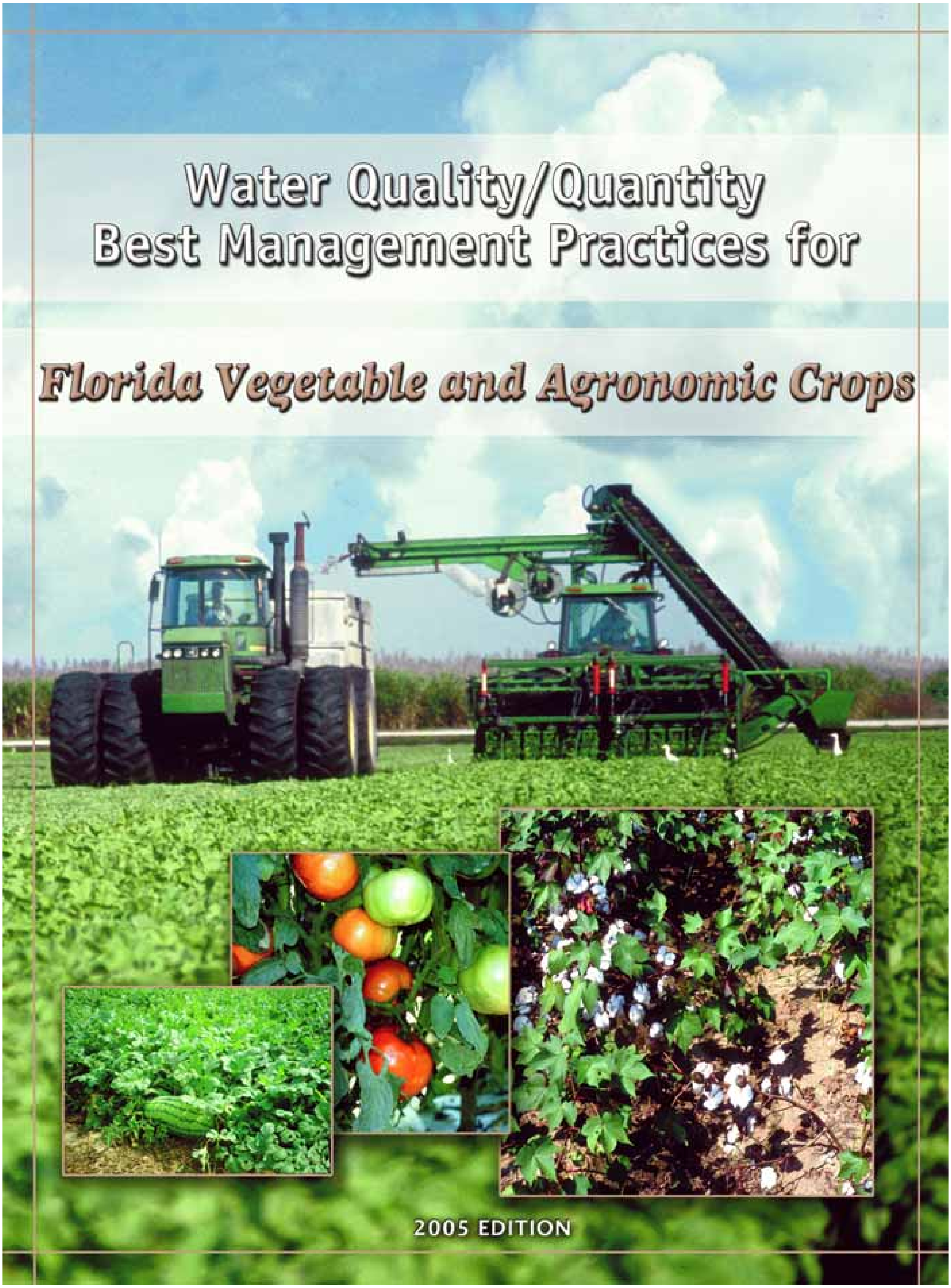
Water Quality/Quantity Best Management Practices for

Florida Vegetable and Agronomic Crops



2005 EDITION

Florida Department of Agriculture and Consumer Services
CHARLES H. BRONSON, Commissioner
The Capitol • Tallahassee, FL 32399-0800

Please Respond to:

COMMENTS BY COMMISSIONER CHARLES H. BRONSON

Dear Best Management Practices Partners:

Congratulations on completing the *Water Quality/Quantity Best Management Practices for Florida Vegetable and Agronomic Crops*. This manual, which has since been adopted into Department rules, reflects nearly three years of hard work by a statewide Steering Committee. When used by producers, the manual will protect water quality for vegetable operations statewide, and for agronomic operations that are primarily confined within the north-central Florida and panhandle regions.

This manual itself provides a valuable collection of many useful, commonsense techniques referred to as Best Management Practices, or BMPs, that are directed at enhancing and protecting water quality. While BMPs have been in place for many years in our state, their role was reaffirmed in 1999 with the passage of the Florida Watershed Restoration Act which is the primary mechanism for implementing Florida's Total Maximum Daily Load program. As such, the work completed on pesticide management, conservation practices and buffers, erosion control/sediment management, nutrient and irrigation management, water resources management, and seasonal and temporary farming operations for this manual reflects the sincere desire of the agricultural community to protect and preserve Florida's natural resources. This commitment was directly reflected in the abundance of technical knowledge and local experience that formed the broad-based membership of both the Steering Committee and subordinate Technical Workgroups.

In today's global environment, Florida row crop growers must utilize all tools available to them in order to remain competitive. Without Best Management Practices, which create reasonable environmental standards for participating growers, their ability to remain competitive in the face of changing regulations is uncertain at best. I believe that BMPs help to accomplish this task. Despite all of the challenges faced by agriculture, including recent hurricane damage and our ongoing struggle to find alternatives to traditional soil fumigation techniques, Florida row crop production provides a bounty of fresh vegetables which are sold nationwide. These same cropland acres are also critical to protecting water quality, providing valuable water recharge areas and creating perennial open or "green" spaces throughout Florida's production regions. Many row crop farmers also practice the age-old art of crop rotation which naturally helps maintain soil and nutrient resources.

As a fifth generation Floridian whose family has always been involved in agriculture, I want to thank all who participated with the Department in the development of this important BMP manual. With the active support and participation of so many dedicated people, I remain optimistic about agriculture's future. I trust that you will join me in supporting this valuable water resources protection effort.

Sincerely,

Charles H Bronson

ACKNOWLEDGEMENTS

A Steering Committee was established in 2001 to guide the development of BMPs and the overall structure of this BMP manual. Additionally, two subcommittees were formed to support the efforts of the Steering Committee, and they were charged with developing specific BMPs associated with their area of responsibility. The subcommittees were referred to as the Universal Conservation Standards Working Group and the Water Resources Working Group.

It should be noted that an effort of this magnitude could not have been accomplished without the tireless dedication of all participants. The following is a list of individuals who participated in the development of this manual. Each of these individuals and their organizations made important contributions to the process, and their work is sincerely appreciated.

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INTRODUCTION

BEST MANAGEMENT PRACTICES (BMPs) HISTORY AND PURPOSE:

With the passage of the Federal Clean Water Act (FCWA) in 1972, states were required to assess the impact of nonpoint sources of pollution on surface and ground waters, and establish programs to minimize them. Florida's Nonpoint Source Management Program was established in 1978 and has undergone numerous changes over the years. The program requires the use of structural and nonstructural BMPs to minimize nonpoint source pollution, either through traditional regulation (i.e., Environmental Resource Permits) or through voluntary measures (i.e., implementation of BMPs).

Section 303(d) of the FCWA also requires states to identify impaired water bodies and establish total maximum daily loads (TMDLs) for pollutants entering these water bodies. TMDLs establish the maximum amount of pollutants that can be discharged to a water body and still have it meet designated uses such as swimming, fishing, or as a potable water use. Once a TMDL is set, an implementation plan must be developed that specifies the activities that watershed landowners will undertake to reduce point and nonpoint source pollutant loadings. Many of the 44,000 commercial farmers who produce food, fiber, and livestock on approximately 10 million acres in Florida will be required to meet specific water quality load allocations. Water quality targets will be achieved through a combination of regulatory, non-regulatory, and incentive-based measures. To address TMDLs, the Florida legislature passed the 1999 Florida Watershed Restoration Act that gives the Florida Department of Agriculture and Consumer Services (FDACS) the authority to develop interim measures, BMPs, cost-share incentives, and other technical assistance programs to assist agriculture in reducing pollutant loads in target watersheds. This law defines a process for the development of TMDLs for impaired waters as required by section 303(d) of the Federal Clean Water Act. It directs the FDACS to identify and adopt by rule BMPs for agricultural nonpoint sources. The Florida Department of Environmental Protection (FDEP) must also verify that these BMPs are effective at reducing pollutant loading to these waters. By law, agricultural producers who voluntarily implement these BMPs, which have been verified effective and adopted by rule, will receive a "presumption of compliance" with state water quality standards. They will also be eligible for cost-share money to implement selected BMPs once eligible practices are identified.

By definition, BMPs are a practice or combination of practices determined by the coordinating agencies, based on research, field-testing, and expert review, to be the most effective and practicable on-location means, including economic and technological considerations, for improving water quality in agricultural and urban discharges. BMPs are typically implemented as a "BMP treatment train" that includes a combination of nonstructural and structural practices which have been determined to be effective for reducing or preventing pollution. BMPs must be: technically feasible, economically viable, socially acceptable, and based on sound science. This manual is a living document. Over time, BMPs will be modified and adjusted as additional research is conducted and/or as economic conditions change.

GENERAL APPLICABILITY:

The practices outlined in this manual are intended to be applied statewide by both vegetable and agronomic crop farmers. Along these lines, the focal crops for which the manual was written to address are vegetables, potatoes, corn, soybeans, peanuts, peppers, sugarcane, and cotton. For the purposes of this manual, vegetables also include tomatoes, cucumbers, strawberries, melons and various types of squashes. Other row crops outside the purview of this manual (for example, hay and other forage grasses) may be covered under other state rules or BMP programs.

RELATIONSHIP OF THIS MANUAL TO STATE REGULATORY PROGRAMS:

Water Quality Standards – FDEP

Section 403.021, Florida Statutes (F.S.) presents as public policy the protection, maintenance, and improvement of surface water quality for the purpose of public water supply; propagation of wildlife, fish and other aquatic life; and for domestic, agricultural, industrial, recreational, and other beneficial uses. FDEP, which establishes state water quality standards, identifies BMPs as acceptable measures to reduce agricultural nonpoint source pollution to protect nearby waters and to achieve the level of pollution reduction required by established TMDLs for agricultural nonpoint source pollution sources.

Nitrate Program – FDACS

Chapter 576, F.S., authorizes the FDACS to develop BMPs to protect the state's water resources and preserve the agricultural industry by reducing nitrate and phosphorus residues in groundwater and surface water through the creation and implementation of fertilizer BMPs.

Surface Water Permits (ERPs) – Water Management Districts

The water management districts are responsible for permitting the construction and operation of surface water management systems within their jurisdictional boundaries, pursuant to Part IV of Chapter 373, F.S. Permits authorize activities which are deemed not harmful to the water resources of the District or to otherwise conflict with public interest. While all water management districts with the exception of the Northwest Florida Water Management District administer an Environmental Resource Permit (ERP), South Florida Water Management District also has a Works of the District and a Surface Water Improvement and Management Permit. Note that the implementation of certain BMPs may necessitate an ERP. BMP Activities that may require an ERP have been identified with the figure 

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Contact your regional water management district for permitting and exemption requirements. In addition, see the common agricultural exemptions listed below.

National Pollution Discharge Elimination System (NPDES) Stormwater Regulations -FDEP

The FDEP is required to regulate the discharge of certain point sources of pollutants into state waters through the issuance of NPDES discharge permits. According to section 403.927, F.S., agricultural activities and agricultural water management systems are generally not subject to NPDES permitting. Permits may be required for an agricultural system if there is an ultimate point of discharge to surface waters.

GOALS RELATED TO WATER QUALITY AND QUANTITY:

Implementation of BMPs at the farm level is key to maintaining the quality and quantity of ground and surface waters. FDACS is required by law to develop, implement, and adopt by rule interim measures or BMPs which improve water quality and water use efficiencies in agricultural production systems. Generally, any BMP that reduces pollutants or reduces the volume or rate of runoff will be beneficial to water quality. Conserving water used in agricultural production not only saves water but also reduces the risk of leaching or discharging nutrients and chemicals into receiving waters. The state comprehensive plan requires the elimination of inadequately treated agricultural wastewater and stormwater discharges. Additionally, the state Water Resource Implementation Rule (Chapter 62-40, F.A.C.) establishes minimum stormwater treatment performance standards. For new stormwater discharges, the BMPs must provide at least an 80% reduction of the average annual loading of pollutants (95% for discharges to Outstanding Florida Waters). For existing stormwater discharges, the stormwater treatment performance standard is the reduction of pollutants as needed to protect, maintain, or restore the beneficial uses of the receiving water body.

STATUTORY EXEMPT AGRICULTURAL ACTIVITIES:

Pursuant to subsection 373.406(2), F.S., any person engaged in the occupation of agriculture may alter the topography of any tract of land for purposes consistent with the practice of agriculture. These activities may not be for the sole or predominant purpose of impounding or obstructing surface waters. Agriculturalists also have the right to capture, discharge, and use water for purposes permitted by law. Activities generally deemed normal and necessary in the practice of agriculture which may qualify for a statutory exemption from an ERP include but are not restricted to:

a) Construction of unpaved access roads and the placement of bridges and culverts that do not impede the flow of surface waters
b) Site preparation and land clearing
c) Fencing
d) Plowing and/or chopping
e) Planting and harvesting
f) Brush management and burning
g) Land leveling
h) Conservation tillage

For definitions of these and other activities, consult with FDACS and/or refer to USDA-NRCS specifications in the Florida Field Office Technical Guide, Section IV. Prior to conducting an agricultural activity that is believed to be exempt, it is recommended that confirmation be obtained from either the water management district or FDACS.

BMP EVALUATION AND IMPLEMENTATION

Background:

In 2001, a Steering Committee was formed to develop this manual. This forum allowed for agricultural association groups, industry, state agencies and other stakeholders to exchange ideas in order to develop a group of practices for producers to follow to protect water resources.

In general, Florida vegetable and agronomic crop producers have experienced considerable variation in the application of surface water regulations, primarily dependent upon which water management district has jurisdiction. The transient nature of many of these farms has also compounded the regulatory situation in some cases. Moreover, this segment of the industry has operated without a unified, state endorsed BMP manual. Similar BMP manuals for other agricultural operations have been in place for more than a decade, and have yielded a mature BMP program.

Implementing a logical subset of practices outlined in this manual develops an industry “baseline”. This standardization of practices will identify growers who are practicing their livelihood in a sound and responsible manner. A second outcome, consistent with state law, recognizes that widespread application of BMPs provides significant reduction in pollutant loading, helping to better protect healthy waters and restore impaired waters. This “baseline” set of BMPs is considered equivalent to the standard level of waste treatment applied to wastewater plants, industrial facilities, and/or urban stormwater systems, thus providing compliance with the Florida Watershed Restoration Act and the TMDL Technical Advisory Committee Allocation Report to the Legislature. However, in some impaired waters, additional BMPs and other treatment projects (i.e., regional stormwater treatment areas) may be needed to meet FDEP established TMDL goals.

Selecting BMPs for multiple commodities in different production regions is a difficult process. This manual uses a hierarchical approach to BMP implementation. The development of a BMP Implementation Plan rests on the following key steps:

- General or universal BMPs applicable to all farming operations
- A decision-tree tool for additional BMP requirements
- Use on-farm assessments to “fine tune” BMP plans
- Development of a computer assisted, web-based system for use by growers in the future

The following sections describe the intended application for each of the above categories. Bear in mind that education is the key factor to ensure the overall success of BMP programs. Grower training programs are also needed to ensure that BMPs are applied and implemented properly.

Inventory of Current Farm Practices:

In order for the program to have statewide applicability, BMPs for each farm must be determined in a reasonable and practicable manner. Farmers first need to perform an inventory of existing or current farm practices. It is understood that many growers are already using many of the BMPs outlined in this manual.

Performing an inventory of current farm practices will provide documentation that some of these BMPs have already been put in place. Moreover, this initial inventory will also facilitate the future integration of BMPs after performing the decision-tree analysis and subsequent on-farm assessment. Think of the decision-tree as a “front-end” decision support tool, and the on-farm assessment as a “back-end” fine tuning process. Both of these tools work in concert with one another.

Decision Tree Feature:
Following the inventory of current farm practices, growers should use and follow the decision-tree within this section to help more accurately identify all BMPs applicable to their farming operation. This tool is intended to be used like a flow chart, in that users start at the top and work their way through all “branches” until an endpoint or outcome is reached. Upon first glance, you will note that the first decision process or rectangle directs all users of this BMP manual to employ the general list of BMPs and refers the user to Attachment No. 1. From here, users simply work their way down through the decision process steps until they reach the block(s) that best describes their situation. Broad “break points” include row crop operations on plastic, North Florida farming, temporary or seasonal farming operations, special physiographic regions and special TMDL basins that already have a Basin Management Action Plan developed. The implication here (after completing the decision-tree analysis) is that participating growers will implement both the general BMPs and the applicable second tier decision-tree BMPs.

