Water Budget and Nutrient Balance Worksheet

WATNUTFL Version 6.0

Users Guide

Introduction

WATNUTFL version 6.0 is a Microsoft (MS) Excel® spreadsheet revised by Florida USDA, Natural Resources Conservation Service (NRCS) Engineering Section. The program assists the user in the design of the waste storage facility and the development of a nutrient management budget for utilization of animal waste by land applying to crops. This program is based on the criteria set forth in the NRCS conservation practice standards Waste Storage Facility, Code 313, Nutrient Management, Code 590, and the NRCS Animal Waste Management Field Handbook (AWMFH) and AWMFH Florida Supplements.

Note: Before using this program, it is highly recommended that users receive training on the use of this program.

Spreadsheet Purpose and Description

The purpose of this spreadsheet is to assist the user in estimating manure and wastewater production, determining storm runoff from areas where manure is concentrated, and preparing a water budget and nutrient balance. These computations are used to size waste storage and treatment facilities and determine acres of crops required for the application of animal wastes from confined animal operations in accordance with the standards and specifications of the NRCS. The nutrient analysis section assists with developing the nutrient budget as required by the conservation practice standard Nutrient Management, Code 590.

Running the Spreadsheet

To run WATNUTFL, start MS Excel®. Make sure that iteration is activated. To do this, go to <Tools>, <Options…>, <Calculations> tab, check <Iteration>, and enter 100 under the maximum iterations. Open the file <watnutfl.xls>. The MS Excel® spreadsheet displays "Enable Macros" and "Disable Macros". Be sure to click <Enable Macros>. The spreadsheet will not run properly without the macros enabled. A screen appears asking for a password. The spreadsheet is password protected and the user should click on <Read Only>. See Figures 1 and 2.

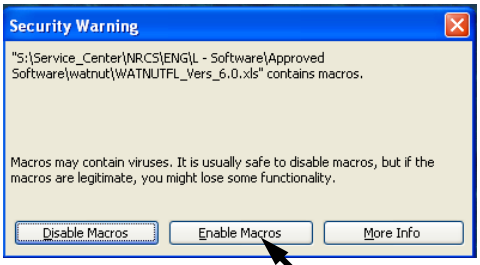

Figure 1 Click on *Enable Macros*

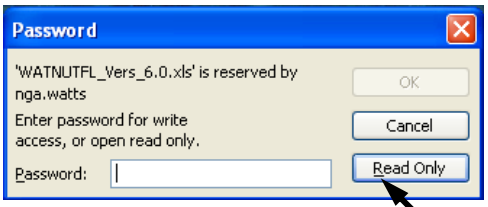

Figure 2 Click on *Read Only*

The spreadsheet consists of seventeen worksheets (appears as tabs at the bottom of the spreadsheet):

(1) "Instructions"

(2) "Cover Sheet"

(3) "AWMFH Tables"

(4) "Intro"

(5) "Animal 1"

(6) "Animal 2"

(7) "Animal 3"

(8) "Water Use"

(9) "Runoff"

(10) "Anaerobic"

(11) "Nutrient Losses"

(12) "Pond Structure"

(13) "Nutrient"

(14) "Monthly"

(15) "Rain&Evap"

(16) "Con-Use"

(17) "Summary"

The "Instructions" worksheet contains a link to the program documentation and instructions. The "Cover Sheet" worksheet documents the names, addresses, phone numbers, and general information about the operation of the animal waste management plan is being developed. It provides documentation for the designer's name and date of completion as well as for the person checking the design. The "AWMFH Tables" worksheet is an information sheet with waste/manure characteristics and nutrient losses data taken from the AWMFH.

Note: For all the worksheets, all cells in blue are data entries to be entered by the user. *Do not* use the "Tab" key to move from cell to cell. Instead use the mouse or the arrow keys. To clear any data that are already included in the cells, right mouse click and choose *"clear contents"*.

References

This worksheet requires several references available from the NRCS in order to provide input data specific to the county or area. This data consists of rainfall, evaporation, and crop consumptive use. With this data and the knowledge of the rules, regulations, and operation of the agricultural enterprise, this worksheet should assist producers, engineers, Technical Service Providers, and other professional consultants in developing site-specific manure and wastewater production rates, minimum capacity of storage structures, and acreage of crops needed to utilize the waste.

Intro (Worksheet)

First, enter data on the "Intro" worksheet. Begin by entering the operator and the company name, address, and phone number. Choose from the drop down menu the number of different types of animals using the same waste management system and the type of waste storage facility.

