilizer application of anhydrous ammonia	apex.OUT
Fno	Single	kg/ha	Fertilizer application of organic nitrogen	apex.OUT
Fpo	Single	kg/ha	Fertilizer application of organic phosphorus	apex.OUT

Table B.1 continued

Fpl	Single	kg/ha	Fertilizer applied labile phosphorus	apex.OUT
Soil Depth	Single	m		apex.OUT
Soil Water	Single	none		apex.OUT
Soil Bd	Single	t/m^3		apex.OUT
Soil Sand	Single	%		apex.OUT
Soil Clay	Single	%		apex.OUT
Soil Ph	Single	none		apex.OUT
Selected Variable 1	Single	various		apex.OUT
Selected Variable 2	Single	various		apex.OUT
Selected Variable 3	Single	various		apex.OUT
Selected Variable 4	Single	various		apex.OUT
Selected Variable 5	Single	various		apex.OUT
Selected Variable 6	Single	various		apex.OUT
Selected Variable 7	Single	various		apex.OUT
Selected Variable 8	Single	various		apex.OUT
Selected Variable 9	Single	various		apex.OUT
Selected Variable 10	Single	various		apex.OUT
Number Crops	Integer	none		apex.OUT
Crop 1 Id	Text	none		apex.OUT
Crop 1 Yield	Single	t/ha		apex.OUT
Crop 1 Biomass	Single	t/ha		apex.OUT
Crop 1 Yln	Single	kg/ha	Nitrogen in crop yield	apex.OUT
Crop 1 Ylp	Single	kg/ha	Phosphorus in crop yield	apex.OUT
Crop 1 Fn	Single	t/ha	Nitrogen applied	apex.SUS
Crop 1 Fp	Single	t/ha	Phosphorus applied	apex.SUS
Crop 1 Water Stress	Single	days		apex.OUT
Crop 1 Nitrogen Stress	Single	days		apex.OUT
Crop 1 Phosphorus Stress	Single	days		apex.OUT
Crop 1 Temperature Stress	Single	days		apex.OUT
Crop 1 Curve Number	Single	none		apex.OUT
Crop 2 Id	Text	none		apex.OUT
Crop 2 Yield	Single	t/ha		apex.OUT
Crop 2 Biomass	Single	t/ha		apex.OUT
Crop 2 Yln	Single	kg/ha	Nitrogen in crop yield	apex.OUT
Crop 2 Ylp	Single	kg/ha	Phosphorus in crop yield	apex.OUT
Crop 2 Fn	Single	t/ha	Nitrogen applied	apex.SUS
Crop 2 Fp	Single	t/ha	Phosphorus applied	apex.SUS
Crop 2 Water Stress	Single	days		apex.OUT

Table B.1 continued

Crop 2 Nitrogen Stress	Single	days		apex.OUT
Crop 2 Phosphorus Stress	Single	days		apex.OUT
Crop 2 Temperature Stress	Single	days		apex.OUT
Crop 2 Curve Number	Single	none		apex.OUT
Crop 3 Id	Text	none		apex.OUT
Crop 3 Yield	Single	t/ha		apex.OUT
Crop 3 Biomass	Single	t/ha		apex.OUT
Crop 3 Yln	Single	kg/ha	Nitrogen in crop yield	apex.OUT
Crop 3 Ylp	Single	kg/ha	Phosphorus in crop yield	apex.OUT
Crop 3 Fn	Single	t/ha	Nitrogen applied	apex.SUS
Crop 3 Fp	Single	t/ha	Phosphorus applied	apex.SUS
Crop 3 Water Stress	Single	days		apex.OUT
Crop 3 Nitrogen Stress	Single	days		apex.OUT
Crop 3 Phosphorus Stress	Single	days		apex.OUT
Crop 3 Temperature Stress	Single	days		apex.OUT
Crop 3 Curve Number	Single	none		apex.OUT
Crop 4 Id	Text	none		apex.OUT
Crop 4 Yield	Single	t/ha		apex.OUT
Crop 4 Biomass	Single	t/ha		apex.OUT
Crop 4 Yln	Single	kg/ha	Nitrogen in crop yield	apex.OUT
Crop 4 Ylp	Single	kg/ha	Phosphorus in crop yield	apex.OUT
Crop 4 Fn	Single	t/ha	Nitrogen applied	apex.SUS
Crop 4 Fp	Single	t/ha	Phosphorus applied	apex.SUS
Crop 4 Water Stress	Single	days		apex.OUT
Crop 4 Nitrogen Stress	Single	days		apex.OUT
Crop 4 Phosphorus Stress	Single	days		apex.OUT
Crop 4 Temperature Stress	Single	days		apex.OUT
Crop 4 Curve Number	Single	none		apex.OUT
Crop 5 Id	Text	none		apex.OUT
Crop 5 Yield	Single	t/ha		apex.OUT
Crop 5 Biomass	Single	t/ha		apex.OUT
Crop 5 Yln	Single	kg/ha	Nitrogen in crop yield	apex.OUT

Table B.1 continued

Crop 5 Ylp	Single	kg/ha	Phosphorus in crop yield	apex.OUT
Crop 5 Fn	Single	t/ha	Nitrogen applied	apex.SUS
Crop 5 Fp	Single	t/ha	Phosphorus applied	apex.SUS
Crop 5 Water Stress	Single	days		apex.OUT
Crop 5 Nitrogen Stress	Single	days		apex.OUT
Crop 5 Phosphorus Stress	Single	days		apex.OUT
Crop 5 Temperature Stress	Single	days		apex.OUT
Crop 5 Curve Number	Single	none		apex.OUT

