United States Department of Agriculture

Natural Resources Conservation Service

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April 30, 1998

NATIONAL ENGINEERING HANDBOOK SERIES
210-VI
AMENDMENT FL-6 (PART 651)

SUBJECT: ENG - AGRICULTURAL WASTE MANAGEMENT FIELD HANDBOOK

Purpose. To transmit Chapter 10, Appendix 10D - Geotechnical, Design, and Construction Guidelines, Chapter 15, Computer Software and Models and Florida amendments to various chapters of the Agricultural Waste Management Field Handbook (AWMFH).

Effective Date. Upon receipt.

Explanation of Changes. Chapter 10, Appendix 10D - Geotechnical, Design, and Construction Guidelines and Chapter 15 Computer Software and Models are new additions to the AWMFH. Previously issued amendments to the AWMFH have been updated to add additional guidelines and to make editorial corrections. Amendment FL-5 superceds all previously issued amendments.

Several of the AWMFH amedment changes are editorial in nature. The major changes in the enclosed amendments are as follows:

- Section 651.0103 (page FL1-5a) was amended to remind designers to check the requirements of local rules and regulations prior to the design of waste management systems and to remind the landowner to consult with state and local agencies regarding regulations.

- Section 651.1105 (page FL11-37) was amended to clarify the application of phorphorus to hydrologic soil groups B/D and B/C soils. Section 651.1105 was also amended to require the waste management system designer to advise landowners if the waste management system is designed for over application of phosphorus and possible future limitations.

- Section 651.1504 (page FL15-2) was added to include information on approved Florida software for use in designing waste management systems.

----MORE---

Filing Instructions.

Make pen and ink changes on the directive tabulation sheet.

Remove and Destory	Insert
Directive Tabulation Sheet (7/96)	Directive Tabulation Sheet (4/98)
Page FL1-i (1/95)	Page FL1-i (4/98)
Page FL1-5a (1/95)	Page FL1-5a (4/98)
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Page FL7-i (7/94)	Page FL7-i (4/98)
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---	Chapter 10, Appendix 10D - Geotechnical,
Design,	and Construction Guidelines (11/97)
Page FL10-i (7/96)	Page FL10-i (4/98)
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---	Chapter 15 Computer Software and Models
(3/96)	
---	Page FL15-i (4/98)
---	Page FL15-2 (4/98)

Jesse T. Wilson
State Conservation Engineer

Enclosure

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United States Department of Agriculture

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August 29, 2001

NATIONAL ENGINEERING HANDBOOK SERIES
210-VI
AMENDMENT FL-11 (PART 651)

SUBJECT: ENG – AGRICULTURAL WASTE MANAGEMENT FIELD HANDBOOK (AWMFH)

Purpose. To supplement Section 651.0606 "Nutrient removal by harvesting of crops" of the National Engineering Handbook Series (NEH), Part 651, AWMFH.

Effective Date. Upon receipt.

Explanation of Changes. Section FL651.0606 was revised to include information on types of data sources and proper use of data sources for developing a nutrient management plan for waste application.

The section on nutrient removal example was confusing to many users and was removed from the previous amendment.

Filing Instructions.

Remove and Destroy	Insert
Page FL6-i (4/98)	Page FL6-i (8/01)
Pages FL6-22a – FL6-22d (8/99)	Page FL6-22a – FL6-22c (8/01)

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Enclosures

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April 6, 2001

NATIONAL ENGINEERING HANDBOOK SERIES
210-VI
AMENDMENT FL-10 (PART 651)

SUBJECT: ENG – AGRICULTURAL WASTE MANAGEMENT FIELD HANDBOOK (AWMFH)

Purpose. To supplement Section 651.0704 "Site investigations for planning and design" of the National Engineering Handbook Series (NEH), Part 651, AWMFH.

Effective Date. Upon receipt.

Explanation of Changes. Section FL651.0704 was revised to include reference to the National Engineering Manual (NEM) Part 531, Geology. This supplement serves to remind those planning and designing agricultural waste management structures to follow policy on geologic investigations.

Filing Instructions.
Make pen and ink changes on the directive tabulation sheet.

Remove and Destroy	Insert
Page FL7-i (March 1999)	Page FL7-i (April 2001)
Pages FL7-20(1) – FL7-20(2) (March 1999)	Page FL7-20(1) – FL7-20(2) (April 2001)

Make pen and ink changes on the directive tabulation sheet.

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December 11, 2000

NATIONAL ENGINEERING HANDBOOK SERIES
210-VI
AMENDMENT FL-9 (PART 651)

SUBJECT: ENG – AGRICULTURAL WASTE MANAGEMENT FIELD HANDBOOK

Purpose. To supplement Section 651.96 Typical Agricultural Waste Management Systems and Section 651.0403(f) Animal waste characteristics for poultry of the National Engineering Handbook Series (NEH), Agricultural Waste Management Field Handbook (AWMFH) and to transmit amendments to various chapters of the Agricultural Waste Management Field Handbook.

Effective Date. Upon receipt.

Explanation of Changes. This supplement transmits FL651.96 which describes rotational grazing systems for nutrient removal through forage removal by grazing animals and FL 651.0403(f) which provides animal waste characteristics for poultry litter.

Additional AWMFH amendment changes are as follows:

- Removal of FL651.1004(f) Dead Swine Composting. NEH Part 637, Environmental Engineering provides information on all aspects of composting including on-farm mortality management.

- Removal of FL651.1105 Nutrient Management. Guidelines for determining limiting nutrient for waste application are addressed in NRCS conservation practice standard Nutrient Management, Code 590 (12/00).

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Filing Instructions.

Make pen and ink changes on the directive tabulation sheet.