The "Intro" worksheet can be printed by selecting the print button at the bottom of the worksheet. Next, select the <Animal 1> worksheet at the bottom of the spreadsheet.

Animal 1, Animal 2, Animal 3 (Worksheets)

The program allows three different types of animals to use the same waste management system. The animal species must be selected using the respective codes to correctly access the proper values for manure constituents.

Estimates of the constituents of manure are based on values from the NRCS AWMFH dated March 2008. These values can be over written by the user by choosing user defined. Nutrient content in feed in this sheet is for documentation purposes. The user must choose from the drop down menu if default values or user defined values will be used in the calculations of the manure and nutrient produced by the animal(s).

The worksheet then calculates the daily manure production rate based on the number and live weight of livestock or poultry held in confinement buildings and/or open lots. Manure from "Buildings" section is handled in the Waste Storage Facility or Waste Treatment Lagoon and manure from "open lots" is deposited as excreted onto a field (i.e., pasture). The total live weight is adjusted for the fraction of time the animals spend respectively in confinement buildings or in open lots. This value is used for an annual nutrient balance, thus the number of animals and confinement period should be adjusted to account for this. This is especially true of poultry broilers which will have a wide variation in live weight and number of animals throughout the year. Manure from buildings is flushed to the waste storage facility/waste treatment lagoon while open lot manure and solids collected are used in the dry manure spreading. Thus broiler litter would be accounted for in open lot, and a dairy would be divided depending upon time spent in pasture and in feeding barns.

Repeat for "Animal 2" and "Animal 3" as needed.

The "Animal 1", "Animal 2", and "Animal 3" worksheets can be printed by selecting the print button at the bottom of each worksheet. Next, select the <Water Use> worksheet.

Water Use (Worksheet)

This worksheet deals with the volume of manure and wastewater from the confinement buildings only.

The wet manure volume is based on the AWMFH data and is wet manure production divided by bulk density.

The estimated water required for manure removal is a required input for a total flush system or a manual scrape with wash system. Actual quantities should be used in lieu of estimates. In addition, the user supplies estimates of volume of cleanup and wash water in the building and another category defined as other water that enters the

wastewater system such as "drinking water" and "other water used for cleanup," which can be a significant fraction of the wet manure volume. If any amount of the waste water is used for recycling, this amount of water should be entered under “Flush Water Adjust + or – “ or “Other Adjust + or –“. Total manure and wastewater volume is the sum of the above components.

This worksheet allows for monthly adjustment for the amount of water used. This is very useful in accounting for cooling water added during summer months.

A computation is made for the minimum net effect manure and waste water storage volume required. As part of the capacity requirements for storing manure and wastewater from confinement buildings, additional storage is allocated where needed for sludge or solids accumulation. A procedure based on live weight of the animals computes the annual accumulation of sludge. The user can plan the desired storage allocation based on this annual production.

The “Water Use” worksheet can be printed by selecting the print button at the bottom of the worksheet. Next, select the <Runoff> worksheet.

Runoff (Worksheet)

This worksheet provides a procedure for estimating the volume of runoff entering a runoff control structure (RCS). RCS includes waste storage facility and waste treatment lagoon. The runoff volume consists of: (1) the manure contaminated runoff from the open-lot surface (i.e. those areas that are covered with manure and void of vegetation); (2) the runoff from any areas between the edge of the open lots and the RCS (if roof runoff is not diverted from the RCS’s roof area should also be added); and (3) direct rainfall into the WSF.

The design rainfall is obtained from the “Rainfall Frequency Atlas” the 25-year frequency, 24-hour duration rainfall event. The runoff volume from the open lot areas is automatically computed after entering the NRCS soil cover complex curve number obtained from TR-55, usually the curve numbers 90 to 95. The runoff volume from the areas between the RCS and the edge of the feedlot is determined using an appropriate soil cover complex curve number that properly reflects runoff characteristics of the soil and vegetation present. The direct rainfall into the WSF is equal to the magnitude of the 25-year, 24-hour storm.

The recommended treatment volumes and the sludge accumulation ratios that are assumed in these calculations are different for each species of livestock. These values were selected based on data contained in Chapter 4 of the NRCS AWMFH.