Table B.2: Yearly Output

Select Id	**Long Integer**	**none**	**none**	**apex.OUT**
Farm Id	Long Integer	none	none	apex.OUT
Yearly	Integer	none	none	apex.OUT
Subarea	Integer	none	none	apex.OUT
Area by Field	Single	ha		apex.OUT
Tmx	Single	c	Maximum Temperature	apex.OUT
Prcp	Single	mm	Precipitation	apex.OUT
Q	Single	mm	Runoff	apex.OUT
Prk	Single	mm	Percolation	apex.OUT
Yp	Single	kg/ha	Phosphorus loss with sediment	apex.OUT
Ssf	Single	mm	Subsurface flow	apex.OUT
Rssf	Single	mm	Subsurface flow that returns to surface stream	apex.OUT
Yn	Single	kg/ha	Organic nitrogen loss with sediment	apex.OUT
Qn	Single	kg/ha	NO3 loss in runoff	apex.OUT
Ssfn	Single	kg/ha	Mineral nitrogen loss in subsurface flow	apex.OUT
Prkn	Single	kg/ha	Mineral nitrogen loss in percolate	apex.OUT
Gmn	Single	kg/ha	Gross nitrogen mineralized	apex.OUT
Dn	Single	kg/ha	Nitrogen loss by denitification	apex.OUT
Dprk	Single	mm	Deep percolation	apex.OUT
Nfix	Single	kg/ha	Nitrogen fixed by leguminous crops	apex.OUT
Et	Single	mm	Evapotransporation	apex.OUT
Qp	Single	kg/ha	Soluble phosphorus loss in runoff	apex.OUT
Mnp	Single	kg/ha	Phosphorus mineralized	apex.OUT
Avol	Single	kg/ha	NH3 nitrogen volatilization	apex.OUT

Table B.2 continued

Nitr	Single	kg/ha	Nitrification NH3 conversion to NO3	apex.OUT
Musl	Single	t/ha	Soil loss from water erosion using modified MUSLE equation	apex.OUT
Fnmn	Single	kg/ha	Fertilizer application of nitrate	apex.OUT
Fnma	Single	kg/ha	Fertilizer application of anhydrous ammonia	apex.OUT
Fno	Single	kg/ha	Fertilizer application of organic nitrogen	apex.OUT
Fpo	Single	kg/ha	Fertilizer application of organic phosphorus	apex.OUT
Fpl	Single	kg/ha	Fertilizer applied labile phosphorus	apex.OUT
Soil Depth	Single	m		apex.OUT
Soil Water	Single	none		apex.OUT
Soil Bd	Single	t/m^3		apex.OUT
Soil Sand	Single	%		apex.OUT
Soil Clay	Single	%		apex.OUT
Soil Ph	Single	none		apex.OUT
Selected Variable 1	Single	various		apex.OUT
Selected Variable 2	Single	various		apex.OUT
Selected Variable 3	Single	various		apex.OUT
Selected Variable 4	Single	various		apex.OUT
Selected Variable 5	Single	various		apex.OUT
Selected Variable 6	Single	various		apex.OUT
Selected Variable 7	Single	various		apex.OUT
Selected Variable 8	Single	various		apex.OUT
Selected Variable 9	Single	various		apex.OUT
Selected Variable 10	Single	various		apex.OUT
Number Crops	Integer	none		apex.OUT
Crop 1 Id	Text	none		apex.OUT
Crop 1 Yield	Single	t/ha		apex.OUT
Crop 1 Biomass	Single	t/ha		apex.OUT
Crop 1 Yln	Single	kg/ha	Nitrogen in crop yield	apex.OUT
Crop 1 Ylp	Single	kg/ha	Phosphorus in crop yield	apex.OUT
Crop 1 Fn	Single	t/ha	Nitrogen applied	apex.SUS
Crop 1 Fp	Single	t/ha	Phosphorus applied	apex.SUS
Crop 1 Water Stress	Single	days		apex.OUT
Crop 1 Nitrogen Stress	Single	days		apex.OUT
Crop 1 Phosphorus Stress	Single	days		apex.OUT
Crop 1 Temperature Stress	Single	days		apex.OUT

