Minnesota Feedlot Annualized Runoff Model

(MinnFARM)

An Evaluation System to Estimate Annual Pollutant Loading and Prioritize Feedlot Pollution Potential

Users Guide
Version 2.1
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Introduction

MinnFARM was developed to calculate the annual pollutant loading from a feedlot in Minnesota. The model is based in part on algorithms from the Feedlot Evaluation Model (1982) model developed by the Agricultural Research Service for prioritizing feedlot pollution potential based on a single 25yr 24 hr event. With a limited number of inputs, MinnFARM estimates annual pollutant loadings for COD, Phosphorus, Nitrogen, BOD_5 and fecal coliforms at the end of a defined treatment area. In addition, the model predicts whether the feedlot is likely in compliance with Minnesota Pollution Agency water quality standards. MinnFARM also requrest inputs of the type of receiving water and a distance to this water and uses this information along with annual loadings of BOD_5 and Phosphorus, BOD_5 concentration to prioritize feedlots for state or federal cost share assistance to mitigate the runoff.

Please send all comments and concerns related to the model or this documentation to schmi071@umn.edu

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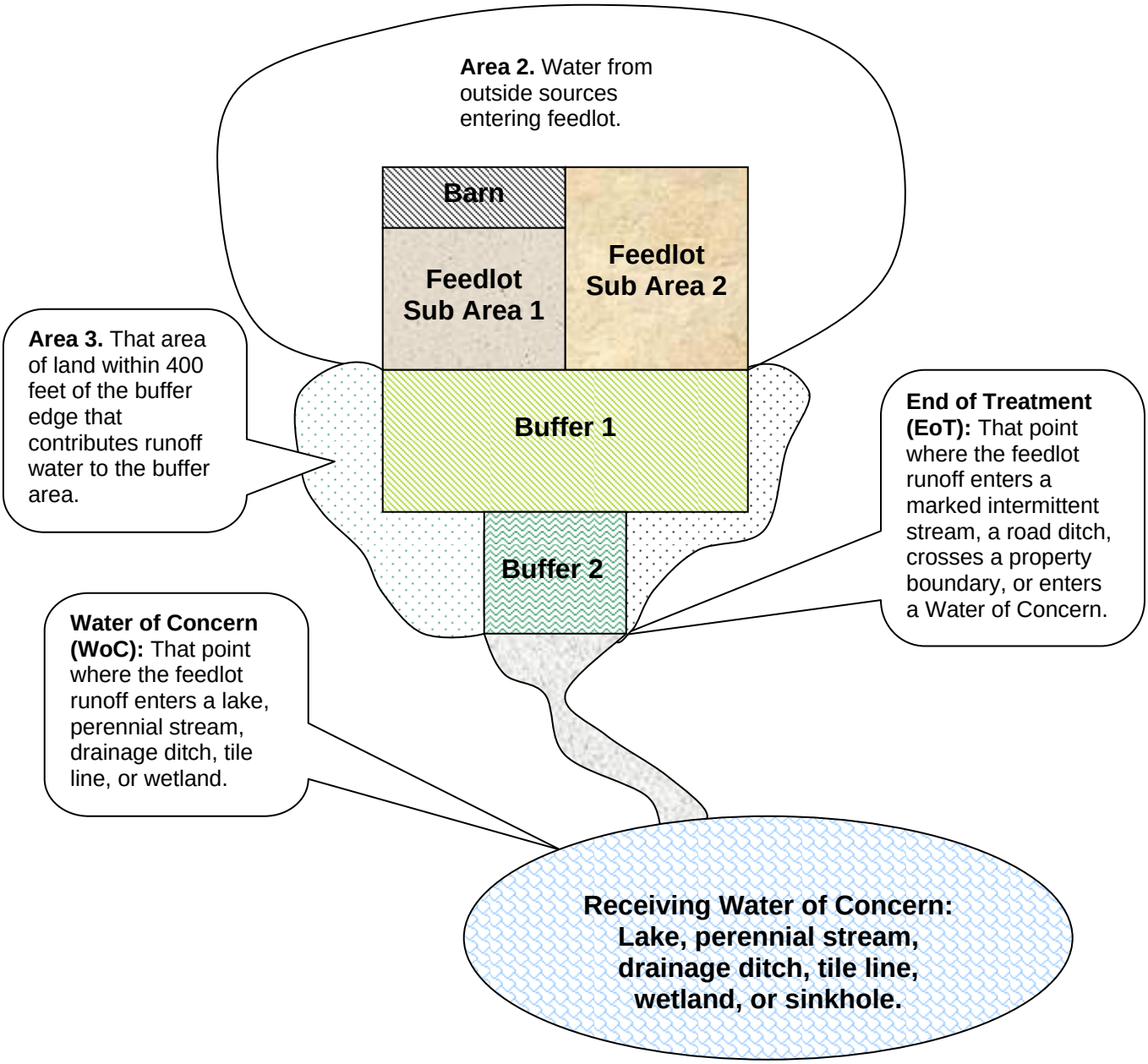
Background

An Evaluation System to Rate Feedlot Pollution Potential, a system developed in 1982 by the USDA, Agricultural Research Service (ARS) in Morris, Minnesota, has been used extensively in Minnesota to rate and document the pollution potential of feedlots. It was developed to prioritize technical and financial services provided by government agencies that, then and now, have limited resources. The authors performed extensive literary searches and field research for gathering data to develop a scientifically based model.

From 1998 through 2001, the Board of Water and Soil Resources (BWSR) provided training on the use of the feedlot evaluation system to about 230 individuals from Soil and Water Conservation Districts, the Natural Resource Conservation Service, the Minnesota Pollution Control Agency, county feedlot officers, consulting firms, and others. The purpose of the training was for participants to have a uniform understanding of the technical logic used in program development.

In October, 2002, the University of Minnesota, in conjunction with the Minnesota Pollution Control Agency and with significant field assistance from individuals from the SWCD, BWSR, NRCS, and County Feedlot Officers began a series of new training sessions. Along with these trainings an EXCEL based version of FLEval was developed. This upgrade in software simplified or eliminated some of the hand calculations that were necessary in the DOS version of the FLEval program and was much more user friendly. The original tech guide developed by ARS in 1982 was updated to reflect these new software changes.

In 2004, an EPA 319 grant was awarded to evaluate and update the original algorithms used in the model and add additional algorithms to estimate annual loadings from the feedlot (rather than just the loading and concentrations from a 25-yr, 24-hr storm event). This new model (MinnFARM) has several other features that are discussed in this users guide. Some of the information in this guide refers to the original FLEval manual (ARS, 1982). Other information is taken from the Technical Guide originally drafted in 2001 by Justin Jeffery at the Board of Water and Soil Resources and updated in 2002 by David Schmidt, University of Minnesota.



General site sketch showing critical features required in the model.

