EC198

Feed Nutrient Management Planning Economics (FNMP$)

Connecting Feed Decisions with Crop Nutrient Management Plans

Spreadsheet Instructions
Version: 3/7/08

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This spreadsheet estimates:

1) Land requirements for agronomic utilization of the manure;
2) Labor and land application equipment time requirements;
3) The costs associated with land application; and
4) The potential nitrogen and phosphorus nutrient value of manure.

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Table of Contents

Contact Information 2
Introduction 3
Setup Instructions 4
Software Requirements 4
Activate Macros 4
Improve Screen View 4
Getting Started 6
An Overview of the Seven-step Process 8
Data Entry Instructions
Estimating Excretion
Step1 11
Step 2 11
Step 3 12
Nutrient Availability
Step 4 15
Land and Distance
Step 5 18
Economics
Step 6 21
Summary
Step 7 25
Conclusion 25
Appendix A. Uniquely Colored Cells and Buttons 27
Appendix B. Project Team 28

Common Acronyms and Definitions:

AFO: Animal Feeding Operation
ASABE: American Society of Agricultural and Biological Engineers
CAFOs: Concentrated Animal Feeding Operations
CNMPs: Comprehensive Nutrient Management Planning
FNMP$: Feed Nutrient Management Planning Economics
N or N-based: nitrogen or nitrogen-based
P or P-based: phosphorus or phosphorus-based

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The most current version of FNMP$, and the instruction manual, are available at:

http://manure.unl.edu/computer.html

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Introduction

With the ability to integrate feed management decisions and animal performance measures into the nutrient planning processes, this software tool has been developed to aid producers and their advisors. *Feed Nutrient Management Planning Economics (FNMP$)* is designed to estimate the impact of feed-program decisions on the crop nutrient program. Feeding crude protein and phosphorus (P) above minimum animal requirements produces manure with additional nutrients. Feeding decisions will influence a nutrient plan's land access requirements, labor and equipment needs, and costs associated with land application as well as value of the manure. Decisions to include phytase in a swine or poultry ration, or to replace corn with distillers grains in a dairy or beef ration, have far-ranging implications. This tool will help quantify the resulting changes.

In addition, this tool helps determine the overall cost and benefit of manure application, including the impact that animal feed program will have. FNMP$ estimates:

- excreted and crop-available manure nutrients in manure;
- land requirements for agronomic utilization of the manure;
- labor and land application equipment time requirements; and
- the costs associated with land application.

FNMP$ provides additional value by evaluating the impact of various manure management decisions on economic considerations. For example, with the recent implementation of a P-Index risk assessment on Concentrated Animal Feeding Operations (CAFOs), fields are being identified that must receive manure at a P-based rate. P-based rates are typically lower than nitrogen (N)-based rates, requiring additional land access and time for manure applications. FNMP$ can be used to evaluate the economic, time, and land consequences of these and other decisions.

Thanks to an improved ability to provide accurate and farm-specific estimates of nutrient excretion, FNMP$ allows users to more comprehensively evaluate the costs and benefits associated with manure application. By estimating excretion with existing procedures for estimating land requirements and evaluating economic factors, this new tool provides a unique opportunity to integrate feed management decisions into the comprehensive nutrient management planning (CNMP) process. As one of the six components of a CNMP, feed management provides an important opportunity to improve the environmental and financial performance of an animal feeding operation (AFO).

The FNMP$ program is one component of a suite of tools which analyze opportunities for adjusting the feed program as part of a CNMP, while FNMP$ assists in determining the adjustments' economic impacts.

The software generates individualized data as it estimates excretion, based on operation-specific feed rations and animal performance. Generalized data contained in the program can be modified by the user for maximum customization and, in return, maximum benefit.

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Setup Instructions

Software Requirements

This 2,000 kilobyte spreadsheet was created with Microsoft Excel 2000®. Because of the substantial use of macros for many of the operations, it would be rather difficult to execute this spreadsheet in a different program.

Activate Macros

This spreadsheet contains many macros performing a wide variety of functions. Without these macros, many of the critical spreadsheet functions will be lost. In Excel 2000®, two steps (*Figures 1* and *2*) are necessary to allow the use of macros:

a. Enabling Use of Macros *(Figure 1)*. When Excel 2000® is opened (without the FNMP$ application), the security level for Excel must be set to "Medium." To do this, click on the "Tools" button on the menu bar; then "Macro;" and then "Security." This will expose the Security window. Click on the "Medium" setting.

b. Next, open the file "FNMP$." Click on the "Enable Macros" button. Once the file is open, test the functioning of the macros by clicking on any of the buttons on the spreadsheet. If they do not work, repeat step 1a.

Improve Screen View

Individual user screen sizes and settings may result in individual pages fitting the screen improperly, requiring additional scroll bar maneuvering in order to view an individual page in its entirety. The information seen in a single screen can be adjusted by completing the following steps. It is best to adjust the information that fits into one screen so that all yellow background area (the "User Viewing Area") within the left-to-right limits of the screen can be seen.

In Excel 2000® operating systems, adjust the viewing area *(Figure 3)* by following these steps:

a. Click on "View" and then "Zoom." Adjust the "% Zoom" according to personal preferences.

b. Adjust the screen resolution by clicking on "Start" (located in the lower-left-hand corner on most computers). Then click on "Settings;" "Display;" and then "Settings" again. Screen size can be adjusted by going to a higher resolution, such as "1280 x 1024" or "1400 x 1050." Generally, the higher resolution will produce better viewing quality. If the text is too difficult to read, increase the font size with the "Zoom" option described above.

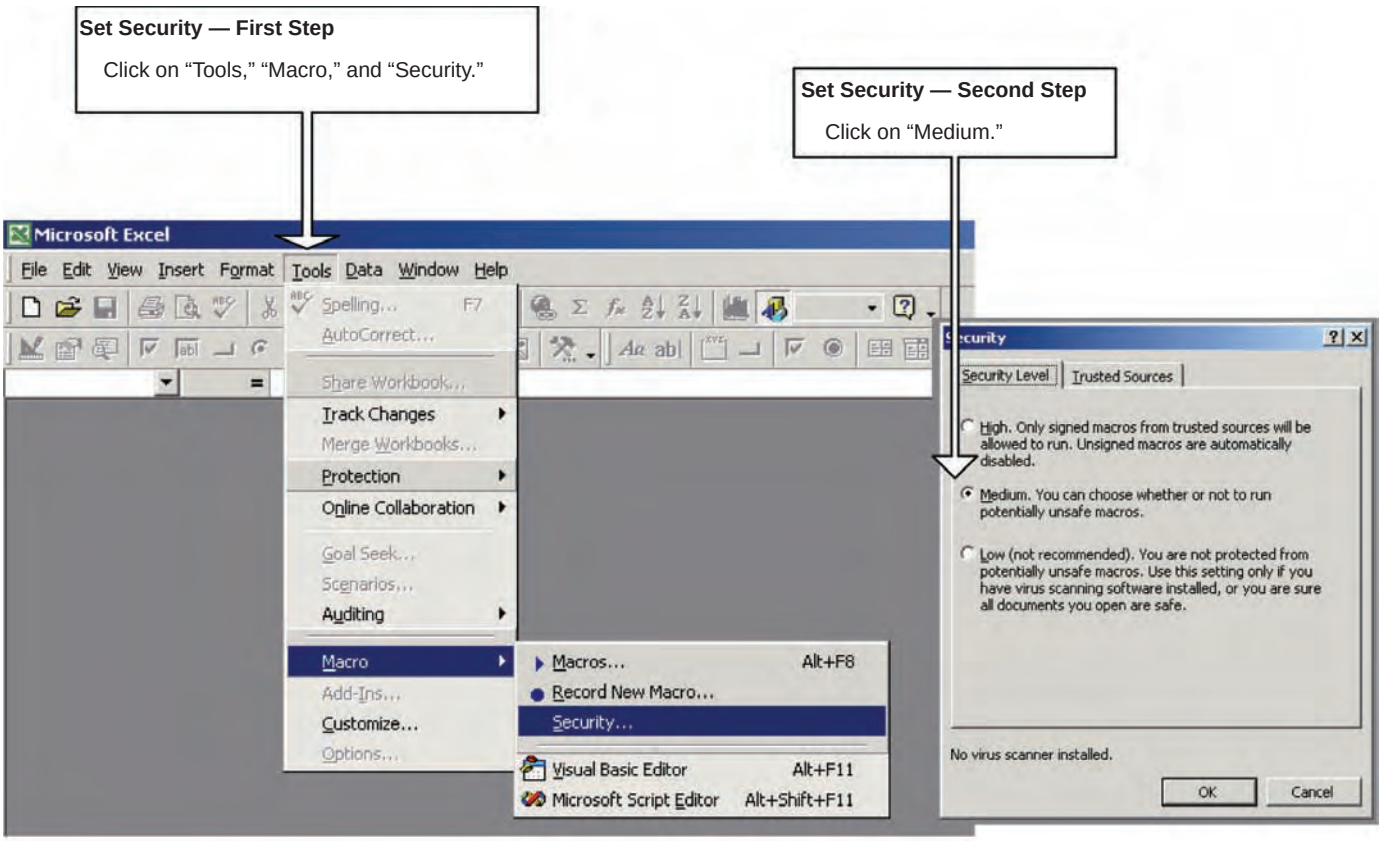

Figure 1. These directions provide instructions for enabling macros in Excel 2000® operating systems.

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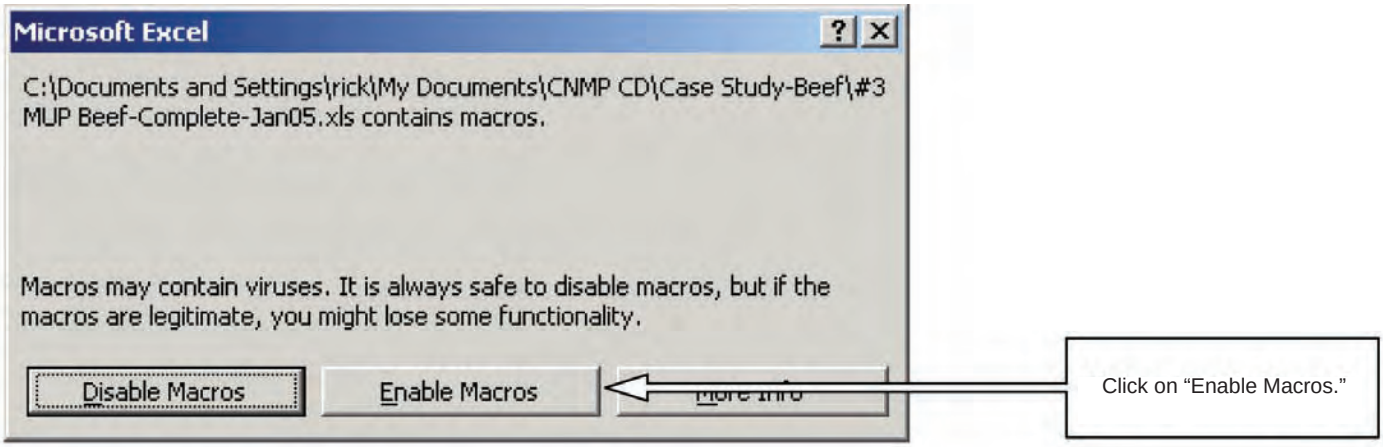

Figure 2. You must enable macros to use the spreadsheet.