Table B.2 continued

Crop 1 Curve Number	Single	none		apex.OUT
Crop 2 Id	Text	none		apex.OUT
Crop 2 Yield	Single	t/ha		apex.OUT
Crop 2 Biomass	Single	t/ha		apex.OUT
Crop 2 Yln	Single	kg/ha	Nitrogen in crop yield	apex.OUT
Crop 2 Ylp	Single	kg/ha	Phosphorus in crop yield	apex.OUT
Crop 2 Fn	Single	t/ha	Nitrogen applied	apex.SUS
Crop 2 Fp	Single	t/ha	Phosphorus applied	apex.SUS
Crop 2 Water Stress	Single	days		apex.OUT
Crop 2 Nitrogen Stress	Single	days		apex.OUT
Crop 2 Phosphorus Stress	Single	days		apex.OUT
Crop 2 Temperature Stress	Single	days		apex.OUT
Crop 2 Curve Number	Single	none		apex.OUT
Crop 3 Id	Text	none		apex.OUT
Crop 3 Yield	Single	t/ha		apex.OUT
Crop 3 Biomass	Single	t/ha		apex.OUT
Crop 3 Yln	Single	kg/ha	Nitrogen in crop yield	apex.OUT
Crop 3 Ylp	Single	kg/ha	Phosphorus in crop yield	apex.OUT
Crop 3 Fn	Single	t/ha	Nitrogen applied	apex.SUS
Crop 3 Fp	Single	t/ha	Phosphorus applied	apex.SUS
Crop 3 Water Stress	Single	days		apex.OUT
Crop 3 Nitrogen Stress	Single	days		apex.OUT
Crop 3 Phosphorus Stress	Single	days		apex.OUT
Crop 3 Temperature Stress	Single	days		apex.OUT
Crop 3 Curve Number	Single	none		apex.OUT
Crop 4 Id	Text	none		apex.OUT
Crop 4 Yield	Single	t/ha		apex.OUT
Crop 4 Biomass	Single	t/ha		apex.OUT
Crop 4 Yln	Single	kg/ha	Nitrogen in crop yield	apex.OUT
Crop 4 Ylp	Single	kg/ha	Phosphorus in crop yield	apex.OUT
Crop 4 Fn	Single	t/ha	Nitrogen applied	apex.SUS
Crop 4 Fp	Single	t/ha	Phosphorus applied	apex.SUS
Crop 4 Water Stress	Single	days		apex.OUT

Table B.2 continued

Crop 4 Nitrogen Stress	Single	days		apex.OUT
Crop 4 Phosphorus Stress	Single	days		apex.OUT
Crop 4 Temperature Stress	Single	days		apex.OUT
Crop 4 Curve Number	Single	none		apex.OUT
Crop 5 Id	Text	none		apex.OUT
Crop 5 Yield	Single	t/ha		apex.OUT
Crop 5 Biomass	Single	t/ha		apex.OUT
Crop 5 Yln	Single	kg/ha	Nitrogen in crop yield	apex.OUT
Crop 5 Ylp	Single	kg/ha	Phosphorus in crop yield	apex.OUT
Crop 5 Fn	Single	t/ha	Nitrogen applied	apex.SUS
Crop 5 Fp	Single	t/ha	Phosphorus applied	apex.SUS
Crop 5 Water Stress	Single	days		apex.OUT
Crop 5 Nitrogen Stress	Single	days		apex.OUT
Crop 5 Phosphorus Stress	Single	days		apex.OUT
Crop 5 Temperature Stress	Single	days		apex.OUT
Crop 5 Curve Number	Single	none		apex.OUT

Table B.3: Crop Yield Output

ID	Long Integer	none	none	apex.ACY
Subarea Id	Integer	none	none	apex.ACY
Year	Integer	none	none	apex.ACY
Crop Name	Text	none	none	apex.ACY
Grain Yield	Single	t/ha	none	apex.ACY
Forage Yield	Single	t/ha	none	apex.ACY
Biomass	Single	t/ha	none	apex.ACY
Nitrogen Applied	Single	kg/ha	fn	apex.ACY
Phosphorus Applied	Single	kg/ha	fp	apex.ACY
Nitrogen Stress	Single	days	none	apex.ACY
Water Stress	Single	days	none	apex.ACY

Table B.4: Monthly SWAT Output

ID	Long Integer	none	none	apex.MSW
Year	Integer	none	none	apex.MSW
Month	Integer	none	none	apex.MSW
Runoff	Single	mm	q	apex.MSW
Sediment	Single	t/ha	y	apex.MSW
N in Sediment	Single	kg/ha	yn	apex.MSW
P in Sediment	Single	kg/ha	yp	apex.MSW
N in Runoff	Single	kg/ha	qn	apex.MSW
P in Runoff	Single	kg/ha	qp	apex.MSW
Pesticide Name	Text	none	none	apex.MSW
Qpst	Single		none	apex.MSW
Ypst	Single		none	apex.MSW

Table B.5: Organic C and N Output

ID	Long Integer	none	none	apex.ACN
Subarea Id	Integer	none	none	apex.ACN
Year	Integer	none	none	apex.ACN
Total Organic N	Single	mm	q	apex.ACN
Total Organic C	Single	t/ha	y	apex.ACN
Organic N Layer 1	Single			apex.ACN
Organic N Layer 2	Single			apex.ACN
Organic N Layer 3	Single			apex.ACN
Organic N Layer 4	Single			apex.ACN
Organic N Layer 5	Single			apex.ACN
Organic N Layer 6	Single			apex.ACN
Organic N Layer 7	Single			apex.ACN
Organic N Layer 8	Single			apex.ACN
Organic N Layer 9	Single			apex.ACN

Table B.5 continued

Organic N Layer 10	Single	apex.ACN
Organic C Layer 1	Single	apex.ACN
Organic C Layer 2	Single	apex.ACN
Organic C Layer 3	Single	apex.ACN
Organic C Layer 4	Single	apex.ACN
Organic C Layer 5	Single	apex.ACN
Organic C Layer 6	Single	apex.ACN
Organic C Layer 7	Single	apex.ACN
Organic C Layer 8	Single	apex.ACN
Organic C Layer 9	Single	apex.ACN
Organic C Layer 10	Single	apex.ACN