A Guide to Gathering Field Information for MinnFARM

1. Owners and/or operators name.
2. Begin by drawing a sketch of the feedlot and local watershed showing watershed boundaries, building locations, feedlot areas, roof areas, direction water of flow, well locations, and other pertinent features. Note that distance estimates are adequate for use in MinnFARM.
3. Determine the following information for each sub-feedlot of feedlot:
    a. Type of animal. (NOTE-There may be several types.)
    b. Number of each type of animal including what may be expected in the event of expansion over at least the next 10 years.
    c. The management of the animals on the feedlot. For example, are they under a roof or on pasture or some other lot during part of the time? Also, are they on the lot throughout the year or seasonally?
    d. The size of the lot.
    e. The percentage of lot that is paved.
    f. The average slope of the lot.
    g. The frequency of paved lot cleaning (days between cleaning).
4. Locate the End of Treatment (EoT) for the runoff water from the feedlot. This is the point where there the runoff enters a property boundary, a marked intermittent stream, a road ditch, or a Water of Concern (WoC). The EoT is discussed more fully in Definitions and Clarifications.
5. Locate the Water of Concern (WoC). This is the point where the feedlot runoff enters a lake, perennial stream or wetland that is of concern. Indicate the name of the water body on the site sketch or input sheet. The WoC is discussed more fully in chapter Definitions and Clarifications.
6. Determine the area of watershed contributing water to the feedlot area. This is often roof runoff or farmstead area. This area is noted as Area 2 on the site sketch.
7. Determine the area of watershed contributing water to the buffer area. Note this as Area 3 on the site sketch.
8. Determine the distance from the EoT to the WoC. Note that the EoT and the WoC could be the same point and therefore the distance would be zero.
9. Break watershed into the following areas:
    a. Feedlot area.
    b. Roof area from which rain falls directly on the feedlot.
    c. Tributary area, Area 2. (Clean water that runs across feedlot.)
    d. Buffer area. (Flat vegetated area where runoff water receives treatment).
    e. Adjacent area, Area 3. (Clean water that does not cross the feedlot but does run through the buffer area.)
10. Determine the vegetative cover for Area 2 and Area 3. If the area is farmland, use the typical crop <u>rotation</u>:
    a. Row Crop Contour or Straight rotation (e.g. corn-soybeans)
    b. Small Grain Contour or Straight rotation (e.g. continuous wheat)
    c. Alfalfa Rotation (e.g. alfalfa-small grain-corn rotation)
    d. Fallow (nothing planted)
    e. Permanent Pasture or Grassland (poor, fair, or good condition during summer months)
    f. Permanent Meadow
    g. Lawn
    h. Driveway or Road
    i. General Farmstead (50% mix of lawn and gravel driveway)
    j. Woods
    k. Roof

11. Determine the hydrologic soil group for the Area 2 and Area 3. Choices are A, B, C and D. This information is found in local soils maps. (NOTE-Sometimes there are more than one hydrologic soil group. Use the driest choice (e.g., given a choice of C or D, use C since D soils are wetter than C soils).
12. Gather the following information on the buffer:
    a. Vegetative cover (same list as given in #10)
    b. Hydrologic Group (A, B, C, or D)
    c. The length and width, in feet, and the slope, in percent, of each buffer section. A new buffer section is defined by a different cover type or change in slope.

MinnFARM Data Input Sheet

Farm Name_____ **Date of Visit** _____

Address/phone _____ **Evaluator** _____

Date of site visit _____ **County** _____

Feedlot Information

Sub-lot 1_____ Snow removal?_____

Lot size = _____ ac/ft2 % paved = _____ Scrapes lot every _____days Lot slope = _____%

	Spring (Apr/May)			Summer (Jun-Aug)			Fall (Sept/Oct)			Winter (Nov-Mar)		
Animal Type	#	Lbs	Hr/day	#	Lbs	Hr/day	#	Lbs	Hr/day	#	Lbs	Hr/day

Sub-lot 2_____

Lot size = _____ ac/ft2 % paved = _____ Scrapes lot every _____days Lot slope = _____%

	Spring (Apr/May)			Summer (Jun-Aug)			Fall (Sept/Oct)			Winter (Nov-Mar)		
Animal Type	#	Lbs	Hr/day	#	Lbs	Hr/day	#	Lbs	Hr/day	#	Lbs	Hr/day

Sub-lot 3_____

Lot size = _____ ac/ft2 % paved = _____ Scrapes lot every _____days Lot slope = _____%

	Spring (Apr/May)			Summer (Jun-Aug)			Fall (Sept/Oct)			Winter (Nov-Mar)		
Animal Type	#	Lbs	Hr/day	#	Lbs	Hr/day	#	Lbs	Hr/day	#	Lbs	Hr/day

Sub-lot 4_____

Lot size = _____ ac/ft2 % paved = _____ Scrapes lot every _____days Lot slope = _____%

	Spring (Apr/May)			Summer (Jun-Aug)			Fall (Sept/Oct)			Winter (Nov-Mar)		
Animal Type	#	Lbs	Hr/day	#	Lbs	Hr/day	#	Lbs	Hr/day	#	Lbs	Hr/day

MinnFARM Data Input Sheet (Page 2)

Runoff Data Input

Area 2 or area contributing clean water to the feedlot

Roof Area _____ sq ft or acres

	Area	Units	Cover type or rotation	Soil Type	Hydro Group
2a		Acres or sq ft			
2b		Acres or sq ft			
2c		Acres or sq ft			
2d		Acres or sq ft			
2e		Acres or sq ft			
2f		Acres or sq ft			

Buffer Area

	Length (ft)	Width (ft)	Slope (%)	Cover Type/Rotation	Soil Type	Hydro Group
Ba						
Bb						
Bc						
Bd						

Area 3 or area contributing clean water to the buffer

	Area	Units	Cover type or rotation	Soil Type	Hydro Group
3a		Acres or sq ft			
3b		Acres or sq ft			
3c		Acres or sq ft			
3d		Acres or sq ft			
3e		Acres or sq ft			
3f		Acres or sq ft			

Receiving Water Input

Is this feedlot in a TMDL designated area? _____If so, What type of TMDL? _____

What is the End of Treatment for this runoff? (Marked Int. Stream, Property Boundary, Road Ditch, or WoC)

What is the final Water of Concern? (Lake, River or Stream, Drainage Ditch, Public Wetland, Non-public Wetland, Sinkhole). Does the runoff enter a lake within the same minor watershed N or Y name of lake _____

What is the distance from End of Treatment (EoT) to the Water of Concern (WoC)? _____ miles or feet

Other Comments? _____

_____

Data Entry

The EXCEL worksheet is similar to the data collection form. All data is entered in the EXCEL workbook worksheet marked “INPUT”. Note that there is no particular order for entering the data but make sure that no data remains from previous MinnFARM runs. It advised to keep the original MinnFARM file as a template and rename it for every farm. The soil database is also entered on a site specific basis which also makes the use of a template very valuable.

Brief Explanation of Data Inputs:

Farm Information:	Enter the farm name and address for future reference along with the date of the evaluation and the name of the evaluator.
County:	Use the drop down menu to select the county where the feedlot is located. This provides the rainfall data used in the model.
Animals the Same?:	Are the animal numbers the same all year. If so, click **YES**. This will shade all of the seasons except the spring (April-May that will now be listed as “Average Annual Numbers”). If not, click **NO** which will allow entry of different animal types, weights and numbers by season.
Sub-lots 1-4:	This entry is the area of the feedlot subject to direct rainfall. This entry may be in acres or square feet. This feedlot can be broken into sub-feedlots provided these lots have the same Area 2, Area 3 and buffer. These sub-lots are divided by fences and have different management practices, different animal numbers, or different concrete areas.
% Paved:	This entry is an estimate of the amount of concrete (or other impermeable surface) on the lot. Note that “Percent Paved” is entered for each sub-lot.
Scrapes lot every:	This is the cleaning frequency for the concrete portion of the lot listed in days. Do not enter a cleaning frequency for the earthen portion of the lot. This cleaning frequency is for each sub-lot.
% Slope:	Enter the average slope on the sub-lot.
Snow Removed feedlot:	Enter the average percent of annual snowfall removed from all of the sub-lots. Understandably, this is a difficult value

	to estimate. If it is common practice to remove all snow from large snowfall events use 60%.
Snow removed Area 2:	Input the average percent of annual snowfall removed from Area 2. If it is common practice to remove snow only from large snowfall events use 60%.
Animals:	Animal type refers to animals on the feedlot of the same species and average maximum weight. This is the typical maximum number of animals that could be found on the lot at any time during the specific season. Also, provide the average weights of the animals and the average hours per day on the lot.
Area 2-Roof:	This entry is the area of roof that contributes runoff directly onto the feedlot. This entry may be in acres or square feet.
Area 2 Information:	This area is also known as the tributary area and is the area whose runoff flows across the feedlot and mixes with direct rainfall and runoff on the feedlot. This area includes roof areas that do not contribute runoff directly onto the feedlot (roof water that falls directly on to the feedlot is entered in the previous step) or to Area 3, the adjacent area. This entry is in acres or square feet. Up to six contributing areas may be entered. Also, enter the cover type, the soil type, and the hydrologic group (A, B, C, or D) for each Area 2.
Buffer Information:	Enter the buffer length and width (feet), average buffer slope (%), cover type, soil type, and hydrologic group.
Area 3 Information:	This area is also known as the adjacent area and is the remaining watershed area to the discharge point, not including the feedlot, buffer, or tributary areas. This area does not include the buffer area. This entry may be in acres or square feet. Up to six areas may be entered. Note that Area 3 can significantly alter the results of the model run. Therefore, it is recommended that large Area 3's be used with caution. Also, enter the cover type, soil type, and hydrologic group for each Area 3.
EoT:	End of Treatment: Point at which runoff from the feedlot and buffer area either enters a road ditch, crosses a property boundary, enters a mapped intermittent stream, or a Water of Concern (WoC). The EoT can be the same point as the WoC.

