United States Department of Agriculture
Natural Resources Conservation Service

Animal Manure Nutrient Balance

Excel Spreadsheets
Versions 3.1a and 3.1e
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written by:
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Introduction:

The "Animal Manure Nutrient Budget" Excel spreadsheets are designed to assist with the many calculations that are necessary when planning an animal manure nutrient management plan. The spreadsheets are basically the same with the exception that Version 3.1a (actual) is used when "actual" manure samples are available and Version 3.1e (estimated) is used when manure values are not know and need to be "estimated". The spreadsheets can be used in a variety of ways. The output from the program can be used as stand alone information for a nutrient management plan or as backup/appendix material for a more formalized comprehensive nutrient management plan. The spreadsheets, however, cannot be used to identify sensitive fields or areas where animal manure should not be applied because of slope, flooding, closeness to neighbors or water bodies, etc. This information should be included in other parts of the comprehensive nutrient management. Aerial maps identifying sensitive fields and areas should also be a part of the plan.

Several features are contained in the spreadsheets that help with the development of a nutrient management plan. They include:

- Automatic lookup of production and crop uptake values
- Lookup tables for production values, nutrient losses, crop uptake, and other values
- Allocation of manure production to confinement and grazing
- Consideration for reduction of nutrient content due to losses:
  - during Storage
  - from Volatilization
  - from Denitrification
  - from Mineralization
- Ability to account for bedding material
- Application rates for both nitrogen and phosphorus
- Accounting for wash water and runoff for liquid manure
- Application rates in tons/acre for solids and thousand gallons/acre for liquids
- Ability to evaluate expected nutrient changes due to changes in moisture content
- Ability to input actual/estimated weight of manure in lbs/cuft
- Estimate of nutrient content in lbs/ton for solid manure and lbs/thousand gallons for liquid manure
- A worksheet to evaluate the contributions from grazing to a given field
- A worksheet to aid in calculating spreader calibration information
- A worksheet to account for nutrient additions from various potential sources and for balancing nutrient applications within a given crop rotation
- A specification sheet to calculate and document application rates on individual fields under specific conditions
- A conversion calculator

One drawback with the spreadsheet is that it does not account for the amount of runoff water, rainwater or additional water that may inadvertently get into a solid storage system. Where possible, water should be diverted around these structures.

Spreadsheet Setup:

The animal manure nutrient balance program is contained in an Excel spreadsheet file named ***"Manure_Act_Nut_Content_3.1a.xls" and "Manure_Est_Nut_Content_3.1e .xls"***. There are several worksheets within each file. They are in the following order and can be accessed by clicking on the tab at the bottom of the screen:

Man. Bal.	This is the main worksheet that calculates manure production, nutrient losses, application rates, and manure nutrient content for solid manure.
Graz.Nut.	This worksheet accounts for the contribution of nutrients from grazing animals on given fields and is available only in Version 3.1e.
Liq. Bal.	Liquid manure production, nutrient losses, application rates, and manure nutrient content for liquid manure is calculated by this worksheet.
Cal. Tables	This worksheet provides calculations for calibration of solid and liquid spreaders. It gives the distance that the spreader has to travel to achieve the desired application rate, as well as loads/acre and total loads for identified crops and acreage.
Rot. Bal.	This worksheet can be used to account for all sources of nutrients in a given rotation and modified to balance out both commercial and organic applications of nutrients.
Spec. Sheet.	This worksheet can be used to provide individual specifications on an individual field for a given crop. It provides recommendations based on manure test information and crop uptake estimates or known soil test information. This worksheet is available only in Version 3.1a.
Dry Prod. Values	All of the data related to the production of solid manure such as the daily production of manure by a given animal in volume and weight, nutrients excreted by the animals, percent moisture of the various types of manure, daily bedding requirements, and characteristics of various types of bedding are contained in this worksheet. The nutrient and volume values from this table load automatically into the manure balance worksheet.
Wet Prod. Values	This worksheet contains similar production data as the "***Dry Prod. Values"*** worksheet. It also contains

typical daily flush values, waste deposition by area, and typical runoff values.

Losses Values for typical storage losses, denitrification, mineralization, and volatilization are contained in this worksheet.

Crop Uptk This worksheet contains nutrient uptake information for various crops. Data from this table loads automatically into the manure balance worksheet.

Conv. Calc. This handy little calculator can be used to make those pesky little conversions that are necessary when the available data is not in the desired unit(s).

Loading the Spreadsheets:

The spreadsheets can be loaded by first making a subdirectory for the file to reside in and then copying the file into that subdirectory. The spreadsheets can be run for an individual operation, renamed, and saved within the same subdirectory. Once the file is in the desired subdirectory, start it by double clicking on the file or by running **"Excel"** and open the file titled "***Manure_Act_Nut_Content_3.1a.xls*" or "*Manure_Est_Nut_Content_3.1e.xls*"**. The spreadsheets were designed using **"Excel 2003"**. There may be problems when trying to run the spreadsheets with an older version of Excel. Both spreadsheets run basically the same with the exception that actual manure test data is entered into 3.1a. In addition, 3.1a contains a worksheet titled ***"Spec. Sheet"***.