Table B.6: Watershed Output

ID	**Long Integer**	**none**	**none**	**apex.OUT**
Year	Integer	none	none	apex.OUT
Month	Integer	none	none	apex.OUT
Prcp	Single	mm		apex.OUT
Qss	Single			apex.OUT
Qsw	Single			apex.OUT
Qts	Single			apex.OUT
Qtw	Single			apex.OUT
Ys	Single			apex.OUT
Yw	Single			apex.OUT
Yns	Single			apex.OUT
Ynw	Single			apex.OUT
Yps	Single			apex.OUT
Ypw	Single			apex.OUT
Qns	Single			apex.OUT
Qnw	Single			apex.OUT
Qps	Single			apex.OUT
Qpw	Single			apex.OUT
Ymus	Single			apex.OUT
Ymuw	Single			apex.OUT

Appendix C - APEX0604 and APEX0806 Miscellaneous Parameter Table Definitions

THIS FILE CONTAINS DEFINITIONS OF S-CURVE AND MISCELLANEOUS PARAMETERS USED IN APEX0604 20090630 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. THECURVE 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 SCRP. TO ILLUSTRATE THE PROCEDURE CONSIDER THE TWO SCRP VALUES IN THE FIRST LINE OF THE PARM1310.DAT FILE(90.05,99.95). SCRP(1,1)=90.05 , SCRP(1,2)=99.95. WHEN SPLIT WE HAVE X1=90. Y1=0.05; X2=99. Y2=0.95.

APEX USES THESE TWO POINTS TO SOLVE THE EXPONENTIAL EQ 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 EQ IS Y=X/(X+EXP(B1-B2*X)) WHERE B1 AND B2 ARE THE APEX DETERMINED PARAMETERS.

----S-CURVE PARAMETER DEFINITIONS-----

SCRP(1,N) = EXPRESSES THE EFFECT OF SOIL COURSE FRAGMENT CONTENT ON PLANT ROOT GROWTH RESTRICTION. X = % COURSE FRAGMENT. (N=1,2)

SCRP(2,N) = GOVERNS SOIL EVAPORATION AS A FUNCTION OF SOIL DEPTH. X = SOIL DEPTH (MM)

SCRP(3,N) = DRIVES HARVEST INDEX DEVELOPMENT AS A FUNCTION OF CROP MATURITY. X = % OF GROWING SEASON.

SCRP(4,N) = NRCS RUNOFF CURVE NUMBER SOIL WATER RELATIONSHIP. EXCEPTION TO NORMAL S-CURVE PROCEDURE--SOIL WATER FRACTIONS TAKEN FROM SCRP(25,N) TO MATCH WITH CN2 AND CN3(AVERAGE AND WET CONDITION RUNOFF CURVE NUMBERS).

SCRP(5,N) = ESTIMATES SOIL COVER FACTOR USED IN SIMULATING SOIL TEMPERATURE. X = TOTAL ABOVE GROUND PLANT MATERIAL DEAD AND LIVE.

SCRP(6,N) = SETTLES AFTER TILLAGE SOIL BULK DENSITY TO NORMAL VALUE AS A FUNCTION OF RAINFALL AMOUNT, SOIL TEXTURE, AND SOIL DEPTH. X = RAINFALL(MM) ADJUSTED FOR SOIL TEXTURE AND DEPTH.

SCRP(7,N) = DETERMINES THE ROOT GROWTH AERATION STRESS FACTOR AS A FUNCTION OF SOIL WATER CONTENT AND THE CRITICAL AERATION FACTOR FOR THE CROP. X = SOIL WATER-CRITICAL AERATION FACTOR.

SCRP(8,N) = DETERMINES THE PLANT STRESS CAUSED BY N OR P DEFICIENCY. X = % OF OPTIMAL N OR P CONTENT PRESENT IN PLANT.

SCRP(9,N) = CALCULATES THE PEST DAMAGE FACTOR AS A FUNCTION OF TEMPERATURE, CONSIDERING THRESHOLDS FOR 30-DAY RAINFALL AND ABOVE GROUND PLANT MATERIAL. X = SUM OF DAILY MINIMUM TEMPERATURE WITH RAINFALL ADJUSTMENT.

SCRP(10,N)= CALCULATES THE EFFECT OF WATER STRESS ON HARVEST INDEX AS A FUNCTION OF PLANT WATER USE. X = PLANT WATER USE DURING CRITICAL PERIOD.

SCRP(11,N)= GOVERNS P USE BY PLANTS AS A FUNCTION OF SOIL P CONCENTRATION. X = SOIL LABILE P CONCENTRATION.

SCRP(12,N)= GOVERNS N VOLATILIZATION AS A FUNCTION OF SOIL DEPTH. X = DEPTH AT THE CENTER OF A SOIL LAYER(MM).

SCRP(13,N)= CALCULATES WIND EROSION VEGETATIVE COVER FACTOR AS A FUNCTION OF ABOVE GROUND PLANT MATERIAL. X = VEGETATIVE EQUIVALENT(C1*BIOM+C2*STD+C3*RSD). WHERE C1, C2, AND C3 ARE COEFFICIENTS, BIOM IS ABOVE GROUND BIOMASS, STD IS STANDING DEAD PLANT RESIDUE, AND RSD IS FLAT RESIDUE.