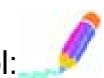
Synthesis of BMPs into Farm Plan:
Ultimately, BMPs need to be incorporated into a farm plan. Education was mentioned earlier as a key factor to ensure BMP program success. Proper planning results in informed, progressive decisions. These “decisions” are then recorded as a list of things to do. To fully integrate BMPs into a meaningful farm plan also requires the use of the following steps: an on-farm assessment, a quality assurance program that details operation and maintenance requirements, and incorporation of other federal conservation planning requirements, as appropriate.

<u>On-farm Assessment</u> - All growers should perform an environmental assessment of their crop production operations. This resource allocation assessment process is a tool that will aid in identifying which BMPs should be considered to achieve the greatest economic and environmental benefit. On-farm assessments generally use guidelines or checklists to assist producers in determining the application of all reasonable BMP. To reiterate, the on-farm assessment is to be used after reviewing the General BMPs and any additional decision-tree BMPs. FDACS Ag-Teams may be able to assist growers with these on-farm assessments. The Indian River Citrus and Cow/Calf BMP manuals have already used this on-farm assessment tool to help growers choose the appropriate suite of BMPs for their operation. The BMP assessment checklist is also located within this section.

<u>Quality Assurance Program</u> - Having a viable Quality Assurance (QA) Program is very important to ensure that BMP implementation is occurring on track. The QA program also serves to build overall program credibility and further provides assurance that BMPs are constructed or installed as designed in accordance with the “Notice of Intent to Implement” form. In general, the BMP QA program includes proper operation and maintenance, record keeping, and the use of FDACS Ag-Team and/or Soil and Water Conservation District staff in order to verify that BMPs are being maintained through routine site visits.

Federal Conservation Planning Requirements – Growers applying for and receiving federal cost-share monies to install BMPs may be required to have a Conservation Plan developed by either the USDA-NRCS or an approved third party vendor. These plans, which typically address soil, water, nutrients, air, natural resources, human and other impacts, may in large part satisfy many of this BMP manual's requirements. Growers with updated Conservation Plans who are not also subjected to specific decision-tree requirements are strongly encouraged to request an equivalency review. This can be accomplished by contacting either the local USDA-NRCS District Conservationist or local FDACS Ag-Team staff. At a minimum, the Conservation Plan should be incorporated as part of the BMP Implementation Plan, as discussed below.

Formulation of BMP Implementation Plan – All BMP evaluation records should be clearly and logically structured and will serve as the focal point for the BMP Implementation Plan. These plans also become the roadmap for pertinent BMP record keeping, operation and maintenance practices, and specific timelines for implementation of all applicable BMPs. The goal of the plan is to protect water quality while maintaining, or even improving, the profitability of the farm. Again, this plan will serve as the foundation for all BMP decisions; therefore, it should be thoughtfully and deliberately developed.

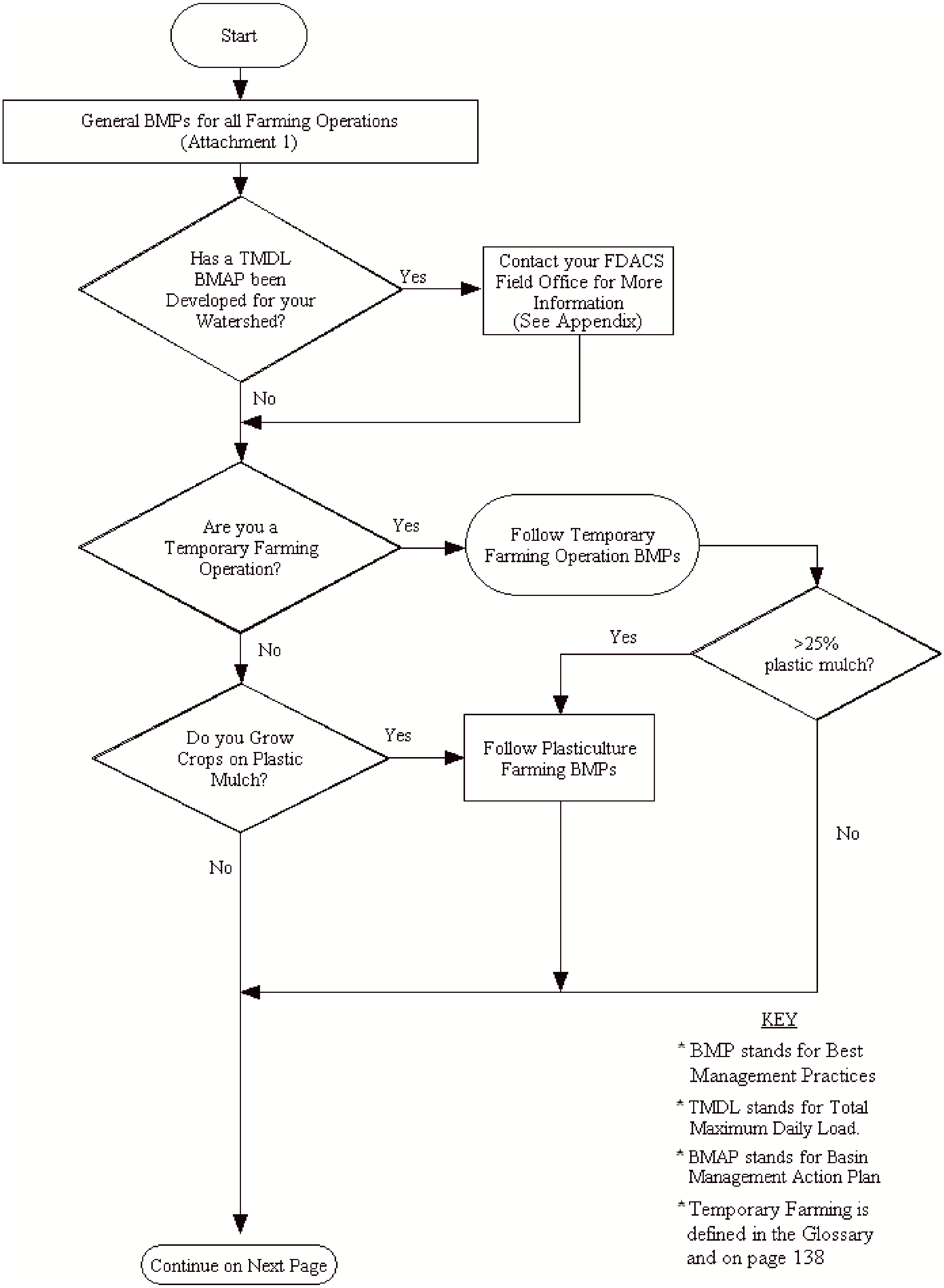
Record Keeping - BMPs requiring record keeping are identified with the following symbol: 

Computer Assisted BMP Selection:

In the late 1990's, it became apparent that the amount of technical expertise needed to assist individual growers throughout the state would be in very short supply when the new water quality regulations began to take effect. It would also be very difficult to verify the water quality effectiveness of every suite of BMPs for every farmer. Considerable effort among industry, FDACS, FDEP, IFAS, and others was spent to address this issue.

Agency partners are working to develop a web based "artificial intelligence" or "virtual extension agent" system that would allow a grower to identify their farm and fields on aerial satellite photos, input selected crops, identify critical parameters, and interactively generate a suite of BMPs for that farm, including a particular cropping sequence. Estimates of costs, yields, water quality effects, links to futures information, and expected revenues could all be factored in. It is hoped that this system will be fully operational by 2010.

BMP DECISION TREE FLOWCHART



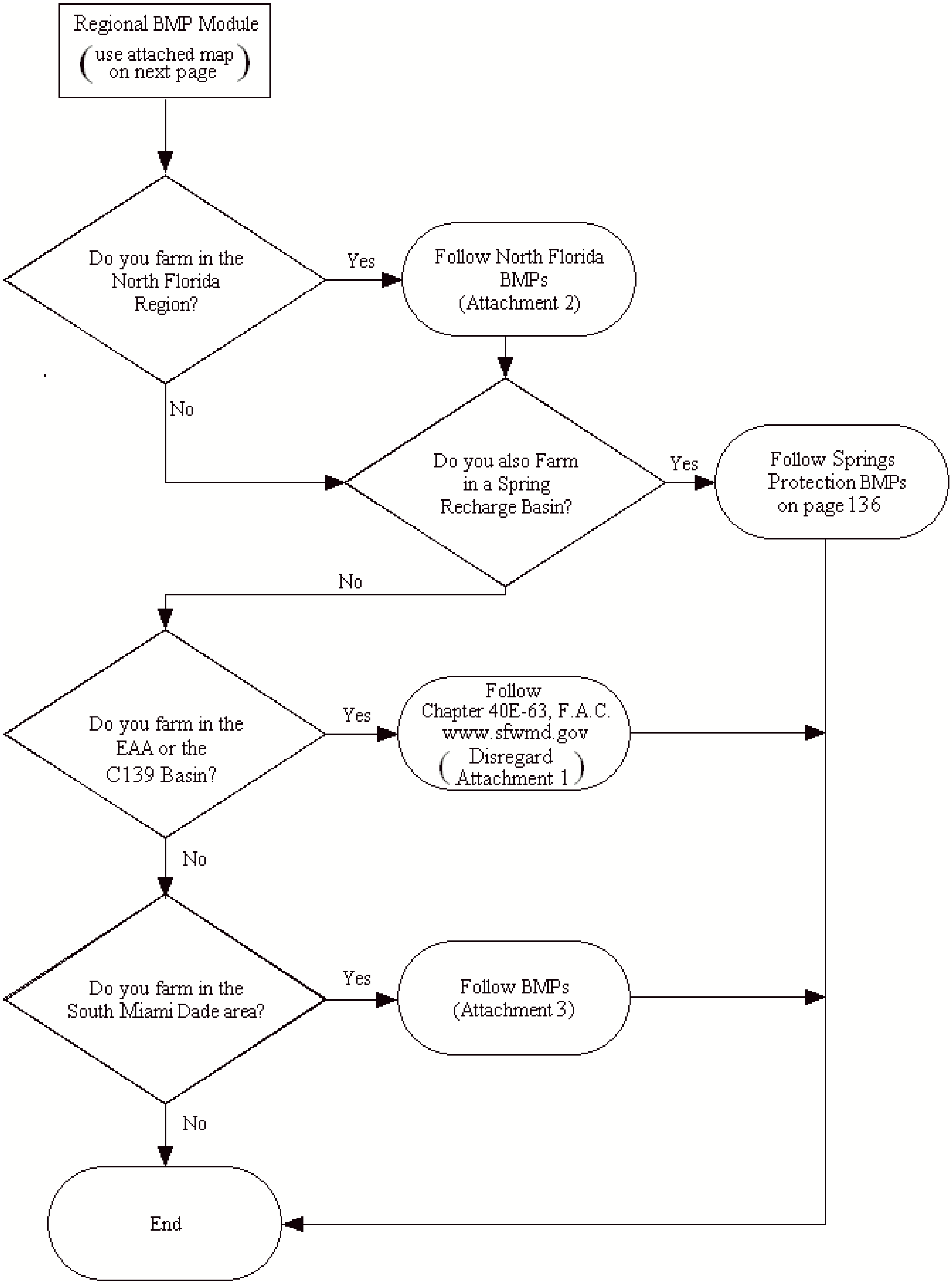
KEY

* BMP stands for Best Management Practices

* TMDL stands for Total Maximum Daily Load.

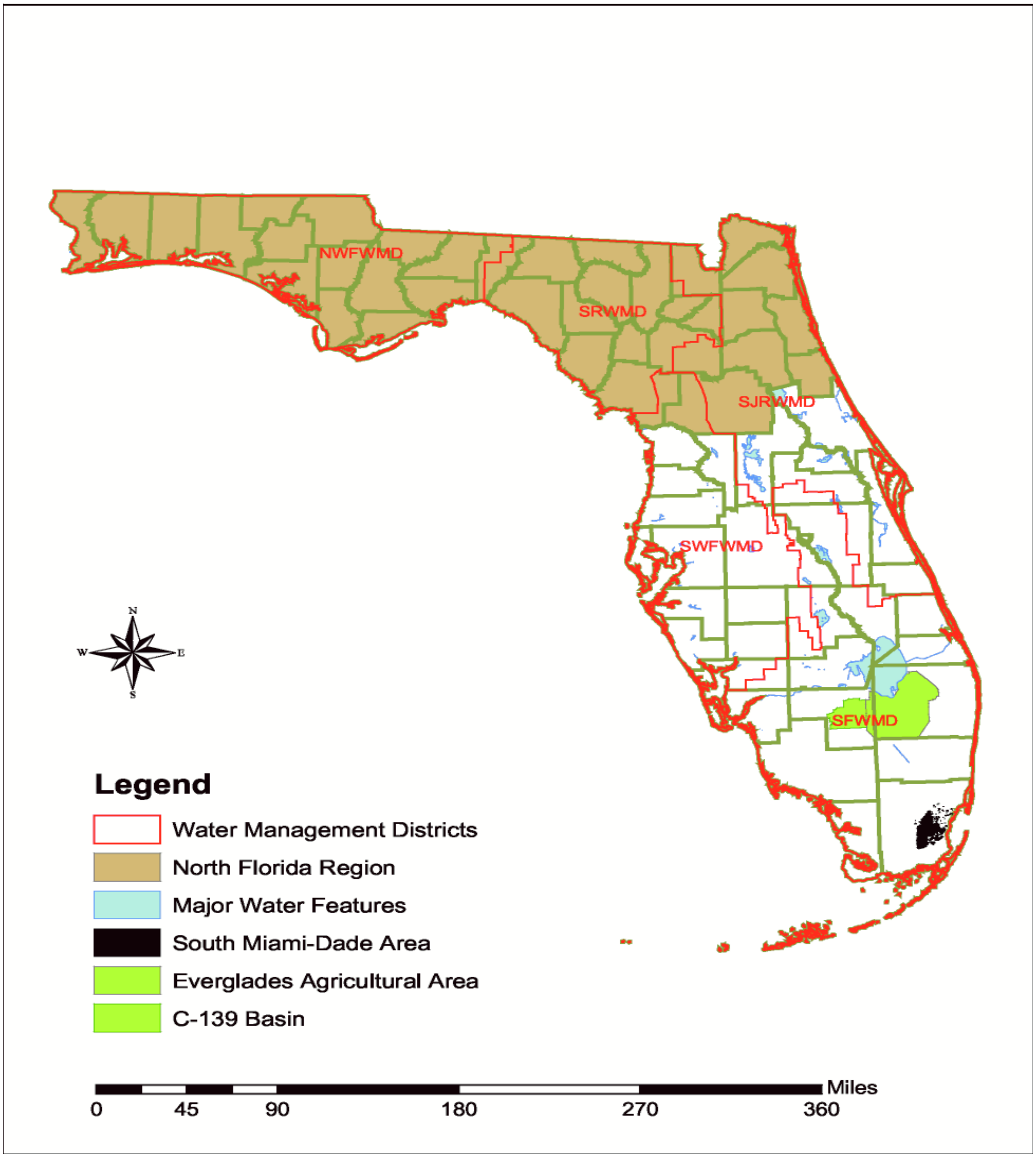
* BMAP stands for Basin Management Action Plan

* Temporary Farming is defined in the Glossary and on page 138


Regional BMP Module
(use attached map on next page)
Do you farm in the North Florida Region?
Yes
Follow North Florida BMPs (Attachment 2)
No
Do you also Farm in a Spring Recharge Basin?
Yes
Follow Springs Protection BMPs on page 136
No
Do you farm in the EAA or the C139 Basin?
Yes
Follow Chapter 40E-63, F.A.C. www.sfwmd.gov (Disregard Attachment 1)
No
Do you farm in the South Miami Dade area?
Yes
Follow BMPs (Attachment 3)
No
End

GEOGRAPHIC REGIONS MAP

This map is to be used in conjunction with the decision tree flowchart on the preceding pages. Persons using this should follow the flowchart path and associated BMP criteria.