Man. Bal.:

When the spreadsheet is first activated, the worksheet/tab labeled ***"Man. Bal."*** will be displayed. This is the main worksheet of the program. Boxes that are highlighted in yellow are those in which the user can enter data. Those in white are locked and cannot be changed. The white boxes contain either titles, information, or display calculations that are made automatically by the program. These boxes are protected and cannot be modified. The boxes in green show manure application rates and the estimated nutrient content of the manure that is produced on the operation.

The spreadsheet can be used to determine nutrient content and application rates for alternative systems and methods of manure storage, handling, and application. It can also be used to determine the number of acres needed to properly dispose of the manure produced on the given operation or determine application rates for any given crop that may be grown on the operation.

Sample information will be displayed in the spreadsheet when it is first opened. The following subheadings provide instructions and detail the information that must be entered in or that is automatically calculated:

For: Enter the name of the person or operation that the nutrient balance is being calculated for. This name will be automatically displayed in all other worksheets where the person's name or operation is displayed.

County: Type in the county that the person or operation resides in.

System: Enter a brief description of the type of system that is being evaluated (e.g. Solid Waste System w/Bunkers).

File Name: The name that the file will be saved under should be entered here. This can be used to find the given file in the computer subdirectory. This feature will allow information for any given operation to be saved and recalled at any time desired. After this information has been entered, save the file under the new name. This will prevent the original file from being overwritten. It would be a good idea to save a backup copy of the file somewhere other than the subdirectory that files will be saved to.

Date: "Todays" date is automatically displayed. If a different date is desired, then type in the desired date. Once a new date is typed in "todays" date will no longer be displayed. If it is desirable to save the information as calculated on a given date then "today's" date should be reentered.

By: Enter the name or initials of the person(s) doing the evaluation.

Type of Animal: Input the type of animal(s) that are confined in the facility being evaluated. Although the spreadsheet is to be used mainly for evaluating animals in confinement, it can also be used to evaluate the nutrients that would be excreted under grazing operations. The name of the animal must be typed in exactly as shown in the same column behind the tab labeled ***"Dry Prod. Values"***. This is necessary in order for the computer to lookup the right values. If it is desired to enter the same animal type more than once, enter the name as it appears adding a consecutive number at the end (i.e. Heifers1 and Heifers2). This may be desirable if the same animal type is confined at more than one facility or average weights are different for the same type of animal. The computer will look up the values by evaluating the animal name alphabetically. Put a **"0"** in the cell to erase all calculations on the line. If **"#####"** signs appear in any of the cells on a row enter a **"0"** in the animal type column.

ManureProductionValues: Production values for N, P205, K20, and Volume will be automatically entered after the type of animal has been entered. Check to make sure that the animal name has been spelled correctly and that the values from the lookup table (***Dry Prod. Values***) are correct. These values come from the NRCS Animal Waste Management Field Handbook(AWMFH).

Animal #'s: Input the total number of animals to be evaluated. The number may represent the number of animals currently maintained at the operation or the number of animals that will be maintained at the operation in the future.

A.U.'s: This value stands for "Animal Units" and represents the average weight of the animals. The number is entered as a decimal. For example, a 1400-lb dairy cow is entered as "1.4" while a 650-lb beef cow would be entered as 0.65

Number of Days in System: A **"0"** should be entered in the cell if the number of days in the system is "0". Otherwise, enter the number of days that the animals are grazed and/or confined in the system. The number of days does not have to add up to 365. For example, if beef cows are confined for 180 days and taken to forestland the rest of the year, enter 180 days in the confined column and 0 in the grazing column. Another example may be where Dry Dairy Animals are grazed on pasture during the summer months and are confined during the winter. Days of grazing is not entered in Version 3.1a.

Manure Test Values in lbs/ton: In Version 3.1a, enter the lbs of N, P205, and K20 from the manure test. You may have to convert the data from other units. If phosphorus data is in lbs/ton of P, multiply by 2.3 to obtain lbs/ton of P205. If potassium data is in lbs/ton of K, multiply by 1.2 to obtain lbs/ton of K20.

Net Nutrients Available in lbs: The computer automatically calculates the net (after losses) nutrients for N, P205, and K20 for both grazing and confined animals. These numbers are expressed in lbs and are calculated by multiplying the nutrient production value, the number of animals, the animal units, and the number of days either grazing or confined in the system.

Nutrient Retention Values: Different management systems contribute to different nutrient contents of the manure. Nutrients are lost in four major areas. These losses are due to variable methods of storage, losses of nitrogen due to volatilization after land application, denitrification losses due to the climate and water regime within the soil, and variable rates of mineralization of the nutrients over a given time period. The values that should be entered can be found by clicking on the tab labeled ***"Losses"***. The values represent the percent of nutrients that are retained rather that lost.

Confinement Bedding & Manure Weight/Volume: Enter the type of bedding that is used in the confined operation. The name that is typed in must be typed in exactly as the bedding types found behind the tab labeled ***"Dry Prod. Values"***. If typed in correctly the value in the box that shows the mixed lbs/cuft will be automatically entered. The volume that is calculated is based on the effective density of the bedding. A value must be entered in this box in order for the program to calculate correctly.