Remove and Destroy	Insert
Page FL4-i (8/99)	Page FL4-i (12/00)
----------	Page FL4-14(1) (12/00)
----------	Page FL9-i (12/00)
----------	Page FL9-8(1) – FL9-8(4) (12/00)
Page FL10-i (4/98)	----------
Page FL10-66a – FL10-66d (4/98)	----------
Page FL11-i (8/99)	----------
Page FL11-37 – FL11-38 (8/99)	----------

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Enclosures

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August 9, 1999

NATIONAL ENGINEERING HANDBOOK SERIES
210-VI
AMENDMENT FL-8 (PART 651)

SUBJECT: ENG - AGRICULTURAL WASTE MANAGEMENT FIELD HANDBOOK

Purpose. To supplement Section 651.0403, Animal Waste Characteristics – Beef; 651.0606 Nutrient Removal by Harvesting of Crops; and 651.1105, Nutrient Management; of the National Engineering Handbook Series, Agricultural Waste Management Field Handbook (AWMFH).

Effective Date. Upon receipt.

Explanation of Changes. This supplement transmits FL651.0403, FL651.0606 and FL651.1105.

- FL651.0403 provides animal waste characteristics for beef where grazed forage is the primary diet.
- FL651.0606 revises Table FL6-6b - Maximum Application Rates and Estimated Yields.
- FL651.1105 is revised to clarify soil limiting features for applying agricultural waste and adds a table of guidelines for determining limiting nutrient for waste application.

Filing Instructions.

Make pen and ink changes on the directive tabulation sheet.

Remove and Destroy	Insert
Page FL4-i (4/98)	Page FL4-i (8/99)
------	Page FL4-10a (8/99)
Page FL6-22a – FL6-22d (4/98)	Page FL6-22a – FL6-22d (8/99)
Page FL11-i (4/98)	Page FL11-i (8/99)
Page FL11-36 (4/98)	Page FL11-36 – FL11-37 (8/99)

Jesse T. Wilson
State Conservation Engineer

Enclosure

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United States Department of Agriculture

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March 25, 1999

NATIONAL ENGINEERING HANDBOOK SERIES
210-VI
AMENDMENT FL-7 (PART 651)

SUBJECT: ENG - AGRICULTURAL WASTE MANAGEMENT FIELD HANDBOOK

Purpose. To supplement Section 651.0704 Geologic and Ground Water Considerations, of the National Engineering Handbook Series, Agricultural Waste Management Field Handbook (AWMFH).

Effective Date. Upon receipt.

Explanation of Changes. This supplement transmits FL651.0704. FL651.0704 is revised to include changes in the revision to Chapter 7 of the AWMFH and to clarify requirements for geologic investigations in high risk areas.

Filing Instructions.

Make pen and ink changes on the directive tabulation sheet.

Remove and Destory	Insert
Page FL7-i (4/98)	Page FL7-i (3/99)
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Enclosure

DIST: AWMFH

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February 19, 2004

NATIONAL ENGINEERING HANDBOOK SERIES
210-VI
AMENDMENT FL-12 (PART 651)

SUBJECT: ENG – AGRICULTURAL WASTE MANAGEMENT FIELD HANDBOOK (AWMFH)

Purpose. To supplement Section 651.0606 "Nutrient removal by harvesting of crops" of the National Engineering Handbook Series (NEH), Part 651, AWMFH.

Effective Date. Upon receipt.

Explanation of Changes. Section FL651.0606 was revised to include information on continuous grazing pasture systems and to add information on phosphorous and potassium to Table FL6-6a – Maximum Application Rates and Estimated Yields.

Filing Instructions.

Remove and Destroy	Insert
Page FL6-i (8/01)	Page FL6-i (2/04)
Pages FL6-22a – FL6-22c (8/01)	Page FL6-22a – FL6-22d (2/04)

Make pen and ink changes on the directive tabulation sheet.

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State Conservation Engineer

Enclosures

DIST: AWMFH

Contents:

FL651.0103 State Laws and Regulations FL1-5a

FL651.0103 State Laws and Regulations

Animal waste management systems are regulated by the Florida Department of Environmental Protection (FDEP) under the following rules: Chapter 62-670 Florida Administrative Code (F.A.C.) (formerly Chapter 17-670) "Feedlot and Diary Wastewater Treatment and Management Requirements" dated April 2, 1990, Chapter 62-660 F.A.C. (formerly Chapter 17-660) "Industrial Wastewater Facilities" dated May 19, 1994, and Chapter 62-522 F.A.C. "Groundwater Permitting and Monitoring Requirements dated April 14, 1994. Installation of animal waste management systems may also require permits from water management districts under Chapter 40(A,B,C, or D)-2 F.A.C., "Consumptive Use of Water" and/or Chapter 40 (A,B,C, or D)-4 F.A.C., "Management and Storage of Surface Water". Designers of waste management systems shall be familiar with FDEP Chapter 62-670, 62-660, 62-522 F.A.C, and any local rules or regulations that may apply to waste management systems. Prior to commencing technical assistance, the landowner shall be advised to consult with the local FDEP, water management district, and local authorities to determine if the waste management facility must comply with any of their rules and regulations.

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FL651.0403(f) Animal Waste Characteristics - Poultry	FL4-14(1)

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Table FL4-8 Beef waste characterization – as excreted	FL4-10a
Table FL4-15 Poultry waste characterization - litter	FL4-14(1)

FL651.0403 Animal waste characteristics - dairy

Table FL4-5 provides values for dairy waste characteristics for Florida. These values shall be used in lieu of the values presented in Table 4-5 of the AWMFH except for those waste characteristics not presented. The values for dairy waste characteristics shown in Table FL4-5 are based upon the Institue of Food and Agricultural Services (IFAS) circular 1016, "Dairy Manure Management: Strategies for Recycling Nutrients to Recover Fertilizer Value and Avoid Environmental Pollution".