Total RCS storage is a summation of these three components of runoff volume. This volume allocated to runoff can either be designed into a single waste storage facility or added to other allocations for storage in a second stage lagoon. If designed as part of a two stage system the total surface area and drainage area of both ponds must be considered in determining storage requirements.

Finally, a summary of all liquid manure and wastewater storage allocations is provided for determining the size of a waste storage facility. The program adds the minimum design wastewater storage volume to the minimum design runoff volume and designed sludge accumulation storage. The designer can include additional storage volume as required after computing the water budget based on storage volumes and crop acreage on which crops will be using the nutrients.

The “Runoff” worksheet can be printed by selecting the print button at the bottom of the worksheet.

Anaerobic (Worksheet)

This worksheet provides a method of computing the primary anaerobic lagoon volume based primarily on criteria for treatment volume. The unit treatment volume has been derived based on two fundamental criteria: (1) the volatile solids loading rate (lbs/day/cu ft) and (2) sludge accumulation ratio (Chapter 10 AWMFH) assuming an average rate of settling solids accumulation in the bottom of the lagoon.

The major output is the total liquid treatment volume (i.e. the liquid volume to be maintained at nearly all times in the lagoon to provide for digestion). This is the major criteria for designing primary lagoons. Additional allowances can be made for sludge storage to prolong the life of the lagoon before cleanout is required, and design rainfall runoff from open-lots, direct precipitation into the lagoon, and any additional storage that the designer wants to include. These components of lagoon capacity are added together to provide a value for the total primary lagoon capacity. The calculated treatment volume is not included in the total volume in the pond design. If the

user wants to use the anaerobic treatment volume as the designed volume, the user has to enter this in the *Additional needed storage* in the <Pond Structure> worksheet.

The "Anaerobic" worksheet can be printed by selecting the print button at the bottom of the worksheet.

Nutrient Losses (Worksheet)

An estimate of the amount of crop land that would need to be provided for utilization of manure and/or wastewater is made in the final section of the manure and waste water computations and is based on an allowable application rate for available nitrogen or phosphorous. The estimating procedure considers only the land area that would be needed under various assumptions of nitrogen and phosphorous loss during manure storage, handling, treatment, and land application (Chapter 11, AWMFH).

This section also allows for removal of solids from a storage pond and collected solids and export of manure from the farm. "Percentage of Manure Collected from Open Lots and/or Concrete Area not in Waste Water" is the percentage of the raw manure that will not go into waste storage facility. In the specific nutrient section, "Percentage of Nutrient (N, P_2O_5, or K_2O) in Collected Manure before Losses" is the percentage of nutrient in the percentage of raw manure collected that remained in the manure/solids. For example, if the dairy dry-scrapes, 100% of the raw manure will not go into the waste storage facility (pond). Due to high water usage (misters and spilled water) the dry-scraped manure contains only 90% of the N, 90% of P_2O_5, and 50% of K_2O. Therefore, "Percentage of Manure Collected from Open Lots and/or Concrete Area not in Waste Water" is 100% and Percentage of Nutrient (N, P_2O_5, or K_2O) in Collected Manure before Losses" are 90%, 90%, and 50% respectively.

Care should be taken when using Table 11-5 and Table 11-6 to make sure that the combined percentage of loss does not exceed the percent of urea in the manure being considered since these losses are based upon ammonia volatilization.

A feature is available by choosing "Override Default Values" under Nutrient Levels in Waste heading to make adjustments in the quantity of nutrients N, P, and K contained in both the liquid and solid wastes. These adjustments are appropriate when the operation uses special or unique handling or treatment systems which cause the concentration of nutrients to shift from liquid to solid or vice versa. Another possible use of this feature would be if test results on samples indicated a different makeup of nutrients from the computed values. At the display of this screen, the computed values are shown along with the input cells to assist the user in making adjustments.

Consideration should be given to land application of wastewater from feedlots where the salt content may be a limiting factor since that problem is not taken into account in this worksheet.

The "Nutrient Losses" worksheet can be printed by selecting the print button at the bottom of the worksheet.

Pond Structure (Worksheet)

The water budget portion of the worksheet contains input data specific to the site of the RCS and agricultural operation for which the system is being designed. Following are explanations of the data required to complete this portion:

(a) Location No.
Identifies the location of the system which triggers loading of pre-input climate data (monthly evaporation, evaporation coefficient, and monthly rainfall) and crop consumptive use. Seven climatic zones and 11 specific city locations have been pre-loaded into the spreadsheet. See Table 1.