WoC:	Water of Concern: The point at which the runoff from the feedlot enters a water that sustains aquatic life. These are Lakes, Streams or Rivers, Drainage Ditches, Tile lines, and Type 3, 4, or 5 wetlands (public wetlands), non-public wetlands, or sinkholes with a direct connection to groundwater. Type 2 wetlands (non-public wetlands) could also be a water of concern on case by case basis. Note also if the streams, drainage ditches, or tile lines transport the water to a lake within the minor watershed.

Definition of Worksheets

Introduction tab: A worksheet containing a brief discuss of the model and worksheet definitions.

INPUT &OUTPUT tab: All inputs are made on this page. This includes feedlot information and buffer information along with information on the EoT and WoC. Some cells have red triangles that indicate a comment or clarification for the particular input. Sliding your cursor over the triangle will make the comment appear.

The third page of this worksheet summarizes the output or results of the model run. Outputs include summary data for the farm, the seasonal and annual loadings for all the pollutants at the WoC, the INDEX, the FLEval rating – a similar rating as would be calculated using FLEval 1.08, and a **DRAFT** MPCA regulatory indicator based on BOD loading.

Combined Lots tab: This worksheet is used when there are multiple feedlots on the same site and there is a need to determine some indication of compliance with the regulatory standard. Enter the BOD and P loading from each of the feedlots along with the allowable load limits. The spreadsheet will calculate the combined compliance indicator. Not this will not determine a combined INDEX value.

Soils tab: This data table allows for the user to input up to 155 different soil types. The recommended inputs on this page are the specific soil names, numbers and hydrologic groups in the geographic area where the user is working. These inputs are linked to the INPUT tab soil type selection. Once the soil information is input it is recommended that the entire spreadsheet be saved as a template file such as MinnFARM Template Stearns.xls and used as the template for future MinnFARM runs in the area.

Standard Values tab: This worksheet provides a summary of the default values used in the current version of the model.

Designated Storm tab: This worksheet is used for designing buffers and allows a user to evaluate runoff from a specific rainfall event. The user inputs a specific 24-hr storm rainfall and the model will determine the depth of flow in the buffers as per the data entered in the INPUT & OUTPUT tab of the model. The user also can input the % of the pollutant that is soluble, the duration of the peak flow during the storm, and the % of the total volume of rainfall occurring during this time period. These inputs do not affect the main calculations in the model. The purple shaded boxes reflect the

current settings in the model. The model outputs the pollutant reductions for this specific storm event based on these inputs.

Revisions tab: This worksheet describes all of the revisions made to the model since the release Version 1.0 and the impact these changes have on the model results.

Definitions and Clarifications

INPUT & OUTPUT Worksheet

Farm and Date Information

The first inputs asked for in the model are the farm name and address along with the date of the evaluation and the name of the evaluator. This information is useful for future reference and is listed on the Summary Output at the bottom of the worksheet.

Are animals the same all year?

The MinnFARM model recognizes that farm management may result in animal numbers and weights on a particular feedlot that may change considerably over the course of the year. The model is set up to handle these changes on a seasonal basis with the seasons designated as Spring (April and May), Summer (June through August), Fall (September and October), and Winter (November through March).

This first question refers specifically to the animal numbers changing seasonally on the farm but also to the general management and operation of the feedlot throughout the year. In most cases the average animal numbers and weights on the feedlots will remain fairly constant (typical variation of less than 25%) throughout the year. If this is the case, this first question should be answered "YES." By answering "YES", the input boxes for the Summer, Fall, and Winter seasons will be shaded and any information that is in these boxes will be ignored by the model calculations. The "Spring (April-May)" Label will change to "Average Annual Numbers" and the input boxes in this section of the page will be un-shaded. Input the average annual animal types, numbers, and weights in these cells as per instructions below. Although the other input boxes will be shaded and any numbers in the cells ignored, the information will still be legible on the printout. Therefore to avoid confusion, all numbers in these shaded boxes should be deleted. It is best to start each model run with a blank template.

If the animal numbers or animal management change significantly during the year, such as with pasture systems where animals are only on the lots during the winter or winter and spring, the first question should be toggled to "NO." This will allow seasonal entry for animal numbers, animal weights and time on lot. Note that this toggle to "NO" affects all the sub-lots. For instance, if there are two sub-lots and one was managed the same throughout the year and one was managed differently throughout the year the question would be answered "NO" and the seasonal information must be input for both of the sub-lots.

Feedlots and Sub-lots

Feedlots are defined as the area where the animals are confined and where there is no roof or permanent vegetation. The feedlot contributes runoff water to a single buffer area

and a point or area with recognized as the same End of Treatment (EoT). The feedlot can be broken into sub-lots with each sub-lot defined by a specific management practice or group of animals. Typically the sub-lots are fenced areas within the main feedlot with different animal numbers, animal weights, or animal time on lot. Each sub-lot can have mixed species, different animal weights, and different times on the lot. The user can define up to four distinct animal groups for each sub-lot. Note that for each sub-lot the animal species, weights or time on the lot can change seasonally. This is especially relevant for pasture systems where the animals are moved off the feedlot for part of the year. In such cases, the question posed on the INPUT tab of the spreadsheet "Are the animal numbers the same all year?" should be toggled to "NO". This allows for individual input for each season of the year. Note that if this is toggled to "NO" all of the sub-lots must be filled in for all seasons even if the animal numbers stay the same on these other lots.

Sub-Lot Characteristics

Lot Area

The area of the sub-lot can be input in either acres or square feet (ft^2). This area is defined as the confined area where manure accumulates and is exposed to rainfall and subsequent runoff. These lots can have a dirt or concrete base. An area with vegetation (a pasture area) is not considered a feedlot or sub-lot. At some farms there are large, fenced, open areas with some vegetation and some dirt. This often occurs when there is a designated feeding area but the confined area is very large and allows for pasture grazing. In such cases, the dirt area (manured area) is the area defined as the sub-lot. Animal lanes are not typically considered a sub-lot or part of a sub-lot. Although there may be no vegetation in these areas due to heavy animal traffic, the amount of manure distributed on this area is minimal as compared with feedlots or feeding areas.

% Paved

Lots can have a base of concrete, blacktop, dirt, or other material. Paved areas can be cleaned easily and thoroughly which can result in reducing the amount of manure available for runoff. Dirt lots can not be cleaned as well but also allow for more of a rainfall event to be stored on the lot so during small rainfall events, there is less runoff. Both of these factors are considered in the model. This input asks for the % of the sub-lot that is paved. Note that the % paved is evaluated on a sub-lot by sub-lot basis.

Cleaning Frequency

As indicated above, if manure is removed from a lot, there is less manure available for runoff. However, credit for lot cleaning is only given to concrete lots. The cleaning frequency requested as an input value is the number of days between lot cleanings and pertains only to the concrete portion of the lot. Depending on the animal numbers and frequency of cleaning the amount of pollution leaving the lot could be reduced.

Slope

Each sub-lot can have its own slope and % of concrete and cleaning frequency. The slope is the average slope for the sub-lot. Increasing the slope will increase the amount of runoff from the lot only if the lot is a dirt. It is assumed that both flat and sloped concrete lots will have the same amount of runoff.

Note: A heavily bedded lot may result in less runoff from the lot due to the absorption of rainwater. Currently, no factors are included in the model to specifically address this issue.