Table FL4-5 Dairy Waste Characterization - as excreted[1/]

		Lactating	Dry
Raw manure (feces & urine)	lb/d/1000#	89.30	57.10
Moisture	%	88.10	88.00
Total Solids	% w.b.	11.90	12.00
Total Solids	lb/d/1000#	10.60	6.90
Volatile Solids	lb/d/1000#	8.86	5.71
Fixed Solids	lb/d/1000#	1.74	1.19
COD	lb/d/1000#	9.79	6.29
BOD_5	lb/d/1000#	1.41	0.91
Total Nitrogen (NRC, Low)[2/]	lb/d/1000#	0.43	0.26
Total Nitrogen (NRC, High)[2/]	lb/d/1000#	0.50	0.31
Phosphorous (diet 0.4% P)	lb/d/1000#	0.08	0.07
Phosphorous (diet 0.45% P)	lb/d/1000#	0.09	0.07
Phosphorous (diet 0.6% P)	lb/d/1000#	0.13	0.11
Potassium (diet 0.8% K)	lb/d/1000#	0.17	0.14
Potassium (diet 1.2% K)	lb/d/1000#	0.28	0.22

[1/] Use high N, P, and K if data is not available.

[2/] Data are from Van Horn (1990). Crude protein percent of total diet dry matter used in calculation for "NRC, Low" were 13.8% and 11.0% for Lactating and Dry with "NRC, High" having 15.3% and 12% for Lactating and Dry.

FL651.0403 Animal waste characteristics – beef

Table FL4-8 provides values for beef waste characteristics for Florida, where grazed forage is the primary diet constituent (≥ 80% of diet). These values shall be used for preparing nutrient budgets for beef grazing operations in lieu of the values presented in Table 4-8 of the AWFMH. The values for beef cattle waste characteristics values presented in Table FL4-8 are based upon results from the NRCS - Texas A & M University, Forage Quality Improvement Project, review of forage nutrient values in Table 6-6 of the AWMFH, and the publication "Nitrogen and Phosphorus in Beef Cow-Calf Production", Kunkle, W.E., 1994.

Table FL4-8 Beef Cattle Fecal Waste Characterization – as excreted [1/]

Component	Units	Yearling	Cow
N	lb/d/1000#	0.20	0.18
P	lb/d/1000#	0.052	0.046

[1/] Average daily production for age class noted.

FL651.0403(f) Animal waste characteristics - poultry

Manure testing is always the preferred method to obtain nutrient content of manure or litter. For planning purposes and in situations where test results are not available, values in Table FL4-15 should be used

Nutrient content for poultry litter is shown in Table FL4-15. These values are averages of manure/litter samples tested at the University of Florida Institute of Food and Agricultural Sciences (IFAS) manure testing lab. Samples were taken from litter storage facilities and from poultry houses. Most of the manure/litter tested by IFAS fall within the ranges in Table FL4-15. These values are not as excreted manure or litter.

For layers since little or no sawdust is added and the frequency of litter/manure cleanout is less than broiler litter cleanout, use the higher end of the range in Table FL4-15.

Table FL4-15 Poultry waste characterization - litter

N	53 – 59 lbs/ton
P_2O_5	55 – 65 lbs/ton
K_2O	45 – 56 lbs/ton

Chapter 6 Role of Plants in Waste Management

Contents

FL651.0606	**Nutrient Removal By Harvesting Crops**	**FL6-22a**
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FL651.0606 Nutrient removal by harvesting of crops

(a) Data Sources

When developing a nutrient budget, there are several sources of crop removal data that can be used to calculate waste utilization rates. The sources of data should be evaluated and the best source of data chosen to develop the nutrient budget.

On Farm Data. Sometimes a producer will have the cropping history of a particular crop that can be used in developing the nutrient budget. If the producer has kept accurate yield records, then this is potentially the best source of data for a nutrient budget. The planner should inquire about the past fertilization practices that created those yields to insure that the fertilization rate is reasonable. If fertilization rates were excessive, it indicates that over fertilization occurred and thus yields were inflated and excessive nutrient loss to leaching or surface runoff also probably occurred. In this case, on farm records would not be a good reference for crop removal data.

County Data. If on farm data is not available, then yield data of neighboring producers or producers, which are on similar soil types within the county, would be potentially the next best source for calculation of crop removal. The local county extension agent may be helpful in locating this type of data. Again, the same caution applies to this source of data. The fertilization practices should be considered to insure that reasonable fertilization rates were used.

AWMFH Amendment Recommendations. NRCS Florida has developed some information regarding crop uptake values and amended the AWMFH. This does NOT apply to the regular section within Chapter 6 of the AWMFH which is discussed below. Table FL 6-6a has values for bermudagrass/ryegrass rotation under different irrigation conditions for both hayland and grazing situations.

IFAS Recommendations. The University of Florida, Institute of Food and Agricultural Sciences (IFAS) has published

"UF/IFAS Standardized Fertilization Recommendations for Agronomic Crops", SL-129 which contains fertilization recommendations for many commonly grown crops in Florida. SL-129 does state that the recommendations are based upon economic considerations for a typical producer and may not apply to a waste utilization situation. The reason for this is that as an example it may not be economical for fertilization of forage grass for beef operations based upon an economic return in terms of beef cattle weight gain versus money spent on fertilizer. Whereas, under a similar dairy operation where it cost money to distribute waste, it makes economic sense to apply waste at higher application rates as long as it does not create a water quality problem.

IFAS publications, other than SL-129, may have been produced with certain industries in mind. These publications should be used with caution. The planner must understand the nature of the recommendation(s) and the situation applicable for the recommendations.

AWMFH Data. The data within the AWMFH are based upon a national database of crop yields and nutrient concentrations. Since this data is national in scope, more localized data is preferable. Since local data is not always readily available, this data source provides a method for crop nutrient removal when not covered by one of the above data sources.