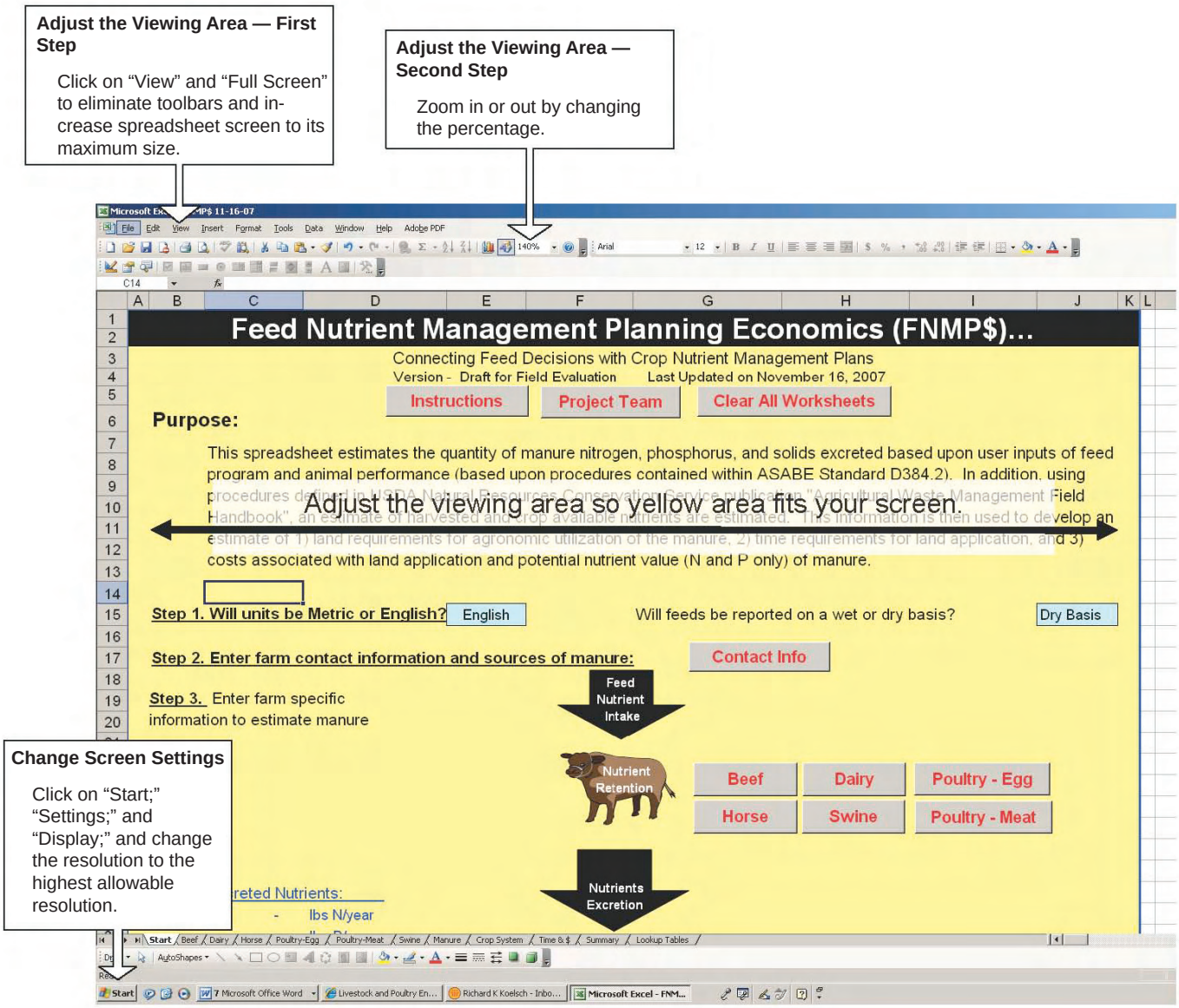

Figure 3. Adjust the viewing area and change the screen settings, as needed, according to personal preferences.

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Getting Started

Make a new file for your own spreadsheet

Open the original worksheet, but before inputting any information, save it as another file. Program designers recommend this to keep the original spreadsheet unaltered, and easy to go back to if you have to start over. To save it as another file, go to the main menu and choose "Save File As" and give it a new name, such as FNMP$ for John Doe or MyFNMP$. Remember to save this new file frequently, in case of computer glitches, operator errors or power problems.

Inputting data

Seven unique steps are outlined on the "Start" page *(Figure 4)* for completion of the entire spreadsheet. Throughout all seven steps, take all opportunities to customize data and alter default values according to actual farm values. Input as much farm-specific data as practical. A grey button is tied to each step, which takes you to additional worksheets. Upon completing each worksheet, return to the "Start" page by clicking "Start."

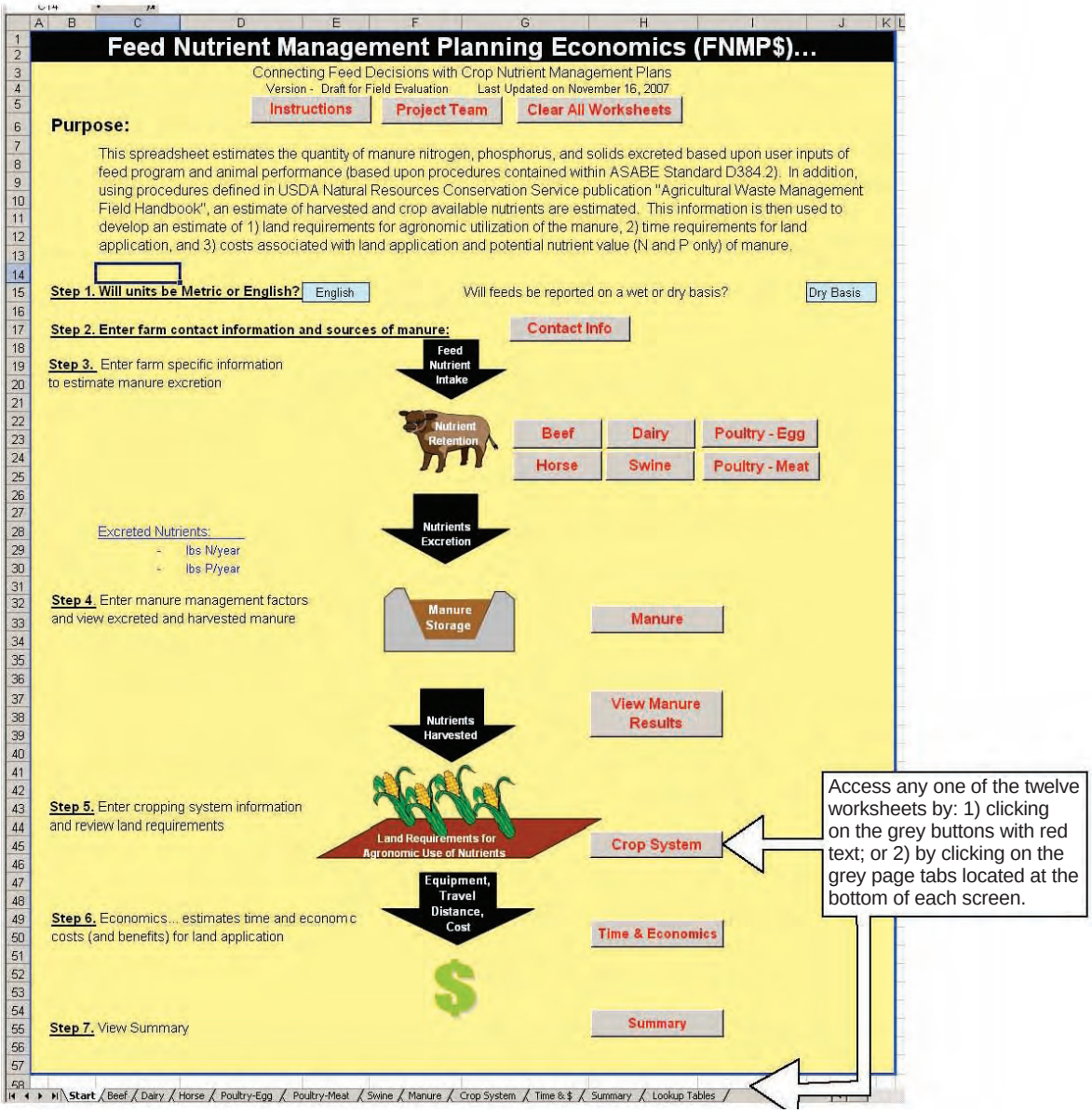

Figure 4. The FNMP$ tool consists of a seven-step process, as outlined on the "Start" page. Grey buttons and page tabs (bottom of screen) assist in navigation among the seven steps.

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The twelve worksheets may be accessed from the "Start" page by clicking on the grey "Start" buttons or by clicking on the appropriate tab located at the bottom of the computer screen *(Figure 4)*.

All farm-specific information is entered in unprotected **light-blue cells**. Clicking on some of them will produce an arrow on the right-hand side of the cell *(Figure 5)*. These cells contain a dropdown list of possible inputs. Scroll through the entire list of entries on the dropdown menus, so as not to miss any of the options (use the vertical sliding bar on the right-hand side of the dropdown menu to do this). In these instances, select an option, but do not type an entry. If an arrow doesn't appear on the right-hand side of the cell, you must input the appropriate data.

Light-blue cells with a red upper-right-hand corner will reveal a popup text box containing instructions for that particular cell. Moving the cursor over these cells exposes the popup text box. Additional uniquely colored cells are explained in Appendix A.

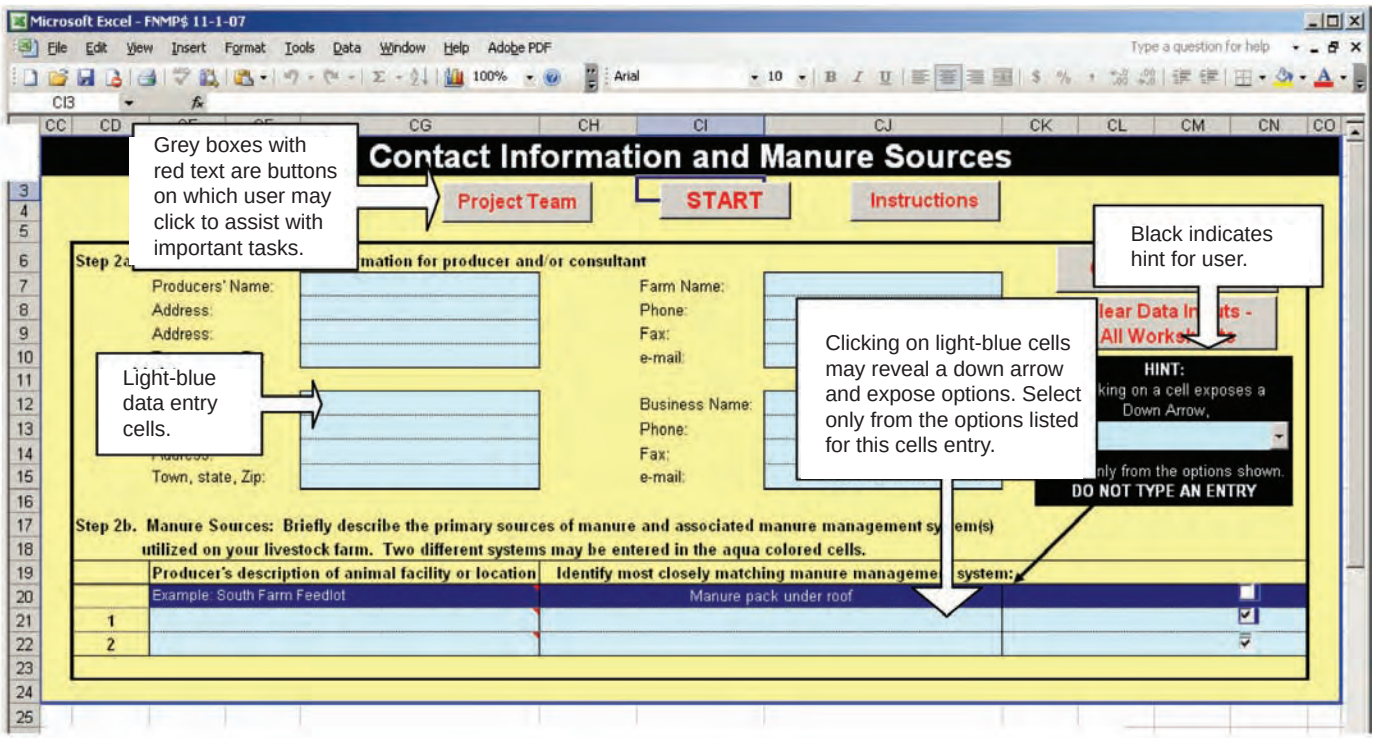

Figure 5. Colors of individual cells or buttons provide an indication of their purpose.

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An Overview of the Seven-step Process

The spreadsheet consists of four unique software modules for completing an analysis of manure nutrient excretion, harvested and crop-available manure nutrients, land requirements and distance traveled, and time and costs associated with land application of manure. The general organization of this software is illustrated below *(Figure 6)*.

The software has been divided into seven user-defined steps *(Table 1)*. Complete each step, as outlined in the spreadsheet. You'll be rewarded with a detailed summary *(Figure 17)* upon completion of *Step 7.**

Steps 1-3
Estimating Excretion

These steps will result in an estimate of manure nitrogen, phosphorus and potassium excretion as well as the mass and volume of manure produced. These estimates are based on animal performance and feed ration. Beef, swine, and poultry work groups used an animal mass balance approach, where excretion is estimated as a difference between intake and retention in body mass or animal products (eggs or meat). Dry matter excretion was based on estimates of feed digestibility, with adjustments based upon research literature for solids in urine.

*Specific user input and resulting outputs are summarized in *Table 1.*

The horse work group used existing data sets, to which equations were fitted, to publish separate equations for exercised and sedentary horses.

The dairy section provides two options for estimating excretion for lactating cows: (1) a Mass Balance Estimate; and (2) equations based upon existing data sets (Regression Equation Estimate). The dairy work group also proposed equations for dry cows and heifers.

Step 4
Manure Management and Nutrient Availability
(Page Tab: Manure)

Step 4 addresses nutrient availability. First, it estimates harvested manure based upon nutrient retention factors for specific animal housing and manure storage systems. Next, it estimates crop-available nutrients based upon application method and type of manure.