Enter the number of animal units that are bedded. This number may or may not be the same as the value in the box titled **Total A.U.'s:**. The number of animal units that are bedded can be determined by multiplying the number of animals bedded by the animal units. (Example 107 lactating cows * 1.4 + 35 dry cows * 1.4 + 75 heifers * .6 = 244 animal units).

Next enter the number of days that the animals are bedded during the year. Then enter the lbs/day/animal unit of bedding material that is used. Estimated values can be obtained by clicking on the tab labeled ***"Dry Prod. Values"***. An alternative way of coming up with this value is to query the operator and find out the total tons of bedding that is used during the year and then begin entering values until the box that shows the tons/year has the correct tonnage.

A moisture value must be entered. Estimated values can be found in the sheet for ***"Dry Prod. Values"***. The entry after K20 values in the storage loss section is for the

moisture content of the fresh manure for the given type of animal. The spreadsheet will automatically calculate the tons and cubic yards of manure and bedding produced in the system.

Crop Information: This section is not labeled, but contains cropping information. In the first series of yellow boxes, enter the crops that are grown in the rotation and/or that manure will be applied to. The crop names must be spelled exactly as found behind the tab labeled ***"Crop Uptk"***. When entered in correctly the amount of nutrient removed by the crop annually will be automatically entered into the N, P205, and K20 columns.

Next enter the field numbers, acres, and yields for each crop. The yield level must correspond with the appropriate units as given in the ***"Crop Uptk"*** sheet (i.e tons, bu, cwt, etc.). The amount of N, P205, and K20 in lbs required per field will automatically be calculated. Put a **"0"** in the crop and yield cells to erase all calculations on the line or if the **"#####"** signs appear in the row.

The next column labeled soil/crop N credits can be used if soil test values are available or if estimated values are available. As shown in the example data, alfalfa produces it own nitrogen, thus the value of 330 lb/ac. The amount of N that must be applied to make up the balance is automatically calculated in the next column. This nitrogen could be supplied through additions of animal manure or commercial fertilizer.

The last two columns highlighted in green provide the application rate in tons per acre for N and P205. These application rates are the estimated rates of application based on the total production, retention values, and expected moisture content of the manure. Please note that under actual field conditions, manure nutrient values, moisture content, and weight can vary significantly based on handling methods, application methods, amount and type of bedding added, temperatures, and the amount of precipitation that may have come in contact with the manure. The calculated values from this worksheet should be used as estimates only. More accurate values can and should be obtained through the use of manure and soil test values. If application rates are desired for crops that are not currently grown in the rotation, simply enter the crop name and yield in the appropriate cells but do not enter any acres. Also note that applying manure on the basis of nitrogen will apply phosphorus at a rate that exceeds crop uptake rates. It is important to understand this relationship and account for it in any nutrient management plan.

Fertilizer Value: Summary information for N, P205, and K20 are contained in this section. The first six rows compare the total nutrients required against the net nutrients available and then calculate either an excess of nutrients or the need for additional nutrients to be added. The amount in excess or to be added is given for the total acres as well as per acre. Be cautious using these per acre values. Where several crops are shown to have manure applied to them, the actual nutrient requirement is different for each crop.

The next two rows show the total and lbs per ton net nutrients that are available in the stored manure. If the number of days that animals are confined or grazed in the system is less than one year, then this number represents the net nutrients available during the given time period. The green highlighted values are perhaps the most

valuable information on the spreadsheet. They show the estimated net nutrients in lbs per ton of manure. These numbers can and should be compared with actual manure test values to see if they are reasonable. These numbers will be used later in the ***"Rot. Bal."*** worksheet.

The next two rows show the total net nutrients that are available from grazing. The second row in the series shows the amount of nutrients that would be in the droppings assuming that they were spread equally. Be cautious of this number as it is based on the total acres shown. For this number to be accurate, only those acres that are grazed should be entered in the crop section above. A more accurate analysis of the nutrients deposited on each field during grazing can be found by clicking on the tab labeled ***"Graz. Nut."***.

The percent of crop nutrient needs supplied by animals is given in the last row. These values are based on the crops and total acres entered in the crop section, and can be changed by changing the crop, acreage, and yield information. Note that values over 100% indicate that more nutrients are produced than acres of crop are available to utilize the nutrients. The numbers in the first row are used to determine the total number of acres of alfalfa needed to utilize all of the manure based on phosphorus. This information can be viewed by looking to the right of the spreadsheet (Lines 44 thru 50, columns R thru T). Alfalfa is used as an indicator of the total acres needed over time to balance the nutrients produced by the animals. On any given year, the actual amount of acres needed for application will depend on the crop(s) that the manure is applied to. The "acres needed" information can be used to determine if the operation has enough acres to apply the manure to without causing phosphorus and potassium levels to be elevated over time. When the number of acres needed is close to or less than the number of acres available, the operation needs to look at finding other ways of disposing of their manure. The number of acres needed will print out on the manure calibration sheet on the tab labeled "Cal. Tables".

Spreader Calculations: Values in this section help determine total manure weight and provide estimates of the number of loads of manure to spread and the time that it will take. When manure and bedding are mixed the percent moisture will generally be lower than fresh manure values. The computer automatically adjusts the percent moisture when mixed with bedding.