Research Data. Sometimes research data on a particular crop will be available. Since research data is collected for a variety of reasons, it may be that the yield data collected was collected for a situation for which it is not applicable to the same situation. This data can be used when no other data source exists.

(b) Hierarchical Order for Using Data Sources

In developing a nutrient management plan, the order in which data sources should be used is as follows:

(1) On Farm Data
(2) County Data
(3) AWMFH Amendments
(4) IFAS Recommendations
(5) AWMFH Data
(6) Research Data

(c) Multiple Cropping Systems

Typically, crop removal data is given for a single crop rotation. Occasionally a crop is grown which does not reach full maturity before it is harvested. Planners should be aware of the growing season of crops grown in multiple crop rotations to be sure that yield estimates are accurate. As an example, ryegrass is a typical small grain winter crop grown in Florida. The growing season for ryegrass is from November to May. This crop does much of its growth late in the season. Harvested at the end of its growing season, yields are typically 2 tons per acre. However, ryegrass grown in rotation with bermudagrass is not allowed to reach maturity since bermudagrass begins its season in March to April. The ryegrass may be harvested to allow the bermudagrass to begin growing or the growth of the bermudagrass may impede the growth of the ryegrass. Typically grown in this rotation, ryegrass yields are reduced to 1 ton per acre. Planners need to make adjustments in expected yields accordingly for crops grown within multi-crop systems.

(d) Nitrogen application rates for bermudagrass/ryegrass in dairy rotational grazing pastures and dairy waste application on hayland fields.

Nitrogen application rates are needed to assist with determining dairy stocking rates and animal waste application rates for proper nutrient management. This amendment provides information and guidance on nitrogen application rates for bermudagrass/ryegrass rotation pasture and hayland. This amendment is not intended to address other factors affecting stocking rate such as the effect of livestock on soil and plant health.

Computer modeling using Groundwater Loading Effects of Agricultural Management Systems (GLEAMS) was used to predict nitrogen leaching based upon nitrogen application under various conditions. The values presented in Table FL6-6a were predicted to leach less than 10 ppm nitrate averaged over a 20 year period. This data should be used to determine nutrient application rate until research data is available.

BACKGROUND. Because of a lack of research data on pasture grass uptake under a typical Florida dairy rotational grazing systems, FL NRCS modeled a rotational grazing system using the computer model GLEAMS. The model was used to determine proper nitrogen application rates in order to reduce nitrate leaching to groundwater. During the summer of 1992, the NRCS conducted interviews with eight dairy producers in the Middle Suwannee River Area. Data was collected on pastures, high intensity areas (HIA), barns, manure storage facilities, herd size, soils, crops grown, manure spreading methods and cooling methods. The data from the interviews was used to develop "typical" values to input into the GLEAMS computer model.

Two of the best management practices (BMPs) modeled were rotational grazing of pastures and application of dairy waste on cropland. Two different soil types were modeled for these BMPs. The first soil type consisted of a well drained soil with an average water holding capacity less than 0.1 inch per inch and a hydraulic conductivity of 3 inches per hour throughout the profile. The second soil type consisted of a heavier soil with a higher clay and silt content. This soil was modeled with a average water holding capacity of 0.2 inch per inch and had a slowly permeable layer below the root zone which a hydraulic conductivity of 0.1 inch per hour. The hydrology soil group for these soils was an A for the first soil and a C for the second soil. Each of the BMPs were modeled under four different water management scenarios. These scenarios were as follows:

1. Intensive Management - irrigation to meet the full consumptive use demand of the bermudagrass/ryegrass crop with a well drained soil.

2. Moderate Management - irrigation is applied but does not meet the consumptive use demand during peak consumptive use periods.
3. No Irrigation Dry - no irrigation is applied to the bermudagrass/ryegrass crop with a well drained soil.
4. No Irrigation Wet - no irrigation is applied to the bermudagrass/ryegrass crop with a soil which has a high clay content for Florida soils and has a higher average water holding capacity.

A series of modeling runs was done for each of the above scenarios to determine the nitrogen application rate which would result in an average nitrate leaching rate of 10 ppm over a 20 year period. The results of the analysis showed that the no irrigation with a high water holding capacity soil could have as much nitrogen applied as the well drained soil with intensive water management. The heavier soil holds the nitrogen in the root zone longer for use by the crop. Also, more rainfall runs off the heavier soil rather than infiltrate into the soil profile which reduces water leaching through the profile.

Presented in Table FL6-6a are the maximum values which were determined to be the proper nitrogen application rates based upon the 10 ppm nitrate leaching criteria. For situations which fall between the defined categories in Table FL6-6a, the professional judgment of the engineer/planner will be required to determine the proper nitrogen application rate using the data provided above. The rate of nitrogen application used in the waste management plan shall be documented by the designer.

Table FL6-6a - Maximum Application Rates [1/] and Estimated Yields [2/]

Crop Rotation		Intensive Irrigation Management and No Irrigation with Wet Soil [3/]	Moderate Irrigation Management	No Irrigation with a Dry Soil [4/]
Bermudagrass/ Ryegrass Rotational Grazed Pasture 3 week rotation	N lb/ac/yr	395	335	265
	P (P_2O_5) lb/ac/yr	47 (108)	40 (92)	31 (71)
	K (K_2O) lb/ac/yr	141 (169)	112 (135)	98 (118)
	Bermudagrass Yield - ton/ac/yr	3.5	3.0	2.5
	Ryegrass Yield - ton/ac/yr	1.5	1.0	1.0
Bermudagrass/ Ryegrass Hayland 6 week harvest interval	N lb/ac/yr	520	460	385
	P (P_2O_5) lb/ac/yr	60 (137)	53 (121)	44 (101)
	K (K_2O) lb/ac/yr	281 (338)	224 (270)	182 (220)
	Bermudagrass Yield - ton/ac/yr	8.5	7.0	5.5
	Ryegrass Yield - ton/ac/yr	1.5	1.0	1.0

1/ This is the total amount of N that can be applied after losses. Losses include mineralization, leaching, denitrification, and application.
2/ Based on GLEAMS computer modeling.
3/ Wet soil refers to a soil with an average water holding capacity of 0.2 inches per inch in the root zone, a hydrologic soil group C, and a restrictive layer below the root zone.
4/ Dry soil refers to a soil with an average water holding capacity of 0.1 inches per inch, a hydrologic soil group A, and no restrictive layers which would hold water within the root zone for extended periods

(e) Continuous grazing pasture systems.