Percent Snow Removal

The model includes calculations for pollutant runoff during the spring snowmelt. However, it is also understood that some farm management includes snow removal from the feedlots or from Area 2 (see definition below). Removal of this snow will reduce the amount of snowmelt runoff thereby reducing the annual pollutant load coming from the feedlot. Determining the annual average % of snow removed can only be done on a very general basis. Discussions with the farmer will provide information on general snow removal practices. Often, snow will be removed only if there is a large snow fall event. The recommended input value for this practice would be 60%. Note that if credit is given for snow removal, the snow must be moved to a location where the snow pile runoff will not flow through the feedlot. These input boxes are located on the top right of the spreadsheet just above the "Winter" input cells.

Type of Animal, Animal Numbers, Animal Weight, Time on Lot

For each sub-lot there can be up to four different types, sizes, or management of animals. For each type of animal there can be seasonal changes in animal numbers, average animal weight, and management practices. The model allows for input of these parameters.

Type of animal

Use the drop down menus to most accurately reflect the type of animal on each sub-lot. Current available animal types are "Beef Steer", "Beef Cow", "Dairy Heifer", "Dairy Cow", "Dairy Young Stock", "Horse", "Swine", "Sheep", "Llama", "Buffalo" and "Elk". If the animal type is not represented in the drop down menu, use the term "Other." This "Other" should be described in the notes section at the bottom of the INPUT & OUTPUT page. The model uses the animal type and animal weight to determine the amount of manure and manure nutrients excreted. If the term "None" is used, the model will not recognize any of the subsequent entries of animal number, animal weight, or time on lot.

Number of animals

Often the animal numbers on a particular sub-lot change throughout the year or throughout a season. This input value is the average number of animals at any one particular time on the sub-lot. If these numbers change significantly throughout the year then the box indicating "Are animal numbers the same all year" should be toggled to "NO". In this case, each season will need to have inputs for average animal numbers. Significant changes in animal numbers means that the numbers, weights, or time on lot vary more than 25% throughout the year.

Average animal weight

For each animal type listed there must be a corresponding average animal weight. This animal weight is an average for the specific animal group for the season or for the year.

For instance, on a beef lot the steers will add weight throughout the season and throughout the year. Depending on management, the animals could stay on the same sub-lot throughout the year which would result in a large variation in weights throughout the year. For such a lot management the use of "Animals the same all year" should be toggled to "NO" and the average seasonal weights adjusted. Other management on beef lots moves similar numbers and weights of animals through the lot on a recurrent basis. If this is the case, the question "Are animal numbers the same all year?" should be toggled to "Yes". The average weight for this group would then be the average annual weight.

Average number of hours per day on the lot

Feedlots can be managed in many different ways. Some lots are used for exercise lots with animals only on the lot for a few hours each day. Some lots are managed so the animals are on the lot 24 hours each day. Some feedlots allow animal free access to both a roofed area and an outdoor lot.

The "Time on lot" input refers to the average amount of time the animals are actually on the lot and contributing manure to the lot on a daily basis. If there are times of the year when no animals are on the lot then the "Animals the same all Year?" should be toggled to "YES" and the numbers input accordingly. For open systems where animals have access to both outdoor and indoor areas the amount of time spent on the lot is assumed to be the fraction of the confinement area exposed to rainfall and runoff. For instance, if the animals are in a confined area of 400 ft^2 and one-quarter of the area is covered by a roof, the sub-lot area would be defined as 300 ft^2 and the time on lot would be 75%. In some cases, animals have free access to a vegetated pasture area but there is also a main feeding area where most of the manure accumulates and where there is no vegetation. In this case, the sub-lot is defined as the dirt area where the manure accumulates.

The time on lot is defined as the estimate of how much time the animals are actually on the feeding area or better, an estimate of how much of the total manure is deposited in this area. Often during feeding the animals are excreting manure, so although the time feeding might only be 2 hours per day the actual fraction of manure deposited on this feeding area is much higher – possibly up to 75% of the manure excreted or the equivalent of 18 hours on the lot. A visual estimate of the manure accumulation will help with this assessment. If the manure pack is quite heavy a larger estimate of time on lot should be input into the model.

Animal Unit Density (AUD)

The Animal Unit Density (AUD) is a function of the animal species, animal weight, animal time on lot, cleaning frequency, and the size of the lot. This is an internal calculation in the model that estimates the average manure cover on the lot. The output of this value (shaded in purple) is provided to users as a indicator of how changes in the model input parameters impact the results of the model. If the AUD is equal to any value greater than 100, it is assumed that the lot is 100% covered with manure. This is indicated on the INPUT worksheet by the purple shaded value AUD=XX. If this value is over 100, the lot has a maximum pollution potential for the given size of lot. For instance, if the AUD is equal to 150 and some additional cleaning of the lot brings the AUD to 110 there will be no changes in the pollutant potential from the lot. The only reductions will come if the AUD is reduced to some value less than 100. An AUD of 50 indicates that the

specific lot area will contribute 50% fewer pollutants as the same size lot with an AUD of 100 or greater. A visual estimate will verify if the AUD value is correct. If there is little manure accumulation yet the AUD is 100 or more, it is possible that the time on lot, animal numbers, or animal weights are not being appropriately assigned. For instance, a lot that is visually only half covered in manure should have an AUD of approximately 50.

Area 2

During rainfall events runoff water will be generated from all land areas and roofs. Those areas that are upslope of the feedlot and whose runoff water passes through some portion of the feedlot are defined in the model as "Area 2". The model allows the user to define up to six different contributing areas (Area 2s) along with an additional input for total roof area. This single "roof area" is typically the roof area that contributes rainfall directly on the feedlot. However, roofs can be listed in either the single roof area input or can be listed as one of the Area 2 inputs. Different Area 2's defined by different vegetative cover or soil hydrologic group (see definitions below) and can be input on a per acre basis or a per square foot basis. MinnFARM assumes that any water running across the feedlot from these areas moves additional nutrients off the feedlot in the runoff water. As such, decreasing Area 2 through diversions or other means will reduce the annual loading from the lot. This in turn will likely reduce the INDEX value.

Cover Type, Soils, and Hydrologic Group

The model uses the NRCS Curve Number (CN) method to estimate runoff amounts from the feedlot, Area 2, Area 3, and buffer. This runoff estimation method requires the input of the vegetative cover, the soil hydrologic group and the land area.

Cover Type

In general, increasing the amount of vegetation decreases the amount of runoff. This cover type choice should reflect the vegetation that will be present during the **summer growing season**. The model choices are "Row Crop" rotations (e.g. corn/soybean), "Alfalfa" rotations (e.g. alfalfa/small grain/corn) "Pasture/Grassland", "Lawn", "Driveways", "Farmstead" (a mix of driveways and lawn), "Roof", or "Woodland" areas. For those areas where there is a growing crop the input parameter should be the long term estimate of the cover crop during the growing season (summer months). The model will adjust this cover, and respective estimates of runoff, automatically for each season. See Appendix A for more discussion on Vegetative Cover designations.

Soil Type

The model requests an input for "Soil Type" for Area 2, Area 3 and the buffer area. Although the actual soil type name or number is not used for any of the model calculations, it is important to document this information for future reference. "Soil type" is a drop down menu defined by the user. To change these values in the drop down menu, the user must initially customize the spreadsheet by opening the "Soil Types" worksheet and input the soil types for their particular county or geographic area. This input is in the first column (highlighted in yellow.) The model allows the entry of 155 different soil types. These entries can include both the soil name and soil number along with the hydrologic grouping. This information is found in local soils maps. This soil information

can also be copied in from other spreadsheets. It is suggested that these values are input into a template MinnFARM version specific for the user and that this template be used for all subsequent MinnFARM runs.

Hydrologic Group

As noted, the amount of runoff from a particular area is a function of the vegetative cover but is also a function of the soil properties, mainly the ability of the soil to absorb moisture. This soil parameter is defined as the soil hydrologic group with choices A, B, C, and D. A is the soil type with the highest ability to absorb moisture (sandier soils) and D has the lowest ability to absorb moisture (heavy clays). As such, selecting "Hydro Group A" for a specific area will result in much less runoff than the selection of "Hydro Group B". These values for hydrologic groupings are found in soils maps and are related to the soil type. A soil hydrologic group must be entered for all Area 2, Area 3, and Buffer areas. See Appendix A for more detailed definitions of hydrologic groupings.