SCRP(14,N)= CALCULATES SOIL TEMPERATURE FACTOR USED IN REGULATING MICROBIAL PROCESSES. X = SOIL TEMPERATURE(C).

SCRP(15,N)= ESTIMATES PLANT POPULATION EFFECT ON USLE C FACTOR. X = PLANT POPULATION (P/M^2)

SCRP(16,N)= INCREASES SNOW MELT AS A FUNCTION OF TIME SINCE THE LAST SNOWFALL. X = TIME SINCE THE LAST SNOWFALL(D)

SCRP(17,N)= COMPONENT OF THE PLANT WATER STRESS FACTOR BASED ON SOIL WATER CONTENT. X = RATIO OF ROOT ZONE SOIL WATER CONTENT TO PLANT AVAILABLE WATER STORAGE VOLUME.

SCRP(18,N)= ADJUSTS CN2 AS A FUNCTION OF UPLAND SLOPE STEEPNESS. X = UPLAND SLOPE (%).

SCRP(19,N)= REGULATES FEEDLOT DUST EMISSION BASED ON MOISTURE CONTENT OF LITTER. X = WATER IN LITTER/WEIGHT OF LITTER.

SCRP(20,N)= SIMULATES OXYGEN CONTENT OF SOIL AS A FUNCTION OF DEPTH.USED IN MICROBIAL PROCESSES OF RESIDUE DECAY. X = DEPTH TO CENTER OF EACH SOIL LAYER(M)

SCRP(21,N)= DISTANCE FACTOR IN SPATIAL RAINFALL GENERATOR.
X = DISTANCE FROM STORM CENTER TO SUBAREA CENTROID(KM).

SCRP(22,N)= GOVERNS PLANT WATER STRESS AS A FUNCTION OF SOIL WATER TENSION. X = GRAVIMETRIC + OSMOTIC TENSION.

SCRP(23,N)= ESTIMATES PLANT GROUND COVER AS A FUNCTION OF LAI.
X = TOTAL LAI OF ALL GROWING PLANTS.

SCRP(24,N)= ESTIMATES PLANT GROUND COVER AS A FUNCTION OF STANDING LIVE BIOMASS. X = STANDING LIVE BIOMASS(T/HA).

SCRP(25,N)= SIMULATES O2 CONTENT OF SOIL AS A FUNCTION OF C AND CLAY. USED IN MICROBIAL PROCESSES OF RESIDUE DECAY. X = F(C/CLAY)

SCRP(30,N)= EXCEPTION TO NORMAL S-CURVE PROCEDURE--SETS SOIL WATER CONTENTS COINCIDING WITH CN2 AND CN3. X1 = SOIL WATER CONTENT AS % OF FIELD CAPACITY - WILTING POINT; X2 = SOIL WATER CONTENT AS % OF POROSITY - FIELD CAPACITY.

-----MISCELLANEOUS PARAMETERS-----

PRMT(1) = CROP CANOPY-PET(1_2) FACTOR USED TO ADJUST CROP CANOPY RESISTANCE IN THE PENMAN-MONTEITH PET EQ.

PRMT(2) = ROOT GROWTH-SOIL STRENGTH(1_2) NORMALLY 1.15<PRMT(2)<1.2. SET TO 1.5 TO MINIMIZE SOIL STRENGTH CONSTRAINT ON ROOT GROWTH. PRMT(2)>2. ELIMINATES ALL ROOT GROWTH STRESS.

PRMT(3) = WATER STRESS-HARVEST INDEX(0_1) SETS FRACTION OF GROWING SEASON WHEN WATER STRESS STARTS REDUCING HARVEST INDEX.

PRMT(4) = WATER STORAGE-N LEACHING(0_1) FRACTION OF SOIL POROSITY THAT INTERACTS WITH PERCOLATING WATER AS N LEACHING OCCURS.

PRMT(5) = SOIL WATER LOWER LIMIT(0_1) LOWER LIMIT OF WATER CONTENT IN THE TOP 0.5 M SOIL DEPTH EXPRESSED AS A FRACTION OF THE WILTING POINT WATER CONTENT.

PRMT(6) = WINTER DORMANCY(H)(0_1) CAUSES DORMANCY IN WINTER GROWN CROPS. GROWTH DOES NOT OCCUR WHEN DAY LENGTH IS LESS THAN ANNUAL MINIMUM DAY LENGTH + PRMT(6).

PRMT(7) = N FIXATION(0_1) AT 1. FIXATION IS LIMITED BY SOIL WATER OR NITRATE CONTENT OR BY CROP GROWTH STAGE. At 0 FIXATION MEETS CROP N UPTAKE DEMAND. A COMBINATION OF THE 2 FIXATION ESTIMATES IS OBTAINED BY SETTING 0 < PRMT(7)< 1.

PRMT(8) = SOLUBLE P ADSORPTION COEF(.1*M^3/T)(10_20) P CONCENTRATION IN SEDIMENT DIVIDED BY THAT OF THE WATER.

PRMT(9) = PEST DAMAGE MOISTURE THRESHOLD(MM)(25_150) PREVIOUS 30-DAY RAINFALL MINUS RUNOFF.

PRMT(10) = PEST DAMAGE COVER THRESHOLD(T/HA)(1_10) CROP RESIDUE + ABOVE GROUND BIOMASS.