A continuous grazed pasture is a pasture which does not meet the criteria for rotational grazing as described in the AWMFH Florida Amendment Chapter 9, FL651.96(a). Pastures managed as continuous grazing pastures will have lower nutrient removal rates than rotationally grazed pasture systems.

From observations, lower nutrient removal rates are due to the following:

- continuous grazed pastures tend to have waste poorly distributed within the pasture caused by uneven grazing by the animals,
- areas of the field closest to the barn or gate will likely be over grazed (and have waste over applied) and the areas furthest out in the pastures will be under utilized, and
- after just a few years of continuous grazing, improved varieties of grasses tend to be replaced by less productive common varieties (i.e. coastal bermudagrass will be replaced by common bermudagrass).

Continuous grazed dairy herd pastures should be planned for application rates consistent with IFAS SL-129. For South Florida pastures, this document recommends 0.0 lbs. phosphorous per acre per year be applied to pastures since there is no economic return under cow/calf operations. However, since dairy pasture systems have different economic dynamics, the values for North Florida can be used (i.e., 160 lbs N/ac/yr, 40 lbs P_2O_5/ac/yr, 80 lbs K_2O/ac/yr under the High N option for bahiagrass).

These values can be adjusted as appropriate for practices such as planting cool season grasses or haying pasture fields during periods of the year when forage growth exceeds the forage requirement of the pastured animals. An agronomist should be consulted to determine the extent that the values should be adjusted based on the nutrient removed in the harvested material.

When continuous grazing pasture systems are used, management techniques should be used to prevent the development of denuded areas to the extent practicable. When denuded area cannot be prevented, runoff should be captured and treated appropriately from these areas.

(e) Continuous grazing pasture systems.

A continuous grazed pasture is a pasture which does not meet the criteria for rotational grazing as described in the AWMFH Florida Amendment Chapter 9, FL651.96(a). Pastures managed as continuous grazing pastures will have lower nutrient removal rates than rotationally grazed pasture systems.

From observations, lower nutrient removal rates are due to the following:

- continuous grazed pastures tend to have waste poorly distributed within the pasture caused by uneven grazing by the animals,
- areas of the field closest to the barn or gate will likely be over grazed (and have waste over applied) and the areas furthest out in the pastures will be under utilized, and
- after just a few years of continuous grazing, improved varieties of grasses tend to be replaced by less productive common varieties (i.e. coastal bermudagrass will be replaced by common bermudagrass).

Continuous grazed dairy herd pastures should be planned for application rates consistent with IFAS SL-129. For South Florida pastures, this document recommends 0.0 lbs. phosphorous per acre per year be applied to pastures since there is no economic return under cow/calf operations. However, since dairy pasture systems have different economic dynamics, the values for North Florida can be used (i.e., 160 lbs N/ac/yr, 40 lbs P_2O_5/ac/yr, 80 lbs K_2O/ac/yr under the High N option for bahiagrass).

These values can be adjusted as appropriate for practices such as planting cool season grasses or haying pasture fields during periods of the year when forage growth exceeds the forage requirement of the pastured animals. An agronomist should be consulted to determine the extent that the values should be adjusted based on the nutrient removed in the harvested material.

When continuous grazing pasture systems are used, management techniques should be used to prevent the development of denuded areas to the extent practicable. When denuded area cannot be prevented, runoff should be captured and treated appropriately from these areas.

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FL651.0704 Site investigations for planning and design

Onsite geologic investigations is basic to sound conservation planning and engineering in all NRCS programs. National Engineering Manual (NEM) requires that an appropriate geologic investigation and interpretation be conducted for all dams sites and conservation practices, components of practices, or structures that involve significant ground construction activity, such as ponds, pond sealing, and waste storage facilities. Refer to NEM Part 531 for geologic investigation procedures and requirements.