Table 1- Locations with pre-input climate data

Location No	Location
1	Climatic Zone 1
2	Climatic Zone 2
3	Climatic Zone 3
4	Climatic Zone 4
5	Climatic Zone 5
6	Climatic Zone 6
7	Climatic Zone 7
8	Vero Beach, Indian River County
9	Belle Glade, Palm Beach County
10	Flamingo, Monroe County
11	Ft Lauderdale, Broward County
12	Gainesville, Alachua County
13	Lake Alfred, Polk County
14	Lake City, Columbia County
15	Lisbon, Lake County
16	Milton, Santa Rosa County
17	Moore Haven, Glades County
18	Tamiami Trail, Dade County

The pre-loaded data contains water budget data for 4 crop alternatives: (1) Bermudagrass, (2) Bermudagrass/small grain, (3) corn/sorghum/small grain, and (4) corn/pasture/small grain. See table below for the location number and location. If data for other locations are desired, refer to Climatic Data Entry Section. Climatic zones 1-7 are based upon National Engineering Handbook, Part 652, Irrigation Guide, Figure FL4-1 Climate Zones of Florida.

(b) 30 Day CN, Drain to Pond

The NRCS curve number used to determine amount of runoff into pond adjusted to a 30 day duration. This is taken from the NRCS Technical Note Eng-FL-22 –30 Day Curve Number.

(c) 30 Day CN, Crop Field

The NRCS curve number applicable to the soil cover complex of the field on which application of wastewater will be made adjusted to a 30 day duration from the NRCS Technical Note Eng-FL-22 –30 Day Curve Number.

(d) Additional Needed Storage

This section of the worksheet has been added to assure that spill from the storage pond does not occur. Since the water budget is based upon crop consumptive use, it may be necessary to increase the storage volume to allow for periods when crop water demand is low. The program has been set up so that this value must be correct before you can continue to other variables. To the right of the entered value is an indicator of how close the designed storage is to the ideal storage. If this value is unrealistically high, it can be reduced by adding a minimum monthly irrigation amount in <Nutrient> worksheet (see Minimum Monthly Irrigation and User Notes) or increasing irrigated acreage. This value will also be reduced by adding more irrigated acreage.

The following data is to be entered as input in the Storage-Area Table for the WSF section. The designer may choose a circular or rectangular pond.

Circular Pond - Enter a bottom diameter in feet for the circular pond and above that entry specify the side slopes (horizontal to vertical ratio). Enter maximum design depth.

Rectangular Pond - Enter a Zero for the Circular Pond bottom diameter; then enter side and end slopes (horizontal to vertical) and the width and length of the top of the pond. Enter the maximum pond depth.

Irrigation Efficiency, % - For the irrigation system proposed for application of wastewater, enter the irrigation system efficiency expected.

(e) General Discussion of Water Budget Table

The water budget table is a modification of the example outlined in NRCS Engineering Technical Report, Hydrology 210-18-TX3. A discussion of the mechanics of the table by columns follows:

Col. 1 - Monthly precipitation in inches for a location at or near the site.

Col. 2 - Monthly runoff (inches) computed with the NRCS Curve No. for the irrigated field soil-cover complex and adjusted from one-day to thirty day curve number.

Col. 3 - Inflow to the pond from runoff which is calculated using the thirty day NRCS Curve No. for the area above the pond and including the pond area. These calculations are performed in two columns outside the normal working bounds of the work sheet. (Acre feet/Month)

Col. 3a - Other inflow to the pond such as generated washdown or wastewater from a dairy. Expressed in acre-feet per month.

Col. 4 - Effective precipitation in the area of the irrigated field in inches per month.

Col. 5 - Gross evaporation in inches per month. The worksheet will automatically apply the pan evaporation coefficient before performing the net evaporation computations.

Col. 8 - Net evaporation on the pond in acre-feet per month.

Col. 10 - Crop demand for the month computed from the consumptive use of the crop for the acreage available but with consideration for the rainfall, etc., occurring during the month.

Col. 10b - Actual withdrawal in acre-feet made during the month not to exceed the crop demand.

Col. 11 - Storage at the end of the month. The figure above the January amount is taken as the same as December. If the two do not agree, press the F9 key to recalculate the worksheet. The maximum

storage computed in this column should not encroach on the storage allocation for the 25-year, 24-hour runoff. If it does, then additional storage should be considered if land area and crops used for liquid disposal are already optimized.