Attachment No. 1

General BMPs for all Farming Operations

All farming operations using this BMP manual shall reasonably attempt to implement the following BMPs in order to establish a baseline set of BMPs to ensure a reduction in pollutant loading to impaired receiving waters. Depending on the farm's site specific conditions, all of these baseline BMPs need not be implemented. Only implement those BMPs applicable for your location and production system. This Tier-1 or first level of BMP protection also includes many of the practices that are identified as "essential" under USDA-NRCS conservation planning procedures. The proposed minimum set of BMP practices are:

Access Roads	Page No. 50
Ditch Construction and Maintenance	Page No. 65
Farm Ponds	Page No. 129
Filter Strip	Page No. 35
Flood Protection	Page No. 124
Integrated Pest Management	Page No. 14
Irrigation Scheduling	Page No. 115
Irrigation System Maintenance and Evaluation	Page No. 112
Optimum Fertilization Management	Page No. 93
Riparian Buffers	Page No. 39
Temporary Erosion Control Measures	Page No. 56
Well Head Protection	Page No. 28
Wetlands Protection	Page No. 30

Attachment No. 2

North Florida BMPs

The North Florida region is generally construed to depict the geographical region that would include agricultural production areas within both the Northwest Florida Water Management District and the Suwannee River Water Management District. With the exception of plasticulture farming in the Quincy and Middle Suwannee regions, most farmers in these areas grow agronomic crops, practice some form of conservation tillage, and generally farm on heavier loam-type soils with a greater depth to groundwater than similar operations in South Florida. Moreover, many of these same farmers routinely practice crop rotations which include nitrogen-fixing peanuts rotated with cotton. This region’s BMPs have been subdivided into three categories and include:

A. Non–Irrigated Cropland

- Demonstrate that you have a USDA-NRCS Conservation Plan updated within last 5 years or follow the BMP manual recommendations (i.e., Implement appropriate General BMPs from attachment No. 1)
- Limit in-field ditches to a maximum depth of 8”

B. Irrigated Non-Plasticulture Cropland

- Have an irrigation system evaluation performed every 5 years and implement recommendations, as appropriate
- If farming in a nutrient-impacted TMDL basin, develop an Irrigation and Nutrient Management Plan consistent with the Basin Management Action Plan
- Follow selected Erosion Control & Sediment Management BMPs and the Contour Farming BMP from the Conservation Practices and Buffers chapter if determined by an on-farm assessment as applicable
- If farming potatoes and/or cabbage in St. Johns, Putnam or Flagler counties, follow the BMP recommendations set forth in the Tri-County Agricultural Area Water Quality Protection Cost Share Program
- Limit in-field ditches to 12” or less (below grade cuts)

C. Plasticulture Farming Standards

- Follow criteria in Water Resources Chapter on pages 123-137.

Attachment No. 3

South Miami Dade BMPs

The South Miami-Dade area on the lower east coast of the Florida peninsula is generally a sub-tropical marine climatic zone that is warm year round with distinct rainy and dry seasons. The area supports an assortment of row crop farming consisting of vegetable and specialty crops. This area is very unique in that most farming takes place on calcareous (rock-land and marl) soils that have a shallow depth to the porous limestone bedrock below. Only one surficial aquifer exists , the Biscayne aquifer, and this aquifer is used for irrigation and drinking water; this aquifer is the sole source of drinking water for over 3 million people in the region. The thickness of the Biscayne aquifer is highly variable, ranging from 20 feet thick on its western edge to more than 300 feet thick toward the coast. The aquifer is highly permeable and is overlain in most places by only a thin layer of porous soil or sometimes exposed at the land surface. These geologic characteristics and its unconfined nature make this aquifer especially vulnerable to contamination from surface water runoff and percolation. As such, the application of BMPs to farming operations in this area becomes even more critical to protect the water resources. This region's BMPs have been subdivided into two categories below and include:

A. Non–Irrigated Cropland

- Demonstrate that you have a USDA-NRCS Conservation Plan updated within last 5 years or follow the BMP manual recommendations (i.e., Implement appropriate baseline BMPs from attachment No. 1)
- Utilize scouting for integrated pest management, as appropriate

B. Irrigated Cropland

- Use soil moisture monitoring devices with crops on plasticulture to more accurately schedule irrigation events
- Follow the Wellhead Protection BMP and consider special protection for open irrigation wells
- Consider converting big gun irrigation units to low volume irrigation systems, if feasible
- Develop a management plan that includes periodic establishment of a summer cover crop to take up any excess nutrients and to build organic matter content
- Employ scouting for integrated pest management, as appropriate, by grower, farm employee or professional scout
- Limit in-field ditches to a maximum depth of 12" or less
- If farming on marl soils, which are soils comprised of clay-like materials mostly carbonate in origin, the following BMPs are also required:
    - Consider laser grading farm fields as needed
    - Bed rows to reduce flood damage caused by fluctuating water tables and/or the management of water control structures by the SFWMD, if needed

PESTICIDE MANAGEMENT

Historical efforts to control pests involved the use of naturally occurring elements (i.e., sulfur and arsenic) and specific plants found to discourage pests. This approach to pest management, which was used with only limited success, remained largely unchanged for many generations. Major petrochemical advances, including the development of DDT in the late 1940's, triggered the era of agrichemicals. Since that time, thousands of compounds have been developed to control pests, diseases, insects, and weeds to improve product quality and increase yields. Over the past 50 years, many lessons have been learned about the use of pesticides and the unintended environmental and human consequences that can result from the use and misuse of these compounds. In the past 20 years, great strides have been made in the development of pesticides that are more target-specific, less harmful to the environment, and safer for those who handle and apply these products. Farmers have also learned to use a combination of chemical controls, biological controls, and other management practices (i.e., crop rotation) to improve overall pest control while minimizing the amount of chemicals that are applied. This integrated approach, which is commonly referred to as Integrated Pest Management or IPM, has become the cornerstone of modern pest management.

At the federal level, the U.S. Environmental Protection Agency (EPA) regulates the use of pesticides under the "Federal Insecticide, Fungicide, and Rodenticide Act" (FIFRA) and the "Federal Food, Drug and Cosmetic Act". Federal laws require that all pesticides sold in the U.S. bear an EPA registration number; consumers are protected by setting tolerance levels for pesticide residues on food products; and pesticide handlers and agricultural workers who might be exposed to pesticides are protected. At the state level, FDACS regulates the use of all pesticides, including those classified as "Restricted Use Pesticides". In accordance with the Florida Pesticide Law (Chapter 487, F.S.) and Rule (5E-2, F.A.C.), persons who use or supervise the use of restricted-use pesticides must be certified and licensed by FDACS. FDACS also issues a "Pesticide Applicators License" to individuals who pass required examinations. The training and examinations, which are administered by the University of Florida - Institute of Food and Agricultural Sciences (IFAS), include the "General Standards Core Exam" and more specific applicator categories. For more information on applicator certification and licensing and pesticide laws and regulations in Florida, visit the FDACS web site at http://www.safepesticideuse.com or UF/IFAS Pesticide Information Office's web site at www.pested.ifas.ufl.edu.

Responsible handling of chemicals and pesticides is an extremely important element of proper farm management and environmental stewardship. Proper handling, application, and disposal practices included in this chapter are designed to minimize the risk of environmental problems, protect the farm's water supply, and protect pesticide handlers and agricultural workers and the public from harm.

1 INTEGRATED PEST MANAGEMENT

Integrated pest management (IPM) is a philosophy of managing pests that aims to reduce farm expenses, conserve energy, and protect the environment. IPM does not mean that pesticides will be excluded. Instead, it means that pesticides are just one of many weapons used against pests. Pesticides should be used judiciously and only when needed. The goals of an IPM program are improved control of pests, more efficient pesticide management, more economical crop protection, and reduction of potential hazards to humans and the environment through reduced pesticide exposure.

IPM accomplishes these goals through the use of resistant plant varieties, improved management, parasites and predators, biological control agents such as *Bacillus thuringiensis* (BT), and selective use of synthetic pesticides. Although detailed IPM programs have not been developed for all crops, IPM principles can be applied in many cases using logic.

Working definition:

IPM is a broad, interdisciplinary approach to pest management using a variety of methods to systematically control pests which adversely affect crop production and quality.

Key BMP Subcategories:

1A BASIC STEPS FOR AN IPM PROGRAM – *Things to Do: BMP(s)*

√ Identify key pests and beneficial organisms, as well as the predominant life cycles and factors affecting their populations.

√ Select preventative cultural practices to minimize pests and enhance biological control strategies. These practices may include soil preparation, crop rotation, resistant varieties, modified irrigation methods, cover crops, augmenting beneficial insects, etc.

√ Predict economic losses and risks so that the cost of various treatments can be compared to the potential losses.

√ Use knowledgeable “scouts” to monitor pest populations to determine if or when a control measure might be needed.

√ Select pesticides that will control target pests and use them sparingly because they can also harm beneficial insects.

√ Continue to monitor pest populations to evaluate results of the decision and the effectiveness of corrective actions. Use this information when making similar decisions in the future.
√ Reduce spray drift and leave a buffer zone if the pesticide label requires one.

1B VARIETY SELECTION - *Things to Do: BMP(s)*

Plant-variety selection is a good management tool that allows the grower to select plants that are well adapted to a particular setting. Today's commercial plant varieties are also more insect and disease resistant, more cold and drought tolerant, and may require lower nutrient and/or pesticide inputs to sustain a crop.
√ Select varieties based on factors such as maturity, lodging resistance, climate, market value, yield potential, and pest resistance.
√ Inventory your surroundings and specific pest target(s) and select varieties accordingly.

Things to Avoid: Potential Pitfalls

X Do not let spray or dust drift to other crops and off-site areas.
X Do not make applications during severe *temperature inversion*, or when rain and high-velocity winds are expected.
X Avoid using the same insecticide and fungicide class more than three times in a row on any crop, if possible. Using materials in the same class more than three times in a row risks increasing resistance over more than one generation.

Other Considerations:

- Pests can inhabit a crop for weeks before it actually pays to control them.
- Spraying certain pesticides at night can reduce harm to beneficial insects.
- Different pesticides have different effects on aquatic organisms (fish, shellfish, etc.). Choose a chemical compound that has lower toxicity to aquatic organisms when applying a pesticide close to a stream, canal or pond.
- Coordinate pesticide applications with current soil moisture, the weather forecast, and irrigation scheduling requirements for precision application.
- Carefully control the quantity of irrigation water to minimize pesticide leaching and runoff.

Key References:

(1) Best Management Practices for Agrichemical Handling and Farm Equipment Maintenance by the Florida Department of Agriculture and Consumer Services and the Florida Department of Environmental Protection, http://www.dep.state.fl.us/water/nonpoint/docs/nonpoint/agbmp3p.pdf
(2) Integrated Pest Management Program at the University of Florida, http://ipm.ifas.ufl.edu/
(3) USDA Regional Pest Management Centers Information System, http://www.ipmcenters.org
(4) Southern Region Pest Management Center, http://www.pmcenters.org/southern/
(5) Integrated Pest Management in the Southern Region, http://ipm-www.ento.vt.edu/nipmn/
(6) Biocontrol Web Site, http://cmave.usda.ufl.edu/biocontrol/
(7) University of Florida, Entomology and Nematology Department, http://entnemdept.ifas.ufl.edu/
Integrated Pest Management and Florida Tomatoes: A Success Story in Progress, http://nfrec-sv.ifas.ufl.edu/ipm_tomato_rpt.htm
(8) IFAS Circular 1105, Agricultural Chemical Drift and Its Control, http://edis.ifas.ufl.edu/AE043

(9) IFAS Circular PI-1, Use Management Practices to Protect Groundwater from Agricultural Pesticides, http://edis.ifas.ufl.edu/PI001

(10) Soybean Best Management Practices Manual

2 PESTICIDE MIXING AND LOADING ACTIVITIES

Extreme caution should be used when handling concentrated chemicals to prevent accidental spills and expensive hazardous waste cleanups. It is also important to understand how improper mixing and loading operations can contaminate soils and pollute ground and surface water resources. General mixing and loading guidelines are important and should be a part of the overall management scheme.

Working Definition:

Pesticide mixing and loading activities consist of preparing pesticides for application.

Key BMP Subcategories:

2A GENERAL MIXING AND LOADING ACTIVITIES – *Things to Do: BMP(s)*

√ Locate operations well away from ground water wells and areas where runoff may carry spilled pesticides into surface water bodies.

√ Use berms to keep spills out of surface waters if such areas cannot be avoided.

√ Measure pesticides and diluents accurately to ensure that the correct volumes and concentrations are produced.

2B FIELD MIXING AND NURSE TANKS – *Things to Do: BMP(s)*

√ Use dedicated mix-load wells which have been retrofitted or conduct mixing and loading operations at random locations in the field away from wells or surface water bodies.

√ Dig up and containerize contaminated soil immediately if a pesticide is spilled at the field mixing site, and make proper disposition of this material following all applicable rules and regulations.

√ Consider using a *nurse tank* to transport clean water to the field in order to fill the sprayer.

√ Voluntary guidelines specifically for mix-loading of pesticides and fertilizers for Miami-Dade County have been developed and can be found in the *Handbook for the Voluntary Retrofit of Open, Uncased Agricultural Wells*.

√ Always use a check valve or air gap separation to prevent backflow into the nurse tank when loading a sprayer.

√ Leave adequate headspace (usually 10%) when filling the tank.
√ Also consider using a *portable mixing center* for in-field spill containment.

PERMANENTLY LOCATED MIXING AND LOADING FACILITIES:

By constructing a permanent mixing/loading facility, you can minimize the risk of pesticide accumulation in the environment. A permanently located mixing and loading facility, or *chemical mixing center (CMC)* is designed to provide a place where spill-prone activities can be performed over an impermeable surface that can be easily cleaned, thus facilitating the recovery of spilled materials. While this is optional, growers should note that the *CMC* may not be permitted on leased land.

2C CONSTRUCTION AND DESIGN OF CHEMICAL MIXING CENTER – *Things to Do: BMP(s)*

√ Construct the facility with an impermeable surface (such as sealed concrete).
√ Locate the facility in close proximity to, or as part of the pesticide storage building to reduce the potential for accidents and spills when transferring pesticides to the mixing site.
√ Assess the level of training and supervision required by the personnel that will be using the center, so that it is operated in a safe and responsible manner.
√ Install a roof with an overhang on all sides to protect against windblown rainfall.
√ Install a sump that is small, easily accessible for cleaning, and can pump liquids from the sump to a sprayer or storage tank.
√ Locate a CMC away from wells or surface water bodies and above the 100-year floodplain.

2D MANAGEMENT OF CMC FACILITY – *Things to Do: BMP(s)*

√ Follow the label instructions for handling spills and rinsate, and clean up all spills immediately.
√ Pump the sump dry, and clean it by the end of each week.
√ Remove from the sump any liquid and sediment and apply them as a pesticide at less than the label rate.

Things to Avoid: Potential Pitfalls

X Do not introduce pesticides into a dedicated nurse tank.
X Do not leave a spray tank unattended when filling.
X Avoid mixing pesticides adjacent to wetlands and other surface waters.

Applicable Technical Criteria:

♦ Areas around public water system wells should receive special consideration and may be designated as wellhead protection areas. Before mixing or loading pesticides in such areas, consult with state and local government officials to determine if special restrictions apply.

Key References:

(1) Best Management Practices for Agrichemical Handling and Farm Equipment Maintenance by the Florida Department of Agriculture and Consumer Services and the Florida Department of Environmental Protection, http://www.dep.state.fl.us/water/nonpoint/docs/nonpoint/agbmp3p.pdf
(2) Farming for Clean Water in South Carolina, a Handbook of Conservation Practices
University of Florida, Institute of Food and Agricultural Sciences (IFAS), http://edis.ifas.ufl.edu
(3) Water Quality/Quantity BMPs for Indian River Area Citrus Groves, http://www.ircitrusbmp.ifas.ufl.edu/Web%20Documents/BMp%20Manual/BMP%20Manual.htm

(4) Visit https://www.mwpshq.org/construc.html for ordering information on plans for proper design of pesticide containment facilities
(5) Building Plans and Management Practices for a Permanently-Sited Agricultural Mixing/Loading Facility in Florida. SM-58, 1997. IFAS Publications Office, University of Florida, Institute of Food and Agricultural Sciences. P.O. Box 110011, Gainesville, Florida, 32611. Phone (352)-392-1764.
(6) MWPS-37, Designing Facilities for Pesticide and Fertilizer Containment. Revised 1995. Midwest Plan Service, 122 Davidson Hall, Iowa State University, Ames, Iowa 50011-3080. Phone (515)-294-4337.

3 SPILL MANAGEMENT

Spills happen. The sooner you can contain, absorb, and properly dispose of a spill, the less chance there is that it will cause harm to individuals or the environment. Unmanaged spills - which can contaminate soils, surface waters, and ground water resources - can result in significant harm to plants and animals. Remember, there are severe penalties for failing to report a spill that is required by law.

Working Definition:

Spill management consists of the following steps: proper containment, collection, and disposal of spilled pesticide materials in order to minimize its release into the environment.

Key BMP Subcategories:

3A SPILL CLEAN-UP – *Things to Do: BMP(s)*

√ Always use appropriate personal protective equipment (PPE) as indicated on the material safety data sheet (MSDS) and/or the pesticide label.

√ If a pesticide container leak has developed, take immediate action to contain the leak. Place the leaking container in a compatible bucket or barrel.

√ Contain the spilled material by using barriers and absorbent materials such as activated charcoal, cat litter, dry sand, or soil.

√ Collect spilled material, absorbents, and containers and place them in a secure location using properly label container(s).

√ Store labeled containers of spilled materials until they can be applied as a pesticide according to the label.

√ Follow the recommendations outlined in the “Best Management Practices for Agrichemical Handling and Farm Equipment Maintenance” when dealing with fuels, solvents, and/or waste products.

3B SPILL REPORTING REQUIREMENTS- *Things to Do: BMP(s)*

√ Comply with all applicable federal, state, and local regulations regarding spill response training for employees, spill reporting requirements, spill containment and cleanup.

- √ Report any accidental release if the spill quantity exceeds the “reportable quantity” of active ingredient.
- √ Note the date, time, name of the substance, and estimated release amount should you need to legally report a spill.

Things to Avoid: Potential Pitfalls

X Always report a legally reportable spill. Failure to report to the authorities can result in administrative, civil, and in some cases criminal liabilities.