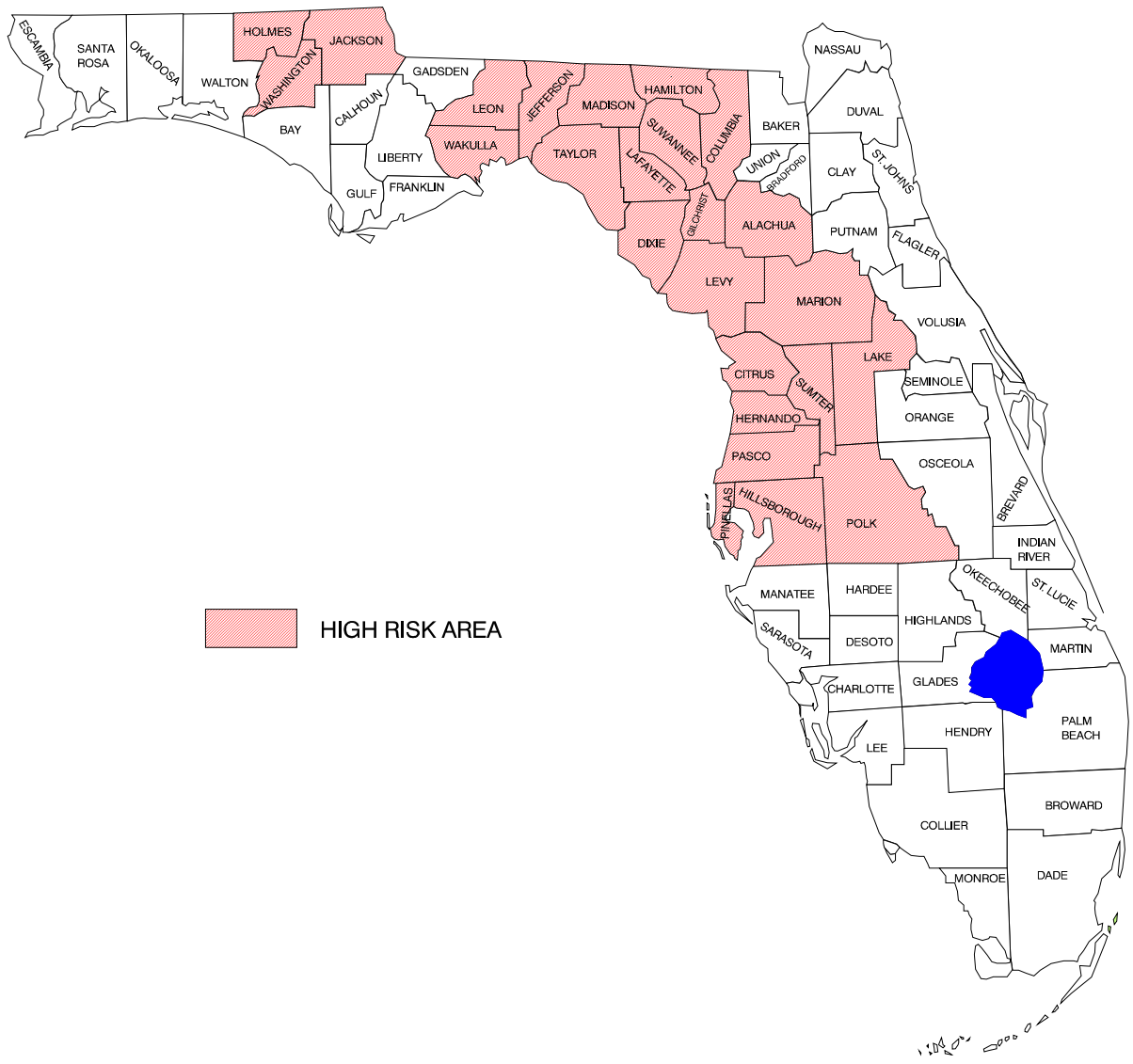
There is a high risk of failure of waste facilities (waste storage ponds, lagoons, etc.) in certain areas of Florida by sinkholes developing in the bottom or sides of earthen structures when they are filled with effluent. These failures are serious in that a failure will result in effluent discharging directly into the Floridan Aquifer, which is the main source of domestic and municipal water supplies in those areas.

Figure FL7-1 delineates the high risk areas in Florida. Figure FL7-1 does not split counties, if part of the county is high risk, the entire county is included.

When a request for assistance is received to construct a waste facility in the delineated high risk area, the following geologic investigation procedure will be followed:

1. An engineer with appropriate engineering job approval authority will determine if the specific location is in a high risk area by reviewing topographic maps, soils maps, aerial photography, literature, etc., and by making an on-site review.
2. If the responsible engineer determines that the site is high risk, the following actions shall be taken:
   a. The ground penetrating radar (GPR) will be used initially to investigate the site. The site will be investigated on a minimum grid of 25 feet and extend a minimum of 25 feet beyond the planned structure top slopes. On existing facilities, begin the grid as close to the existing waterline perimeter as possible and extend 25 feet beyond the anticipated enlargement. A GPR report will be prepared describing the subsurface material and any anomalies.
   b. The responsible engineer will determine the extent of geologic borings needed to verify the underlying geology. The responsible engineer shall request the services of a geologist when needed to determine the extent of geologic investigations.
      i) A minimum of 4 soil borings per site will be taken on a maximum 100 feet centers.
      ii) The soil boring will extend to a minimum depth of 10 feet below the planned excavation depth or to limestone whichever is less. The depth of borings may be reduced once 4 feet of clay is found below the design bottom of the facility and no additional depth is needed to determine if sufficient clay is available for use in lining the side slopes of the facility.

Figure FL7-1 High Risk Areas for Siting Waste Storage and Waste Treatment Facilities



Content

FL651.96 Typical Agricultural Waste Management Systems FL9-8(1)

Table

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Figure

Figure FL9-1 Growth Stages of Grasses and Legumes and their Effect on Intake, Digestibility, and Dry Matter Production (from Blaser, et al. 1986) FL9-8(2)

FL651.96 Typical agricultural waste management systems.

(a) Rotational grazing systems for nutrient removal by grazing animals.

Rotational grazing systems are key components of waste management systems utilizing grazed forage crops to remove nutrients from the soil. A poorly designed and managed grazing system will limit the amount of forage produced and consumed by the animals and thereby limit the amount of nutrient uptake by plants. In addition, a poorly designed and managed grazing system will have more denuded areas where high levels of nutrients are applied and there is little if any vegetation to utilize the nutrients.

Rotational grazing systems for nutrient uptake shall have a sufficient number and size of paddocks to allow the vegetation to remain vigorously growing when conditions are acceptable for plant growth. The grazing plan shall specify (1) the length of the grazing period, (2) length of the recovery period, (3) the number of paddocks needed for each herd, and (4) the size of the paddocks.

The following criteria shall be used in planning the rotational grazing system for nutrient application sites:

- Recovery period 21 days between grazing events (minimum) or when plants reach minimum stubble height to begin grazing as shown in conservation practice standard Prescribed Grazing, Code 528A.
- Grazing period 5 days total length (maximum).
- A minimum of 5 paddocks will be provided per grazing system.
- The stocking density should not exceed the maximum pounds of animal per acre shown in Table FL-9-1 for the length of the grazing period.