Animal housing and manure storage retention factors were gathered from Chapter 11 of the *Agricultural Waste Management Field Handbook* (SCS, 1992). Procedures for estimating ammonia retention during land application were adapted from tabular values located in the same reference.

Manure organic nitrogen availability following land application estimates were based on procedures used in Nebraska for nutrient planning. You can modify nutrient retention estimates to allow for regionally appropriate retention factors.

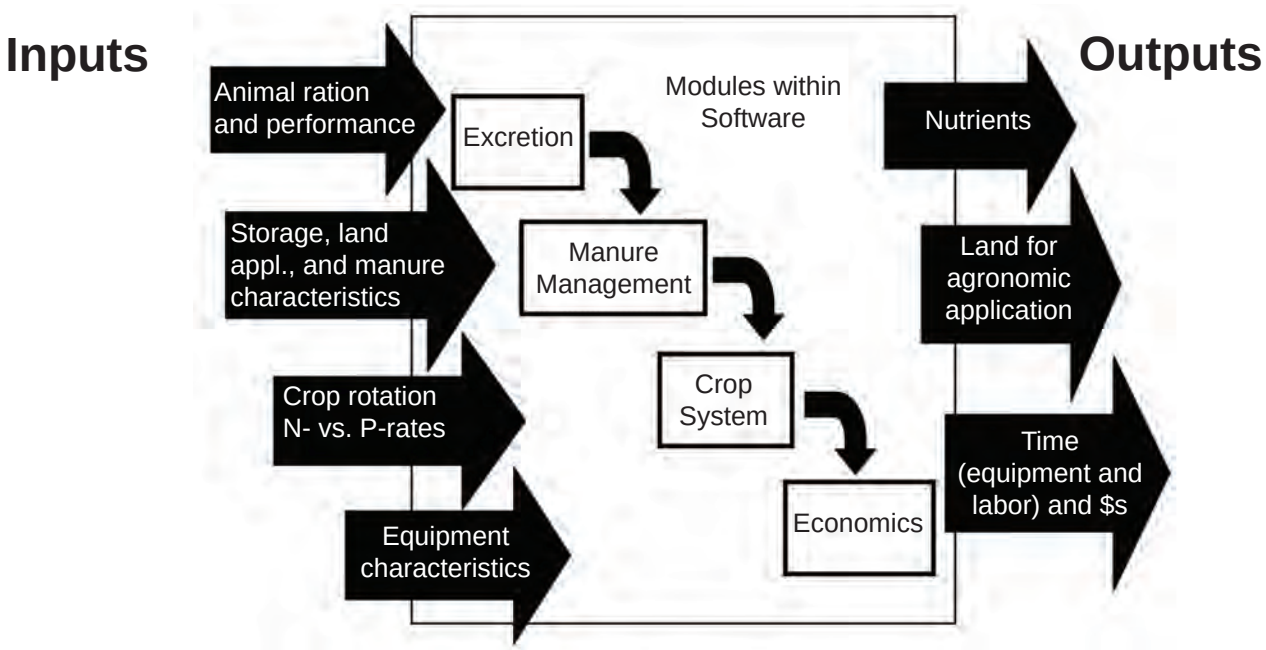

Figure 6. General flow of software information.

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Table 1. Summary of key user inputs and outputs of individual modules within FNMP$.

Module	*Primary User Inputs*	*Module Outputs*
Estimating Excretion (*Steps 1-3*)	• Number and weights of animals • Ration nutrient concentration • Feed intake • Animal performance (e.g. weight gain, days on feed) • Facility housing animals	• Total nitrogen excreted • Total phosphorus excreted • Excreted solids mass and concentration
Nutrient Availability (*Step 4*)	• Manure housing/storage type • Nutrient retention in storage (optional) • Crop availability of nutrients (optional) • Manure moisture and ash concentrations	• Crop available nitrogen • Crop available phosphorus • Harvested manure mass (dry and liquid systems) and volume (liquid systems only)
Land and Distance (*Step 5*)	• Crop rotation, yield, and crops receiving manure • Crop nutrient requirements (optional) and credits from non-manure sources • Basis for application rate • Average field size • Land availability • Value of nutrients	• Manure nutrient concentration • Land application rate • Land requirements • Average and maximum travel distance
Economics (*Step 6*)	• Application and nurse tank/truck equipment • Application equipment operating characteristics • Operating costs (optional)	• Application time for spreading equipment and nurse tank/truck • Total annual costs for manure application • Nutrient value of manure • Net costs of manure application
Summary (*Step 7*)	• Summary of conditions changed in each of the options summarized in *Step 3*.	**For up to 3 options...** • Excreted and crop-available N and P_2O_5 • Land required per year and per 4-year planning horizon • Transportation distances • Application time by activity • Nutrient value estimates • Application cost estimates • Net value estimates

Step 5

Cropping System for Estimating Land and Distance

(Page Tab: Crop System)

An estimate of required land application area is provided in *Step 5.* Manure may be applied at a nitrogen-based rate or a phosphorus-based rate — assuming one, two, or four years of phosphorus can be applied with a single manure application.

Crop-available nutrients estimated in the software are balanced against crop removal rates for nitrogen and phosphorus. Once the land area is determined, an estimated average and total travel distance are determined. The distance estimate assumes fields and roads are organized on a square mile-by-mile grid basis.

You will also need to input estimated values for the land area in crop production and for crop production accessible to the manure from the animal feeding operation.

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Step 6
Economics (Page Tab: Time & $)

Located within *Step 6* is an estimate of:

- equipment and labor time for completing manure application;
- annualized costs (including fixed and variable costs) associated with land application only;
- approximate value of the crop-available nutrients in manure.

Select equipment from a preset list of options. You can change default values — for inputs like speed, swath width and prices — for various inputs.

The machinery and labor time and expense estimates follow the recommendations of the North Central Farm Machinery Task Force. Manure-supplied nutrients are valued at commercial fertilizer prices if needed for crop production (e.g., nitrogen is valued for crops requiring nitrogen fertilizer but is not assigned a value when applied to legume crops) and are modifiable.

While on the *Economics* step, you can save up to three options by pressing the Option 1, 2, or 3 buttons to compare different alternatives in the summary.

Step 7
Summary (Page Tab: Summary)

Once a farm has been simulated by completing *Steps 1-6*, view the summary results. The "Page Tab: Summary" contains the results from any scenarios that were saved in *Step 6.* By comparing these options, you see the impact of management changes to outputs.

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Data Entry Instructions for *Steps 1-3:* Estimating Excretion

Purpose: *Steps 1-3* will result in an estimate of excreted manure nutrients, manure mass and manure volume (slurry or liquid manures only).

Primary User Inputs	*FNMP$ Outputs*
Ration nutrient concentration Feed intake Animal performance (e.g. weight gain, days on feed) Facility housing animals	Excreted nitrogen mass Excreted phosphorus mass Excreted solids mass and concentration

To illustrate how you might use the FNMP$ software tool, the following instructions — written as generically as possible — refer to a beef feedlot example. The program has the ability to track multiple species as it analyzes and prepares an individualized report for an operation.

To begin data entry, start with *Step 1*, located on the "Start" page. Work through each page, from right to left. Complete, in their entirety, the worksheets contained within each of the seven steps.

Step 1 — Will units be in Metric or English? Will feed be reported on a wet or dry basis? (**See** *Figure 6*)

- At this time, the tool is only available using English measurements (e.g., lbs, acres, bushels).
- Answer, "Will feeds be reported on a wet or dry basis?" Click on the light-blue cell to produce an arrow and dropdown menu. This menu allows the user to select wet or dry basis *(Figure 7)*.

Step 2 — Enter Farm Contact Information and Sources of Manure (**See** *Figure 8*)

- Click on the "Contact Info" box on the "Start" page to view.

Step 2a Contact information for the producer and/or consultant.

- Enter contact information into the blue boxes.

Step 2b Identify up to two unique primary manure sources and manure management systems.

- Enter the producer's common name for the animal facility or location.