<u>Applicable Technical Criteria:</u>

- ♦ The National Response Center is the federal government’s centralized reporting center. Their phone number is 1-800-424-8802. Reportable quantities of Restricted Use Pesticides may be listed on the Material Safety Data Sheets. A complete list of pesticides and reportable quantities is available from the Department of Community Affairs, http://www.dca.state.fl.us/cps/SERC/htcl.htm#Section304 .
- ♦ Florida Law requires reporting of oil and hazardous substance spills to the State Warning Point (Call 1-800-320-0519 or 850-413-9911).

Key References:

(1) Best Management Practices for Agrichemical Handling and Farm Equipment Maintenance by the Florida Department of Agriculture and Consumer Services and the Florida Department of Environmental Protection, http://www.dep.state.fl.us/water/nonpoint/docs/nonpoint/agbmp3p.pdf
(2) University of Florida’s Pesticide Information Office, http://pested.ifas.ufl.edu/
(3) Proper Disposal of Pesticide Waste PI-18, http://edis.ifas.ufl.edu/PIO10
(4) CHEMTREC, http://www.chemtrec.org/
(5) U.S. EPA Emergency Response Program, http://www.epa.gov/superfund/programs/er/triggers/haztrigs/hazhow.htm

4 PESTICIDE APPLICATION EQUIPMENT WASH WATER AND CONTAINER MANAGEMENT

Washwater from pesticide application equipment and pesticide containers must be managed properly since both will contain pesticide residues. Proper handling of the washwater must be used to prevent contamination. Likewise, empty pesticide containers can also pose a risk to the environment and must be properly managed.

Working Definition:

Pesticide application equipment washwater is the water (rinsate) that is used to clean the containers/equipment after the pesticide is applied.

Key BMP Subcategories:

4A PESTICIDE CONTAINER MANAGEMENT – *Things to Do: BMP(s)*

√ Always wear the required PPE when conducting rinse operations.

√ Pressure-rinse or triple-rinse empty containers and add the rinse water to the sprayer.

√ Shake or tap non-rinseable containers such as bags or boxes so that all dust and material falls into the mix tank.

√ Puncture the pesticide containers after cleaning to prevent re-use (except glass and refillable mini-bulk containers) and keep dry.

√ Recycle rinsed containers in counties where a program is available, or follow the product's label for proper disposal. For more information, refer to the reference section at the end of this BMP.

4B MANAGING WASHWATER – *Things to Do: BMP(s)*

√ Wash application equipment at random areas in the field using water from a nurse tank.

√ Wash the inside of the application equipment on a mixing/loading pad. This rinsate may be applied as a pesticide (preferred) or stored for use as make-up water for the next compatible application.

√ Use the rinsate as a *diluent* for future mixtures of pesticides if the pesticide in the rinsate meets the following criteria:

1. It is labeled for use on the target site where the new mixture will be applied.
2. The amount of pesticide in the rinsate in combination with the amount of pesticide in the mixture does not exceed the label rate.
3. If the rinsate is going to be used to dilute a mixture containing the same pesticide or a compatible pesticide.

Things to Avoid: Potential Pitfalls

X Do not wash the equipment near wells or surface water bodies.

X Do not add the rinsate to a pesticide mixture if the pesticide label does not list the rinsate as an acceptable diluent or if the rinsate contains strong cleaning agents such as bleach or ammonia.

Applicable Technical Criteria:

♦ Check with your local landfill before taking containers for disposal.

♦ Check the label and local ordinances for information concerning burning of empty containers.

Key References:

(1) Best Management Practices for Agrichemical Handling and Farm Equipment Maintenance by the Florida Department of Agriculture and Consumer Services and the Florida Department of Environmental Protection, http://www.dep.state.fl.us/water/nonpoint/docs/nonpoint/agbmp3p.pdf.

(2) University of Florida's Pesticide Information Office, http://www.pested.ifas.ufl.edu/

(3) Pesticide Safety, http://edis.ifas.ufl.edu/CV108

(4) Proper Disposal of Pesticide Waste PI-18, http://edis.ifas.ufl.edu/PI010

(5) Pesticide Container Rinsing PI-3, http://edis.ifas.ufl.edu/PI003

5 PESTICIDE EQUIPMENT CALIBRATION

Proper application of pesticides will help a farm reduce costs and increase profits. Improper application results in wasted chemicals, marginal pest control, excessive carry-over, and/or possible crop damage. Not only does measuring correctly save you money, but it will also keep you in compliance with the label and reduce risks to applicators, farm workers, and the environment.

Working Definition:

Calibration is the process of measuring and adjusting pesticide application equipment to prescribed specifications.

5A EQUIPMENT CALIBRATION – *Things to Do: BMP(s)*

√ Check the Private Applicator Manual or other manuals from the manufacturers of both equipment and nozzles for information on calibrating equipment.

√ Make sure that all components of the application equipment are clean and in good working order and calibrate them regularly.

√ Become familiar with the machinery and follow the manufacturer's directions carefully. Pay particular attention to parts such as nozzles and hopper openings that regulate how much pesticide is released. If these parts are clogged, not enough pesticide will be released. If they are worn, too much pesticide will be released.

√ Apply a non-toxic substitute for the actual pesticide (i.e., plain water) when making test applications during calibration runs. If the pesticide is a dust, granule, fumigant, or liquid diluted with a liquid other than water, it is generally better to use the actual pesticide in the test runs.

√ Calibrate your equipment by measuring the amount of pesticide applied to a part of an acre and mathematically calculate how much would be applied to an entire acre.

√ Check the flow rates of all nozzles on the sprayer so they are similar.

√ Calibrate new sprayers or when nozzles are replaced. Recalibrate as needed based on spray coverage and after replacing nozzles, since new nozzles may wear and the flow rate may increase rapidly.

Things to Avoid – Potential Pitfalls:

X Do not calibrate equipment near wells, sinkholes, or surface water bodies.

X Do not assume that equipment will continue to deliver the same rate forever. Clogging, corrosion, and normal wear will eventually cause the delivery rate to change.

Applicable Technical Criteria

- ♦ If the equipment's actual application rate is not within $\pm$5% of the desired rate, then it needs to be recalibrated.
- ♦ Consult the operator's manual concerning the proper calibration and correct cleaning method for each type of application equipment.

Operation and Maintenance:

- ■ Be aware of chemical effects on equipment and recalibrate equipment periodically to compensate for this.
- ■ Record calibration dates for future reference.

Key References:

(1) Best Management Practices for Agrichemical Handling and Farm Equipment Maintenance by the Florida Department of Agriculture and Consumer Services and the Florida Department of Environmental Protection, http://www.dep.state.fl.us/water/nonpoint/docs/nonpoint/agbmp3p.pdf

(2) Farming for Clean Water in South Carolina, a Handbook of Conservation Practices

(3) Water Quality/Quantity BMPs for Indian River Area Citrus Groves, http://ircitrusbmp.ifas.ufl.edu/web%20Documents/BMP%20Manual/BMP%20Manual.htm

(4) IFAS publication AE-261, Calibration of Chemical Applicators Used in Vegetables, http://edis.ifas.ufl.edu/CV110

(5) IFAS publication SS-AGR-102, Calibration of Herbicide Applicators, http://edis.ifas.ufl.edu/WG013

(6) IFAS publication PI-23, Broadcast Boom Sprayer Nozzle Uniformity Check, http://edis.ifas.ufl.edu/PI015

(7) IFAS publication PI-24, Broadcast Boom Sprayer Calibration, http://edis.ifas.ufl.edu/PI016

(8) The Private Applicator Pest Control Manual (SM53) is available from the IFAS Extension Bookstore. It may be ordered by contacting the IFAS Extension Bookstore at 1-800-226-1764 or may be ordered from their web site at http://ifasbooks.ufl.edu/.

CONSERVATION PRACTICES AND BUFFERS

Runoff water from agricultural lands may pick up sediment, nutrients, pesticides and other contaminants. These and other constituents can then be carried to surface water as well as directly to groundwater. They can then alter the aquatic ecosystem found in surface water bodies and can revert them from swimmable, fishable areas to places that can no longer be used to support recreational activities. If these contaminants reach the groundwater, they may also impact drinking water systems since most of Florida's drinking water supply comes directly from groundwater.

The following BMPs are designed to help protect water quality by helping to impede the runoff or leaching process. By impeding the flow of runoff, sediments, nutrients, pesticides, and other contaminants can be filtered out before reaching downstream water bodies. Not only will the following BMPs help to maintain and improve water quality, the BMPs can serve other purposes as well. Some of these BMPs can also help wildlife populations by serving as habitat. Also, cattle grazing at planned rates may be an additional tool to help control nuisance and exotic vegetation in buffer strips. Others will also help to increase populations of beneficial insects, which may help to control pests and increase crop yields.

It has been nearly three-quarters of a century since the United States embarked on a national program for soil and water conservation. Soil and water conservation programs are not just an exercise in science and technology, but also posture government to be effective in dealing with the nation's private landowners. Conservation should be considered the cornerstone of every BMP.

6 WELL HEAD PROTECTION

With the majority of Florida's existing water supply coming from groundwater sources (*aquifers*), coupled with the increases in demand that have been projected, it is extremely important that we make every effort to protect this valuable resource. Well head protection, which involves the use of regulations and common-sense measures related to well placement and practices near wells, is one of the most important ways to protect the quality of groundwater sources.

Working Definition:

Well head protection is the establishment of protection zones and safe land use practices around public and private potable (drinking) water supply wells in order to protect aquifers from accidental contamination.

Key BMP Subcategories:

6A WELL PLANNING - *Things to Do: BMP(s)*

√ Carefully plan the location of new wells. Site wells as far as possible from likely pollutants such as septic tanks or chemical mixing areas.

√ Abandoned or flowing wells should be properly plugged or valved before constructing any new wells.

6B WELL DRILLING AND OPERATION - *Things to Do: BMP(s)*

√ Drill new wells according to local government and water management district code. This is particularly important in areas of increased vulnerability such as Miami-Dade County.

√ Maintain records of well construction. Proper records are important in case problems rise with the well.

√ Construct new wells on higher ground and up-gradient from sources of possible contamination or flooding.

√ Use backflow prevention devices when *fertigating* or *chemigating* in accordance with state regulations.

Things to Avoid: Potential Pitfalls

- **X** Never store agrichemicals in the well house itself.
- **X** Avoid mixing within 100 feet of any well or surface water body unless label or local restrictions are more restrictive.

<u>Applicable Technical Criteria:</u>

- ♦ Shallow wells should be properly screened, and deep wells should be cased at least 10 feet into the aquifer bed.
- ♦ At a minimum, surround wells with a concrete slab 4 inches thick and 2 feet wide in all directions. Check local regulations concerning the exact size for your area.

<u>Operation and Maintenance Issues:</u>

- ■ When possible, geophysically log each well to determine well integrity. Many existing wells have no construction records and logging the wells can verify proper casing depths to ensure that the casing is deep enough and intact.
- ■ Inspect wellheads and pads regularly for leaks or cracks. Repair them promptly.
- ■ Test domestic well water regularly. Pollutants can enter from a number of sources.

Other Considerations:

- ● Always remember…. Your family could be drinking what reaches the water supply. Using sound practices and common sense reduces the risk of contaminating your family's drinking water.
- ● Overpumping of higher capacity agricultural irrigation wells may result in unforeseen problems, such as salt water intrusion, cross contamination of different aquifers, and/or inadvertent movement of potential contaminants within the well's *zone of influence.*
- ● Fueling and livestock areas should be located as far as possible from wells.

Key References:

(1) USDA-NRCS Conservation Practice Standard, Water Well, Code 642, http://www.nrcs.usda.gov/technical/efotg
(2) Farming for Clean Water in South Carolina: A Handbook of Conservation Practices
(3) SJRWMD Aquifer Protection Program, http://sjr.state.fl.us/

7 WETLANDS PROTECTION

Wetlands are important components of Florida's water resources. They often serve as spawning areas and nurseries for many species of fish and wildlife, play important flood-storage roles, cycle nutrients in runoff water, contribute moisture to the hydrologic cycle, add plant and animal diversity, and provide recreational opportunities to the public. Wetlands are complex transitional ecosystems between aquatic and terrestrial environments. Prior to substantial development in Florida, wetlands - including open waters and seasonally flooded areas - covered about half of the state. Today, that area has been greatly reduced, primarily because early water management efforts in Florida focused on draining wetlands to facilitate urban development and augmentation of agricultural lands.

Today, the evolution of environmental law has successfully abated earlier trends in wetland destruction (i.e., dredge and fill) impacts. Subsection 373.019(17), Florida Statutes defines "wetlands" to mean *those areas that are inundated or saturated by surface water or ground water at a frequency and a duration sufficient to support, and under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soils. Soils present in wetlands generally are classified as hydric or alluvial, or possess characteristics that are associated with reducing soil conditions.* Florida wetlands generally include swamps, marshes, bayheads, bogs, cypress domes and strands, sloughs, wet prairies, riverine swamps and marshes, mangrove swamps, and other similar areas. As such, this definition provides the concept for the types of areas intended to be included as wetlands by state regulators having authority over wetland issues. The 1994 State Wetland Rule, Chapter 62-340, F.A.C., entitled "Delineation of the Landward Extent of Wetlands and Surface Waters" requires that regulating entities use this unified statewide methodology when determining wetland boundaries. An important determinant under section 62-340.300 of the rule is that the regulating entity must first directly apply the statutory wetland definition (above) in balance with reasonable scientific judgment when evaluating scientific factors (plants, soils, hydrology) affecting ultimate wetland decisions.

In general, most isolated wetlands under 0.5 acres in size that are not used by threatened or endangered animal species are exempt from habitat protection. However, the federal government's USDA-NRCS does not recognize this exemption and may require mitigation for dredge/fill impacts on these smaller wetlands.

Working Definition:

Wetlands are typically low areas with seasonal or permanent standing water within the agricultural landscape that provide wildlife habitat and natural filtration for farmland runoff.

Key BMP Subcategories:

7A WETLAND PROTECTION AND IMPACT AVOIDANCE - *Things to Do: BMP(s)*

Wetlands exist as isolated features in the landscape or are contiguous to flowing watercourses. Given the engineering mechanics associated with the drainage layout of most farm systems, these areas naturally lend themselves to incorporation within the larger farm site plan. The goal of this manual is to provide information on how to protect them from permanent impacts associated with dredging, filling, *hydroperiod* alteration due to increased or decreased water levels, and/or degradation of water quality. It is the intent of this manual to recommend practices which would not adversely affect either onsite (project area) or offsite wetlands. As such, all proposed activities must first consider elimination and/or reduction of wetland impacts through practicable design alternatives or modifications. Preserving and incorporating all regulated wetlands into the system design and using upland buffers (sized as determined below) reduces adverse impacts to wetlands and their habitats. Unless superceded by an ERP, growers should strive to incorporate the following wetland buffers:

√ All onsite isolated wetlands > 1 acre in size must contain a minimum 35-foot undisturbed upland buffer landward from the exterior boundary of the wetlands.

√ All onsite isolated wetlands between ½ acre and 1 acre in size must contain a minimum 50-foot undisturbed upland buffer landward from the exterior boundary of wetlands, unless the wetland areas (including buffers) exceed 15% of the total land area. If exceeding the 15% threshold, buffers should be a minimum 25-feet.

√ All onsite perennial watercourses (i.e., creeks, rivers) must contain a minimum 25-foot undisturbed upland buffer landward from the exterior boundary of the wetlands.

√ Prior to construction of any upland land-based water quality treatment system (i.e., filter strip) that ultimately discharges to surface waters, the landward extent of any receiving water must be determined by either FDACS, FDEP, the regional water management district, or applicable local regulatory agencies. This determination is necessary to prevent the construction of water-treatment facilities within *jurisdictional wetlands* pursuant to Chapter 62-340, F.A.C.

7B WATER QUALITY TREATMENT AND FIELD DISCHARGES - *Things to Do: BMP(s)*

In general, isolated wetlands may be used for water-quality treatment purposes if the wetland is wholly owned by the landowner and the owner/operator is utilizing all appropriate BMPs. To minimize impact to the wetland, the BMP treatment train concept should be used. Pretreatment practices such as filter strips, buffers, or grassed waterways can substantially reduce pollutants, especially suspended solids, and allow the wetland to more naturally reduce nutrients. A controlled method of discharge must be assured and the inflow must mimic predevelopment flow patterns.

√ If applicable, design and install upland sediment sumps outside of wetland buffers to prevent scouring and minimize sediment transport.

√ Use spreader swales and other devices to encourage sheetflow through the upland buffer prior to discharging into wetlands and maintain watersheds and point(s) of discharge during pre-and post-development conditions.

√ Comply with applicable Class III state water quality standards (Chapter 62-302, F.A.C.) for total suspended solids and dissolved oxygen when using wetlands to treat runoff water.

√ Utilize buffers around wetlands to help provide treatment and comply with applicable engineering considerations in the Water Resources chapter of this manual.

7C WETLAND ENHANCEMENT AND CONSTRUCTION - *Things to Do: BMP(s)*

Within Florida, especially on agriculturally zoned lands, many historically drained and altered wetlands exist because, before regulation, *outfall ditches* were typically excavated to drain the wetlands and surrounding lands in order to enhance agricultural production. Given this framework, there may be select opportunities for farmers to restore wetland hydrology and function. Simple restoration measures such as *earthen plugs* placed within the outfall ditch may provide benefits to the resource and farmers alike. Also, landowners may qualify for various USDA-NRCS incentive programs designed to encourage wetland restoration. Your local NRCS District Conservationist can assist you in this matter.