Buffers and Buffer Delineation

Buffers are defined as any area downstream of the feedlot prior to the End of Treatment (as defined below). Typically, this area is thought of as flat and vegetated. However, neither of these criteria for a buffer are required for defining the buffer in MinnFARM. Rather, the buffer is any area between the end of the feedlot and the EoT and can include areas that would have channelized flow during rainfall events.

A maximum of four different buffers can be defined in the model. The criteria for defining these areas are vegetation changes, slope changes, soil type changes, and changes in buffer width.

As indicated above, runoff (and subsequently infiltration) is a function of the vegetative cover and the soil hydrologic group of the particular land area. As such, any changes in either of these should result in a new buffer being defined. Typically, the defined buffers have dramatic visual changes in vegetation, for instance, moving from permanent meadow to cropland. It is unlikely that the soil hydrologic group would change within an area of similar vegetation. Small changes in vegetation could also indicate an additional buffer area. Note that the assigned vegetative cover (land use) should be the cover that is present **during the growing season**. This may be difficult to assess when evaluating a feedlot in early spring. The evaluator may have to rely on the farmer for guidance on this decision.

The slope of the buffer impacts the speed at which the runoff water flows. This in turn impacts the amount of pollutants that are trapped in the vegetation. Therefore, if there are no changes in vegetation but changes in slope a new buffer could be defined. Another reasonable option where there are no dramatic changes in vegetation but some change in slope is to indicate only one buffer but use the average slope. This slope can be measured with a hand level, clinometer, or laser level.

The length of buffer impacts the amount of pollutant infiltration and filtration. The buffer length is easily determined through standard distance measurements using a measuring wheel, pacing, cloth tape, or a GPS system.

Buffer width also impacts the infiltration of the runoff and the filtration of the pollutants. Narrower buffers have less infiltration area. In addition, depth of flow through these narrow buffers can become quite significant during large rainfall events. Higher depths of flow reduce the filtration capacity of the buffer. However during small storms even a narrow buffer can have a low flow depth and serve to filter pollutants. The model uses the width dimension to calculate the infiltration and filtration of the pollutants, thus limiting the effectiveness of the buffer during large rainfall events where there is a higher flow depth that limits filtration.

Buffer width is defined as the width of the buffer where the change in elevation across the buffer exceeds three inches. In conducting this evaluation, minor superficial changes in elevation should be neglected such as hoof imprints and small soil ridges. Figure 1 provides a visual of this measurement.

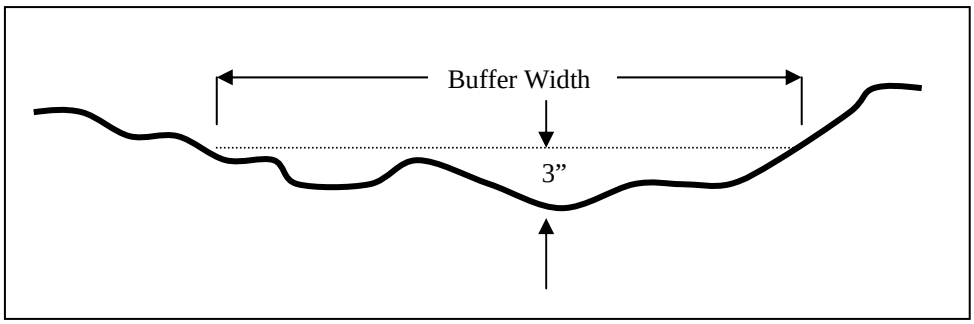


Figure 1. Buffer width determination

Many buffers are rectangular so the flow direction, length and width are easy to determine and the delineation of additional buffers is straightforward. However, there are other sites where the buffer area is more in the shape of a triangle or some other geometric shape with a variety of slopes and contours (Figure 2). Determination of these buffers is more challenging. In general, try to imagine the flow paths for both small runoff events and large runoff events and use average lengths, widths and slopes rather than divide the area into several smaller buffers.

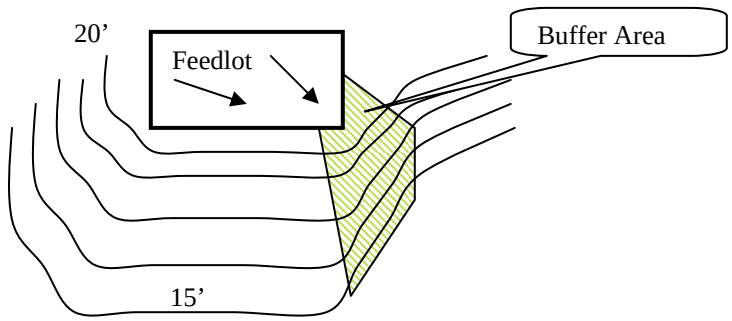


Figure 2. Irregular Shaped Buffer Area

Often there is a question of where the buffer begins. Sometimes there is good vegetation beginning at the edge of the feedlot. At other sites, the manure and dead vegetation extend beyond the edge of the confinement area because of the slopes of the feedlot thereby causing solids to flow off the lot. Another example is where there are no physical boundaries between the defined feedlot and other areas such as pastures or animal lanes. In such cases, the buffer should begin at the edge of the manure flow or where vegetation begins

Sometimes animals have not been on the feedlot for a period of time when the observer is at the site gathering data for the evaluation, for example when a feedlot has been cleaned and is waiting arrival of another group of animals. In these cases, it is important to observe how the buffer has been functioning. In the area adjacent and below the feedlot, where manure deposition on the buffer is obvious, the buffer is probably not functioning.

Area 3 (Adjacent Area)

Area 3 is defined as the area adjacent to the buffer area that contributes runoff to the buffer between the edge of the feedlot and the EoT. Note that the buffer is not part of Area 3.

Because Area 3 adds to the total runoff volume but very little to the pollutant load, additional Area 3 will decrease the concentrations of the pollutants at the EoT. Area 3 does not increase the load from the feedlot but may reduce the efficiency of the buffer area because of the increased depth of flow in the buffer resulting from the additional water. Area 3 will reduce the pollutant concentration at the EoT because of the dilution effect.

Realistically, the timing of the feedlot runoff and the timing of the Area 3 runoff will likely not coincide with each other – especially with large Area 3’s. As such, the model is currently recommends that Area 3 be limited to 400 feet on either side of the buffer. The model calculates the theoretical maximum Area 3 that should be included in the model. This calculation is reported on the INPUT & OUTPUT sheet just to the right of the Area 3 inputs. This calculation is the length of the buffers (in feet) multiplied by 800 feet (400 feet on either side of the buffer). Although the model does not limit the size of Area 3, the

recommended maximum Area 3 should be adhered to unless a justification can be made otherwise. Note that Area 3 will have no impact on the draft MPCA compliance value, a slight influence on the INDEX value but could have a dramatic effect on the FLEval rating.

Receiving Water Information

The MinnFARM model calculates the annual loading at the end of the buffer area for phosphorus (P), chemical oxygen demand (COD) biological oxygen demand (BOD_5), Total Kjeldahl Nitrogen (TKN) and fecal coliform bacteria for a given feedlot. This information is provided on the results summary on the bottom of the INPUT & OUTPUT worksheet. In addition to this estimate, the model assesses the relative pollution potential for the site. This relative pollution potential includes this annual pollutant loading along with the potential for high concentrations of organic material (high BOD_5 concentrations), the quality of receiving water for this runoff and the distance from this final receiving water. The following questions are used to consider this pollution potential ranking.

Is the Area in a TMDL Area?

Minnesota is in the process of evaluating impaired waters. If the feedlot in question is in an area under investigation (noted as a Total Maximum Daily Load or TMDL area) other criteria for pollution potential may exist. A feedlot in a TMDL area may or may not include a requirement for a MinnFARM evaluation.