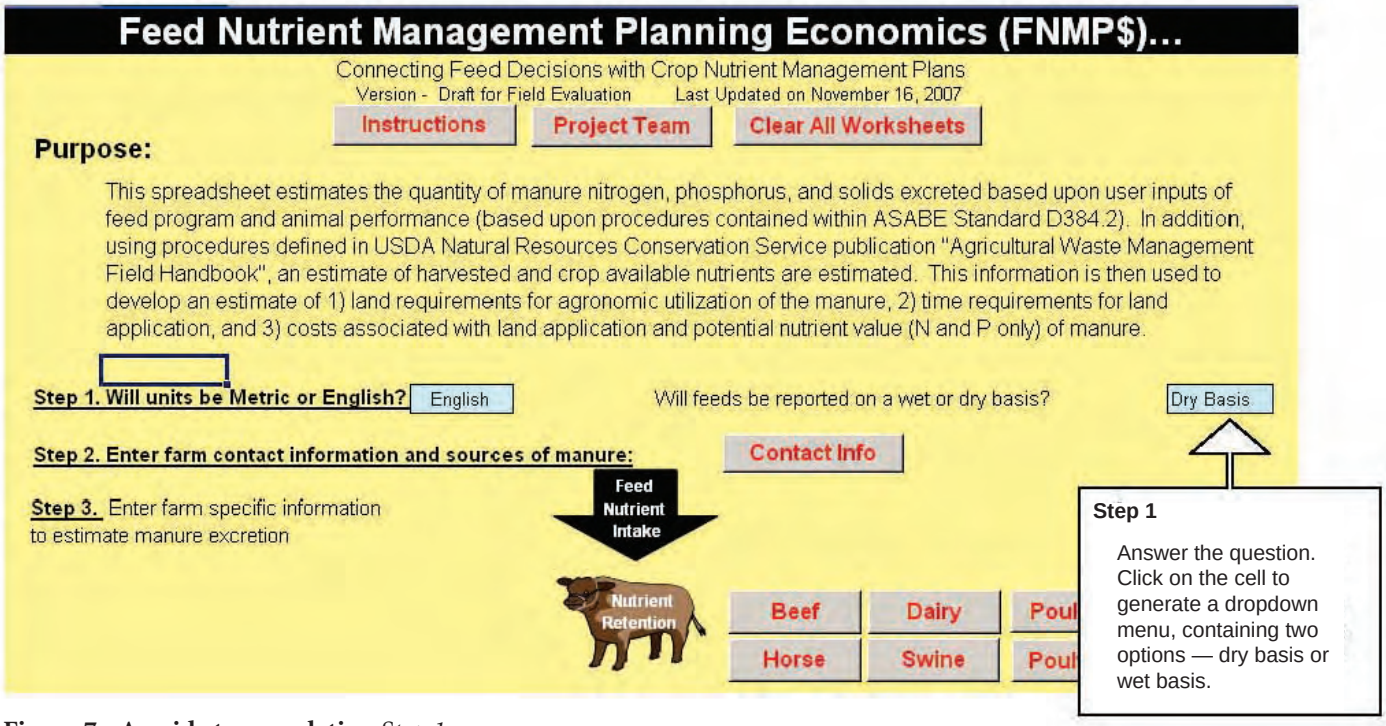

Figure 7. A guide to completing *Step 1.*

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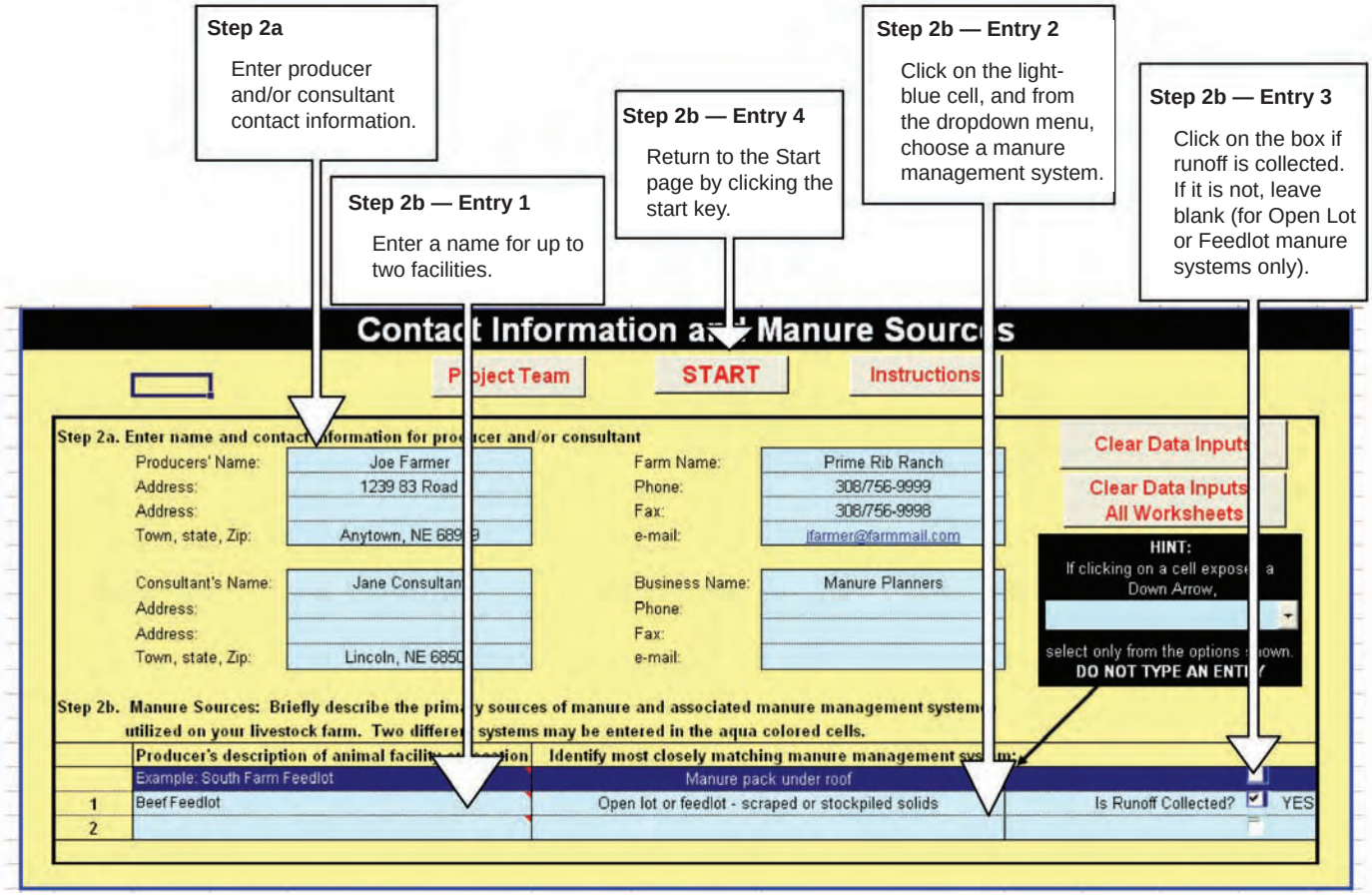

Figure 8. A review of entries for *Step 2.*

- Moving to the next cell to the right, choose — from a dropdown list of options — the type (or closest option) of manure management system used.
- If an "Open lot or feedlot" system is selected in the previous step, identify if the manure runoff is collected. If the preferred answer is "yes," click on the box, which adds a check-mark to the box. If the runoff is not collected, leave the box unmarked.
- A second animal facility can be added following the above three steps.
- Upon completion of *Step 2b*, return to the "Start" page by hitting the "Start" tab, located at the top of the page.

Step 3 — Enter Farm-Specific Information to Estimate Manure Excretion (**See** *Figure 9*)

When nutrients are supplied to animals in excess of that needed for maintenance and production, the excesses are excreted; therefore, an important role of FNMP$ is to estimate the amount of excretion. Equations used in this spreadsheet are based on *ASAE Standard D384.2, Manure Production and Characteristics*.

A unique data entry form has been developed for each species — Beef, Dairy, Poultry-Egg, Horse, Swine, or Poultry-Meat. Each species-specific worksheet has a slightly different layout and requires species-related data. Additionally, each species-specific worksheet has the ability to record and account for multiple groups of animals. Each page also allows for more than one diet to be fed to each group of animals.

From the "Start" page, select the appropriate species for the first primary manure source listed in *Step 2b*. If the operation consists of a second source, as listed in *Step 2b*, repeat *Step 3* for the second species.

Make sure the worksheet is free of any previous data before entering values. This can be achieved by pressing "Clear Data Inputs." Striking the "Clear Data Inputs" tab will remove inputted data for a particular page. Once chosen, the task cannot be undone. All data on that particular page will be permanently removed.

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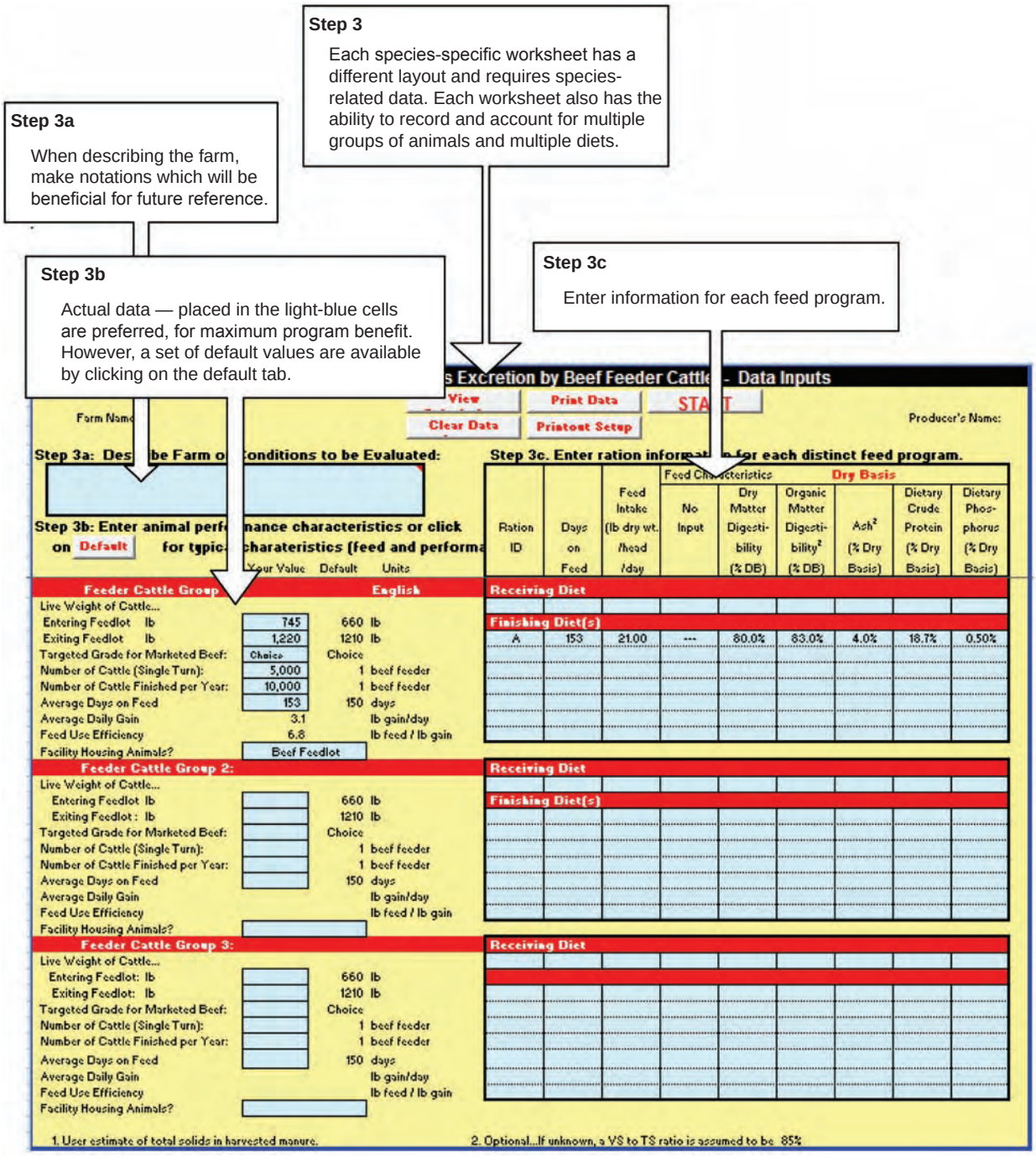

Figure 9. A review of the components of *Step 3.*

Step 3a Describe farm conditions to be evaluated.

- Include any comments relative to the farm, herd, etc., beneficial for future reference.

Step 3b Enter animal performance characteristics.

- If possible, use actual numbers to gain the maximum value from this software tool. However, a list of default values, considered to be typical feed and performance values, is available by choosing "Default." Use all the default values provided by the program or use some of the values and override others by entering a new value in one or more of the light-blue cells.
- For the beef, poultry, and horse sections, a maximum of three different scenarios/groups may be recorded.
- The swine section contains the following categories: nursery phase, grow/finish phase, replacement gilts, gestating sows, and lactating sows.

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- The dairy section allows for inputs related to lactating cows, dry cows, and replacement animals.

Step 3c Enter ration information for each distinct feed program.

- Housed within this table are input lines for the operation's feeding regiment. Multiple lines exist, allowing for the inclusion of the various diets fed to this group of animals. The FNMP$ tool provides a means of quantifying the manure management costs associated with these ration options.

Upon completion of *Step 3c*, return to the "Start" page by hitting the "Start" tab, located at the top of the page. Other options also available at this point include the ability to "View Calculations;" "Clear Data Inputs;" "Print Data Inputs;" or "Printout Setup."

With the completion of *Step 3*, you'll begin to see a summarization of your individual inputs for each primary manure source begin to appear as blue text on the "Start" page *(Figure 10)*.

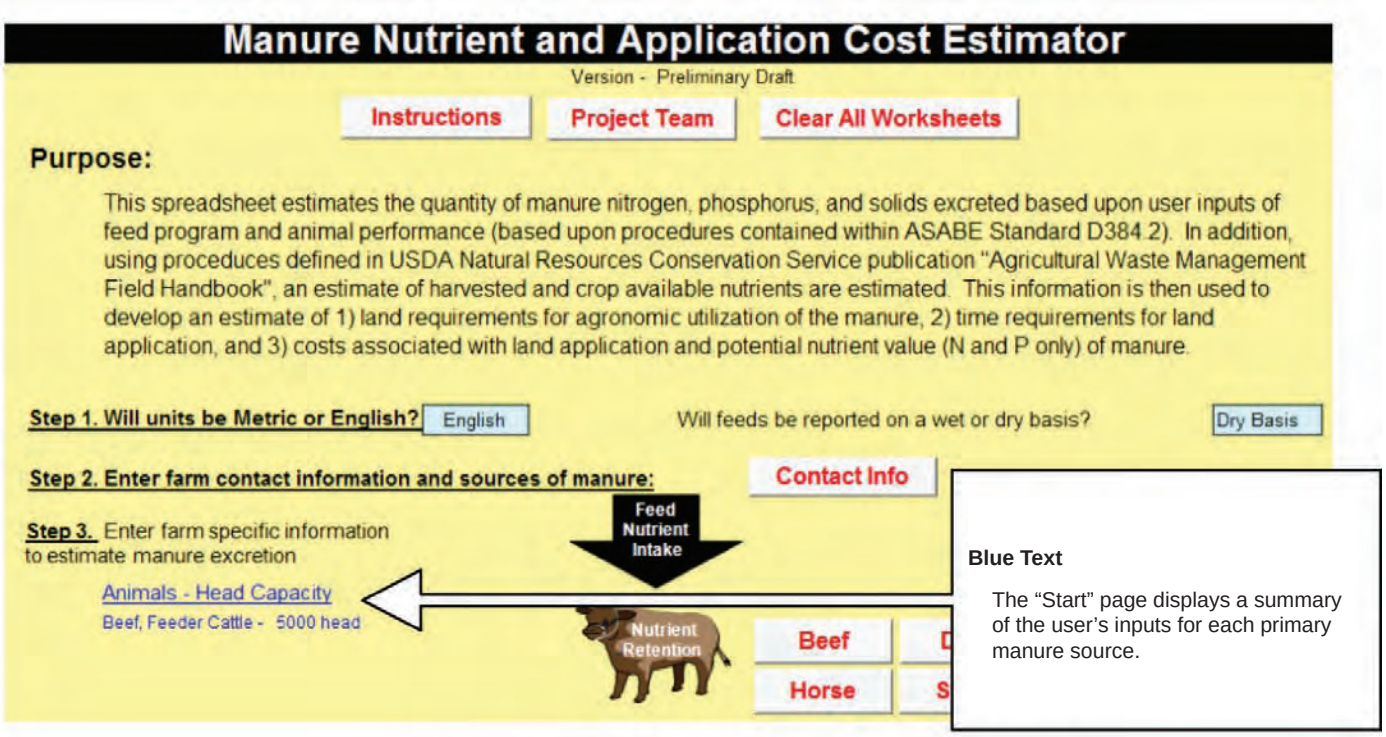

Figure 10. A summary of the user's input data for each primary manure source listed in *Step 3*.

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Data Entry Instructions for *Step 4*
Nutrient Availability

Purpose: Excreted manure mass and nutrients change as a result of management practices. This section will allow an estimate of harvested and crop-available nitrogen, phosphorus and potassium. It will also convert excreted manure mass and volume amounts into harvested manure mass and volume amounts.

Primary User Inputs	*FNMP$ Outputs*
Manure housing/storage type Nutrient retention in storage (optional) Crop availability (optional) Land application characteristics Manure moisture and ash concentrations (from representative manure sample)	Crop-available nitrogen Crop-available phosphorus Harvested manure mass and volume (for liquid systems only)

Step 4 — Enter Manure Management Factors and View Excreted and Harvested Manure (**See** *Figure 11*)

- From the "Start" page, click on the "Manure" tab.