PRMT(11) = MOISTURE REQUIRED FOR SEED GERMINATION(MM)(10_30) SOIL WATER STORED MINUS WILTING POINT STORAGE IN THE PLOW DEPTH (PMX = PRMT(43).

PRMT(12) = SOIL EVAPORATION COEF(1.5_2.5) GOVERNS RATE OF SOIL EVAPORATION FROM TOP 0.2 M OF SOIL.

PRMT(13) = WIND ERODIBILITY COEF(0_3) ADJUSTS WIND SOIL ERODIBILITY FACTOR DOWNWARD AS LOOSE MATERIAL IS ERODED.

PRMT(14) = NITRATE LEACHING RATIO(0.1_1) NITRATE CONCENTRATION IN SURFACE RUNOFF TO NITRATE CONCENTRATION IN PERCOLATE.

PRMT(15) = RUNOFF CN RESIDUE ADJUSTMENT PARAMETER(0.0_0.3) INCREASES RUNOFF FOR RSD<1.0 T/HA; DECREASES FOR RSD>1.0

PRMT(16) = EXPANDS CN RETENTION PARAMETER(1.0_1.5) VALUES > 1.0 EXPAND CN RETENTION PARAMETER AND REDUCE RUNOFF.

PRMT(17) = SOIL EVAPORATION-PLANT COVER FACTOR(0.0_0.5) REDUCES EFFECT OF PLANT COVER AS RELATED TO LAI IN REGULATING SOIL EVAPORATION.

PRMT(18) = SEDIMENT ROUTING EXPONENT(1_1.5) EXPONENT OF WATER VELOCITY FUNCTION FOR ESTIMATING POTENTIAL SEDIMENT CONCENTRATION.

PRMT(19) = SEDIMENT ROUTING COEF(T/M^3)(0.01_0.05) POTENTIAL SEDIMENT CONC WHEN FLOW VELOCITY = 1. M/S.

PRMT(20) = RUNOFF CURVE NUMBER INITIAL ABSTRACTION(0.05_0.4)

PRMT(21) = SOLUBLE C ADSORPTION COEF(.1*M^3/T)(10_20) C CONCENTRATION IN SEDIMENT DIVIDED BY THAT IN WATER.

PRMT(22) = REDUCES NRCS RUNOFF CN RETENTION PARM FOR FROZEN SOIL. FRACTION OF S FROZEN SOIL(0.05_0.5)

PRMT(23) = HARGREAVES PET EQ COEF(0.0023_0.0032) ORIGINAL VALUE = 0.0023.

PRMT(24) = PESTICIDE LEACHING RATIO(0.1_1) PESTICIDE CONCENTRATION IN SURFACE RUNOFF TO PESTICIDE CONCENTRATION IN PERCOLATE.

PRMT(25) = RAINFALL INTENSITY ADJUSTMENT FOR CN(0.O_2.0)
SCN=SCN*EXP(PRMT(25)*(.2-AL5))

PRMT(26) = FRACTION OF MATURITY AT SPRING GROWTH INITIATION(0_1) ALLOWS FALL GROWING CROPS TO RESET HEAT UNIT INDEX TO A VALUE GREATER THAN 0 WHEN PASSING THROUGH THE MINIMUM TEMP MONTH.

PRMT(27) = CEC EFFECT ON NITRIFICATION & VOLATILIZATION(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.

PRMT(28) = UPPER LIMIT OF N FIXATION(KG/HA) (0.1_20.)

PRMT(29) = BIOLOGICAL MIXING EFFICIENCY(0.1_0.5) SIMULATES MIXING IN TOP SOIL BY EARTH WORMS ETC. PRMT(31) SETS DEPTH.

PRMT(30) = SOLUBLE P RUNOFF EXPONENT(1_1.5) PROVIDES NONLINEAR EFFECT FOR SOLUBLE P/RUNOFF EQ.

PRMT(31) = MAXIMUM DEPTH FOR BIOLOGICAL MIXING(M)(0.1_0.3)

PRMT(32) = ORGANIC P LOSS EXPONENT(1_1.2) PROVIDES NONLINEAR EFFECT FOR ORGANIC P LOSS EQ.

PRMT(33) = COEFFICIENT IN MUST EQ(2.0_3.0) ORIGINAL VALUE = 2.5.

PRMT(34) = HARGREAVES PET EQ EXP(0.5_0.6) ORIGINAL VALUE=0.5. MODIFIED TO 0.6 TO INCREASE PET.

PRMT(35) = DENITRIFICATION SOIL-WATER THRESHOLD(.9_1.1) FRACTION OF FIELD CAPACITY SOIL WATER STORAGE TO TRIGGER DENITRIFICATION.

PRMT(36) = UPPER LIMIT OF DAILY DENITRIFICATION RATE(0.0001_0.5) MAXIMUM FRACTION OF NO3 IN A SOIL LAYER SUBJECT TO DENITRIFICATION.

PRMT(37) = EXPONENT IN DELIVERY RATIO FOR SWAT OUTPUT(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.

PRMT(38) = WATER STRESS WEIGHTING COEF(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<PRMT(38)<1 CONSIDERS BOTH APPROACHES.