√ If using the enhanced wetland as a potential plant nursery/donor site for wetland-mitigation purposes, nurserystock must be native wetland vegetation. Try to avoid the use of heavy equipment when harvesting wetland plants.

√ Before attempting any wetland enhancement and/or restoration modifications, contact FDACS, the appropriate regional water management district or USDA-NRCS. Some restoration activities may actually be exempt from Environmental Resource Permitting requirements pursuant to section 373.406, Florida Statutes.

<u>Applicable Technical Criteria:</u>

♦ Setback wetland buffers and point(s) of discharge into wetlands a minimum of 25 feet and follow the Wetlands Protection and Impact Avoidance criteria above.

<u>Operation and Maintenance Issues:</u>

■ Limit the use of pesticides and fertilizers in and around wetlands and be careful to avoid spray drift impacts.

■ In order to maintain herbaceous cover and control nuisance and exotic species, conduct appropriate wetland buffer roller chopping and/or prescribed burning activities.

Other Considerations:

- If considering USDA benefits and/or federal cost-share programs, become familiar with the Food Security Act's Swampbuster provisions so as to not jeopardize your qualification status.
- Consider installing duck nesting boxes, grassland management, etc., to enhance a wetland's overall wildlife value.
- Obtain and learn to use a county soil survey map to help identify wetland soil types and/or depressional areas – both of which may be unsuitable for crop cultivation.

Key References:

(1) USDA-NRCS Conservation Practice Standard, Wetland Enhancement, Code 659, http://www.nrcs.usda.gov/technical/efotg

(2) Farming for Clean Water in South Carolina: A Handbook of Conservation Practices

(3) Water Management Districts' Environmental Resource Permitting Rule and Basis of Review

8 GRASSED WATERWAYS

Gully formation can be a significant problem, especially in hilly regions, if water conveyance features are not provided to safely direct excess water from agricultural fields. Grassed waterways, which are shallow vegetated channels, are commonly used to direct water off fields and prevent erosion associated with storm events. Grassed waterways are used primarily to convey water, whereas filter strips are intended to provide water quality treatment. Grassed waterways also function by reducing velocities and allowing sediments to settle out of suspension, and in certain soils, allowing infiltration of stormwater. The vegetative cover in a grassed waterway also protects soils within the waterway and provides substrate for soil particle adhesion. As a secondary benefit, grassed waterways provide good wildlife habitat. From a design standpoint, grassed waterways are commonly used with terraces, diversions, and contour farming activities.

Working Definition:

Grassed waterways are natural or constructed, vegetated channels that are used to convey runoff water from fields, terraces, diversions or other water-collection features in order to minimize soil erosion and protect water quality.

Key BMP Subcategories:

8A GRASSED WATERWAY PLANNING - *Things to Do: BMP(s)*

√ Use visual inspections and, if necessary, topographic maps and basic survey equipment to identify areas where grassed waterways are needed to convey water from fields.

√ Select vegetation (usually a non-invasive grass) that is suited to the climate and soil type of the area.

√ Develop a plan that includes locations, dimensions, grades, construction sequences, management and maintenance.

√ Construct grassed waterways during the dry season to minimize sediment transport during construction and prior to the establishment of vegetation.

8B GRASSED WATERWAY CONSTRUCTION AND MANAGEMENT - *Things to Do: BMP(s)*

√ Grade and contour side slopes to maintain function and integrity.

√ Divert water around the grassed waterway until vegetation is established.

√ Irrigate, fertilize and mow as necessary to promote the establishment of a dense vegetative cover. (Note: *Fertilization and irrigation should not be needed after vegetation is established*)

Things to Avoid: Potential Pitfalls

X Lift tillage equipment and shut off spray equipment when crossing waterways, and avoid crossing waterways when soils are flooded or saturated.

X Do not use the grassed waterway as a roadway for accessing farm fields.

X If livestock have access to grassed waterways, grazing should be closely managed to address potential food safety concerns and to maintain adequate vegetative cover.

Applicable Technical Criteria:

♦ Side slopes should not be steeper than 2 horizontal to 1 vertical, and should be designed to accommodate equipment crossing.

♦ Technical criteria on minimum capacity, maximum water velocity, maximum width and appropriate depth are provided in the USDA-NRCS Conservation Practice Standard, Grassed Waterway, Code 412 and the USDA-NRCS Engineering Field Handbook - Part 650.

Operation and Maintenance Issues:

■ Control invasive plant species that may compete with the establishment of native plants.

■ Inspect waterways after significant storm events and repair damaged areas by filling, compacting or seeding as appropriate.

■ Periodically mow waterways and remove cut vegetation and deposited sediment as needed to maintain the waterway's capacity.

■ Small grains or cool-weather grasses can be planted during winter months to maintain vegetative cover.

■ Exclude livestock when waterways are flooded or saturated.

Other Considerations:

● Consider the implementation of soil conservation measures in farm fields or other disturbed areas that drain to the waterway in order to minimize sediment loss and maximize water quality protection.

● Bunch grasses and perennial *forbs* can be planted along the margins of waterways to improve wildlife habitat.

Key References:

(1) USDA-NRCS Conservation Practice Standard, Grassed Waterway, Code 412, http://www.nrcs.usda.gov

(2) Farming for Clean Water in South Carolina: A Handbook of Conservation Practices

9 FILTER STRIPS

Runoff water from disturbed lands can pick up sediment, nutrients, and other contaminants and carry them to vulnerable receiving waters. Filter strips, which are vegetated areas located between active farm lands and environmentally sensitive areas, are designed to protect water quality by providing a natural treatment process. Filter strips purify runoff water by reducing velocities and allowing particulates to drop out of suspension and/or adhere to vegetation. Filter strips often serve as the last line of defense that can be used to improve water quality before discharge into receiving waters. As an additional benefit, properly sited, constructed, and maintained filter strips also serve as additional habitat for wildlife and beneficial insects.

Working Definition:

Filter strips are permanent areas of native grass, small grains, or other vegetation that are used to purify runoff water by trapping soil particles and attached contaminants before they are discharged to receiving water bodies.

Key BMP Subcategories:

9A FILTER STRIP PLANNING - ***Things to Do: BMP(s)***

√ Use visual inspections and, if necessary, topographic maps and basic survey equipment to identify potential filter strip areas where surface water flows have the potential to carry sediment and contaminants into receiving waters.

√ Select vegetation that is suited to the climate and soil types of the area.

√ Develop a plan that includes locations, dimensions, grades, construction sequences, management, and maintenance.

9B FILTER STRIP CONSTRUCTION AND MANAGEMENT - ***Things to Do: BMP(s)***

√ Construct filter strips during the dry season to minimize sediment transport during construction and prior to the establishment of vegetation.

√ Balance cuts and fills to maximize the use of local materials, and carefully grade the area prior to planting to promote sheet flow across the strip.

√ Irrigate, fertilize, and mow as necessary to promote the establishment of a dense vegetative cover.

Things to Avoid: Potential Pitfalls

X If livestock have access to filter strip areas, grazing should be closely managed to prevent soil compaction and loss of adequate vegetative cover.

X Avoid heavy equipment usage and grazing when filter strips are saturated with water.

Applicable Technical Criteria:

♦ The ratio of the drainage area above the filter strip to the filter strip area should not exceed 50:1, and slopes across the strip should be gradual (less than 3%) to minimize water velocities and maximize sediment removal.

♦ Filter strips should be at least 20 feet wide, and greater widths (travel distance) may be necessary if vegetation density is less than optimal or slope across the strip is greater than optimal.

Operation and Maintenance Issues:

■ Control invasive plant species that may compete with the establishment of native plants.

■ Inspect filter strips after significant storm events, repair rills or gullies that have formed, and remove unevenly deposited sediment that could impair *sheet flow*.

■ Periodically mow filter strips and remove cut vegetation from the filter strip area.

Other Considerations:

● Consider the implementation of soil conservation measures in farm fields or other disturbed areas that drain to the filter strip in order to minimize sediment loss and maximize water quality protection.

● In terms of filter strip function, adequate plant density is more important than travel distance across the strip.

Key References:

(1) USDA-NRCS Conservation Practice Standard, Filter Strip, Code 393, http://www.nrcs.usda.gov/

(2) Farming for Clean Water in South Carolina: A Handbook of Conservation Practices

10 FIELD BORDERS

Field borders are strips of permanent vegetation planted at the edge(s) of cropland fields. Field borders function primarily to reduce erosion from wind and water, protect soil and water quality, and provide wildlife habitat. Field borders can also be used as a management tool to help reduce harmful insect populations and can provide turning areas for farm equipment.

Working Definition:

A field border is a strip of permanent vegetation established at the edge of or around the perimeter of a farm field.

Key BMP Subcategories:

10A PLANNING CONSIDERATIONS - *Things to Do: BMP(s)*

√ Plan so that the field borders are wide enough so you can turn your equipment around.

√ Locate borders around the entire perimeter of the field or, at a minimum, in areas where runoff enters or leaves the field.

√ Assess whether *waterbars* or berms may be needed to break up or redirect concentrated water flow within the borders.

√ Plant borders during the time of year that will assure the most success for survival for the vegetation being planted.

10B VEGETATION SELECTION – *Things to Do: BMP(s)*

√ Include herbaceous plants that attract beneficial insects and provide wildlife food and cover.

√ Consider native species, when feasible, which are adapted to your climate and soil type.

√ Consider over-seeding the border with legumes for plant diversity and wildlife benefits.

Things to Avoid: Potential Pitfalls

X Avoid herbicide drift into the border from adjacent croplands.

X Avoid fertilization of mature field borders.

Operation and Maintenance Issues:

- Remove sediment when 6 inches or more have accumulated at the field border.
- Repair *rills* and small channels that may develop across the border, and reseed as necessary.
- Control grazing if livestock have access to field borders.
- Shut off spray equipment and raise tillage equipment when turning on a field border.
- Fertilize, mow, harvest, and control noxious weeds to maintain plant vigor in the border.
- Let native plants reseed themselves.

Other Considerations:

- Field borders are more effective and provide more environmental benefits when planted around the entire field.
- To increase water and soil trapping efficiency, consider establishing a narrow strip of stiff-stemmed upright grass at the crop/field border interface.
- Consider plants tolerant of sediment deposition and of chemicals planned for application.

Key References:

(1) USDA-NRCS Conservation Practice Standard, Field Border, Code 386, http://www.nrcs.usda.gov/

(2) Farming for Clean Water in South Carolina – A Handbook of Conservation Practices

11 RIPARIAN BUFFERS

A *riparian* buffer is part of a whole-farm conservation plan or buffer system to help reduce excessive amounts of sediment, organic material, nutrients, and pesticides in surface runoff from agricultural areas. Riparian buffers also help to reduce excess nutrients and other chemicals in groundwater *lateral flow* that contributes to a receiving stream system's base flow. Riparian buffers are most effective when positioned next to perennial or intermittent streams, lakes, ponds, wetlands and areas with high groundwater recharge potential, and also provide valuable habitat.

Working Definition:

A riparian buffer is an area of trees and/or shrubs located adjacent to natural waterbodies.

Key BMP Subcategories:

11A RIPARIAN BUFFER PLANNING – *Things to Do: BMP(s)*

√ Include a zone (identified as zone 1) that begins at the normal water line, or at the top of the bank, and extends a minimum distance of 15 feet, measured horizontally on a line from the water body.

√ Include a zone (identified as zone 2) that begins at the edge or landward extent of zone 1 and extends a minimum distance of 20 feet, measured horizontally on a line from the water body.

√ Design zone 3 in accordance with the Filter Strip BMP criteria as specified in this manual.

√ Locate and size watercourse crossings to minimize impacts to buffer vegetation and function.

11B VEGETATION SELECTION – *Things to Do: BMP(s)*

√ Consider native shrub and tree species based on their compatibility in growth and shade tolerance.

√ Plan for vegetation that has multiple values such as those suited for timber, biomass, nuts, fruit, nesting, aesthetics and tolerance to locally used pesticides.

√ Consider species that resprout when establishing buffers nearest to watercourses.

√ Make sure that the planting consists of two or more species with individual plants suited to the seasonal variation of soil moisture conditions.

11C ESTABLISHING THE AREA - *Things to Do: BMP(s)*

√ Plant the buffer to coincide with the time of year that ensures survival of the selected species.

√ Apply supplemental irrigation, if necessary, to assure early survival and establishment of selected species.

√ Conduct rollerchopping and/or prescribed burns as necessary to maintain the native vegetation within the buffer and to discourage the establishment of nuisance exotic vegetation.

Things to Avoid: Potential Pitfalls:

X Avoid tree and shrub species that may be alternate hosts to pests, or that may be noxious or undesirable.

X Avoid layouts and locations that would concentrate flood or return flows.

<u>Applicable Technical Criteria:</u>

♦ See the Key Reference Section for required plant densities for buffer plantings.

♦ The minimum combined width of zones 1 and 2 should be 100 feet or 30 percent of the geomorphic flood plain, whichever is less; however, in no case shall the combined widths of zones 1 and 2 be less than 35 feet.

<u>Operation and Maintenance Issues:</u>

■ Inspect the buffer periodically, and restore as needed in order to maintain the intended purpose(s).

■ Replace dead trees or shrubs and carefully control undesirable vegetation to reduce competition.

■ Removal of tree and shrub products such as timber, nuts, and fruit is permitted in zones 2 and 3 provided the intended purpose is not compromised by loss of vegetation or harvesting disturbance.

■ Felling and skidding of trees shall be directed away from the watercourse or water body and shall be accomplished in a manner to prevent the creation of channels that are perpendicular to the stream. Follow the silviculture BMPs when appropriate.

Other Considerations:

● An adequate adjacent natural seed source must be present when using natural regeneration to establish a buffer.

● Where concentrated flow, sheet and/or rill erosion is a concern in the area up-gradient of zone 2, consider the addition of a filter strip.

● When concentrated flow, excessive sheet and/or rill erosion cannot be controlled vegetatively, consider structural or mechanical treatments. (e.g., terraces, diversions, grassed waterways).

Key References:

(1) USDA-NRCS Conservation Practice Standard, Riparian Forest Buffer, Code 391, http://www.nrcs.usda.gov/technical/efotg

(2) NRCS FL Technical Note Forestry FL-17, General Specifications for Establishing Riparian Forest Buffers, Soil Conservation Service, USDA, 1979, http://www.nrcs.usda.gov/

(3) Management For Wildlife, A Supplement to Wildlife Standard and Specifications for Florida. Gainesville, FL.

(4) Division of Forestry's Silviculture BMP Manual, 2000.

12 CONTOUR FARMING

Contour farming involves the establishment of rows/furrows that follow the land's natural contours. This practice is used to minimize erosion and control runoff on highly sloping land. Properly established contour lines are generally perpendicular to the primary direction of the slope, and connect points of nearly equal elevation. Farming on the contour also increases infiltration and reduces runoff rates. This practice is often used in conjunction with other practices (e.g., terraces, buffer strips or diversions) that are designed to control excessive runoff due to slope.

Working Definition:

Contour farming is the practice of establishing crop rows that follow lines of contour and are perpendicular to the slope.

Key BMP Subcategories:

12A PLANNING AND ESTABLISHMENT – Things to Do: BMP(s)

√ Establish row direction as closely as possible to the natural contour in order to minimize erosion.

√ Follow the contour line established for all tillage and planting operations.

√ Deliver all runoff from contouring to stable outlets, such as grassed waterways, field borders, water and sediment control basins, or underground outlets for terraces and diversions.

Things to Avoid: Potential Pitfalls:

X Avoid the establishment of contour rows that exceed the critical slope length, unless supported by other practices (e.g., terraces, buffer strips or diversions) that either reduce slope length below the critical length or reduce overland flow velocities.

<u>**Applicable Technical Criteria:**</u>

♦ Contour farming is most effective on slopes between 2 and 10 percent.

- ♦ Design contours with row grades that are not less than 0.2 percent to prevent ponding. This is particularly important for soils with slow to very slow infiltration rates (soil hydrologic groups C or D) and with crops sensitive to ponded water conditions.
- ♦ Design contours with maximum row grades not to exceed 4 percent or one half of the up- and down-hill slope percentage used for erosion prediction, whichever is less.

Operation and Maintenance Issues:

- ■ Establish and maintain permanent contour markers to help keep crop rows at designed grades.
- ■ Farming operations should begin on the contour baselines and proceed both up and down the slope in a parallel pattern until patterns meet.
- ■ Establish sod turn strips on sharp ridge points or other areas, as needed, where contour row curvature becomes too sharp to keep machinery aligned with rows during field operations.

Other Considerations:

- Grassed waterways, water and sediment control basins, underground outlets, or other suitable practices should be used to protect areas where concentrated flow erosion is probable.
- Contour farming may need to be used in combination with other conservation practices to control runoff and erosion.

Key References:

(1) USDA-NRCS Conservation Practice Standards, Contour Farming - Code 330, Contour Buffer Strips - Code 332, and Terrace - Code 600, http://www.nrcs.usda.gov/

(2) Farming for Clean Water in South Carolina: A Handbook of Conservation Practices

(3) Predicting Soil Erosion by Water, A Guide to Conservation Planning with the Revised Universal Soil Loss Equation (RUSLE). 1997. USDA Agricultural Research Service, Agricultural Handbook No. 703.