Notice that previous inputs have transferred to this worksheet. Additionally, using a set of program defaults based on previous user inputs, the software has made calculations and placed the resulting values throughout each of the three tables.

Based on the producer's manure management system, as entered in *Step 2*, the tool automatically generated a default value for entries related to available nitrogen, available phosphorus, and percent ash, located within the *Step 4* worksheets. These defaults are located in a yellow cell and have a light-blue cell directly below.

You may override the yellow-celled default values and input a new value by making an entry in the light-blue cell. Any changes to the default values will cue the program to recalculate and provide updated values.

Instruction Tab: Throughout *Step 4*, the instructions tab (a yellow cell with red text) offers additional step-by-step information for accurately completing the "Describe Manure Management Factors" worksheets.

Step 4 requires you to reference a representative manure sample, or provide information on typical ash and moisture content in harvested manure.

Step 4a Nitrogen to be managed annually after losses from housing, storage and land application.

- For each source identified in *Step 2*, the program has entered a value for excreted nitrogen. Available nitrogen, after storage and housing loses, has been calculated based on the program default.
- Retain the program-inserted default, or enter a customized value in the light-blue box (located directly below the yellow-celled default). The tool calculates the amount of nitrogen retained.
- Next, choose the appropriate application method. If the nutrients are surface-broadcast, enter values for days between application and incorporation and soil conditions at the time of incorporation. For all other application methods, these values are null and void, and therefore become blackened cells which don't require an entry.
- Assigned values are placed in the column entitled, "Nitrogen Availability to Crops." These values may be overwritten by inserting customized numbers in the light-blue cells, directly below the yellow-celled defaults.
- Total "Crop Available N" values are listed on the last column of the table.

At this point, you can choose to "Clear Data Inputs;" "Print Setup;" "Print;" "Start;" or "View Manure Results." Most likely, you will simply proceed to *Step 4b*.

Step 4b Phosphorus and potassium to be managed annually after losses from housing, storage and land application.

- For each source identified in *Step 2*, the program has entered a value for excreted phosphorus. Available phosphorus, after storage and housing losses, has been calculated based on the program default.
- The user may retain the predetermined default or enter a customized value in the light-blue box, located directly below the yellow-celled default. The tool calculates the amount of phosphorus retained.
- Available phosphorus after land application losses and crop availability is considered and calculated based on the program default.

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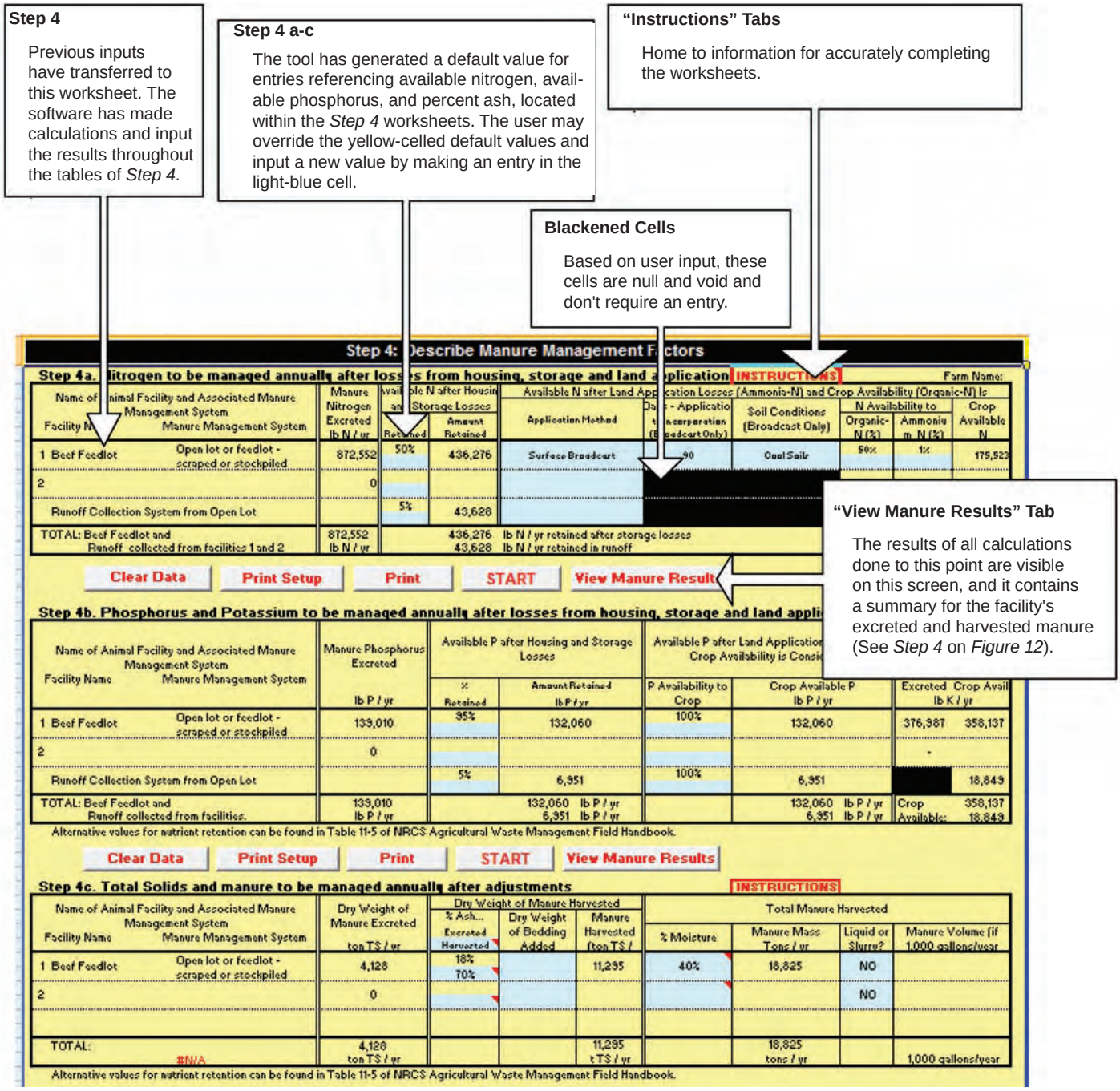

Figure 11. A review of the procedures involved with *Step 4.*

- You may retain the inserted percent default or enter a customized value in the light-blue box, located directly below the yellow-celled default. The tool calculates the amount of crop-available phosphorus and the amount of excreted and crop-available potassium.

  Crop-available values are listed in column K for phosphorus and column N for potassium.

  At this point, you can choose to "Clear Data Inputs;" "Print Setup;" "Print;" "Start;" or "View Manure Results." Most likely, you will proceed to *Step 4c*.

Step 4c Total solids and manure to be managed annually after adjustments.

- For each source identified in *Step 2*, the program calculates a value for the dry weight of the manure excreted.

- The next item to evaluate is percent ash. You may elect to keep the default value, or obtain the actual value from a representative manure

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sample (recommended). Ash would increase if sand or soil is mixed with the manure.

- In tons per year, enter the dry weight of added bedding, which is the final number needed for the program to calculate the dry weight harvested per year.
- To determine the total amount of manure harvested, enter a value for percent moisture, as found on a representative manure sample (recommended).
- Identify if it is in liquid or slurry form by making a selection from the light-blue cell.
- Under the "Liquid or Slurry?" heading, answer "yes" or "no." If manure is in a liquid or slurry form, a total volume can be calculated. It is not practical to calculate a volume for solid manures.

CAUTION: The procedure used for calculating manure mass and volume is reasonable only for those manure management systems that conserve manure solids. This method is not accurate for treatment systems such as anaerobic lagoons, anaerobic digesters or compost systems.

Manure mass and volume may be altered by water addition or evaporation, depending upon estimated total solids entered. No reduction in solids due to treatment processes or increases due to feed or bedding additions is assumed. Volumes are estimated for slurry or liquid manure only.

- On the "Manure" page and the "Start" page (under *Step 4*) is a "View Manure Results" tab. By clicking on this tab, the results of all calculations done to this point are visible. This section contains the facility summary for excreted and harvested manure *(Figure 12)*. For each primary manure source identified in *Step 2*, it identifies the amount of nitrogen, phosphorus, potassium, total solids, volatile solids, and manure mass in total pounds per year. The manure volume is also included for liquid or slurry manures and measured in 1,000-gallon outputs per year. An individual animal group breakdown is also displayed.
- At this point, choose "Print;" "Start;" or "View Manure Inputs." To continue to *Step 5*, choose "Start."

Step 4. Manure Nutrient and Solids Excretion and Harvested - Results of Calculations

Conditions Evaluated:

Farm Name:

Producer Name:
June 18, 2007

Facility Summary for Excreted Manure

	Nitrogen	Phos-phorus	Potassium	Total Solids	Volatile Solids	Manure Mass[1]	Manure Volume[1,2]
	lbs/year						(1,000 gal/yr)
Beef Feedlot							
	872,552	139,010	376,987	8,256,928	6,776,906	103,211,601	12,435
	-	-	-	-	-	-	-
TOTALS							
	872,552	139,010		8,256,928	6,776,906	103,211,601	12,435

Facility Summary for Harvested Manure

	Nitrogen	Phos-phorus	Potassium	Total Solids	Volatile Solids	Manure Mass[1]	Manure Volume[1,2]
	lbs/year						(1,000 gal/yr)
Beef Feedlot							
	175,523	132,060	358,137	11,295	6,776,906	37,649,475	
					-	#VALUE!	
Runoff Collection System from Open Lot							
		6,951	18,849				
TOTALS					-	0	
	175,523	139,010		11,295	6,776,906	#VALUE!	-

Individual Animal Group Summary for Excreted Manure

Species	Number of Animals	No. of Finished Animals	Nitrogen	Phos-phorus	Potassium	Total Solids	Volatile Solids	Manure Mass[1]	Manure Volume[1,2]
			lbs/year						
Feeder Cattle	5,000	10,000	872,552	139,010	376,987	8,256,928	6,776,906	103,211,601	

1. Manure mass and volume may include water addition or evaporation depending upon estimated total solids entered. No reduction in solids due to treatment processes or increases due to feed or bedding additions is assumed.
2. Volumes are estimated for slurry or liquid manure only.

Print | START | View Manure Inputs

Figure 12. This section for *Step 4* contains the facility summary for excreted and harvested manure for each primary nutrient source identified in *Step 2*.

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Data Entry Instructions for *Step 5*
Land and Distance

Purpose: Management and regulatory decisions can have significant impact on the land necessary for managing manure nutrients. These decisions and other issues will also influence the hauling distance for manure.

Primary User Inputs	*FNMP$ Outputs*
Crop rotation, yield, and crops receiving manure Crop nutrient requirements (optional) and credits from non-manure sources Basis for application rate Average field size Land availability Value of nutrients	Manure nutrient concentration Application rate Land requirements for agronomic application rates Average and maximum travel distance

Step 5 — Enter Cropping System Information and Review Land Requirements (**See** *Figures 13* **and** *14*)

To determine the land requirements for the agronomic use of nutrients, proceed to *Step 5* by clicking on the "Crop System" tab, located on the "Start" page.

Step 5a. Enter information about the most common crop rotation in the region around the animal feeding operation.

- Identify the crops, in rotation, that receive manure. If a four-year rotation is not common, select crops and distribute among the four years in a ratio roughly equal to actual practice. For example, if a common rotation is three years of alfalfa and two years of corn, one might enter a rotation of two years of alfalfa and two years of corn as a close approximation. Note: All four years on the worksheet must have data entered by the user.