PRMT(39) = PUDDLING SATURATED CONDUCTIVITY(MM/H)(0.00001_0.1) SIMULATES PUDDLING IN RICE PADDYS BY SETTING SECOND SOIL LAYER SATURATED CONDUCTIVITY TO A LOW VALUE.

PRMT(40) = GROUNDWATER STORAGE THRESHOLD(.001_1.) FRACTION OF GROUNDWATER STORAGE THAT INITIATES RETURN FLOW.

PRMT(41) = PLANT ROOT TEMPERATURE STRESS EXP(.1_2.) EXP OF RATIO OF SOIL LAYER TEMP TO AVE OF PLANT OPTIMAL AND BASE TEMPS.

PRMT(42) = SCS CURVE NUMBER INDEX COEF(.3_2.5) REGULATES THE EFFECT OF PET IN DRIVING THE SCS CURVE NUMBER RETENTION PARAMETER.

PRMT(43) = PLOW LAYER DEPTH(M) USED TO TRACK SOLUBLE P CONCENTRATION OR WEIGHT, ORGANIC C, AND SOIL WATER CONTENT.

PRMT(44) = UPPER LIMIT OF CURVE NUMBER RETENTION PARAMETER S(1._2.) SUL=PRMT(44)*S1 ALLOWS CN TO GO BELOW CN1.

PRMT(45) = SEDIMENT ROUTING TRAVEL TIME COEF(.5_10.) BRINGS INFLOW SEDIMENT CONC TO TRANSPORT CAPACITY CONC AS A FUNCTION OF TRAVEL TIME AND MEAN PARTICLE SIZE.

PRMT(46) = RUSLE C FACTOR COEF(.5_1.5) COEF IN EXPONENTIAL RESIDUE FUNCTION IN RESIDUE FACTOR.

PRMT(47) = RUSLE C FACTOR COEF(.5_1.5) COEF IN EXPONENTIAL CROP HEIGHT FUNCTION IN BIOMASS FACTOR.

PRMT(48) = ADJUSTS CLIMATIC STRESS FACTOR (AAP/AAT)/PRMT(48) (50_80) SET TO 0.0 GIVES CLF=1.

PRMT(49) = MAXIMUM RAINFALL INTERCEPTION BY PLANT CANOPY(MM) (0.0_15.0)

PRMT(50) = RAINFALL INTERCEPTION COEF(.05_.3)

PRMT(51) = WATER STORAGE CAPACITY OF LITTER (RESIDUE) COEF (.1_.9) FRACTION OF LITTER WEIGHT.

PRMT(52) = EXPONENTIAL COEF IN EQ EXPRESSING TILLAGE EFFECT ON RESIDUE DECAY RATE(5._15.)

PRMT(53) = COEF IN OXYGEN EQ USED IN MODIFYING MICROBIAL ACTIVITY WITH SOIL DEPTH(0.8_0.95)

PRMT(54) = N ENRICHMENT RATIO COEF FOR ROUTING (0.3_0.9) GLEAMS EQ ERTO=MIN(3.5,PRMT(54)/CIN**PRMT(55))

PRMT(55) = N ENRICHMENT RATIO EXP FOR ROUTING (.1_.3) GLEAMS EQ

PRMT(56) = FRACTION DESTROYED BY BURN OPERATION (.5_1.)

PRMT(57) = P ENRICHMENT RATIO COEF FOR ROUTING (.05_.2) GLEAMS EQ ERTP=PRMT(57)/(CY+1.E-4)**PRMT(58)

PRMT(58) = P ENRICHMENT RATIO EXP FOR ROUTING (0.3_0.9) GLEAMS EQ

PRMT(59) = P UPWARD MOVEMENT BY EVAPORATION COEF (1_20)

PRMT(60) = MAXIMUM NUMBER OF DAYS A PASTURE IS GRAZED BEFORE ROTATION (1-365)

PRMT(61) = SOIL WATER UPWARD FLOW LIMIT(0.05_0.95) LIMITS WATER TENSION RATIO USED TO MOVE WATER FROM A LOWER LAYER TO THE ONE ABOVE IT X1=XX*MIN(PRMT(61),(T1-T2)/T1)

PRMT(62) = MANURE EROSION EQ COEF(0.1_0.5) LARGER VALUES INCREASE MANURE EROSION.

PRMT(63) = N ENRICHMENT RATIO FOR DELIVERY TO SWAT(0.8_1.2)ENRICHMENT RATIO FOR APPLICATION TO 8 DIGIT SEDIMENT YIELD SUPPLIED TO SWAT.

PRMT(64) = DUST DISTRIBUTION COEF(0.5_1.5) AFFECTS DUST DISTRIBUTION AS A FUNCTION OF DOWNWIND TRAVEL TIME.

PRMT(65) = RUSLE 2 TRANSPORT CAPACITY PARAMETER (0.001_0.1) REGULATES DEPOSITION AS A FUNCTION OF PARTICLE SIZE AND FLOW RATE.

PRMT(66) = RUSLE 2 THRESHOLD TRANSPORT CAPACITY COEFFICIENT (1.0-10.0) ADJUSTS THRESHOLD (FLOW RATE * SLOPE STEEPNESS)

PRMT(67) = DUST DISTRIBUTION DISPERSION EXPONENT(5.0_15.0) MODIFIES THE EFFECT OF THE ANGLE BETWEEN THE WIND DIRECTION AND THE CENTROID OF DOWNWIND SUBAREAS.