Col. 12 - Surface area at the end of the month is used to compute evaporation on the pond area and is estimated from the storage-surface area table for the runoff control structure.

Col. 13 - The spill column indicates if any spill from the reservoir occurred due to a lack of storage to contain the inflows into the pond during the month after considering the demand on the storage.

The "Pond Structure" worksheet can be printed by selecting the print button at the bottom of the worksheet.

Nutrient (Worksheet)

A nutrient balance is prepared to ensure agricultural waste nutrients applied do not exceed plant usage. The worksheet uses the quantity of nutrients contained in liquid and dry manure and an accounting of each field on which wastes will be applied.

The inventory of each field considers the acreage, crop demand of nutrients, soil characteristics and level of existing nutrients in the soil. The production of nitrogen, phosphorus and potash produced in both liquid and dry manure is automatically loaded from the portion of the worksheet devoted to compute manure and wastewater production.

The values of nutrient production from this worksheet are excellent for planning a new waste management system; however, the producer can better manage nutrients by analyzing samples from waste storage facilities, lagoons, and disposal areas and using sample results as inputs to the Nutrient Balance Worksheet as an operation and maintenance tool. The summary will indicate whether there is excess of individual nutrients from the annual disposal of wastes for the given set of conditions. The summary of acreage for liquid waste disposal is automatically carried to the water budget.

This worksheet is for usage of nutrients from applying the liquid and dry manure (pasture and collected solids) to a growing crop. There are four fields set up to receive the wastes. The choices of crops is derived from the <Con-Use> worksheet and is dependent on the location chosen in the <Pond Structure> worksheet. To add other types of crops to the list, click on the "Edit Crop Consumptive Use" button. The macro will take you to the <Con Use> worksheet to the correlating zone and location chosen in the <Pond Structure> worksheet. The data entered in the <Con-Use> worksheet are the crops to be planted in the particular zone and the corresponding consumptive use.

The user enters field numbers and acreages for each field. Each field has a drop menu of the crops to be planted. If crops to be planted are not in the drop down menu, the user clicks on the "EDIT Crop Consumptive Use" button. The user enters the crop consumptive use information. Return to the <Nutrient> worksheet. Once back to the <Nutrient> worksheet, the user chooses from the drop down menu if the field is to be irrigated with the waste water available. The user can specify the minimum irrigation amount (see comment below). The drop down menu has the option of user define under "Irr." This option is to allow the user to specify by month the irrigation amount of waste water.

The user must enter the uptake amount of the crops for each field. If manure is applied via the animals to the pasture, the amount of N applied is entered. The worksheet will calculate the P_2O_5 and K_2O applied through grazing. If collected solids are applied in any of the fields, enter the N applied and the worksheet will calculate the corresponding P_2O_5 and K_2O. Other sources of nutrients such as the level of nutrients already present as indicated by a recent soils test, application of litter, commercial fertilizer, or combination of the different sources should be entered by choosing the correct source from the drop down menu with the corresponding nutrient. If the option "COMBINATION sources" is chosen, the user has to enter all the sources and the nutrient amount highlighted in blue in the chart titled "Combination Sources."

The plant uptake/use of nutrients may be taken from AWMFH for a given management level of a particular crop considering the NRCS conservation practice standard Nutrient Management, Code 590.

After all entries are entered, the worksheet will calculate if there is a deficit or excess of nutrient in each field. Also, the total amount of nutrient in the waste used is calculated.

(a) Minimum Monthly Irrigation, inches
Application of irrigation is based upon consumptive use minus effective rainfall for this water budget. If a minimum irrigation rate is used regardless of consumptive use, then enter that value here. This minimum irrigation rate will be used for all crops considered.

The "Nutrient" worksheet can be printed by selecting the print button at the bottom of the worksheet.

Rain&Evap (Worksheet)

This worksheet is the rainfall and evaporation data for climate zones and cities that are used in the water budget analysis. Table 2 lists the locations with available rainfall and evaporation data linking to the plant consumptive use data. Data can be entered into a lookup table in the worksheet for as many as 12 additional locations. Upon entry of a Location No. for a pre-entered location, the input data is loaded into the proper cells of the water budget.