Manure moisture can change dramatically depending on the conditions under which it is stored. Temperatures, precipitation, storage type, and handling methods all effect moisture content. Moisture values for typical systems after storage losses can be obtained by clicking on the tab labeled ***"Losses"***. Enter the value from the table or average values obtained from manure tests. Note that when this value is entered the computer automatically calculates an expected weight of the manure when applied. Also note that the N, P205, and K20 values in lbs/ton in the green boxes to the left are automatically adjusted. As moisture content decreases, the nutrient content of manure becomes more concentrated.

In the next yellow box, enter an estimated or actual weight of the manure in lbs/cuft. Fresh manure typically weighs in 60 to 62 pounds per cubic foot. As the moisture content of manure goes down the weight will also go down. The weight of composted manure can be as low as 25 lbs/cuft. One method of determining the weight of any

manure is to weigh a 5-gallon bucket full of the manure. Multiply the full weight minus the empty weight of the bucket by 1.5 to get the weight of the manure in lbs/cuft.

If the capacity of a spreader is not know, it can easily be determined by multiplying the length and width of the spreader, and the height that the spreader is generally loaded to (Exa; A spreader 10' long by 8' wide that is loaded to a 3' depth has 204 cubic feet). Often times, the manufacturer of the spreader will be able to supply the capacity of the spreader in cubic feet or bushels. If the capacity is given in bushels, multiply the bushels by 1.24 to get cubic feet. This number is then put into the cell labeled spreader size (cuft). The computer then automatically calculates the weight of the spreader in tons or in the number of gallons that it holds. The total loads of manure that need to be hauled are then calculated.

To demonstrate the reduction in volume and weight through composting, enter a value of 45% expected moisture and 30 lbs/cuft. Note how the expected weight of the manure and the total loads that need to be hauled are reduced. Also note the corresponding increase in the nutrient content of the manure.

Graz. Nut. (Ver 3.1e only):

This worksheet can be used to calculate the nutrient contribution from grazing animals on fields that are grazed. The worksheet interacts with the ***"Man. Bal."*** worksheet. It can be used in conjunction with the animals that are partially confined or for animals that are grazed only. Since the ***"Graz. Nut"*** worksheet utilizes information from the ***"Man. Bal."*** worksheet, the information on the ***"Man. Bal."*** worksheet must reflect the type of animals, field numbers and acres that calculations are desired for.

Since this worksheet has to interact with the ***"Man. Bal."*** worksheet, **For, Date, File,** and **By** information is automatically entered in the appropriate boxes.

Manure production information and values from the ***"Man. Bal."*** worksheet are also automatically placed in the first series of cells. In the yellow boxes, enter the type and number of animals that will be grazing on the given field. If the fields are not reflective of the fields that are to be grazed, then the desired information must be entered on the ***"Man. Bal."*** worksheet first. Also enter the number of days that the animals will be grazed. This number does not have to correspond with the numbers used on the ***"Man. Bal."*** worksheet. If two different types of animals will be grazing on the same field(s), the field number(s) can be entered twice on the ***"Man. Bal."*** worksheet. Once this information is entered, the spreadsheet will calculate the information in the next series of boxes. Information provided includes additional nutrients needed per acre, excess nutrients needed per acre, and the percent of each nutrient that is supplied to the field. This information can be used to help determine if additional commercial fertilizer or additional manure can and/or should be applied to meet the nutrient needs of the field.

Liq. Bal.:

This worksheet performs basically the same calculations as the ***"Man. Bal."*** worksheet. Production values, however, are divided into two different categories: 1) Manure

Production Values, and 2) Liquid Production Values. Application rates are displayed in 1000 gallons per acre rather than tons per acre. This worksheet may also be used to evaluate nutrient content for the designed storage period or for the whole year as well as nutrient content of sludge material when hauled out of a storage structure. It is important to note that estimating liquid nutrient values is extremely difficult due to variability in the amount of liquid going into any system and should always be backed up with actual liquid manure tests.

Methods of handling wastewater can get very complicated. Wastewater sources may include barn wash water, lot runoff, and precipitation (minus evaporation) on the storage pond. In some cases all solid and liquid manure may be mixed together to make a slurry or a liquid. In other cases the solid and liquid manure may be separated. Liquid manure may be stored in above or below ground concrete structures, transferred into a storage pond, or into an aerobic, or anaerobic lagoon. It may also be directed into an evaporative lagoon. Lot runoff as well will generally be transferred into the liquid manure storage area. This worksheet is designed to help estimate the nutrient content of these various systems. As with all estimates, actual liquid manure samples should be taken in order to obtain more accurate values.

Liquid storage systems are always designed to hold water from a 25 year 24 hour storm. A storm of this size would dilute the nutrient content of water in the system. This spreadsheet, does not account for such a storm since the operator should be managing the system in such a way as to always leave space for the storm.

ProductionValues: If solid manure will be transferred into the liquid system then enter the appropriate values in the first set of yellow boxes. Enter the number of days that the evaluation is being done for as well as the % of the solid manure that will be going into the storage system. Estimates of the percent solid waste that is deposited in the housing, feeding, holding area, and milk parlor are given in the ***"Wet Prod. Values"*** worksheet.