13 LAND LEVELING

Land leveling is a common cultural practice for many of Florida's row crop farmers. Land leveling can improve surface drainage, provide more effective use of rainfall, facilitate installation of more workable drainage systems, control erosion, and improve water quality. Land leveling also permits the uniform and efficient application of irrigation water to the land. In South Florida, most fields have been leveled through years of plowing and disking.

Working Definition:

Land leveling is the process of reshaping the surface of the land to planned grades.

Key BMP Subcategories:

13A PLANNING AND DESIGN ISSUES - *Things to Do: BMP(s)*

The design and layout for leveling land shall be based on a detailed engineering survey, design and layout.

√ Plan all leveling work as an integral part of an overall farm irrigation system designed to enhance the conservation of soil and water resources.

√ Make sure that the soils will be deep enough after leveling so that an adequate, usable root zone remains that will permit satisfactory crop production with proper conservation measures.

√ Level the land to meet the most restrictive requirements if more than one method of water application or more than one kind of crop is planned.

√ Design within the slope limits required for the method(s) of water application to be used, to provide for the removal of excess surface water, and to control erosion caused by rainfall.

13B CONSTRUCTION – *Things to Do: BMP(s)*

√ Carry out construction operations in such a manner that erosion, air and water pollution will be minimized and meet applicable regulations.

√ If not using laser technology, construct to the lines and grades as determined by the design and as staked in the field, and leave all grade stakes undisturbed until leveling is complete.

- √ Eliminate all crop ridges and similar surface irregularities by disking or harrowing before the area is staked.
- √ Following leveling, check that the complete grades, ditch sizes, structures and other *appurtenances* are in accordance with the leveling plan.
- √ Correct all deviations before grading equipment is removed from the site.

Things to Avoid: Potential Pitfalls

- **X** Do not leave exposed areas of highly permeable soils that can inhibit proper distribution of water over the field after the leveling work is finished.
- **X** Do not use reverse grades in the direction of irrigation.

Applicable Technical Criteria:

- ♦ The complete grades shall be plus or minus 0.10 foot of the grades shown on the plan at each grid corner, and at all other points where measurements may be taken.
- ♦ Irrigation land leveling should be conducted in accordance with applicable procedures outlined in Part 650 Engineering Field Handbook, Florida Supplement, Chapter 1, Notekeeping for Irrigation Land Leveling.

Operation and Maintenance Issues:

- ■ Periodic field grading or floating may be needed to eliminate mounds or depressions.
- ■ Complete re-grading may be needed periodically to restore the design gradient.

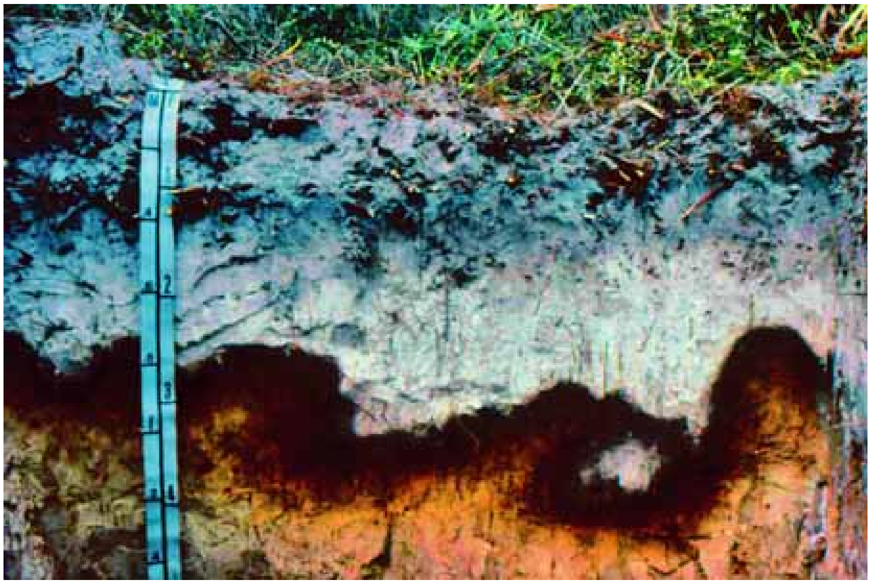
Other Considerations:

- In the design, consider the excavation and fill material required for structures such as ditches, ditch pads, and roadways.
- Consider related structures and measures needed to control irrigation water and/or storm water runoff.
- Consider crops, method of irrigation, soil intake rates, field slope, irrigation stream size and resulting deep percolation and runoff when determining or evaluating length of irrigation runs.
- Consider the depth of cuts and the resulting available plant rooting depths to shallow water tables.
- Consider effects on irrigation efficiencies, and especially on volumes and rates of runoff, infiltration, evapotranspiration and deep percolation.

Key References:

(1) USDA-NRCS Conservation Practice Standard, Precision Land Forming, Code 462 and, Irrigation Land Leveling, Code 464, http://www.nrcs.usda.gov/

14 SOIL SURVEY



Florida crop production occurs on many different soil types, and each soil type has unique water and nutrient holding properties. To properly manage irrigation and fertilization, it is important to know the type of soil and its primary characteristics. Consulting a soil survey is the best way of finding specific information about the soils on a farm.

Working Definition:

A soil survey is the systematic examination, description, classification, and mapping of soils in a particular area.

Key BMP Subcategories:

14A OBTAINING A SOIL SURVEY – *Things to Do: BMP(s)*

√ Request a soil survey for your farm by contacting the local Soil and Water Conservation District, or the USDA-NRCS.

√ Become familiar with the basic characteristics of each soil series that is identified on the property.

√ Use the information from the soil survey to help make farm-management decisions related to irrigation, fertilization, erosion control, etc.

Things to Avoid: Potential Pitfalls

X Soil fertility testing is not a substitute for a soil survey. Soil fertility varies independently of soil series.

Applicable Technical Criteria:

♦ Soil surveys, which are published periodically in a regular series by the USDA–NRCS, contain valuable technical information that is arranged in tabular format following the soil series descriptions. Check the tables in the back of the soil survey manual for specific soil and water scientific properties.

Other Considerations:

- Due to the map scale, soil surveys are most accurate for areas larger than 5 acres.
- Realize that soils different than the one identified by a map unit may be found within that map unit's boundaries. Often, several soil series can be found within the land area demarcated by a single boundary line, referred to as an inclusion.

Key References:

(1) The Nature and Use of a Soil Survey, http://edis.ifas.ufl.edu/SS160
(2) How Contaminants Reach Groundwater, http://edis.ifas.ufl.edu/SS194
(3) Farming for Clean Water in South Carolina: A Handbook of Conservation Practices
(4) National Cooperative Soil Survey, http://soils.usda.gov/

EROSION CONTROL AND SEDIMENT MANAGEMENT

Removal of natural vegetation and/or topsoil in areas prone to soil erosion changes drainage patterns and thereby can cause excess runoff during rain events or during field irrigation. Sediments along with nutrients and pesticides can then drain into surface water or groundwater. This can transform surface water bodies into unusable areas and may pollute the groundwater, which is the main source of drinking water for most Floridians.

The first step in preventing erosion and sediment transport is to limit the movement of soil from agricultural fields. Examples of these types of BMPs include conservation tillage, terraces, proper bed preparation, and critical area planting. The second step in preventing erosion and sediment transport is to remove soil sediments suspended in runoff water before it leaves the field. Examples of practices that could be used to accomplish this are sediment basins and diversion/terraces. These management practices will reduce the mass load of sediment reaching a waterbody and can help to improve water quality. These BMPs and others are described in this chapter. By following these practices, you can do your part to prevent erosion and sedimentation impacts, which will not only protect the water resources but will ensure long-term productivity of agricultural farmland.

15 SEDIMENT BASINS

Sediment basins temporarily trap runoff water and allow sediments to slowly settle out. These small "catchment basins" are typically constructed before or after a control structure and help keep surface waters clean by keeping sediments and other potential pollutants out of waterways. Settling of sediments and suspended material on the bottom of these basins will also tie up many nutrients and/or pesticides present in runoff, and thereby help to improve surface water quality. From a design standpoint, sediment basins differ from wet detention stormwater treatment areas by their smaller size and focus on sediment removal. A sediment basin is often used as a pre-treatment BMP for a wet detention pond.

Working Definition:

A sediment basin is an upland constructed pond used primarily to trap and collect debris or sediment in runoff water.

Key BMP Subcategories:

15A DESIGN AND CONSTRUCTION - *Things to Do: BMP(s)*

√ The storage capacity of the sediment basin shall equal or exceed the volume of sediment that is expected to be trapped at the site during the planned useful life of the basin.

√ Reduce the capacity of the basin proportionately if it is determined that periodic removal of sediment will be practicable.

√ Provide for emergency drainage of sediment ponds for safety and disease vector (e.g. mosquito) control.

<u>Applicable Technical Criteria:</u>

- ♦ Design the pond and outfall control structure, if applicable, to handle a 10-year storm frequency (discharge) without failure or significant erosion.
- ♦ Temporary basins having drainage areas of 5 acres or less and a total embankment height of 5 feet or less may be designed with less conservative criteria if conditions warrant.
- ♦ The embankment shall have a minimum top width of 4 feet, and at least 2 horizontal to 1 vertical side slopes.

Operation and Maintenance Issues:

- Remove accumulated sediment before it significantly reduces the capacity of the basin.
- Check the basin after each major storm event, and keep the basin outlet clear of debris.

Other Considerations:

- Give due consideration to reusing this water for routine irrigation needs, so long as water volumes warrant.
- Consider installing fencing around basins, especially if near highly urbanized areas.

Key References:

(1) USDA-NRCS Conservation Practice Standard, Sediment Basin, Code 350, http://www.nrcs.usda.gov/
(2) Farming for Clean Water in South Carolina: A Handbook of Conservation Practices

16 ACCESS ROADS

Agricultural access roads provide a fixed route for vehicles and farm equipment, and offer both ingress and egress for associated farm fields. Access roads range from seldom used "trails" to more substantial all-weather roads that offer greater year-round accessibility. Properly constructed access roads help prevent water quality impacts by eliminating the formation of gullies; however, improperly constructed access roads are a potential source of long-term erosion and sedimentation problems. Moreover, access roads that are constructed entirely in uplands, constructed at or near grade, and that meet a minimum set of specifications will generally result in little to no impacts on water resources.

Working Definition:

Agricultural access roads are generally upland constructed travel lanes designed to provide all-weather field entry without causing significant erosion.

Key BMP Subcategories:

16A ROAD PLANNING - *Things to Do: BMP(s)*

√ Carefully plan the location of the road and desired drainage features before construction, using soil survey maps, *topographic maps*, and/or available aerial photography in order to minimize watercourse crossings.

√ Use pervious construction materials, when possible, to minimize runoff impacts.

16B ROAD CONSTRUCTION AND DRAINAGE - *Things to Do: BMP(s)*

√ Construct the road during dry conditions and try to complete construction several months before the rainy season begins and before the road is to be used.

√ Balance cuts and fills to maximize the use of local materials, and to provide for good roadbed stability.

√ Minimize road widths consistent with the type and size of vehicles.

√ Keep road shoulders at a gentle slope for fill road construction in order to minimize erosion and to ensure adequate vegetative cover of road shoulders.

√ Maintain pre-development *hydrologic conditions*, especially where seasonal high water table conditions dictate, and use adequately sized and designed culverts, cross ditches, turnouts, etc., consistent with sound engineering principles.

√ Use surface crowning to help direct road runoff into associated roadside swales, when applicable.

Things to Avoid: Potential Pitfalls

X Avoid areas with geologic conditions subject to sinkhole formation or areas that have soils associated with subsidence.

X Avoid constructing permanent, filled agricultural access roads in *jurisdictional wetlands*.

<u>Applicable Technical Criteria:</u>

♦ Set back access roads a minimum of 15 feet from wetlands and other watercourses.

♦ Do not exceed 10% grades and a employ at least 2 horizontal to 1 vertical side slopes on cuts or fills.

♦ Road drainage features shall be appropriately designed using sound engineering principles to maintain predevelopment *base flow* conditions. 

<u>Operation and Maintenance Issues:</u>

■ Check drainage structures periodically to maintain their full function.

■ Regularly repair soft spots, ruts and potholes in roads.

■ Maintain vegetative cover on road banks and re-seed and mow as needed.

Other Considerations:

● Consider providing a turnaround area at the end of dead-end access roads.

● Stabilize soils with vegetation or armor around the ends of pipes to prevent erosion when crossing conveyance systems.

● When access roads are used in conjunction with other field operations, the roads should be sloped towards field production areas.

● In some drip irrigated fields, water has to be applied either by ditches adjacent to roads or via a nurse tank to keep roads passable in dry periods during harvest.

Key References:

(1) USDA-NRCS Conservation Practice Standard, Access Road, Code 560, http://www.nrcs.usda.gov/

(2) FDEP Stormwater and Erosion Control BMPs for Developing Areas, Chapter 6

17 CRITICAL AREA PLANTINGS

Critical area planting is used to stabilize soils in highly erodible areas. Controlling erosion in these "critical" areas reduces sediment transport to waterways, prevents the formation of erosion gullies, and minimizes water quality impacts to downstream water bodies. As a secondary benefit, critical area planting also improves wildlife habitat and makes the site more aesthetically pleasing. Examples of highly erodible or "critical" areas can include dams, levees, ditch banks, road banks, gullies, steep field slopes, construction sites, and denuded areas where vegetation is difficult to establish.

Working Definition:

Critical area planting involves the establishment of vegetation to protect soils in highly erodible areas.

Key BMP Subcategories:

17A PLANNING CONSIDERATIONS – *Things to Do: BMP(s)*

√ Select non-invasive plants that are suited to the soil and climate.
√ Select a seeding mixture to provide short-term, transitional, and long-term cover.
√ Identify critical areas where water control will be required in addition to vegetation to prevent erosion.

17B SITE PREPARATION – *Things to Do: BMP(s)*

√ Install temporary or permanent water control measures (terraces, diversions, etc.), if needed, to protect soils prior to vegetation establishment.
√ Perform all cultural (tillage, etc.) operations at right angles (perpendicular) to the dominant slope.
√ Have the soil tested to determine soil pH and soil nutrient status.

17C ESTABLISHING THE AREA – *Things To Do: BMP(s)*

√ Use a nurse crop of annual grass or small grain to enhance the establishment of a permanent cover.

√ Apply mulch on steep areas to ensure temporary erosion control and adequate groundcover after seeding.
√ Install temporary irrigation, if needed, to improve vegetation establishment.
√ Select plants with low water and nutrient requirements that will survive during prolonged droughts and that will stabilize the soil and provide benefits for wildlife habitat.

Things to Avoid: Potential Pitfalls

X Do not drive on critical areas.
X Do not use tree and shrub species that may be alternate hosts to pests.

Operation and Maintenance Issues:

■ Periodically inspect planted areas, reseed or mulch as needed, and repair any rills or channels that have developed.
■ After the sod is established, mow to control weeds, and only apply fertilizers as needed.

Other Considerations:

- Native or warm-season grasses may benefit from periodic burning.
- Refer to the Conservation Practices and Buffers chapter of this BMP manual for other non-structural control measures.

Key References:

(1) USDA-NRCS Conservation Practice Standard, Critical Area Planting, Code 342, http://www.nrcs.usda.gov/
(2) Farming for Clean Water in South Carolina – A Handbook of Conservation Practices

18 DIVERSIONS/TERRACES

A diversion is a structural practice used to control erosion when other agronomic BMPs, such as conservation tillage, contour stripcropping and critical area planting are not adequate. Typically, a diversion is used to divert water away from highly erodible areas, and is readily employed in some North Florida agricultural production areas. Terraces, which can also provide a diversion function, are usually earthen embankments constructed along a hillside, and are used to provide protection from erosion associated with concentrated surface flows. While diversions and terraces provide active erosion control measures, they are most effective when used in conjunction with other agronomic BMPs.

Working Definition:

A diversion is an earthen embankment, channel, or a combination of ridge and channel works constructed across a slope to safely divert runoff water away from cropland.

Key BMP Subcategories:

18A PLANNING AND DESIGN ISSUES - *Things to Do: BMP(s)*

√ Diversions are effective in most situations, while terraces are not practical on sandy or badly eroded soils. Terracing is not recommended on lands where the slope of the land is either too slight or excessive, or the topography is extremely irregular.

√ Terraces are the most expensive land-treatment BMP for erosion control. Therefore, a system of agronomic BMPs should be thoroughly evaluated before deciding to construct terraces.

√ Good planning will achieve the primary objectives of erosion control, topography improvement, and farm land use.

18B DESIGN AND CONSTRUCTION - *Things to Do: BMP(s)*

√ An adequate and stable outlet is critical to the installation of diversions or terraces. It is important that the eroding area is not occurring elsewhere. In general, grassed waterways, underground outlets, or other stable land forms are used for this purpose.

- √ Select the appropriate cross-section based on the adjacent land use and, in some cases, terraces may be constructed as broad-based features so they can be cropped. Conversely, some terraces have a steep grassed backslope to reduce the amount of earthwork.
- √ Construct terraces roughly parallel to one another to provide increased farm land use.
- √ Insure that buffers are used to address erosion and sedimentation issues that may arise during construction.