Table 2 - Locations with links to plant consumptive use data

No.	Location	County	Zone ID
1.	Climatic Zone 1		1z
2.	Climatic Zone 2		2z
3.	Climatic Zone 3		3z
4.	Climatic Zone 4		4z
5.	Climatic Zone 5		5z
6.	Climatic Zone 6		6z
7.	Climatic Zone 7		7z
8.	Vero Beach	Indian River County	4z
9.	Belle Glade	Palm Beach County	5z
10.	Flamingo	Monroe County	5z
11.	Ft Lauderdale	Broward County	6z
12.	Gainesville	Alachua County	2z
13.	Lake Alfred	Polk County	4z
14.	Lake City	Columbia County	2z
15.	Lisbon	Lake County	3z
16.	Milton	Santa Rosa County	1z
17.	Moore Haven	Glades County	5z
18.	Tamiami Trail	Dade County	5z

Location numbers 19 through 30 have been left as unidentified locations and can be entered with the desired specific location data. Each location can have a ZONE I.D. represented for one of the seven climatic zones defined in the National Irrigation Guide, Florida Supplement, or the user can define another ZONE I.D (OTHER in <Con Use> worksheet). The ZONE I.D. is used to reference the consumptive use chart. The consumptive use chart is set up with four different Default Crops (bermudagrass, bermudagrass/small grain, corn/sorghum/small grain, corn/pasture/small gain). The program uses the consumptive use data for each crop dependent upon the location chosen via the ZONE I.D. Climatic zones 1-7 are based upon National Engineering Handbook, Part 652, Irrigation Guide, Figure FL4-1 Climate Zones of Florida.

The "Rain&Evap" worksheet can be printed by selecting the print button at the bottom of the worksheet.

Con Use (Worksheet)

Should the user decide to use a different crop, values for the consumptive use of the desired crops should be entered in this worksheet for the respective ZONE I.D. (NOTE that a user Defined Location MUST be used to match up ZONE I.D.s). See Table 2.

As an example, a user may decide to use rainfall, evaporation, and consumptive use specific to his/her county. The user could create a Zone ID of county name which would be used on the <Rain&Evap> worksheet and the <CON-USE> worksheet.

The "Nutrient" worksheet can be printed by selecting the print button at the bottom of the worksheet.

Summary (Worksheet)

This worksheet is a compilation of the information entered and calculated. Also, to export the amount of waste to be utilized information to the software AFOPro, select the AFOPro Export button.

The "Summary" worksheet can be printed by selecting the print button at the bottom of the worksheet.

Checks, Warnings and Limitations

The spreadsheets have several error checks and warnings. The spreadsheets check to determine if the input values are within an acceptable range.

Note that when using this program on grazed pasture, it may show larger amounts of phosphorus removed when actually only small amounts of phosphorus are removed. Soil test results and a complete nutrient budget considering the fate of nutrient removal and recycling

must be considered in the nutrient plan. In addition, the amount of nitrogen removed when harvesting the crop(s) is usually less than the amount of nitrogen needed to produce the crop. Therefore, realistic yield goals and UF/IFAS nutrient recommendations must be considered in preparing the final nutrient budget.

Disclaimer Statement

The USDA NRCS cannot assume liability for the use or maintenance of this worksheet or any results it may produce.

User Notes

When using this program, all worksheets must be completed since they are all inter-related. It is suggested to start with the animal worksheet, followed by the nutrient worksheet, and finishing with the water budget section. The user should always go through each section of the worksheet a final time before printing since some alteration later in the worksheet may change results in an earlier section. This is especially true of the water budget section. Almost every change made affects the water budget.

Once the initial data has been entered for the design, then changes can be made to see how they will affect the design. Caution should be used when using a minimum monthly irrigation amount since the water budget is very sensitive to this parameter. Documentation may be required to show that irrigation above crop demands does not cause excess nutrient leaching (i.e. GLEAMS modeling run). Another sensitive value for the yearly water budget is the curve number for the application fields. This curve number needs to be accurate since the effective rainfall for the crops will be determined using this curve number.

The worksheet is macro driven and was written with visual basic for applications running in the background. The user can get out of the macro by using <ctrl><Break> simultaneously.

References

The following references are utilized in the WATNUTFL program.

Florida Conservation Practice Standards:
- Nutrient Management, Code 590
- Waste Storage Facility, Code 313
- Waste Treatment Lagoon, Code 359

Part 651, Agricultural Waste Management Field Handbook
- Chapter 4
- Chapter 6
- Chapter 11

Technical Note Eng-FL-22 – 30 Day Curve Number

National Engineering Handbook, Part 652, Irrigation Guide, Figure FL4-1 Climate Zones of Florida

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