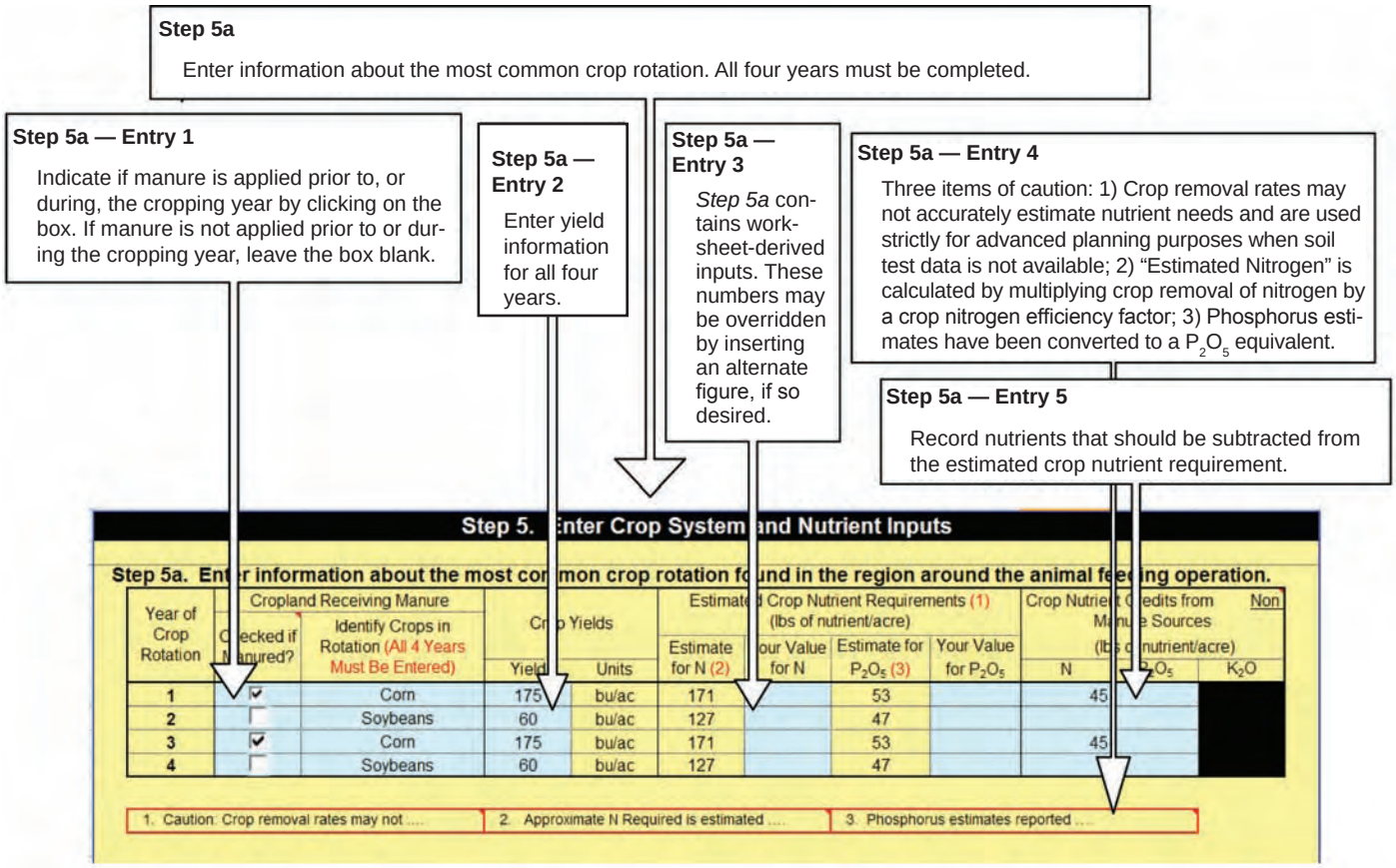

Figure 13. ***Step 5a*** **requires input about the crop rotation. There are also three items of caution to note.**

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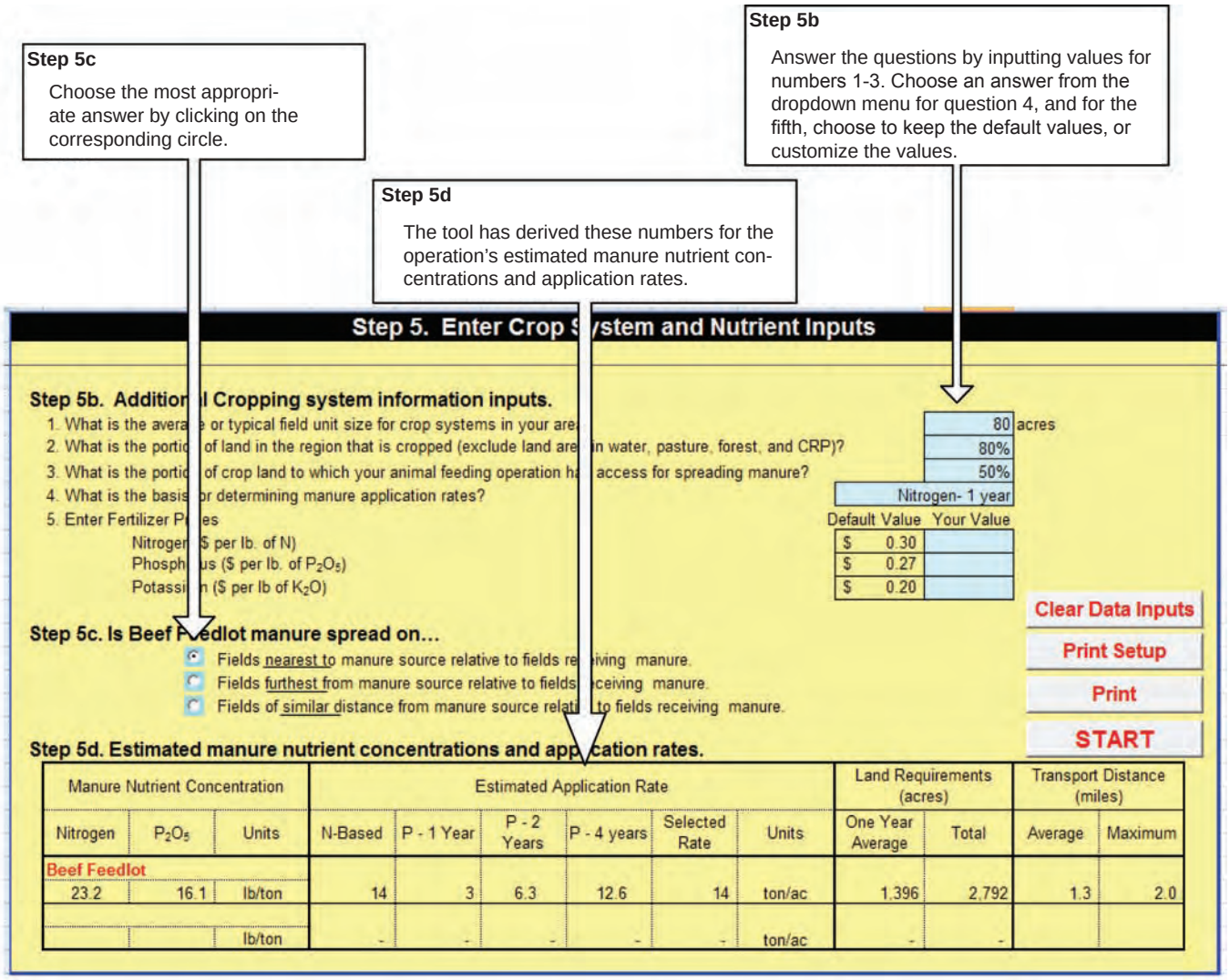

Figure 14. This figure summarizes the final components of *Step 5*, preparing the user to begin *Step 6*.

- If manure is applied prior to — or during — the cropping year, indicate this by clicking on the box located in the second column. If manure is not applied prior to or during the cropping year, leave the box blank.
- Next, enter the yield information (bushels, tons, or cwt per acre depending upon crop), for all four years as a "wet" or "as is" yield.
- Then review and alter as needed — the "Estimated Crop Nutrient Requirements" component of the table, in a measurement of pounds of nutrient per acre. The table contains worksheet-derived inputs for nitrogen and phosphorus. Override these numbers by placing an alternate figure in the light-blue boxes, or leave the spreadsheet assumptions in place as is.

The authors note three items of caution as you complete this section of the table:

Caution 1) Crop removal rates may not accurately estimate nutrient needs and are used strictly for advanced planning purposes when soil test data is not available.

Estimate individual year manure and fertilizer application rates based on a comprehensive nutrient budget that includes soil testing and crediting for residual soil nutrients and nitrogen from legumes and irrigation water (not the purpose of this tool).

Refer to the state land-grant university, the USDA Natural Resource Conservation Service, or environmental regulatory agency resources for assistance in developing a nutrient budget.

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Caution 2) "Estimated Nitrogen" is calculated by multiplying crop removal of nitrogen by a crop nitrogen efficiency factor.

Crop nitrogen efficiency is assumed to be 1.3 for corn, small grains, and forages; 2.0 for warm-season grasses; 1.0 for cool-season grasses; 0.6 for soybeans; and 0.5 for other legumes. It is assumed that soybeans will remove two lbs of nitrogen (60 percent of the crop's nitrogen content) per bushel and all other legumes will remove 50 percent of the crop's nitrogen content from residual soil nitrogen. The programmers assumed that legume nodulation does not completely shut down following manure application, thus the 60 percent and 50 percent factors for soybeans and other legumes.

Caution 3) Those phosphorus estimates reported in *Step 4* as elemental P have been converted to a P_2O_5 equivalent (elemental P X 2.29) in *Step 5*.

The final component of *Step 5a* asks for information to determine the nitrogen and phosphorus (and when applicable, potassium) crop nutrient credits from non-manure sources. Factors of consideration include starter or supplemental fertilizer, legume credits, irrigation water credits or other sources of nutrients that should be subtracted from the estimated crop nutrient requirement.

Step 5b. Additional Cropping system information inputs. Answer five questions:

- What is the average or typical field unit size for crop systems in your area, in acres?
- What percent of land in the region is cropped, excluding land area in water, pasture, forest, and CRP?
- What portion of the cropland does the animal feeding operation have access to for spreading manure?
- What is the basis for determining manure application rates? For this question, choose either 1) nitrogen-1 year, or 2) phosphorus-1, 2, or 4 years, from the dropdown menu on the right-hand side of the cell.
- In dollars per lb, what is the price for: (1) nitrogen, (2) phosphorus and (3) potassium? Use the default answers or you may override the values by inputting a number in the light-blue cells.

Step 5c. Additional manure spread questions:

- If manure is originating from two sources (two facilities identified in *Step 2.* "Contact Information and Manure Sources"), the software allows placing manure from one facility closer to or farther from the first source than manure from the second source. Choose the most appropriate answer for your situation to complete the sentence.

  Is *first manure source* manure spread on:

  "Fields **nearest to** manure source, relative to fields receiving *second source* manure."

  "Fields **furthest from** manure source, relative to fields receiving *second source* manure."

  "Fields of **similar distance** from manure source, relative to fields receiving *second source* manure."

Step 5d. Estimated manure nutrient concentrations and application rates.

- Based on the input from *Steps 5a-5c*, the program has calculated and summarized in tabular format, the manure's nitrogen and phosphorus nutrient concentration, in lbs per ton (or 1,000 gallons, or acre-inch — depending upon previous entries). This value is similar to the results from a manure analysis (and might be compared with a representative manure analysis report), as estimated by the software.
- An estimated application rate has also been determined in tons per acre (or 1,000 gallons, or acre-inch).
- The one-year average, and total acres necessary for the four-year rotation, can be found in the next column, entitled, "Land Requirements."
- The final component of the summary estimates the average and maximum travel distance necessary to land-apply the nutrients.

Upon review of *Step 5d*, choose "Clear Data Inputs," "Print Setup," or "Print." Selecting "Start" will send you to the "Start" page and allow you to input data in *Step 6*.

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Data Entry Instructions for *Step 6*
Economics

Purpose: Once you've noted the quantity of manure to be transported and the distance, you can estimate the time and cost of land application. The software currently provides a database of economic considerations for land, applying manure by solid or slurry spreaders, towed hose or big gun methods. In addition, an estimate of the nutrient value of the manure is included in these steps.

This summary generated in *Step 6* will provide comparison information for up to three scenarios. These three scenarios can be used to compare user-defined variations in animal diet, manure systems, cropping system, and/or application equipment.

Primary User Inputs	*FNMP$ Outputs*
Application equipment Application equipment operating characteristics Operating costs (optional)	Application time Total annual costs for manure application Nutrient value of manure Net costs of manure application

Step 6a. Select Method of Land Application of Manure *(Figure 15)*.

- From the Start page, select the "Time & Economics" button or the "Time & $" worksheet tab to review the application options available.
- Data from previous entries have been forwarded to *Step 6a*, thus providing a summary of the operation's manure source, manure management system, and application method. Review for accuracy.
- Select "Spreader or Tanker Application," "Towed Hose Application," or "Big Gun Application".

Step 6b. Estimate of land, time, and economics.