Enter the kind of wastewater from the ***"Wet Prod. Values"*** worksheet that will be transferred into the liquid storage system. Data for some animal types for P205 and K20 are nonexistent. The computer will leave the white boxes blank if this is the case. In the wash water section, enter the number of gallons of water per head per day that will be used in the system. If actual values are not know, then enter an estimate from the ***"Wet Prod. Values"*** worksheet.

Nutrient Retention Values: Nutrient retention values for liquid systems vary considerably from solid systems. Obtain estimates for these values by clicking on the ***"Losses"*** tab and selecting the appropriate values.

Liquid Manure Production & Volume: This section allows entry of lot runoff and/or precipitation amounts. Enter the size of the lot in square feet from which runoff will enter into the liquid storage system. Next enter the amount of rainfall that will fall during the evaluation period. The program does not calculate evaporation losses. If it is desired to account for evaporation, hand calculations will be have to done and the appropriate value entered. If a concrete structure that holds only barn wash water is used, then enter the size of the structure in square feet for the structure as shown in the example information. The amount of rainfall that will run into the storage system will depend on the type of lot that it falls on. More water will run off

from surfaced lots than unsurfaced lots. Click on the tab for ***"Wet Prod. Values"*** to get estimates of the amount of precipitation that will run off. Lastly, estimate the percent moisture in the runoff. The sample information shows that no solids are in the precipitation that falls on the storage structure. The moisture content of runoff can be highly variable due to storm intensity, slope of the lot, amount of manure in the lot, and etc. There is no known data for this number, but the likely value based on field experience would be between 75 to 98% moisture in the runoff.

The computer calculates the total volume of liquid manure by calculating the solids and liquids separately then adding them together. The percent moisture values in the solid manure, wastewater, and lot runoff become important in determining the liquid/solid volume.

Cropping and Application Information: This section works the same as the ***"Man. Bal."*** worksheet. Note that the sample information shows that 6 acres are needed to properly dispose of the liquid manure on alfalfa on the basis of phosphorus uptake. The boxes in green show the amount of stored nutrients in pounds per thousand gallons.

Application Calculations: This section works the same as the ***"Man. Bal."*** worksheet, except the values are expressed in gallons rather than tons. When liquid manure is applied through some systems such as a big gun or other sprinkler systems, the percent solids generally has to be less than 5%. If large amounts of solid manure are in the system, additional water may need to be added to dilute the solid concentration to the desired content. By entering the desired % moisture, the computer will calculate the amount of water in thousand gallons that needs to be added to the system. Additional information regarding this topic can be found in Chapter 11 of the NRCS AWFMH.

Liquid manure is typically applied through a liquid spreader, and injection system, or through an irrigation system. The volume in cubic feet of a circular tank can be found by multiplying 3.14 times the radius squared times the length of the tank (pi * r^2 * l). Then multiply the area in cubic feet by 7.48 to convert to gallons. Multiply that number by 90% since the tank cannot be filled clear full. Enter this number into the spreadsheet and the number of loads and the hours it will take to apply them will be calculated by the spreadsheet.

Irrigation systems are rated by the gallons per minute that they put out. Enter the pumping rate in gpm in the spreadsheet and it will calculate the number of hours that it will take to pump out the pond. Pond volumes should be marked by a stick that measures the depth of the pond. A table can be developed that shows the number of gallons contained in each 6 to12 inch increment. This allows the operator to pump out partial volumes knowing how much waste has been pumped. The amount pumped is matched with the acres covered to determine the application rate.

Cal. Tables:

An important part of proper manure management involves not only determining the right application rate, but assuring that the right rate is applied to the land. Applying the right rate involves calibration of the equipment. There are several methods that can be

used to calibrate spreader equipment. The elements of calibration include determining the amount of manure that the spreader holds, determining the distance that must be traveled to unload the spreader, and making the necessary adjustments to the spreader to be able to travel the proper distance. It is a must to know the size of the spreader in cubic feet for solid spreaders and gallons for liquid spreaders, the width that the spreader spreads, and the distance that is traveled during a normal application. It is also important to be able to make adjustments to PTO speed, tractor speed, and to the spreader to achieve the right application rate. This worksheet does not provide information on calibration of irrigation equipment. Landowner information, location, date, file name, and planner name or initials are brought in automatically from the ***"Man. Bal."*** worksheet.

The type of spreader and the spread width are the only pieces of information necessary to make this worksheet run. The rest of the information is brought in from the ***"Man. Bal"*** and ***"Liq. Bal."*** worksheets or is automatically calculated by the computer. Calibration information is provided for the same crops, fields, acreage, and application rates calculated in the other worksheets. Information provided includes the distance that must be traveled in feet and miles to apply the desired application rate as well as the loads/acre and the total loads for the total amount of acres in the field(s). The distance in miles is provided only for solid spreaders. This information would be used when manure is spread by a truck spreader and has an odometer. This provides two methods of determining if the proper application rate is method. Proper distance can be measured or the number of loads that are applied to an acre of land can be determined. If the distance traveled or the number of loads hauled is not the same as the desired number, then apron adjustments, PTO settings, speed of the tractor, ram speed, or other adjustments must be made until the proper application rate is achieved.