Things to Avoid: Potential Pitfalls

- **X** Avoid trying to restore a highly eroded crop field with terraces. A temporary diversion may be appropriate to protect the area until permanent vegetation is established.
- **X** Avoid trying to terrace land that is not suitable, as this will result in marginal effectiveness.

Applicable Technical Criteria:

- ♦ The design of diversions or terraces should be performed using the services of an experienced, professional agricultural engineer and agronomist. Engineering guidance can be found in USDA-NRCS FOTG Practice, Terrace, Code 600 and, Diversion, Code 362.

Operation and Maintenance Issues:

- ■ Periodically inspect diversions/terraces, especially immediately following significant storms, prolonged rainfall, or flooding events.
- ■ Maintain the proper cross-section and vegetative cover, per design specifications.
- ■ Remove accumulations of sediment and/or debris from outlets.
- ■ In clean-tillage systems, plow soil toward the terrace crest.

Other Considerations:

- Terraces can increase the infiltration of rainfall, soil moisture, and ground water recharge, thereby reducing stormwater impacts.
- Terraces may increase the downward movement of certain dissolved substances below the rootzone and into the ground water, so take this factor into consideration also.

Key References:

(1) USDA-NRCS Conservation Practice Standard, Terrace, Code 600 and, Diversion, Code 362, http://www.nrcs.usda.gov/

19 TEMPORARY EROSION CONTROL MEASURES

Erosion control measures are used to minimize sediment transport and protect the quality of water bodies that receive runoff from disturbed areas. The most common temporary erosion- control tools include straw or hay bale barriers, silt screens, and silt fences. However, more permanent control can be obtained through the use of specialized blankets and mats, gabions, and other systems used for soil stabilization. The following sections are intended to provide information regarding a few of the more common erosion control options and their applicability. The costs of erosion control options are highly variable, and agricultural producers are encouraged to consider economics and site-specific conditions when selecting the most appropriate erosion- control system for a particular application.

Key BMP Subcategories:

1. Straw or Hay Bale Barrier. A temporary sediment barrier consisting of a row of entrenched and anchored straw or hay bales.

19A Straw Bale Barrier - *Things to Do: BMP(s)*

√ Install bales below disturbed areas that are subject to sheet or rill erosion.
√ Use bale barriers when effective control is needed for less than 3 months.
√ Install bales in a continuous row, perpendicular to the direction of water flow, and place bales tightly together to prevent water from passing between the bales.
√ Use double rows spaced a minimum of five feet apart when the disturbed area is within 50 feet of a receiving water body.
√ If bales are used in conjunction with silt screens, bales should be placed adjacent to the silt screen on the upslope side.

Things to Avoid: Potential Pitfalls

X Do not construct straw or hay bale barriers in streams or swales where hydraulic forces may cause a washout.
X Do not use straw or hay bale barriers for sediment control when site conditions exceed the application specifications identified below.

- X Avoid bare ground situations during construction; sod, seed and protect as necessary to minimize adverse impacts from erosion.

Applicable Technical Criteria:

- ♦ Drainage area should not exceed ¼ acre per 100’ of barrier length.
- ♦ Slope length behind the barrier should not exceed 100’, and slope gradient behind the barrier should not exceed 5%.

Operation and Maintenance Issues:

- ■ Inspect barriers after all significant rainfall events and replace bales as needed.
- ■ Remove sediment deposits whenever they reach one half the height of the barrier.

2. Silt Fence. A temporary barrier consisting of a filter fabric (burlap or synthetic material) stretched across and attached to supporting posts and, in some cases, wire fence material. Small silt fences, which are designed with lighter materials and without the use of supporting wire, are often referred to as “filter barriers”.

19B Silt Fence - *Things to Do: BMP(s)*

- √ Install silt fences perpendicular to the direction of water flow, below disturbed areas that are subject to sheet or rill erosion.
- √ Use filter barriers when effective control is needed for less than 3 months, and use silt fences when longer application periods are needed.
- √ If wire fence material is used to provide extra support, the fence should extend 1” into the trench, be securely attached to the posts using heavy gauge wire staples, and should not extend more than 36” above the original land surface.
- √ Securely fasten filter fabric to the posts or fence material with 8” of the fabric extending into a 4” x 4” trench on the upslope side.
- √ Backfill the trench and compact over the filter fabric.

Things to Avoid: Potential Pitfalls

- X Do not install silt fences in streams or *swales* where the contributing drainage area exceeds 2 acres or where flows will exceed one cubic foot per second.
- X Avoid bare-ground situations during construction; sod, seed and protect as necessary to further minimize soil erosion.

Applicable Technical Criteria:

- ♦ Drainage area should not exceed ¼ acre per 100 feet of barrier length.
- ♦ Slope length behind the barrier should not exceed 100 feet, and slope gradient behind the barrier should not exceed 5%.
- ♦ Silt fences should not exceed 36 inches in height, and filter barriers should be between 15 and 18 inches in height.

Operation and Maintenance Issues:

- ■ Inspect silt fences after significant rainfall events, and make repairs as needed.
- ■ Remove sediment deposits if they reach one half the height of the barrier.

The following BMP techniques are more structural in nature, yet can have specific application(s) at connections to surface waters:

3. Erosion-Control Blankets. Erosion control blankets and mats are made of natural and/or synthetic fibers that are woven to form a highly permeable material. These blankets, which are often photodegradable and/or biodegradable, are commonly used to provide more permanent erosion control on ditch banks, berms, levies and other areas with excessive slope. Erosion control blankets protect soils prior to vegetative establishment and encourage vegetative growth by capturing sediment and providing soil reinforcement. Please contact your local Soil and Water Conservation District or USDA-NRCS for more information or refer to information provided by product manufacturers, distributors and/or dealers.

4. Gabions. Gabions are partitioned, wire-meshed containers that are filled with stone or concrete rubble to form flexible, permeable, monolithic structures such as retaining walls, weirs, and channel linings. Gabions can provide effective long-term erosion control within water conveyance features, especially around water-control structures. Please contact your local Soil and Water Conservation District or USDA-NRCS for more information or refer to information provided by product manufacturers, distributors and/or dealers.

5. Floating Turbidity Barriers. Turbidity barriers or "curtains" are designed to minimize sediment transport from a disturbed area adjacent to or within a water body. Turbidity barriers are commonly used in addition to other sediment controls to provide additional water quality protection. These barriers are designed to trap sediment in low to moderate flow conditions. Turbidity barriers should not be installed across channel flows where higher water velocities can occur. For further information regarding the applicability and usage of floating turbidity barriers, please contact your local Soil and Water Conservation District, USDA-NRCS, or refer to information provided by product manufacturers, distributors and/or dealers.

Key References:

(1) "The Florida Stormwater, Erosion, and Sediment Control Inspector's Manual", January 1999.
(2) Florida Department of Environmental Protection – Stormwater / Nonpoint Source Management Section, http://www.dep.state.fl.us/

20 RAISED BED PREPARATION

A well prepared *planting bed* is important for uniform stand establishment of vegetable crops. Most vegetable production areas in Florida use parallel rows of raised bed systems, which help control erosion and improve overall on-farm water management. Moreover, bed preparation and irrigation are interrelated, in that the design of one dramatically affects the performance of the other. Establishment of a uniform crop stand will both maximize yields and reduce the potential for soil erosion in excessively wet or dry areas.

Working definition:

Bed preparation is a soil tillage process whereby soil is prepared for planting a crop, usually by several passes of various equipment, resulting in a raised bed of loose or pressed soil, uncovered or covered with *plastic mulch*.

Key BMP Subcategories:

20A GENERAL BED PREPARATION– ***Things to Do:*** **BMP(s)**

√ Plow down old crop residues well in advance of crop establishment. Generally, a 6 to 8-week period between plowing down cover crops and crop establishment is recommended to allow decay of the residue.

√ Keep the land disked, if necessary, to prevent new weed cover from developing prior to cropping.

√ Use chisel plowing to penetrate and break tillage or plow pan layers in fields. Breaking tillage pans allows deeper root penetration to better allow plants to absorb water and nutrients.

√ Plan the bed height in relation to the amount of drainage needed in the field. If there is no history of a high water table, then the bed only needs to be high enough to permit rain drainage from the bed surface and to facilitate tight application of the mulch to the bed, if used. Excessively high beds are prone to rapid drying and can be difficult to re-wet.

√ Base the width of the bed on crop specific parameters including the number of rows desired per bed and the cost of the mulch, if used.

√ Line the mouths of cross ditches with plastic to minimize field erosion.

20B PLASTIC MULCH BED PREPARATION – *Things to Do: BMP(s)*

√ Prepare the soil well in advance of mulching. Plowing and rototilling generally prepare the soil well for mulching, yet disking alone in grass pasture fields is not generally sufficient to properly prepare the soil. Mulching requires a smooth, well-pressed bed.

√ Make sure that there is adequate soil moisture to be able to form a good bed for mulching. Dry sandy soils will not form a good bed for tight mulch application. Overhead (sprinkler) irrigation might be needed to supply adequate moisture to dry soils before bedding.

√ Apply all chemicals and some fertilizers to the soil in the bed before or at the time of mulching. Incorporation can be done with a rototiller, rolling cultivator, or bedding disc.

√ Be sure the bed is pressed firmly and that the mulch is in tight contact with the bed when laying mulch. It is critical to adjust the mulch layer so that the edges are buried sufficiently to prevent uplifting by wind.

√ Follow the Plasticulture Farming BMPs in the Water Resources Chapter of this manual.

20C INSTALLING DRIP TUBING IN BEDS – *Things to Do: BMP(s)*

√ Because of the limited lateral wetting with drip irrigation, bed widths can be narrowed, resulting in less dry soil beneath the mulch.

√ Consider the soil-wetting pattern of the tube in relation to placement of the crop. In most situations on soils in Florida, the wetting pattern from the emitter rarely exceeds 9 or 10 inches in any one lateral direction. In most situations, the tubing is placed in the center, or just off-center of the bed with a single lateral per bed. For single-row crops such as tomatoes or melons, the tubing can be placed 3 to 4 inches off-center and the crop planted down the center of the bed. In *twin-row cropping systems*, such as strawberries or peppers, the tubing can be laid right along the center of the bed with the two crop rows placed 4 to 6 inches from the tubing.

√ Drip irrigation laterals can be placed on the surface of the bed, in a shallow groove, or buried at a shallow depth in the bed. Most drip irrigation manufacturers recommend that the drip irrigation lateral tubes be positioned in the bed with the emitter facing upward. This positioning of the emitters normally reduces the potential for clogging of emitters with particulate matter.

√ Drip irrigation installations on *spodosols* may require a second irrigation system to provide sufficient soil moisture for bedding, fumigation, seed germination or crop establishment. Either sprinkler or sub-irrigation can be used for this purpose. For most crops, irrigation can be taken over by the drip system after seed germination or transplant establishment.

Things to Avoid: Potential Pitfalls

X Avoid application of fertilizer to soil that will not end up in the bed since this fertilizer will not be utilized in the absence of a crop and can then become subject to leaching.

X Do not bury drip tubes more than 1 to 2 inches deep because the upward movement of water will be severely limited.

X Avoid allowing plastic mulch to degrade in the field; instead, growers are encouraged to properly remove, recycle, or legally dispose of plastic mulch.

Applicable Technical Criteria:

♦ Row lengths typically vary from 300 to 1200 feet. Refer to the USDA-NRCS Field Office Technical Guide Practice, Row Arrangement, Code 557 for more information; however, note that row lengths and orientations are generally limited by:

1. Erosion, based on slope and soil type;
2. Irrigation requirements, based on length of the drip laterals or the in-field irrigation ditches; and,
3. Drainage requirements of the crop being grown.

- When planting vegetables, the height of the bed should be no more than 12 inches and the bed width will depend on the crop, the number of rows desired per bed, and the cost of the mulch.

Other Considerations:

- Freshly incorporated plant material may promote high levels of *damping-off* organisms such as *Pythium* spp. and *Rhizoctonia* spp. Turning under plant residue well in advance of cropping helps reduce a number of damping-off disease organisms.
- For commercial operations, mulch is applied by machine. There are machines that prepare beds, fertilize, fumigate, lay drip tape, and mulch in separate operations or in combination. The best option is to complete all of these operations in a single pass across the field.

Key References:

(1) Soil and Fertilizer Management for Vegetable Production in Florida, http://edis.ifas.ufl.edu/CV101
(2) Polyethylene Mulching for Early Vegetable Production in North Florida, http://edis.ifas.ufl.edu/CV213
(3) Fertilizer Application and Management for Micro (Drip)-Irrigated Vegetables in Florida**,** http://edis.ifas.ufl.edu/CV141
(4) USDA-NRCS Conservation Practice Standard, Deep Tillage, Code 324 and, Row Arrangement, Code 557, http://www.nrcs.usda.gov/

21 GRADE STABILIZATION STRUCTURES

A grade stabilization structure is generally needed in areas where the concentration and flow velocity of water require structural measures to stabilize the grade in channels or to control gully erosion. Specifically, a side inlet drainage structure is used to lower surface water from field elevations or lateral channels into deeper open channels. Other grade stabilization structures include earth embankments, full flow open structures, and pipe drop structures. These structures may be applied as part of a conservation management system to stabilize the grade and control erosion in natural or artificial channels, prevent the formation or advance of gullies, and/or enhance environmental quality and reduce pollution hazards.

Working Definition:

A grade stabilization structure is used to control the grade and head cutting in natural or artificial channels.

Key BMP Subcategories:

21A PLANNING - *Things to Do: BMP(s)*

√ Remove all brush, trees, stumps, fence rows, and other objectionable materials in such a way that it will not interfere with constructing, shaping, or proper functioning of the grade stabilization structure.

√ Take fill material from approved designated borrow areas. Fill material should be free of objectionable materials.

21B CONSTRUCTION AND DRAINAGE - *Things to Do: BMP(s)*

√ Install structures during dry conditions or properly de-water the site before construction.

√ Place fill in horizontal layers not to exceed 4 inches in thickness, and compact.

√ Spread or dispose of excess fill material in such a way that it will not interfere with the structure.

√ Use silt fences, hay bale barriers, or temporary vegetation and mulching to prevent erosion.

Things to Avoid: Potential Pitfalls

X Avoid driving over any part of a pipe, unless there is a compacted fill of 12" or greater over the pipe.

<u>Applicable Technical Criteria</u>: 

- ♦ It is recommended that growers who are considering federal cost-share design drop pipes in accordance with USDA-NRCS Field Office Technical Guide Practice Standard, Grade Stabilization Structure, Code 410, excerpted as:

		Frequency of Minimum Design, 24 - Hour Duration Storm	
Maximum Drainage Area	Vertical Drop	Receiving Channel Depth	Total Capacity[1]
Acres	Feet	Feet	Year
250	0-5	0-10	1
250	>5-10	>10-20	10
500	0-10	0-20	25

[1]total capacity shall be equal to or greater than the design drainage curve runoff.

- ♦ If site-condition values exceed those shown in the above table, the 50-year storm frequency shall be used for minimum design storage instead.
- ♦ On structures with drainage areas of 3 acres or less, overtopping of the structure is permitted only if damage will be minor and island-type construction would interfere with normal farming operations.

<u>Operation and Maintenance Issues</u>:

- ■ Operation and maintenance shall be in accordance with the requirements of all local, state and federal laws and regulations.
- ■ The structure should be inspected periodically to ensure that it continues to function as planned.
- ■ Remove any blockage of trash and debris that could affect flows through the structure.
- ■ Repair or replace materials that have deteriorated, including rock used for outlet protection.

Other Considerations:

- Structures shall be constructed of durable materials with a life expectancy equal to the planned life of the structure.
- Where conditions make it difficult to establish vegetative cover, consider using non-vegetative coverings such as gravel, concrete, gabions, or other types of protection.
- Structures may trap sediment and attached substances carried by runoff. Consideration should be given to the amount of sediment that will be deposited and allowances made for removal.

Key References:

(1) USDA-NRCS Conservation Standard, Grade Stabilization Structure, Code 410, http://www.nrcs.usda.gov/

22 DITCH CONSTRUCTION AND MAINTENANCE

Agricultural ditches are essential components of the farm-field site plan and layout. As such, they can vary from field ditches to laterals and mains, and are commonly connected to larger canal systems. Depending upon their configuration, ditches have an engineered limit or *conveyance capacity* that governs how much water the ditch can store or convey. An effective farm field ditch network functions primarily to convey and distribute water without causing excessive erosion, water losses, and/or degradation of water quality to the downstream receiving system. Properly designed and constructed agricultural ditches are very important; however, equally important is the implementation of an appropriate maintenance program to ensure that the ditches function well. Ditches are the hydrologic "lifeblood" to the crop and farming operation.

Working Definition:

Agricultural ditches are man-made trenches dug for the purpose of removing excess water from the land and/or providing irrigation water for use by the crop(s).

Key BMP Subcategories:

22A PLANNING AND DESIGN ISSUES - *Things to Do: BMP(s)*

√ Use mapping tools such as topographic maps, soil survey maps, and basic knowledge of the landscape to identify land contours, seasonal high watertable limitations, and/or natural drainage outlets in order to layout the proposed ditch system.