Table FL9-1 – Recommended Maximum Stock Density [1/]

Grazing Period (days)	Max. Stock Density (lbs. animals / acre)	No. of 1,200 lbs. Cows/ac.
1	84,000	70
2	38,400	32
3	24,000	20
4	18,000	15
5	14,400	12

(1) Design and Layout of a Rotational Stocking System [2/]

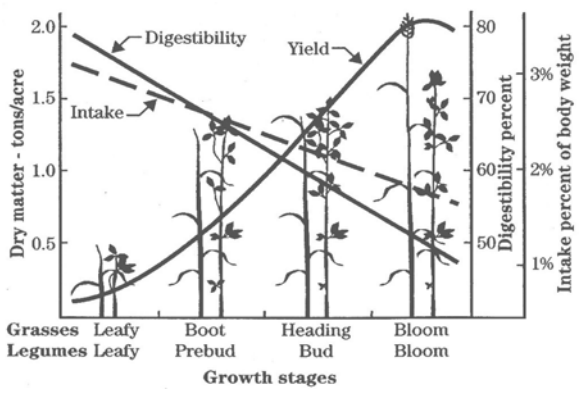
In planning a rotational grazing system, one of the first steps is to evaluate the resource base. The forage types, soils, topography, water, shade, environmentally sensitive areas, and physical facilities should be carefully inventoried before a management plan is developed. It is essential to know what limitations are imposed upon the planned system by the natural resource base as well as limitations of capital, labor, and management expertise.

Nutrient removal through forage removal by animals is the key to the process where rotational stocking is used. To get high levels of removal by grazing animals the forage must be kept in the vegetative stage of growth. Forage in this stage of growth has the highest concentration of nutrients and is very palatable to grazing animals. Mature forages have the highest amount of forage but, the animal intake will be significantly lower and nutrient removal will decline. Figure FL9-1 (same as Figure 5-19 from the National Range and Pasture Handbook) illustrates the relationship between forage maturity and intake.

To keep forage vigorously growing, it is recommended that the stocking system be designed so the animals remove the desired amount of forage in a short time and allow a sufficient recovery period between grazing events.

[1/] Based on forage consumption of 1% of body weight for 1,200 lbs. animal.
[2/] Adapted from NRCS Alabama Guide Sheet No. AL 528.

Figure FL9-1 Growth stages of grases and legumes and their effect on intake, digestibility, and dry mater production (from Blaser, et al. 1986)



There are several guidelines that may be used to help make the system more efficient and work smoother. Those guidelines for developing rotational stocking systems are listed below.

(a) Grazing Periods

"Ideally, grazing periods should be long enough to harvest the forage that exists in a paddock when livestock are turned in, but should not be so long that damage to the plant occurs from uncontrolled defoliation. Short grazing periods also prevent forage from being damaged or wasted through increased amounts of trampling and fouling with manure or urine." [3/]

Cattle take about three (3) days to establish a strong grazing pattern within an individual paddock. If the animals are allowed to remain in a paddock longer than three days, spot grazing and pronounced cattle trails will begin to develop. When the cattle return to the paddock in future grazing cycles, the grazing pattern will be established and they will follow the previous pattern.

Another reason to keep the grazing period short is to reduce the amount of regrowth that is grazed. After five (5) days the animals may remove a sufficient amount of forage regrowth to slow plant growth or kill the plant.

[3/] Emmick, D. L., and D. G. Fox. 1993. Prescribe Grazing Management to Improve Pasture Productivity in New York, Cornell University.

(b) Stock Density

The number of animals should be manipulated so the forage is removed uniformly over the paddock. Low stock densities will usually result in spot grazing and can promote high intensity areas (HIAs). Stocking densities of 40 to 50 dairy cows per acre have been grazed successfully on bermudagrass and stargrass in Florida. In these instances the grazing period has been 24 hours long or less and an adequate recovery period has been provided.

(c) Paddock Configuration

Uniformly sized paddocks with parallel sides are most desirable (ie. keep the paddocks as square as possible). This shape facilitates grazing distribution, additional subdivisions and mechanical activities, better than other shapes. Avoid pie shaped paddocks, as they can create denuded areas and/or HIA's where nutrient uptake is reduced.

(d) Distance to Water

Grazing animals need to drink on a regular basis. As a consequence, they tend to stay within a short traveling distance to the water source. Water is essential for the cow to properly digest the forage consumed. When water intake is limited, forage intake will be reduced. Consumption of water is greater and forage utilization is more uniform when water is available in every paddock and the travel distance is less than 800 feet. As a general rule water should be located within 300 feet of the area where lactating cows are grazing to prevent a reduction in milk production.

(e) Location of Water Troughs or Tanks

Locating water troughs or tanks near the center of the paddock will encourage cattle to graze farther away from the lane or walkway and from the milking parlor. As a result the nutrient deposition will be spread over a larger area.

(f) Portable Water Troughs and Feeders

Using portable water troughs and feeders when possible will allow the trough or feeder to be moved frequently and prevent denuded areas from occurring. It is recommended that the feeders be moved to a new location for each grazing period. Avoid placing the feeders or troughs near shade or cooling ponds, as this will

reduce the distribution of animals and nutrients on the pasture.

(g) Paddock Production

It is important to keep the animals diet as uniform as possible to ensure consistent performance. For this reason paddocks should be sized on their potential to produce forage. If this is not possible the length of the grazing period should be adjusted to compensate for the difference in production.

Paddocks on the most productive soils will be smaller than the average and paddocks on the least productive soils will be larger than the average. Paddock boundaries, which follow the contours and changes in the soil type, allow for more uniform production. Livestock grazing patterns will often follow the forage production patterns of the pasture. If there are several soil types with differing productive potentials uneven grazing may occur. Fences should be planned with the stocking rate and animal production in mind, and not simply to divide the fields into equally sized units.