Rot. Bal.:

The NRCS Nutrient Management Standard requires that a nutrient budget be developed that considers all potential sources of nutrients including animal manure, waste water, commercial fertilizer, crop residues, legume credits, and irrigation water. This worksheet provides a mechanism whereby a nutrient budget based on crop rotation can be evaluated. This method provides an estimate only and should be used in conjunction with more exact information from manure, soil, and/or tissue testing. The worksheet can be used to document the nutrient management system currently being used as well as for the planned system. The second page of the worksheet can be used if a crop rotation contains more than four crops or is longer than four years or for a different (second) crop rotation than is shown on the first page.

Date: As with the other worksheets, "today's" date is automatically entered in the first yellow box. If it is desired to save a specific date then enter the desired date. The computer will no longer automatically bring in "today's" date after the file is saved.

Location: Enter the tract(s) and field(s) that the nutrient balance is developed for.

Crop Rotation: Enter the name of the crop in the first larger box and the number of years that crop is in the rotation in the second smaller box. Once the crop name, and target yield are entered, the computer will automatically calculate the nutrients that are needed for the target yield. There are enough boxes to enter eight crops in the

rotation. If more than four crops exist in the rotation, enter additional crops on page two of the worksheet.

Target Yield/Unit: Put in the target yield for the crop. The target yield should be realistic. It can be determined using the information suggested in the first guideline below. The computer will automatically enter the unit in the units' box.

Nutrient Budget Information: Input the appropriate information (e.g. Normal soil release, N from prior crop, etc.) in the yellow boxes for each of the crops in the rotation. The computer automatically calculates the boxes highlighted in green. Guidance for the values that should be entered in each of the categories is provided in the next section. Two calculators, located to the right of the spreadsheet, are available for help in making calculations for commercial fertilizer and animal manure values. The fertilizer calculator will tell you how many lbs of nutrients will be applied at the designated application rate for the chosen fertilizer form. Enter the lbs of each nutrient applied into the commercial fertilizer section. The second calculator will help in determining the amount of nutrients from manure that will be applied at any given application rate. Enter the tons of manure to be applied. The nutrients calculated in the ***"Man. Bal."*** worksheet are automatically entered into the calculator as well as the total lbs of nutrients that would be applied per acre. Enter the lbs/acre of N, P205, and K20 in the appropriate yellow cells for animal manure. The calculations just below the manure calculator display the number of years of P205 and K20 that will be carried into the alfalfa years. Alfalfa should always be entered as the first crop in the rotation for this to work correctly.

General Guidelines for the Values to Enter in the Rot. Bal. Worksheet:

Target yields should be established on the basis of soil characteristics, historical yields, and level of management, available moisture, and economics. Yields are best established by collection of yearly data by the producer. Yields should be based on averages rather than a high yield obtained once or twice during a rotation. Information on the amount of commercial fertilizer and/or manure added to a field should also be used to determine a given yield response under specific field conditions. In the absence of this information, enter average yields for the county. Average yield information can be obtained from NRCS Soil Survey Manuals or from the local County Extension Agent.

Soil testing is a method used to determine actual nutrient availability. Soil testing can also be used to show trends in nutrient levels. Soil tests should be taken when changing crops or every 1 to 2 years when in a continuous crop. When soil tests are taken, nutrient recommendations should be based on the guidelines in the "Utah Fertilizer Guide". These guidelines are based on fertilizer response curves developed by research throughout Utah. Without a soil test, nutrient recommendations are only an estimate. When soil test information is available, enter the values into the **"Normal soil release"** boxes for the given nutrient and crop.

Mineralization (the release of N from organic matter) is dependent on the percent organic matter in the soil. It requires about 20,000 lbs of residue to increase organic matter by 1 percent. Most Utah soils contain from 1 to 2 percent organic matter. The amount of N released through mineralization is shown in the following table (Enter this value in the **"Normal soil release"** box unless soil test values are entered):

%OM	Approx. Lbs of N Released		
	Silt Loams	Clay Loams	Sandy Loams
1.0	23	18	50
1.5	34	27	75
2.0	45	36	100

Nitrogen supplied when alfalfa is plowed out is dependent on the production of the alfalfa at the time of plow out. The chart below shows the approximate amounts of N available the first and second year after plow out.

Nitrogen Supplied After Plow Out of Alfalfa

	1st year	2nd year
2-4 tons/acre	80 lbs	20 lbs
4-6 tons/acre	150 lbs	30 lbs
6-8 tons/acre	200 lbs	40 lbs

Nitrogen starts to become available to crops about 4 weeks after kill or plow down of a legume crop providing there is favorable soil moisture and temperature. Availability generally increases as soil moisture and temperatures increase. Availability will be greater in the spring if alfalfa is plowed out in the fall rather than in the spring.

If above normal residues are left on the surface or plowed down, 1 lb of additional nitrogen should be added for every 100 lbs of residue.

Animal manure provides varying amounts of nutrients. The amount supplied is dependent on the type of manure and the handling of it. To determine the exact amount supplied, manure samples should be tested in a lab. Samples should be taken as close to application time as possible. Estimated nutrients from the ***"Man. Bal."*** worksheet may be used or information from manure testing may be used to calculate the amount of manure added. If manure is or will be applied to the listed crop, the application rate based on either nitrogen or phosphorus as shown in the ***"Man. Bal."*** worksheet should be used to determine the total nutrients added from the application.