Although the required entries vary with the three application methods, the basic format of *Step 6* is based on two tables, which appear in *Step 6b*. The left-hand table, "User Inputs," requires data entry, while the right-hand

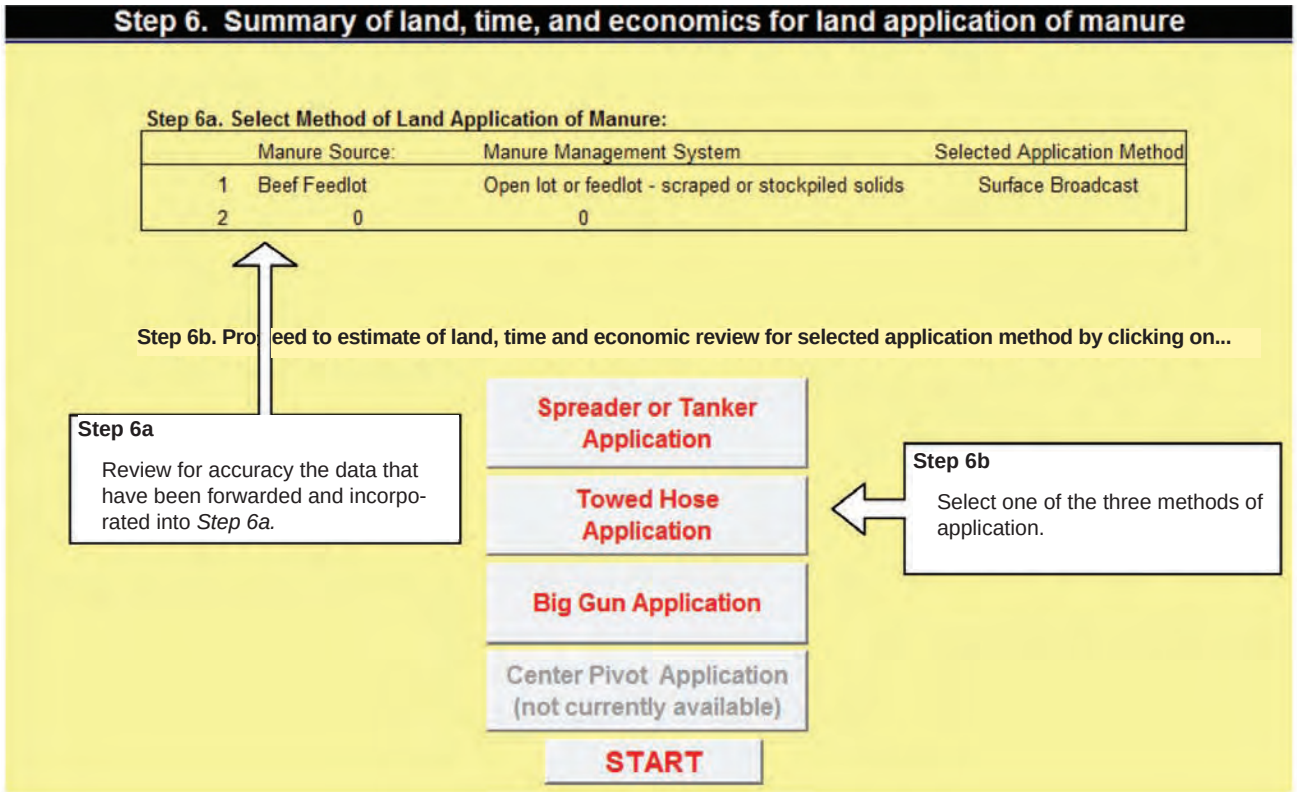

Figure 15. This preview provides a glimpse of the first screen associated with *Step 6*.

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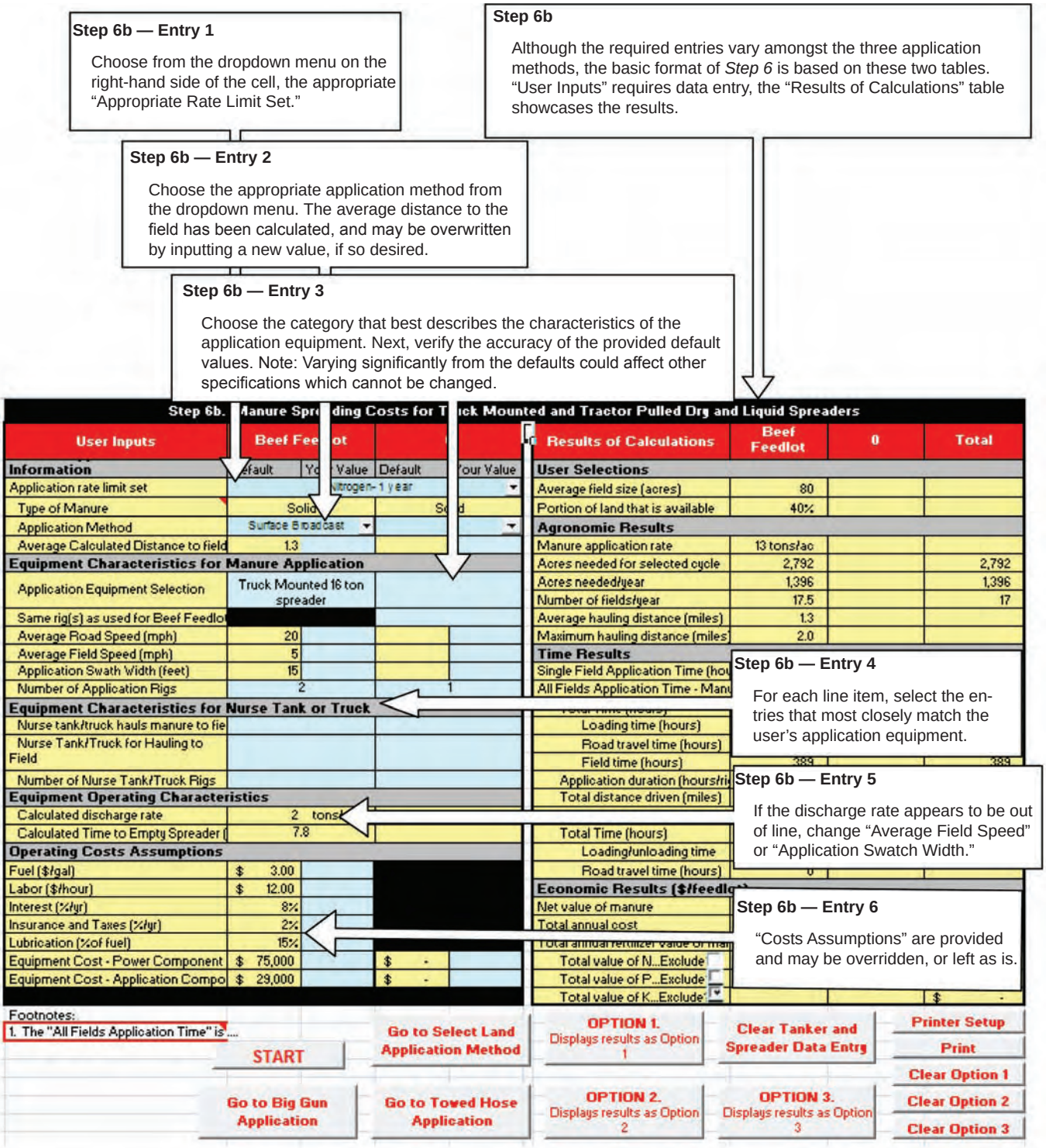

Figure 15. This preview provides a glimpse of the key inputs associated with *Step 6.* User inputs are found in the left-hand portion of this table.

table, "Results of Calculations," showcases the results after the program has completed the appropriate calculations.

First, data entries consistent with the type of application equipment or practice are made in the left-hand table entitled, "User Inputs" *(Figure 16)*.

- Located under the "Manure Application Information" heading, first choose from the dropdown menu on the right-hand side of the cell, the "Application Rate Limit Set." The choices include: nitrogen 1 year or phosphorus 1, 2, or 4 years. This entry revises an earlier entry of the same information and provides a convenient means of reviewing different "What if?" scenarios.

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- Choose the appropriate application method from the dropdown menu. Depending on the application method chosen, available options include: injection, immediate incorporation, surface broadcast, dragline with injection toolbar, dragline with AerWay® toolbar, dragline with surface application or big-gun irrigation. This entry also revises an earlier entry of the same information and provides a convenient means of reviewing different "What if?" scenarios.

- The average distance to the field has been calculated, and, if so desired, may be overwritten by inputting a new value in the light-blue cell.

- The next category describes the characteristics of the application equipment. First, select the entry most closely matching your application equipment. Several options are incorporated into the dropdown menu. Note: All entries are not visible unless you scroll through the list of options located in the dropdown menu.

- The next line items relate to swath or spread width, number of passes, length of dragline, supply method, setup time, application rate, and the number of rigs, or guns, used. If the lists of default values appear to be realistic, rely on the default figures. However, you may also enter customized data, if so desired. Note: Varying significantly from the defaults could affect other specifications, which cannot be changed.

- Number of Rigs. **Instructions:** The total application time listed in the "Results of Calculations" section includes the hours necessary for distributing all manure. For large jobs, multiple application units are often necessary. Check the "Application Duration (hours/rig)" in the right-hand table ("Results of Calculations") to determine if a producer's available window for manure application will accommodate the calculated hours per rig. Enter the number of rigs necessary to model realistic application duration.

- Setup Time per Subfield (for dragline and big-gun application methods only). **Instructions:** A subfield is a field, or portion of a field, that is covered by a single dragline pull. For example, a 1,320-foot drag hose could cover approximately 40 acres in a single setup. Therefore, a 160-acre field would have four subfields. The operator would have to reorganize the drag hose four times to spread manure on the whole field.

- Equipment characteristics for either a nurse tank or truck or traveling gun (only if a nurse tank on truck is used).

- Under the "Equipment Operating Characteristics" section, the program displays a calculated discharge rate. A "Calculated Discharge Warning" may appear, suggesting the entries for speeds and/or swath widths are unrealistic. If the discharge rate appears to be out of line for the user's equipment, change either the entry for speeds or swath widths.

- "Cost Assumptions" defaults for fuel, labor, interest, insurance and taxes, lubrication and equipment costs are provided by the program. These values may be overridden, or left as is.

Results of Calculations. Some notable results from this analysis include *(Figure 17)*:

1. Average field size, in acres, and the percent of land which is available for nutrient application.

2. Application rate, acres needed and hauling distance.

3. Time results, which clearly outline the amount of time (loading, hauling, field, and application time) necessary, are presented next. Also categorized in this area of the worksheet is the anticipated number of miles to be traveled in order to complete the application task.

4. Economic results. The net value of the manure and total annual cost is represented as the final component of *Step 6.* The total annual fertilizer value of the manure has now been calculated and is visible. Nitrogen, phosphorus, or potassium may be excluded in the calculations, if so desired.

Comparisons

A valuable component of this program is found within *Step 6.* The user may compare alternative scenarios to reflect a variety of diets, equipment resources, or other previous inputs. This may be accomplished by setting up one comparison and choosing "Option 1, 2, or 3". User inputs and results are saved in a comparison table discussed in greater detail in *Step 7* (the Summary). Three alternative scenarios can be saved to the Summary table using the "Option 1, 2, or 3" buttons. **Take notes on the conditions that were varied for options 1, 2, and 3. In *Step 7* you will be given the opportunity to record those differences for future reference.**

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Step 6b

Now is the opportunity to review the results for this section. The user's inputs are listed first. Agronomic results and the time results are presented next. Also outlined is the calculated number of miles to be traveled.

Step 6b

The total annual fertilizer value of the manure has been calculated.

Step 6b. Manure Spreading Costs for Truck Mounted and Tractor Pulled Dry and Liquid Spreaders

User Inputs	Beef Feedlot		0	
Information	Default	Your Value	Default	Your Value
Application rate limit set	Nitrogen- 1 year			
Type of Manure	Solid		Solid	
Application Method	Surface Broadcast			
Average Calculated Distance to field	1.3			
Equipment Characteristics for Manure Application				
Application Equipment Selection	Truck Mounted 16 ton spreader			
Same rig(s) as used for Beef Feedlot				
Average Road Speed (mph)	20			
Average Field Speed (mph)	5			
Application Swath Width (feet)	15			
Number of Application Rigs	2		1	
Equipment Characteristics for Nurse Tank or Truck				
Nurse tank/truck hauls manure to fie				
Nurse Tank/Truck for Hauling to Field				
Number of Nurse Tank/Truck Rigs				
Equipment Operating Characteristics				
Calculated discharge rate	2 tons/min			
Calculated Time to Empty Spreader (	7.8			
Operating Costs Assumptions				
Fuel ($/gal)	$ 3.00			
Labor ($/hour)	$ 12.00			
Interest (%/yr)	8%			
Insurance and T				
Lubrication (%c				
Equipment Cos				
Equipment Cos			-	

Results of Calculations	Beef Feedlot			Total
User Selections				
Average field size (acres)	80			
Portion of land that is available	40%			
Agronomic Results				
Manure application rate	13 tons/ac			
Acres needed for selected cycle	2,792			2,792
Acres needed/year	1,396			1,396
Number of fields/year	17.5			17
Average hauling distance (miles)	1.3			
Maximum hauling distance (miles)	2.0			
Time Results				
Single Field Application Time (hou	37			
All Fields Application Time - Manure Application Equipment				
Total Time (hours)	487			487
Loading time (hours)	98			
Road travel time (hours)	0			0
Field time (hours)	389			389
Application duration (hours/ri	244			
Total distance driven (miles)	4,999			4,999
All Fields Application Time - Nurse Tank/Truck				
Total Time (hours)	0			0
Loading/unloading time	0			
Road travel time (hours)	0			
Economic Results ($/feedlot)				
Net value of manure	$ 93,035			$ 93,035
Total annual cost	$ 41,275			$ 41,275
Total annual fertilizer value of mar	$ 134,310			$ 134,310
Total value of N...Exclude	$ 52,657			$ 52,657
Total value of P...Exclude	$ 81,653			$ 81,653
Total value of K...Exclude				$ -

Step 6b

Click on the box to exclude calculation of the value of N, P, or K.