PRMT(68) = MANURE EROSION EXPONENT(0.1_1.0) MODIFIES EQ BASED ON WEIGHT OF MANURE ON SOIL SURFACE.

PRMT(69) = COEF ADJUSTS MICROBIAL ACTIVITY FUNCTION IN TOP SOIL LAYER (0.1_1.)

PRMT(70) = MICROBIAL DECAY RATE COEF(0.5_1.5) ADJUSTS SOIL WATER-TEMPERATURE-OXYGEN EQUATION.

PRMT(71) = MANURE EROSION COEF(1.0_1.5) MODIFIES EROSION ESTIMATE BASED ON ABOVE GROUND PLANT MATERIAL. PLANT MATERIAL LIVE AND DEAD REDUCE MANURE EROSION.

PRMT(72) = VOLATILIZATION/NITRIFICATION PARTITIONING COEF(0.05_0.5) FRACTION OF PROCESS ALOCATED TO VOLATILIZATION.

PRMT(73) = HYDROGRAPH DEVELOPMENT PARAMETER(0.1_0.9) STORAGE DEPLETION ROUTING EXP USED TO ESTIMATE TRAVEL TIME OUTFLOW RELATIONSHIP.

PRMT(74) = PARTITIONS N FLOW FROM GROUNDWATER (0.0_20.0) PRMT(74)=NCH/NCV. RSFN=RSSF*NCH; DPKN=DPRK*NCV.

PRMT(75) = P ENRICHMENT RATIO FOR DELIVERY TO SWAT(0.05_1.5) ENRICHMENT RATIO FOR APPLICATION TO 8 DIGIT SEDIMENT YIELD SUPPLIED TO SWAT.

PRMT(76) = STANDING DEAD FALL RATE COEF(0.0001_0.1) GOVERNS RATE OF STANDING DEAD CONVERSION TO FLAT RESIDUE.

PRMT(77) = RAINFALL AMOUNT TO DELAY PEST PPLICATION(MM)(0.0_25.0) PESTICIDE IS NOT APPLIED ON DAYS WITH RAINFALL GREATER THAT PRMT(77).

PRMT(78) = SOIL WATER VALUE TO DELAY TILLAGE(0.0_1.0) TILLAGE DELAYED WHEN PDSW/FCSW>PRMT(78).

PRMT(79) = AUTO MOW LOWER LIMIT(T/HA)(0.2_3.) AUTO MOW DELAYED UNTIL ABOVE GROUND PLANT MATERIAL EXCEEDS PRMT(79).

PRMT(80) = UPPER LIMIT OF NITRIFICATION-VOLATILIZATION(0.0_0.5) FRACTION OF NH3 PRESENT.

PRMT(81) = TECHNOLOGY COEF(0.0_0.01) LINEAR ADJUSTMENT TO HARVEST INDEX--BASE YEAR=2000

PRMT(82) = NOT USED

PRMT(83) = ESTIMATES DRAINAGE SYSTEM LATERAL HYDRAULIC CONDUCTIVITY (0.1_10.0). DRAINAGE HCL IS MAXIMUM OF PRMT(83)*VERTICAL SC AND APEX ESTIMATE CONSIDERING DRAINAGE TIME AND STORAGE. HCL(L,ISA)=MAX(PRMT(83)*SATC(L,ISA),(PO(L,ISA)-S15(L,ISA))/(24.*DRT(ISA)))

PRMT(84) = COEF REGULATING P FLUX BETWEEN LABILE AND ACTIVE POOL (0.0001_0.001) RMN=PRMT(84)*(WPML(ISL,ISA)-WPMA(ISL,ISA)*RTO)

PRMT(85) = COEF REGULATING P FLUX BETWEEN ACTIVE AND STABLE POOL (0.0001_0.001) ROC=PRMT(85)*BK(ISL,ISA)*4.*WPMA(ISL,ISA)-WPMS(ISL,ISA)

PRMT(86) = N UPWARD MOVEMENT BY EVAPORATION COEF (0.001_20) BASE VALUE=1.0. RELATED DIRECTLY TO UPWARD MOVEMENT.

PRMT(87) = WATERTABLE RECESSION COEF (0.001_1.0) SMALL VALUES SLOW THE WATERTABLE RECESSION.

PRMT(88) = LIMITS DAILY WATERTABLE MOVEMENT (0.001_1.0) FRACTION OF DIFFERENCE BETWEEN WTBL AND WTMN OR WTMX.

PRMT(89) = WATERTABLE RECESSION EXPONENT (0.1_0.9) EXPONENT OF DAY OF YEAR/365

PRMT(90) = REGULATES LATERAL SUBSURFACE AND QUICK RETURN FLOW(0.1_10.) LARGE VALUES INCREASE FLOW.

PRMT(91) = REGULATES EVAPORATION FROM CHANNEL& FLOODPLAIN(0.001_1.)
SMALL VALUES REDUCE CHANNEL & FLOODPLAIN EVAPORATION.

PRMT(92) = RUNOFF VOLUME ADJUSTMENT FOR DIRECT LINK (NVCN=0) (0.1_2.0)
INVERSELY RELATED TO RUNOFF. USED LIKE PRMT(42) IN CN INDEX
METHOD (NVCN=4)

PARM(93) to PARM(96) contain cost parameters