Irrigation waters in Utah supply varying amounts of nutrients. Lower stream reaches in most of Utah supply large amounts of potassium. In addition, soils in Utah contain high background levels of K. The need for K applications may best be determined through a soil test. The nutrients supplied by various streams in Utah can be obtained

from Agronomy Tech Note UT190-4-2 titled "Irrigation Resources in Utah: Water Quality versus Soil Salinity, Soil Fertility and the Environment".

Legume crops growing alone produce their own N through nitrogen fixation. Additions of 10 to 20 lbs/acre of N have proven to increase alfalfa yields. Additions above 20 lbs/ac tend to inhibit the process of nitrogen fixation. Legumes growing as a companion crop in pastures produce N in the following approximate amounts:

Alfalfa	80 - 300 lbs/ac*	*Amounts may vary
Clovers	90 - 120 lbs/ac*	dependent on the
Forage Peas	50 lbs/ac	% legume in the
Sweet Vetch	80 lbs/ac	pasture.

Split applications of N are recommended for irrigated fall grains or crops grown on coarse textured soils.

Nitrogen applied on spring seeded crops is more efficient when applied and incorporated prior to planting. Liquid nitrogen may be applied through irrigation water.

Phosphorous and potassium applications are more efficient when incorporated, or even more efficient, if banded in the soil when soil test levels are low.

The nutrients in animal manure are best utilized by applying and incorporating the manure just prior to the seeding of the next crop.

Good irrigation water management is essential in order to reduce the potential loss of nutrients due to irrigation-induced erosion and/or the leaching of mobile nutrients below the root zone.

Information for these general guidelines was compiled and adapted from the following sources:

Approved Practices in Pasture Management, 4th Edition, 1985
Ortho Agronomy Handbook, 1984
Ortho Hypa Highlights, Volume 1, Jan. 71 - Dec 76
Utah Fertilizer Guide, Nov. 1989
Western Fertilizer Handbook, 7th Edition, 1985

Balance: The main function of the nutrient balance worksheet is to determine if an excess or deficit of nutrients exists. The numbers should be interpreted as estimates of what is likely happening throughout the rotation rather than exact numbers. They provide a valuable tool to help the landowner/operator see if they are applying too many nutrients or not enough. They can also be used to determine if the crops in the rotation are utilizing the available nutrients efficiently. However, following a regular soil and manure testing program will provide more valuable information. In the case of manure applications. It may be desirable to apply an excess amount of P205 during the years annual crops are grown so that the alfalfa crop will have adequate phosphorus during its life cycle. In the example that is shown, manure is applied to

the annual crops on the basis of nitrogen. In so doing excess phosphorus is applied. The sample worksheet shows that enough phosphorus is applied to the three years of annual crops to meet the alfalfa needs for 3 years during the alfalfa rotation.

Comments/Recommendations: Enter any comments or recommendations in the box provided. Information may include recommendations on balancing crop needs, reducing commercial fertilizer applications or the need for additional fertilizer applications, timing and method of application, sources of nutrients, rates of applications, or other information related to proper nutrient management.

Spec. Sheet (Ver 3.1e only):

The specification worksheet should be used to develop yearly specifications for animal manure applications on individual fields. Current soil and manure test information must be obtained before using this worksheet. The worksheet can also be used to document the yearly application of animal manure on a field. Enter the basic information for name, date, planner, office, and purpose(s) for applying this practice.

Field and Soil Information: Enter the year the nutrient application will occur, tract and field information, crop to be grown, realistic yield goal, and then the information from the soil test. The soil test information may be given in ppm or lbs/acre. Change the units by clicking on the cells after the soil test value. The phosphorus value should be entered as ppm P rather than ppm P205. If nutrient application recommendations are given on the report from Utah State University or from another laboratory enter the recommendations for N and P205 into the yellow boxes to the right of the spreadsheet (Columns P and Q, lines 23 and 24). Then click on cell L23 and enter the desired method for calculating application rates. Possible methods include; USU Recommended, USU Calculated, Other Lab Recommendations, or Crop Uptake values.

Manure and Application Information: Enter the type of manure that is being used (solid or liquid), then enter the method of application, incorporation, timing of the incorporation, and basis of application. If phosphorus is selected as the basis of application, an additional line will appear in row 53 showing how much additional nitrogen is needed to meet crop nutrient needs. The other blanks are for recording the actual date of application, field and weather conditions during and just after application, and the actual application rate.

Calculations: The only information that is needed in this section is additional nutrient credits. Planned commercial fertilizer applications would be entered into this section. When the application rate is based on phosphorus, it will be likely that additional nitrogen will need to be added to meet crop needs for nitrogen. The amount needed is shown in item 9.

Dry Prod. Values:

Clicking on this tab brings up information related to the production of animal manure, estimated daily bedding requirements for dairy animals, and information on different types

of bedding. The values come from the NRCS Agricultural Waste Management Field Handbook.

Amounts of bedding that are used by the operation are best determined by asking the producer. The amount may be determined by finding the total number of bales or loads that are used during the years time and multiplying by the average weight of the bales or loads. In the absence of any information, the second table provides the recommended amounts of bedding where animals are housed in stanchions, free stalls, or the bedding is placed loose throughout some area of the feedlot.