Footnotes:
1. The "All Fields Application Time" is ....

START | Go to Select Land Application Method | OPTION 1. Displays results as Option 1 | Clear Tanker and Spreader Data Entry | Printer Setup | Print | Clear Option 1 | Clear Option 2 | Clear Option 3

Go to Big Gun Application | Go to Towed Hose Application | OPTION 2. Displays results as Option 2 | OPTION 3. Displays results as Option 3

Step 6b

As the scenarios are analyzed, the inputs can be changed to reflect varying diets and/or other inputs. The user changes inputs to be compared and then can conduct a side-by-side comparison of up to three options by choosing "Options 1, 2, or 3." Results are displayed in the Summary Table *(Step 7)*.

Figure 17. The right-hand table, "Results of Calculations," displays the results. Additionally, you can compare up to three scenarios, based on your input variations in animal diet and/or application equipment.

- Enter the appropriate inputs into any of *Steps 1* through *6*.
- Check the resulting calculations in *Step 6b*, Results of Calculations. Are these results what you had anticipated?
- Click on Option 1, 2 or 3 to save results to Summary Table *(Step 7)*.
- Repeat this process for alternative inputs.

Upon completion of *Step 6*, return to the "Start" page by hitting the "Start" tab, and complete the final step of the program, *Step 7*.

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Date Entry Instructions for *Step 7* Summary

Purpose: The Summary Table is designed to reassemble key inputs and results from *Steps 1* through *6* and allow a comparison for three options. The table in *Step 7 (Figure 18)* provides the opportunity to directly compare nutrient excretion, the nutrients remaining after losses, and the land requirements for agronomic application of the nutrients, time requirements for labor and equipment to implement a nutrient plan, and costs and potential financial benefits associated with manure application.

Step 7

- To assist with the comparison, make key notations about the characteristics of the scenario being analyzed.
- Click on the "Print Summary" button to provide a written record of the results of your comparisons.
- If you have not done so previously, save your results.

Conclusion

You may now integrate the consequences of feed management decisions into the CNMP process. The impact of dietary changes can be quantified in terms of change to land needs, labor and equipment operating time, and land application costs with the use of the FNMP$ software tool.

This tool allows you to make more informed decisions related to diet change, their impacts on nutrient excretion, and helps you understand the benefits of feed technologies designed to reduce excretion. Research has demonstrated significant differences in excreted and harvested manure nutrients and solids when comparing diets, and CNMPs will need to consider diet formulation effects on manure composition and mass. Additionally, these comparisons can be combined with ration costs to determine a true "least cost ration," that includes both land application and feed costs.

Upon completing all seven steps associated with the FNMP$ tool, a producer has the unique ability to make a connection between animal feeding programs and land requirements for excreted nutrients, labor and equipment time for managing manure, and the economic costs and benefits associated with land application.

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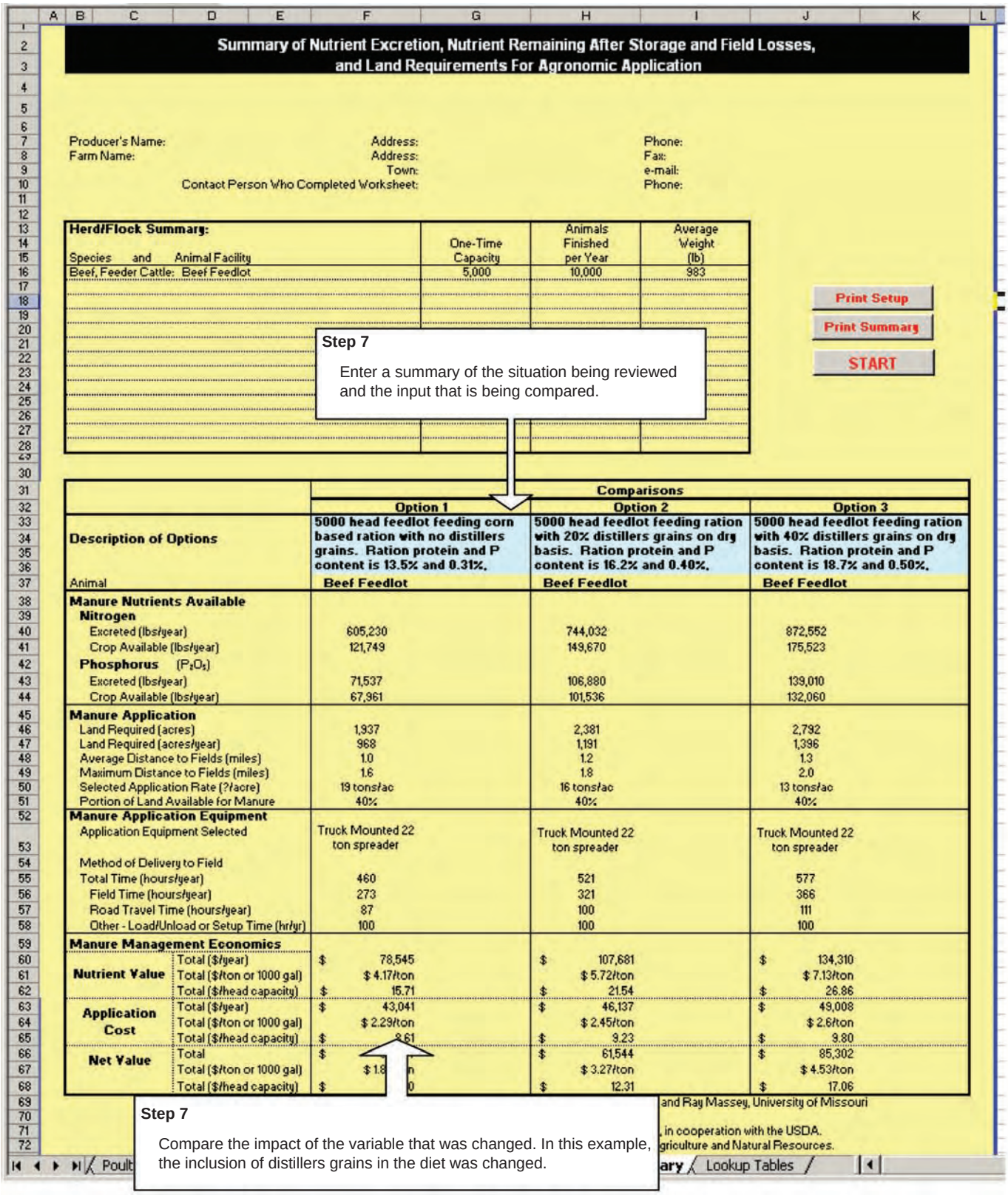

Summary of Nutrient Excretion, Nutrient Remaining After Storage and Field Losses, and Land Requirements For Agronomic Application

Producer's Name: Address: Phone:
Farm Name: Address: Fax:
Town: e-mail:
Contact Person Who Completed Worksheet: Phone:

Herd/Flock Summary: Species and Animal Facility	One-Time Capacity	Animals Finished per Year	Average Weight (lb)
Beef, Feeder Cattle: Beef Feedlot	5,000	10,000	983

Print Setup
Print Summary
START

Step 7

Enter a summary of the situation being reviewed and the input that is being compared.

	Comparisons		
	Option 1	Option 2	Option 3
Description of Options	5000 head feedlot feeding corn based ration with no distillers grains. Ration protein and P content is 13.5% and 0.31%.	5000 head feedlot feeding ration with 20% distillers grains on dry basis. Ration protein and P content is 16.2% and 0.40%.	5000 head feedlot feeding ration with 40% distillers grains on dry basis. Ration protein and P content is 18.7% and 0.50%.
Animal	Beef Feedlot	Beef Feedlot	Beef Feedlot
Manure Nutrients Available			
Nitrogen			
Excreted (lbs/year)	605,230	744,032	872,552
Crop Available (lbs/year)	121,749	149,670	175,523
Phosphorus (P_2O_5)			
Excreted (lbs/year)	71,537	106,880	139,010
Crop Available (lbs/year)	67,961	101,536	132,060
Manure Application			
Land Required (acres)	1,937	2,381	2,792
Land Required (acres/year)	968	1,191	1,396
Average Distance to Fields (miles)	1.0	1.2	1.3
Maximum Distance to Fields (miles)	1.6	1.8	2.0
Selected Application Rate (?/acre)	19 tons/ac	16 tons/ac	13 tons/ac
Portion of Land Available for Manure	40%	40%	40%
Manure Application Equipment			
Application Equipment Selected	Truck Mounted 22 ton spreader	Truck Mounted 22 ton spreader	Truck Mounted 22 ton spreader
Method of Delivery to Field			
Total Time (hours/year)	460	521	577
Field Time (hours/year)	273	321	366
Road Travel Time (hours/year)	87	100	111
Other - Load/Unload or Setup Time (hr/yr)	100	100	100
Manure Management Economics			
Nutrient Value Total ($/year)	$ 78,545	$ 107,681	$ 134,310
Nutrient Value Total ($/ton or 1000 gal)	$ 4.17/ton	$ 5.72/ton	$ 7.13/ton
Nutrient Value Total ($/head capacity)	$ 15.71	$ 21.54	$ 26.86
Application Cost Total ($/year)	$ 43,041	$ 46,137	$ 49,008
Application Cost Total ($/ton or 1000 gal)	$ 2.29/ton	$ 2.45/ton	$ 2.6/ton
Application Cost Total ($/head capacity)	$ 8.61	$ 9.23	$ 9.80
Net Value Total	$	$ 61,544	$ 85,302
Net Value Total ($/ton or 1000 gal)	$ 1.8	$ 3.27/ton	$ 4.53/ton
Net Value Total ($/head capacity)	$	$ 12.31	$ 17.06

and Ray Massey, University of Missouri
, in cooperation with the USDA.
griculture and Natural Resources.

Step 7

Compare the impact of the variable that was changed. In this example, the inclusion of distillers grains in the diet was changed.

Figure 18. The table in *Step 7* provides the opportunity to compare the nutrient excretion, the nutrients remaining after storage and field losses, and the land requirements for agronomic application of the nutrients — for up to three scenarios.

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Appendix A

Uniquely Colored Cells

Light-Blue Cells: These unprotected cells are for data entry by the program user. Clicking on some of the light-blue cells will produce an arrow on the right-hand side of the cell. These cells contain a dropdown list of possible inputs. It is important to scroll through the entire list of entries on the dropdown menus, so as not to miss any of the options (use the vertical sliding bar on the right-hand side of the dropdown menu to do this). In these instances, select an option, but do not type an entry. When an arrow doesn't appear on the right-hand side of the cell, you'll need to input the appropriate data.

Light-Blue Cells, with a Red Upper Right-Hand Corner: Moving the cursor over these cells generates a popup text box containing reference information for that particular cell.

Black Cells: A blackened cell provides the user with a "Hint" about how to proceed..

Grey Buttons with Red Text: These important buttons assist the user in completing a variety of tasks in the spreadsheet (clearing cells, printing, moving to the next section, etc.).

White Cells: White cells contain reference materials and are out of the program area typically used by the program user.

Yellow Cells: Collectively, these cells make up the "User Viewing Area." The majorities of these cells are protected cells, and therefore are for information purposes.

Yellow Cells with Red Text: These cells offer additional instructions only partially displayed until your cursor is placed on top of them.

Primary Buttons

Clear All Worksheets (or Clear Data — All Worksheets): Removes all inputted data. Once chosen, the task cannot be undone. All data is permanently removed.

Clear Data Inputs: Removes inputted data from a particular page. Once chosen, the task cannot be undone. All data on that page is permanently removed.

Contact Info: Contains the contact information for the producer and/or consultant and briefly describes up to two primary manure sources.

Default: Numerous values are incorporated into the worksheet and are presented as "default" values. These are based on what is considered to be a diet typical of the animal group represented. It also assumes the animals are of average performance, as defined by ASABE.

Instructions: Serves as a source of information to assist with the completion of all seven steps associated with the program.

Print: Sends a copy of the worksheet to the user's printer for hard copy output.

Print Data Inputs: Sends the worksheet to the user's printer to generate a hard copy of the data provided by the user.

Print Setup (or Printout Setup): Sets a default printer layout that generally provides the preferred layout for printing of a screen. This button generally needs to be clicked only after the user manually defines a new print area.

Project Team: Identifies project collaborators.

Start: Returns user to the "Start" (front) page.

View Calculations: Takes the user to the white-celled (reference) portion of the worksheet that outlines the programmers' assumptions and the processes used to generate the related outputs.

View Data Inputs: Displays the values provided by the user.

View Manure Inputs: Displays the nutrient-related values provided by the user.

View Manure Results: Provides facility summaries for excreted and harvested manure as well as an excreted manure summary of the individual animal groups.

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Appendix B

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