What is the End of Treatment (EoT)

The EoT is that point at which runoff from the feedlot and buffer area enters a road ditch, crosses a property boundary, enters a mapped intermittent stream, or enters a Water of Concern (WoC). At times, runoff from the buffer will directly enter a WoC which means the EoT is the WoC and should be noted as such. Use the drop down menu to describe the EoT.

Water of Concern (WoC)

The WoC is the point at which the runoff from the feedlot enters waters that sustain aquatic life. These are Lakes (25 acres or more of open water), perennial streams[a], drainage ditches[b], and public[c] or non-public[d] wetlands, or sinkhole with direct connection to groundwater. Type 2 wetlands may be considered a WoC on case by case basis. Use the drop down menu to describe the WoC. Note that if the WoC is a perennial stream, ditch, or tile line, there is additional differentiation to document if the stream, ditch or tile line transports water to a lake within the same minor watershed[e] as the feedlot. Those feedlots that have a lake in the same minor watershed will have a higher index rating than those with no lake in the minor watershed.

> [a]**Perennial Stream:** Flowing stream supporting aquatic life (including aquatic vegetation). This could include a drainage ditch. Such streams are typically depicted on a U.S.G.S. topographic map as a solid blue line.
>
> [b]**Drainage Ditch:** Drainage ditches may be classified as a perennial stream if they sustain aquatic life throughout the year. Other drainage ditches may contain significant amounts of water only during rainfall events. Some user discretion is required to determine if the prioritization of a drainage ditch or a perennial stream.

[c]**Public Waters Wetlands:** "Public waters wetlands" means all types 3, 4, and 5 wetlands, as defined in United States Fish and Wildlife Service Circular No. 39 (1971 edition), not included within the definition of public waters, that are ten or more acres in size in unincorporated areas or 2-1/2 or more acres in incorporated areas. (103G.005 subd. 15a). Maps of public waters wetlands and other public waters can be found at *www.dnr.state.mn.us/waters/watermanagement_section/pwi* Note: Public waters are sometimes referred to as DNR protected waters.

[d]**Non Public Water Wetland:** All other wetlands that are considered to be a water of the state, but do not meet the definition of public waters wetlands. Note: Type II wetlands which normally sustain water for long enough periods of time to be considered a pond or marsh are also included as a water of the state.

[e]**Minor Watershed:** The DNR Minor Watershed Code (minor5) is a five-digit number consisting of the two-digit DNR major watershed code and a three-digit DNR minor watershed number. The numbers yyy are unique within each major watershed. The DNR 'Minnesota Watersheds' GIS file (last revised 99) contains DNR minor watershed delineations, numbers, and names. *http://www.gis.state.mn.us/committe/hydro/watershed_standard_final.html* *http://water.usgs.gov/wsc/* for locating and identification of watersheds.

Distance between EoT and WoC?

As the distance between the EoT and WoC increases, the anticipated pollution potential from the feedlot decreases. This distance can be measured or can be estimated from maps.

Other Comments

This space allows the evaluator to keep track of any other observations on the site that may be useful in the documentation process such as future plans for the farm or some justification for some of the inputs in the model.

MODEL OUTPUT

Model results or outputs are shown at the bottom of the INPUT & OUTPUT page. Combining the feedlot inputs and model results is useful for reporting and recordkeeping. When the INPUT & OUTPUT page is printed these results are on printed on the third page.

Site Summary

The site summary provides a recap of the information input into the model along. In addition, the model calculates and reports the ratio of buffer area to feedlot area. For good buffer treatment it is suggested that this value be 0.5 or greater. This ratio of 0.5 is sometime used in the buffer design criteria.

Receiving Water Summary

This is a also a summary of inputs from above listing if the feedlot is in a TMDL area and what was defined as the EoT and WoC along with the distance between the two. This information is helpful as a double check on the inputs.

Seasonal Runoff Summary

Both seasonal and annual runoff volumes (acre-inches) are reported both at the feedlot edge and at the EoT.

Pollutant loading for COD, Total P, Total N, fecal colliforms, and BOD_5 is reported in a table format. Calculations for these loadings and are based on the number and probability of loading from several different sized storm events throughout a year.

Minnesota Pollution Control Agency Compliance

Currently the Minnesota regulatory standards for runoff from feedlots reference a BOD concentration standard used to regulate point source pollution. This standard (7050.0215 and 7020.2003) limits discharges from non-CAFO units to a monthly average BOD concentration after treatment to 25 mg/L. Because sampling runoff effluent from feedlots is not practical or feasible the MPCA has encouraged the use of computer modeling as a means of evaluating the potential for a feedlot to achieve compliance. In the past, the indicator of feedlot compliance was based on FLEval (a computer model) that estimated the concentration of BOD in feedlot runoff from a 25 yr-24 hr storm. A feedlot was in compliance when the predicted concentration from this runoff event was less than 25 mg/L. Using MinnFARM, which calculates annual load from the feedlot, the compliance indicator changed to a load limit of BOD or P, depending on the type of receiving water. This compliance indicator where the runoff is going to a lake is no more than 2 lbs of P plus 0.01 lbs per 1000 lbs of animal unit on the feedlot up to a maximum of 5 lbs. When the runoff is not going to a lake, the compliance indicator is a maximum of 50 lbs of BOD plus 0.25 lbs per 1000 lbs of animal on the feedlot up to a maximum of 125 lbs. The compliance indicator load limit for the lot is displayed in the output in a grey shaded

box to the right of the predicted annual load for the lot. The statement "Does Evaluation Indicate Regulatory Compliance?" is followed by a "YES" or "NO" depending on if the predicted annual load exceeds the specific load limit. For a detailed discussion of the Minnesota regulations regarding open lots consult the most recent version of MPCA document WQ-F8-35 (http://www.pca.state.mn.us/hot/feedlots.html)

INDEX System

The INDEX value is a calculated value that considers both the pollution potential of the feedlot and the impact on the receiving water body. The INDEX uses the annual BOD_5 loading, the annual P loading, the BOD_5 concentration calculated at the EoT, the distance from the EoT to the WoC, and the type of receiving water. These INDEX values range between 1 and 100 and are meant to be used in the prioritization of feedlot pollution problems with higher INDEX values indicating a higher pollution potential. Baseline values used in the INDEX system (representing an INDEX of 100) are from a fully stocked ¾ acre dirt lot (BOD load of 570 lbs, P Load of 48 lbs, and BOD concentration of 1000 mg/l) going directly into a lake. Note that the INDEX value is **not** utilized to determine compliance with Minnesota regulatory standards. Figure 3 shows how a typical INDEX value would change based on distances from different Waters of Concern. Note that after one mile there are no further reductions in the INDEX value.