Information given in the table for types of bedding is also in alphabetical order. The computer automatically selects the value for "Mixed LBS/CuFt" and enters it into the ***"Man. Bal."*** worksheet. Note that a range has been given for the percent moisture generally found in each type of bedding. An exact percent moisture must be entered into the ***"Man. Bal."*** worksheet.

Wet Prod. Values:

Clicking on this tab brings up information related to the nutrient content of liquid animal manure, typical daily water/flush values, % animal waste deposition by area, and typical runoff values for Utah. The values come from the NRCS Agricultural Waste Management Field Handbook.

Amounts of flush water that are used by the operation can be determined by asking the producer. The amount may be determined through use of water bills, pump information, or other estimates by the producer. In the absence of any information, the second table provides typical amounts of flush water used in various systems. Information in this table comes from the book titled, "Idaho Waste Management Guidelines".

Most dairy animals in a two milking system will deposit about 5% of their total manure in the milking parlor. If the values do not seem representative of the given situation, estimate the percent of total time spent by the animals in any given location and use that value.

Runoff values are listed by surface type. This table comes from Chapter 10 of the NRCS AWMFH. The values are expressed in a range. When selecting a value, consider storm intensity, slope of the lot, and burms or other obstructions that may reduce or eliminate lot runoff.

Losses:

Typical losses for storage, denitrification, and volatilization as well as mineralization rates can be found by clicking the tab labeled ***"Losses"***. All values given in the tables can be found in Chapter 11 of the NRCS Animal Waste Management Field Handbook. Additional values can also be obtained in the same handbook.

Storage Losses: Storage loss values for N, P205, and K20 are given for different storage conditions, as well as for the typical moisture (H20) content. All of the values are given as the percent left. Storage values are given for Beef, Dairy, Poultry, and

Swine. Systems that scrape more often, are covered and watertight, and do not incorporate aerobic or anerobic processes retain more nutrients than those not handled in this manner.

Nitrogen Denitrification: Denitrification is a function of organic matter and soil drainage. Dentrification is the conversion of N03 to N2 gas. Wet conditions and high organic matter content causes the greatest amount of denitrification to occur. Western soils typically have less than 2% organic matter except with a few exceptions (e.g. long term pasture). Practices such as irrigation water management, residue management, and subsoiling can be used to limit the amount of denitrification that occurs in the system.

Ammonia Volatilization Rates: Volatilization occurs only with nitrogen in the form of ammonia (NH4). The process occurs when ammonia is converted to NH3 gas under warm and dry conditions. These losses can be decreased though incorporation methods such as disking, plowing, injection, or irrigating immediately following application. As much as 50% of applied ammonia can be lost if not incorporated within 7 days following application

Mineralization Rates: Mineralization is a process in which nutrients are first immobilized by soil microorganisms and then later released. The microorganisms utilize nutrients in the soil and manure to break down the carbon contained in the manure and bedding. As the breakdown process is completed, the microorganisms die and release the nutrients contained within their cell walls. The process generally takes several years. The rate at which mineralization occurs varies depending on moisture and temperature and time. Manure applied as a one-time application would have a different mineralization rate than manure that is applied continuously over a 3-year or longer time period. Rates given in the table are for continuous application rates over a 3-year or longer time period. Rates for a one-time application can be found in the NRCS Animal Waste Management Field Handbook.

Crop Uptk.:

Clicking on this tab brings up information related to the N, P205, and K20 uptake for various crops. The crop uptake values were obtained from a number of sources including the NRCS Agricultural Waste Management Field Handbook, Ortho Agronomy Handbook, Western Fertilizer Handbook, Chevron Hypa Highlights, Potash and Phosphate Institute, IMC Fertilizer, and the Utah Fertilizer Guide. These values are drawn into several of the individual worksheets. The worksheet can be printed out if desired.

Conv. Calc.:

This worksheet is a conversion factor calculator. It can be used to convert from one unit to another (e.g. bushels to cubic yards). Entering the number of units that is desired to convert from into the appropriate yellow box runs the program. The answer is automatically calculated in the corresponding green box in column D.

Special Instructions:

It is expected that the person using this spreadsheet has a basic knowledge of Excel 2003. If problems are encountered contact either Kerry Goodrich at the address listed on the front page or consult an Excel manual. Problems with **"#####"** signs or **"N/A"** appearing in a row can be remedied by highlighting the yellow boxes and then selecting **Edit** from the main toolbar and then **Clear** and **Clear Contents,** by entering a blank in the cell, or by entering a "0" in the cell.

It is possible that small changes have been made to the program that does not merit changing the version number for the program. If you think that you do not have the most current version of the program check the date the file was saved using Microsoft Explorer. Contact Kerry Goodrich for the most current version or go to the Utah NRCS Electronic Field Office Technical Guide and open the yellow folders labeled Section I\References & Technical Notes\CAFO/AFO Program\Excel Spreadsheets. The Utah eFOTG can be found at:
http://efotg.nrcs.usda.gov/treemenuFS.aspx?Fips=49049&MenuName=menuUT.zip