(h) Animal Trails and Walkways

If lanes are needed they should be used only to facilitate the movement of animals to fresh paddocks, working pens, cooling ponds and milking parlors. When lanes are used each day to access a fresh paddock or a common water source, loss of vegetation, erosion, and potential mud problems will occur. In this situation the lane may have to be surfaced with limerock, gravel or other materials that are resistant to animal traffic. If surfacing the lane is not possible consider having additional lanes so one can be rested while the other is being used.

(i) Number of Paddocks

The optimum number of paddocks will depend on the forage species, animal type due to desired utilization and performance goals, resistance to grazing damage, regrowth habit of the forage, and economic goals.

The ideal system is to have the animals harvest the high quality leaf tips and succulent parts of the forage and leave the lower quality basal leaves and stemmy forage for photosynthesis to maintain the root system and for rapid regrowth.

The number of paddocks required for a particular grazing cycle is determined by the recovery period required by the forage species to attain the “Minimum Stubble Height to Begin Grazing” and the maximum number of days the animals should be left on the paddock to meet the performance goals. Typically the forage growth cycle of forage in Florida is 21 to 35 days. This will vary depending on the forage species, environmental conditions, season of year and management. The recovery period may be reduced if the plants attain the “Minimum Stubble Height to Begin Grazing” as shown in the conservation practice standard Prescribed Grazing, Code 528A.

If the forage growth rate exceeds the animal’s ability to consume it, some paddocks may be dropped from the rotation and harvested as hay or haylage or left as stockpiled forage.

With a grazing period of three to five days and a recovery period of 21 to 35 days, six to eight permanent paddocks is usually sufficient for a grazing system. The number of paddocks can be calculated using the following equation.

Number of Paddocks =

$$\frac{\text{Recovery (rest) Period}}{\text{Days of Grazing}} + 1$$

Additional paddocks may be needed when establishing forages. The forages will require a period of nonuse to become established. This period may last 12 – 16 weeks or longer. Options for providing the establishment period include:

- Increase the confinement time and reduce the grazing time the animals are on pasture.
- Dropping some paddocks from the rotation and increasing the time the length of the grazing period on others.
- Use temporary fencing to create additional paddocks.

Also, in determining the number of paddocks, increased input cost, along with increased management are needed to make the grazing system work. It is suggested that producers who have four to five permanent paddocks with water near the center of each use temporary electric fencing to further divide the paddocks. It is recommended that temporary fences be

installed until the producer is certain where to install permanent fences.

(2) Basic Rotational Grazing Rules to Remember

- Stocking systems are basically systems to feed animals and harvest nutrients from an area.
- Use the higher quality parts of the forage plants for grazing. Rotate the animals to the next paddock before they begin to graze the new regrowth (i.e. approximately 5 days). Avoid forcing high producing animals to eat the low quality basal leaves and stems.
- Maintain sufficient leaf area for photosynthesis to keep a healthy root system to maximize forage production and nutrient uptake. A rule of thumb for keeping sufficient leaf area is to maintain 50 percent of the forage growth for photosynthesis or not graze lower than the recommended minimum stubble height. The minimum stubble height is shown in Table 1 of the conservation practice standard Prescribed Grazing, Code 528A.
- Match the rotation time to the forage growth rate. The rotation among paddocks must not be based on fixed time schedule. Instead it should be based on the available forage and rate of forage growth. During periods of rapid forage growth, the grazing period should be short. When forage growth is slow, the rotation should be slowed down. Maintaining a rigid rotation schedule is the recipe for failure.

(3) Summary of Rotational Grazing System

- Keep grazing periods short.
- Keep stock density high.
- Keep the paddocks as square as possible.
- Keep water within 600 to 800 feet of the animals.
- Locate the water troughs or tanks near the center of the paddock.
- Use portable water troughs, and feeders when possible.
- Paddocks should be of similar production not size.
- Animal trails and walkways should be used only to facilitate the movement of animals to and from paddocks, working pens, cooling ponds and milking parlors.
- Permanent paddocks should be sized to provide similar forage production, and be subdivided as need later.

Chapter 15 Computer Software and Models

Contents	**FL651.1504**	Approved Waste Management and Design Software for Florida	FL15-2

FL651.1504 Approved waste management planning and design software for Florida.

Approved NRCS Florida software for planning and designing animal waste management systems are WATNUTFL, STOWATER and DBCNA. Documentation for this software can be found in the Florida Supplement to the Engineering Field Handbook.

WATNUTFL was developed to assist the user in estimating manure and wastewater production, determining storm runoff from areas where manure is concentrated, and preparing a water budget and nutrient balance. These computations are used to size waste storage and waste treatment facilities and determine acres of land and crops required for the application of animal wastes from confined animal operations.

STOWATER was developed to rout drainage water and runoff from multiple sub-basins given a DRAINMOD daily output file for each sub-basin area to a storage reservoir, then routs water to multiple irrigation areas given a DRAINMOD output file of each of the irrigated fields. The program records a daily water balance based upon evaporation data from an evaporation file created by STOEVAP.EXE. The output from the STOWATER program consists of values for rain, evaporation, drainage, irrigation, sub-basin flooding, reservoir storage, reservoir overflow, dry days, and irrigation deficit on a daily, monthly, and/or yearly basis. This program has been used to size storage reservoirs and irrigation fields for waste management systems installed in high water table soils.

DBCNA was developed to aid in the design of dead bird composting facilities and development of a nutrient management plan for disposal of compost and litter. The first part of the program aids in the proper sizing of the composting facility based upon user inputs of number of birds, market weight, mortality rate, number of cycles per year, cleanout depths, etc. The second part of the program determines the amount of available nutrients to be applied to crops grown and the proper application rates for the litter and compost applied to the selected crops.