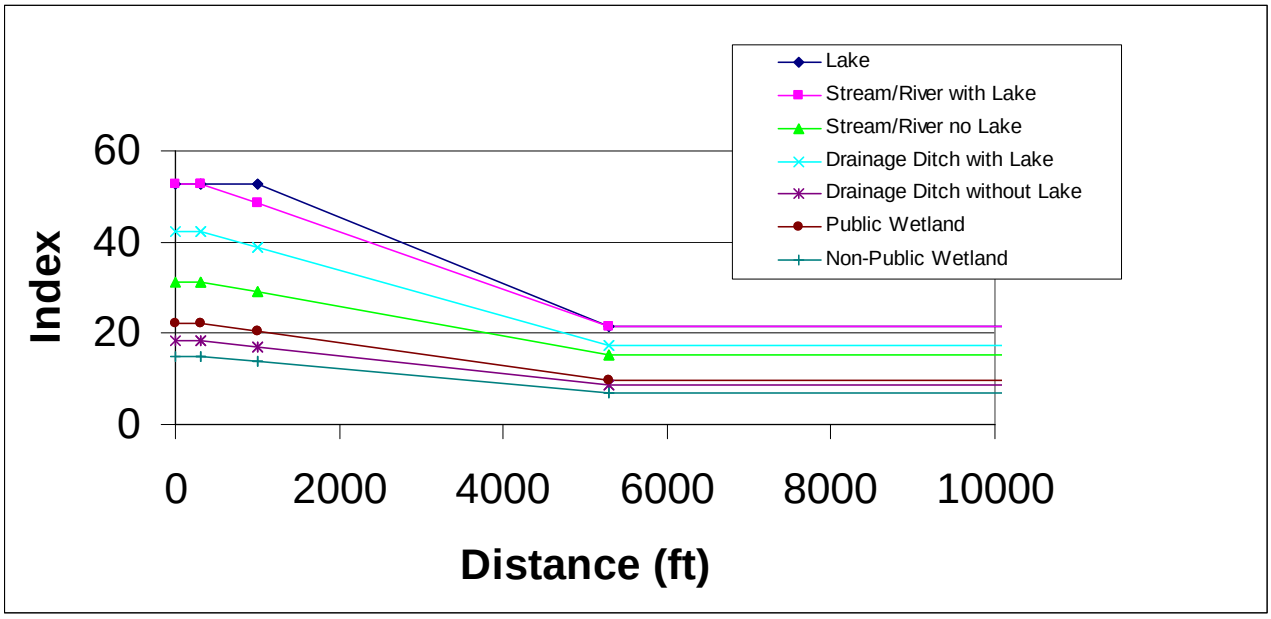


Figure 3. INDEX value as a function of distance for a simulated site.

Designated Storm Event

The Designated Storm Event worksheet is an additional tool that can be used to help evaluate the pollution potential from a feedlot, assist in the design of a vegetative buffer area or in the assessment of a constructed vegetative buffer area, or to calculate loadings and concentrations for a specific storm event. None of the inputs on this worksheet are required for the use of the MinnFARM model nor do any of these calculations or changes made on this spreadsheet impact the MinnFARM model. There are several inputs required for this page and users should be familiar with the selection of curve numbers and calculating peak flows.

The following are inputs required for using this worksheet:

- Specific storm size event that is being evaluated.
- Buffer CN value (seasonal). The model default value is provided.
- Buffer Surface Constant value (seasonal). The model default value is provided.
- Peak flow duration (hours). The model default value is provided.
- Percent of total storm volume entering the buffer during the peak flow duration. The model default value is provided.
    - Note that both the Peak flow time and the % of storm volume event are used to calculate the peak flow rate for the buffer (cfs). Vegetative filter strips are designed based on this value. If the designed cfs is known for the buffer area adjust the Peak flow time and the % of total storm event (and the storm event size) to get the spreadsheet calculated Q_{peak} to match the designed cfs.
- Percent of the nutrients that are soluble. The model default value is provided.

Event specific outputs on this page are:

- Seasonal volume of runoff from the feedlot and buffer,
- Seasonal depth of flow in the buffer,
- Percent reductions in pollutants in the buffer,
- Load and concentrations for the pollutant at the end of the buffer.

Appendix A. Vegetative Cover Determinations

Assessing the vegetative cover or land use is easy if the land it in a standard crop rotation. However, it becomes more difficult for continuously vegetative areas where the quality of the vegetation is on a continuum and changes throughout the year. There is only limited formal guidance on this assessment from the NRCS. This information is provided below and was taken from the NRCS NEH handbook.

Excerpts from
(210-VI-NEH, June 2002)
United States Department of Agriculture
Natural Resources Conservation Service
Part 630 Hydrology National Engineering Handbook

CHAPTER 7. HYDROLOGIC SOIL GROUPS

Group A: (Low runoff potential). Soils having high infiltration rates even when thoroughly wetted and consisting chiefly of deep, well to excessively drained sands or gravels. These soils have a high rate of water transmission.

Group B: Soils having moderate infiltration rates when thoroughly wetted and consisting chiefly of moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission.

Group C: Soils having slow infiltration rates when thoroughly wetted and consisting chiefly of soils with a layer that impedes down- ward movement of water, or soils with moderately fine to fine texture. These soils have a slow rate of water transmission.

Group D: (High runoff potential). Soils having very slow infiltration rates when thoroughly wetted and consisting chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface, and shallow soils over nearly impervious material. These soils **have** a very slow rate of water transmission.

CHAPTER 8 LAND USE AND TREATMENT CLASSES

630.0801 Classification of land use and treatment

In the Natural Resources Conservation Service (NRCS) method of runoff estimation, the effects of the surface conditions of a watershed are evaluated by means of land use and treatment classes. *Land use* is the watershed cover and includes every kind of vegetation, litter and mulch, fallow, and bare soil as well as nonagricultural uses, such as water surface (lakes, swamps) and impervious surfaces (roads, roofs). *Land treatment* applies mainly to agricultural land uses and includes mechanical practices, such as contouring or terracing, and management practices, such as grazing control or rotation of crops. The *classes* consist of use and treatment combinations that actually occur on watersheds.

Land use and treatment classes are readily obtained either by observation or by measurement of plant and litter density and extent on sample areas.

630.0802 Classes

The land uses and treatments described here are listed in NEH 630, chapter 9, table 9–1. This table also shows the runoff curve numbers (CN) for hydrologic soil cover complexes for which the hydrologic conditions are listed.

(a) Cultivated land

Fallow listed in table 9–1 is the agricultural land use and treatment with the highest potential for runoff because the land is kept as bare as possible to conserve moisture for use by a succeeding crop. The loss by runoff is offset by the gain because of reduced transpiration. Other kinds of fallow, such as stubble mulch, are not listed, but they can be evaluated by comparing their field condition with those for classes that are listed.

Row crop is any field crop (maize, sorghum, soybeans, sugarbeets, tomatoes, tulips) planted in rows far enough apart that most of the soil surface is exposed to rainfall impact throughout the growing season. At planting time the crop is equivalent to fallow and may be so again after harvest. In most evaluations the average condition when runoff occurs is assumed. Row crops are planted either in straight rows or on the contour, and they are in either a poor or a good rotation. These land treatments are described later in this chapter.

Small grain (wheat, oats, barley, flax) is planted in rows close enough that the soil surface is not exposed except during planting and shortly thereafter. Land treatments are those used with row crops.

Close-seeded or broadcast legumes or rotation meadows (alfalfa, sweetclover, timothy, and combinations of these) are either planted in close rows or broadcast. This cover may be allowed to remain for more than a year so that year-round protection is given to the soil.

Straight-row fields are those farmed in straight rows either up and down the hill or across the slope. Where land slopes are less than about 2 percent, farming across the slope in straight rows is equivalent to contouring and should be so considered when using table 9–1.

Rotations are planned sequences of crops, and their purpose is to maintain soil fertility or reduce erosion or provide an annual supply of a particular crop. Hydrologically, rotations range from poor to good in proportion to the amount of dense vegetation in the rotation, and they are evaluated in terms of hydrologic effects. *Poor rotations* are generally one crop land uses, such as continuous corn (maize) or continuous wheat or combinations of row crops, small grains, and fallow. *Good rotations* generally include alfalfa or another close-seeded legume or grass to improve tilth and increase infiltration. Their hydrologic effects may carry over into succeeding years after the crop is removed though normally

the effects are minor after the second year. The carryover effect is not considered in table 9–1.

Contoured fields are those farmed as nearly as possible on the contour. The hydrologic effect of contouring results from the surface storage provided by the furrows because the storage prolongs the time during which infiltration can take place. The magnitude of storage depends not only on the dimensions of the furrows, but also on the land slope, crop, and manner of planting and cultivation. Planting small grains or legumes on the contour makes small furrows that disappear because of climatic action during the growing season. The contour furrows used with row crops are either large when the crop is planted and made smaller by cultivation or small after planting and made larger by cultivation, depending on the type of farming. Average conditions for the growing season are used in table 9–1. The relative effects of contouring for all croplands shown in the table are based on data from experimental watersheds having slopes from 3 to 8 percent. Stripcropping is a land use and treatment not specifically shown in table 9–1 because it is a composite of uses and treatments. It is evaluated by the method of example 10–4 in chapter 10. The terraced entries in table 9–1 refer to systems that have open-end level or graded terraces, grassed waterway outlets, and contour furrows between the terraces. The hydrologic effects are due to the replacement of a low-infiltration land use by grassed waterways and to the increased opportunity for infiltration in the furrows and terraces. Closed-end level terraces, not shown in table 9–1, are evaluated by the methods in NEH 630, chapter 12. 8–3 (210-VI-NEH, June 2002)

Conservation tillage is an umbrella term used to represent specific residue management practices, such as no-till/strip-till, mulch-till, or ridge-till. These practices leave all or a portion of the previous crop's residue on the soil surface to: • reduce soil erosion caused by the forces of wind and water, • reduce surface runoff, • increase infiltration, and • reduce evaporation. *No-till* is defined as managing the amount, orientation, and distribution of crop and other plant residue on the soil surface year-round while growing crops in narrow slots or tilled or residue-free strips in soil previously untilled by full-width inversion implements. *Mulch-till* is defined as managing the amount, orientation, and distribution of crop and other plant residue on the soil surface year-round while growing crops where the entire field surface is tilled prior to planting. *Ridge-till* is defined as managing the amount, orientation, and distribution of crop and other plant residue on the soil surface year-round while growing crops on preformed ridges alternated with furrows protected by crop residue (NRCS 1999).

(b) Grassland in watersheds can be evaluated by means of the three hydrologic conditions of native pasture or range shown in table 8–1, which are based on cover effectiveness, not forage production. The percent of area covered (or density) and the intensity of grazing are visually estimated. In making the estimates, consider that grazing on any but dry soils results in lowering of infiltration rates because of compaction of the soil by hooves, an effect that may carry over for a year or more even without further grazing. An alternative system of evaluation is shown in table 8–2. In this system, density and air-dry weights of grasses and litter are used. The air-dry weights are determined by sampling. The field work can be kept to a minimum by sampling a small number of

representative sites rather than a large number of random sites. In the table the classes with plus signs are midway between adjacent classes so that the CN for these classes must be obtained by interpolation in table 9–1. Contour furrows on native pasture or range are longer lasting than those on cultivated land, their length of life being dependent on the soil, intensity of grazing, and on the density of cover. The dimensions and spacings of furrows vary with climate and topography. The CN in table 9–1 are based on data from contoured grassland watersheds in the central and southern Great Plains. Terraces are seldom used on grassland. When they are, the construction methods expose bare soils, and for 2 or 3 years the terraced grassland is more like terraced cropland in its effect on surface runoff.

Table 8–1 Classification of native pasture or range.

Vegetative Condition	**Hydrologic Condition**
Heavily Grazed – no mulch or has plant cover on <0.5 of area	Poor
Not heavily grazed – plant cover on 0.5 to 0.75 of area	Fair
Lightly grazed – plant cover on >0.75 of the area	Good

(c) Meadow is a field on which grass is continuously grown, protected from grazing, and generally mowed for hay. Drained meadows (those having a low water table) have little or no surface runoff except during storms that have a high rainfall intensity. Undrained meadows (those having a high water table) may be so wet that they are the equivalent of water surfaces in the runoff computations of chapter 10. If a wet meadow is drained, its soil-group classification as well as its land use and treatment class may change (see chapter 7 regarding the change in soil classification and/or dual hydrologic soil groups).

(d) Woods and forest Woods are usually small isolated groves of trees being raised for farm or ranch use. The woods can be evaluated as shown in table 8–3, which is based on cover effectiveness, not on timber production. The hydrologic condition is visually estimated. In areas where national or commercial forest covers a large part of a watershed, the NRCS hydrologist is guided by the letter between the Forest Service and the Soil Conservation Service dated November 8, 1954 (USDA 1954).

DO WE NEED THIS TABLE in USERS GUIDE OR NOT?? xxx

Table 9–1 Runoff curve numbers for agricultural lands [1/]

Cover description: cover type	Cover description: treatment [2/]	Cover description: hydrologic condition [3/]	CN for hydrologic soil group: A	B	C	D
Fallow	Bare Soil	---	77	86	91	94
	Crop residue cover (CR)	Poor	76	85	90	93
		Good	74	83	88	90
Row crops	Straight row (SR)	Poor	72	81	88	91
		Good	67	78	85	89
	SR + CR	Poor	71	80	87	90
		Good	64	75	82	85
	Contoured (C)	Poor	70	79	84	88
		Good	65	75	82	86
	C + CR	Poor	69	78	83	87
		Good	64	74	81	85
	Contoured & terraced (C & T)	Poor	66	74	80	82
		Good	62	71	78	81
	C & T + CR	Poor	65	73	79	81
		Good	61	70	77	80
Small grain	SR	Poor	65	76	84	88
		Good	63	75	83	87
	SR + CR	Poor	64	75	83	86
		Good	60	72	80	84
	C	Poor	63	74	82	85
		Good	61	73	81	84
	C + CR	Poor	62	73	81	84
		Good	60	72	80	83
	C & T	Poor	61	72	79	82
		Good	59	70	78	81
	C & T + CR	Poor	60	71	78	81
		Good	58	69	77	80
Close-seeded or broadcast legumes or rotation meadow	SR	Poor	66	77	85	89
		Good	58	72	81	85
	C	Poor	64	75	83	85
		Good	55	69	78	83
	C & T	Poor	63	73	80	83
		Good	51	67	76	80

See footnotes at end of table.

Table 9–1 Runoff curve numbers for agricultural lands [1/] — Continued

Cover description: covertype	treatment [2/]	hydrologic condition [3/]	CN for hydrologic soil group: A	B	C	D
Pasture, grassland, or range-continuous forage for grazing [4/]		Poor	68	79	86	89
		Fair	49	69	79	84
		Good	39	61	74	80
Meadow-continuous grass, protected from grazing and generally mowed for hay		Good	30	58	71	78
Brush-brush-forbs-grass mixture with brush the major element [5/]		Poor	48	67	77	83
		Fair	35	56	70	77
		Good	30 [6/]	48	65	73
Woods-grass combination (orchard or tree farm) [7/]		Poor	57	73	82	86
		Fair	43	65	76	82
		Good	32	58	72	79
Woods [8/]		Poor	45	66	77	83
		Fair	36	60	73	79
		Good	30	55	70	77
Farmstead--buildings, lanes, driveways, and surrounding lots		---	59	74	82	86
Roads (including right-of-way):						
Dirt		---	72	82	87	89
Gravel		---	76	85	89	91

1/ Average runoff condition, and I_a=0.2s.

2/ Crop residue cover applies only if residue is on at least 5 percent of the surface throughout the year.

3/ Hydrologic condition is based on combinations of factors that affect infiltration and runoff, including (a) density and canopy of vegetative areas, (b) amount of year-round cover, (c) amount of grass or close-seeded legumes, (d) percent of residue cover on the land surface (good ≥20%), and (e) degree of surface toughness.

Poor: Factors impair infiltration and tend to increase runoff.
Good: Factors encourage average and better then average infiltration and tend to decrease runoff.
For conservation tillage poor hydrologic condition, 5 to 20 percent of the surface is covered with residue (less than 750 pounds per acre for row crops or 300 pounds per acre for small grain).

For conservation tillage good hydrologic condition, more than 20 percent of the surface is covered with residue (greater than 750 pounds per acre for row crops or 300 pounds per acre for small grain).

4/ Poor: < 50% ground cover or heavily grazed with no mulch.
Fair: 50 to 75% ground cover and not heavily grazed.
Good: > 75% ground cover and lightly or only occasionally grazed.

5/ Poor: < 50% ground cover.
Fair: 50 to 75% ground cover.
Good: > 75% ground cover.

6/ If actual curve number is less than 30, use CN = 30 for runoff computation.

7/ CNs shown were computed for areas with 50 percent woods and 50 percent grass (pasture) cover. Other combinations of conditions may be computed from the CNs for woods and pasture.

8/ Poor: Forest litter, small trees, and brush are destroyed by heavy grazing or regular burning.
Fair: Woods are grazed, but not burned, and some forest litter covers the soil.
Good: Woods are protected from grazing, and litter and brush adequately cover the soil.