√ Utilize appropriate setback distances when drainage ditches are in close proximity to jurisdictional wetlands.

√ Consider – based on the complexity of the farm field design – retaining the services of a professional agricultural engineer to assist with ditch system design and, if applicable, pump sizing issues.

22B DITCH CONSTRUCTION - *Things to Do: BMP(s)*

√ Stake the proposed ditch run and remove obstacles beforehand as needed.

√ Construct ditches with spacings, depths and side-slopes consistent with soil types. Refer to the USDA-NRCS Florida Drainage Guide for information on recommended ditch construction based on specific soil types.

√ Ditch excavation shall be in accordance with any grades and plans, as specified. *Spoil* material shall be deposited in an uplands location or reused on the farm field.

√ Stabilize bare soils and ditch banks through the establishment of native grasses or other appropriate vegetative cover.

√ Utilize the appropriate Erosion Control and Sediment Management BMPs referenced in this chapter to prevent water quality degradation in receiving waters.

22C SYSTEMATIC ROUTINE AND CUSTODIAL MAINTENANCE - *Things to Do: BMP(s)*

Eventual build-up of sediments in ditches reduce the cross-sectional area, increases the water velocity, and can lead to sediment deposition downstream.

√ Selectively control broadleaf vegetation on ditch banks to encourage/maintain a grass cover.

√ Protect ditch banks from erosion in areas subject to high water velocities, using *rip-rap*, concrete, headwalls, or other buffering materials.

√ Clean all perennial ditch features regularly, and remove unconsolidated sediments in order to maintain the designed, cross-sectional area. Consider spreading sediment material back on fields or on roads.

√ Consider establishing a permanent record of the design cross-sectional area using basic survey techniques to define the ditch profile. This would be a useful exercise on larger ditches that have a propensity to "fill in" over time, and may assist you in dealing with regulatory agencies having jurisdiction over surface waters.

22D FLOATING AQUATIC WEED CONTROL - *Things to Do: BMP(s)*

√ Routinely remove any accumulated aquatic weeds at the riserboard control structure(s) to maintain proper drainage and prevent secondary environmental impacts.

√ Use a combination of physical control (e.g., floating barriers, screens, etc.), biological control (e.g., herbivorous fish), and chemical control (e.g., selective herbicides labeled for aquatic applications) to abate weed problems.

Things to Avoid: Potential Pitfalls

X Avoid over-excavating the ditch during routine and custodial maintenance. Only remove sediments down to the original invert elevation of the ditch.

X Don't operate vehicles or farm equipment in, or across, ditches that might damage ditch integrity and result in erosion.

Applicable Technical Criteria:

♦ In general, ditch bank side slopes in very sandy soils should be constructed at a 3:1 ratio; coarse soils at 1:1 or even 2:1; and heavy clay soils at 1/2:1. When side slopes exceed these recommendations, growers should install other site-specific BMPs to minimize erosion.

♦ In general, irrigation ditches should be constructed so that flow velocities do not exceed 1.5 feet per second in coarse sandy soils or up to 0.5 feet per second in fine soils.

Operation and Maintenance Issues:

- Refer to the "Systematic Routine and Custodial Maintenance" section of this BMP for operation and maintenance guidelines.

Other Considerations:

- Agricultural ditches are generally designed and intended to drain lands. Therefore, growers should avoid locating ditches too close to wetlands because of the potential for *hydraulic drawdown* impacts.

Key References:

(1) USDA-NRCS FOTG Conservation, Irrigation Field Ditch - Code 388, Surface Drainage (Field Ditch) - Code 607, and Surface Drainage (Main or Lateral) - Code 608, http://www.nrcs.usda.gov/
(2) American Society of Agronomy: Drainage for Agriculture, http://www.agronomy.org
(3) The Florida Stormwater, Erosion, and Sedimentation Control Inspectors' Manual
(4) Water Management Districts' Environmental Resource Permitting Rule and Basis of Review

23 CONSERVATION TILLAGE

Conservation tillage involves several types of tillage practices or techniques that are designed to maintain crop residue or cover crops on the soil surface. Collectively speaking, these practices help to reduce soil erosion from water and wind, conserve soil moisture, and provide wildlife habitat. The common types of conservation tillage for crop land in Florida are: No-Till, Strip-Till, Ridge-Till, Mulch- Till, and Seasonal-Till.

Working definition:

Conservation tillage is the practice of minimizing tillage to what is necessary while managing crop and other plant residues to enhance soil productivity, increase water infiltration, and minimize wind and water erosion.

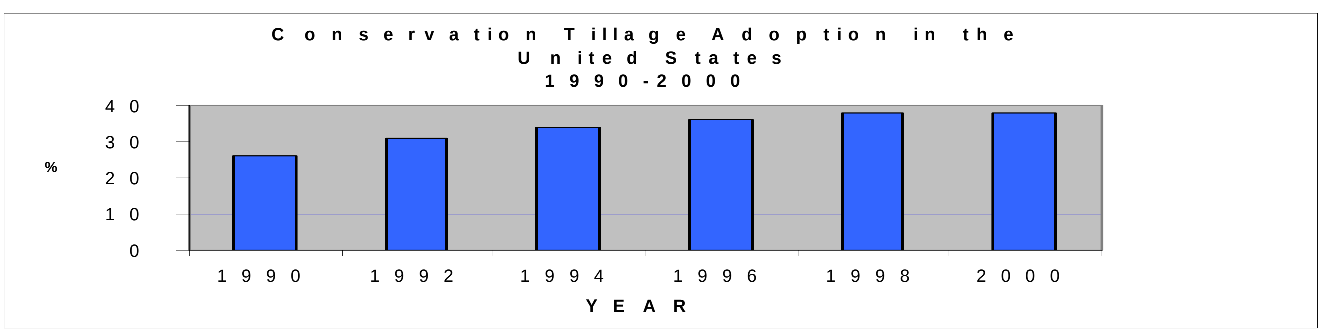
Key BMP Subcategories:

23A PLANNING AND IMPLEMENTATION – *Things to Do:* BMP(s)

√ Uniformly distribute loose residue across the field's surface.

√ Limit baling or grazing in order to retain sufficient residue on the soil surface.

√ Include crops/varieties in crop rotations that produce large amounts of residue, use cover crops, and adjust plantings and row spacing to ensure complete soil coverage and to enhance the production of crop residues.



√ When using no-till or strip-till practices, modify the planter or drill set-up to ensure it will plant directly through untilled residue or in a tilled seedbed prepared as a narrow strip. Planter attachments may consist of devices such as rotary tillers, sweeps, multiple coulters, or row-cleaning equipment.

Things to Avoid: Potential Pitfalls

X Avoid excessive removal of plant residues by such means as burning, baling, grazing, or cutting silage.

Applicable Technical Criteria:

♦ Maintain a minimum of 50 percent residue cover throughout the year.

♦ When strip-till is utilized, seedbed preparation, planting, and fertilizer-placement areas shall disturb no more than one-third of the row width.

♦ When using ridge-till, maintain the top of the ridge at least 3 inches higher than the furrow between the ridges.

♦ When using seasonal tillage, maintain at least 30 percent ground cover after harvest by leaving crop residues undisturbed, or shed, chop, or lightly disk.

Operation and Maintenance:

■ When using ridge tillage, ridge height shall be retained in place throughout the harvest and winter seasons by controlling equipment and/or livestock traffic.

■ After planting, residues shall be maintained in the furrows until ridges are rebuilt the following season.

Tillage Type	Explanation	Typical Statewide Applicability
No-Till	The crop is planted in undisturbed soil, and residue is left on the surface from the prior crop.	North and Central Florida
Strip-Till	The crop is planted in a narrow, cultivated band, no more than one-third of the row width.	North and Central Florida
Ridge-Till	The crop is grown on pre-formed ridges, and soil surface residue is managed year-round.	North Florida
Mulch-Till	Crops are grown where the entire field surface residue is managed year-round and during the growing season.	Central and South Florida
Seasonal Till	The crop is grown in a clean-tilled seedbed, and soil surface residue is managed during part of the year, while growing crops.	Central and South Florida

Key References:

(1) USDA-NRCS FOTG Practices, Residue Management (No Till and Strip Till) - Code 329 A, Residue Management (Mulch Till) - Code 329 B, Residue Management (Ridge Till) - Code 329C,and Residue Management (Seasonal) - Code 344, http://www.nrcs.usda.gov/technical/efotg

(2) Conservation Technology Information Center, Core 4: Crop Residue Management, http://www.ctic.purdue.edu/CTIC/CTIC.html, http://www.ctic.purdue.edu/Core4/Core4Main.html

24 COVER CROPS

Cover crops serve many purposes but are primarily used to protect the land from erosion until the main crop is planted. Cover crops also improve soil structure and composition by adding organic matter and augmenting soil fertility. In addition, cover crops help to prevent erosion by stabilizing soil and by improving soil porosity, which in turn allows rainwater to percolate downward minimizing surface water runoff. When managed properly, cover crops can aid in increasing long-term crop production through improved *tilth*, integrated pest management, and by providing a more natural, slow-release source of nutrients. Cover crops can also serve to "trap" excess nutrients left in the soil after the primary crop is harvested, resulting in improved water quality.

Working Definition:

Cover crops are grasses, legumes, forbs, or other herbaceous plants established to protect the soil from erosion and enhance soil health during fallow periods.

Key BMP Subcategories:

24A CROP PLANNING - *Things to Do: BMP(s)*

√ Carefully plan the crop in order to maximize benefits to the soil and the primary crop.

√ Select a cover crop that is suitable for your climate, soil type, cropping system, and specific goals (i.e., nutrient uptake, nitrogen fixation, etc.).

24B CROP PLANTING - *Things to Do: BMP(s)*

√ Always plant the cover crop as soon as possible after the main crop is harvested.

√ Conduct proper soil preparation prior to planting in order to ensure good water percolation and cover crop establishment.

√ Properly calibrate planting equipment to ensure correct broadcasting rate, planting depth and spacing.

Things to Avoid: Potential Pitfalls

X Avoid using cover crops with weed seeds in order to minimize pesticide use.

Operation and Maintenance Issues:

- Manage grazing so it is not detrimental to the purpose of cover crops.
- Chop and incorporate cover crops into the soil as a *green manure*.
- Dessicate cover crops 3 to 4 weeks prior to tilling them in.

Other Considerations:

- Ensure that the choice of cover crops matches your production system and cropping cycle and that cover crops are planted and tilled in at the right time.
- Consider planting *legumes* as a cover crop. Through the process of *nitrogen fixation*, legumes convert atmospheric nitrogen to organic nitrogen compounds (plant nutrients) that can also be used by the crop and result in lower fertilizer costs.
- Always test your soil, and follow UF/IFAS lime and fertilizer recommendations as closely as possible.
- Remember that cover crops help increase soil organic matter content and soil moisture-holding capacity, possibly allowing you to irrigate less.
- Cover crops may have the potential to harbor insect and disease pests.

Key References:

(1) USDA-NRCS FOTG Practice, Cover Crop, Code 340, http://www.nrcs.usda.gov/
(2) Farming for Clean Water in South Carolina: A Handbook of Conservation Practices
(3) The Encyclopedia of Organic Gardening, Rodale Press

25 CONSERVATION CROP ROTATION

Conservation crop rotation is a management practice used to reduce erosion, improve soil organic matter, and minimize crop disease build-up. Row crop production sometimes depletes soil nutrients, especially when double-cropped or when cultivated as a monocrop on the same land year after year. Use of proper crop rotations to avoid disease buildup is probably the most widely emphasized use of crop rotation. Crop rotation can help break soilborne disease and other pest life cycles. Moreover, incorporating high-residue cover crops into the crop rotation sequence serves two additional purposes: (1) slowly adds available nutrients and organic matter to the soil, and (2) helps to improve soil structure for sandy soils.

Working Definition:

Conservation crop rotation is the practice of growing different crops in a planned sequence on the same farm field.

Key BMP Subcategories:

25A CROP PLANNING AND DESIGN ISSUES - *Things to Do: BMP(s)*

√ Grow crops in a planned, recurring sequence and select crops adapted to the local climate and soil conditions.

√ Select crops that produce enough *biomass* to help reduce soil erosion by water and/or wind forces.

25B SOIL ORGANIC MATTER AND PLANT NUTRIENTS - *Things to Do: BMP(s)*

√ Select crops that can beneficially add organic matter to the soil.

√ Leave enough plant biomass after baling or grazing in order to achieve the desired soil organic matter goal.

√ Grow *nitrogen-fixing* crops immediately prior to or interplanted with nitrogen-depleting crops when crop rotations are designed to add nitrogen to the system.

√ Grow crops or cover crops having rooting depths and plant nutrient requirements that utilize any excess nutrients.

25C MANAGING PLANT PESTS OR DISEASES - *Things to Do: BMP(s)*

√ Alternate crops to break the pest cycle and/or allow for the use of a variety of Integrated Pest Management control strategies.

√ Remove affected crops and alternate host crops during the rotation for the period of time needed to break the life cycle of the targeted pest.

√ Select resistant varieties to help prevent disease infestation.

Things to Avoid: Potential Pitfalls

X Avoid replanting agronomic and/or vegetable crops on recently harvested fields that were planted with the same and/or similar crop (e.g. potato, peppers, and tomatoes are prone to similar pests) to eliminate potential disease carryover issues.

X Avoid the recurring replanting of low-residue crops that also have a high plant *macronutrient* requirement, so as to avoid excessive depletion of soil nutrients.

<u>Operation and Maintenance Issues:</u>

■ Use soil testing to avoid over-fertilizing.

■ Maintain crop residues on the soil surface to increase infiltration and reduce runoff and evaporation rates.

Other Considerations:

- Soil compaction can also be reduced by adjusting crop rotations to include deep-rooted crops that are able to extend to and even penetrate compacted soil layers, as well as avoiding crops that require field operations when soils are wet.
- Where pesticides are used, consider application methods and a crop rotation sequence to avoid negative impacts on the subsequent crop due to residual herbicides in the soil.
- When legumes are planted, use the appropriate inoculant for the legume type.

Key References:

(1) USDA-NRCS FOTG, Conservation Crop Rotation, Code 328, http://www.nrcs.usda.gov/technical/efotg

(2) Farming for Clean Water in South Carolina – A Handbook of Conservation Practices

(3) Crop Rotations for Vegetables and Row Crops, http://www.ncatark.uark.edu/~steved/rotation.html

(4) Cultural Control for Management of Vegetable Pests in Florida, http://www.imok.ufl.edu/LIV/groups/cultural/pests/insects.htm

NUTRIENT AND IRRIGATION MANAGEMENT

Fertilization is important for economic vegetable and agronomic crop production, with nitrogen (N), phosphorus (P) and potassium (K) constituting the macronutrients. Coincidentally, N and P represent the greatest fertilizer cost to farmers and contribute to the majority of the water quality problems. N is especially required for successful production on mineral soils in Florida, because these soils are largely sandy in nature and tend to have a low organic matter content. Thus, these soils retain little water or N so that frequent, intense rainfall, or excessive irrigation can leach N from the root zone into groundwater. N management strategies should be used on vegetable and agronomic farms to maximize crop yields, fruit quality, and to minimize the loss of nutrients to the environment. The more important parameters of crop production are soil type, temperature, tillage, moisture, vegetation type, and fertilizer amount and form. Growers have complete or partial control over the last four parameters.

In order for water to transport a substance, the substance must be either suspended with particulate matter or dissolved in the water. Water movement within the soil usually filters out suspended materials, so only dissolved materials are transported to groundwater. Surface runoff is not filtered, however, so suspended particles can be transported with it.

Nitrate is the predominant soluble form of N found in soil water. Since most agricultural soils are well aerated, other forms of nitrogen, such as ammonium, tend to be quickly oxidized—with the aid of bacteria via the nitrification process—to nitrate (See Figure on page 77). Nitrate, which is readily taken up by plants and microorganisms, has a low affinity for either mineral soil particles or organic matter. Therefore, nitrate tends to remain dissolved until biologically removed, either by plants or by anaerobic microbial conversion to nitrogen gasses through the process of *denitrification*. When nitrate is moved below the root zone into the lower, less biologically-active soil profiles, it is not likely to be subsequently altered, and will eventually reach groundwater supplies or move laterally to surface waters.

Phosphate, the most common form of phosphorus in the soil, has a much lower solubility than nitrate. This means a smaller portion of soil phosphate can dissolve. Phosphorus also has a strong affinity for mineral soil particles leading to its *adsorption* or can precipitate with calcium, aluminum, or iron in the soil. Adsorption and precipitation removes phosphorus from percolating water. There are some sandy mineral soils, particularly in southern Florida, which have an extremely low ability to adsorb P. Free iron and aluminum and other clay components will increase rates of phosphorus adsorption. In general, for most mineral soils, only a very limited amount of elemental phosphorus ever reaches the groundwater.

It has been well established that agronomic and vegetable crops are not 100% efficient in taking up fertilizer N from the soil. Research shows that typically from 50% to 70% of the applied fertilizer N is taken up and used by the crop. The efficiency in N uptake by the crop depends on many factors such as timing of N fertilizer application, placement of the N fertilizer, form and type of N fertilizer, the presence of polyethylene mulches, amount and timing of irrigation, amount and timing of rainfall, and other factors.

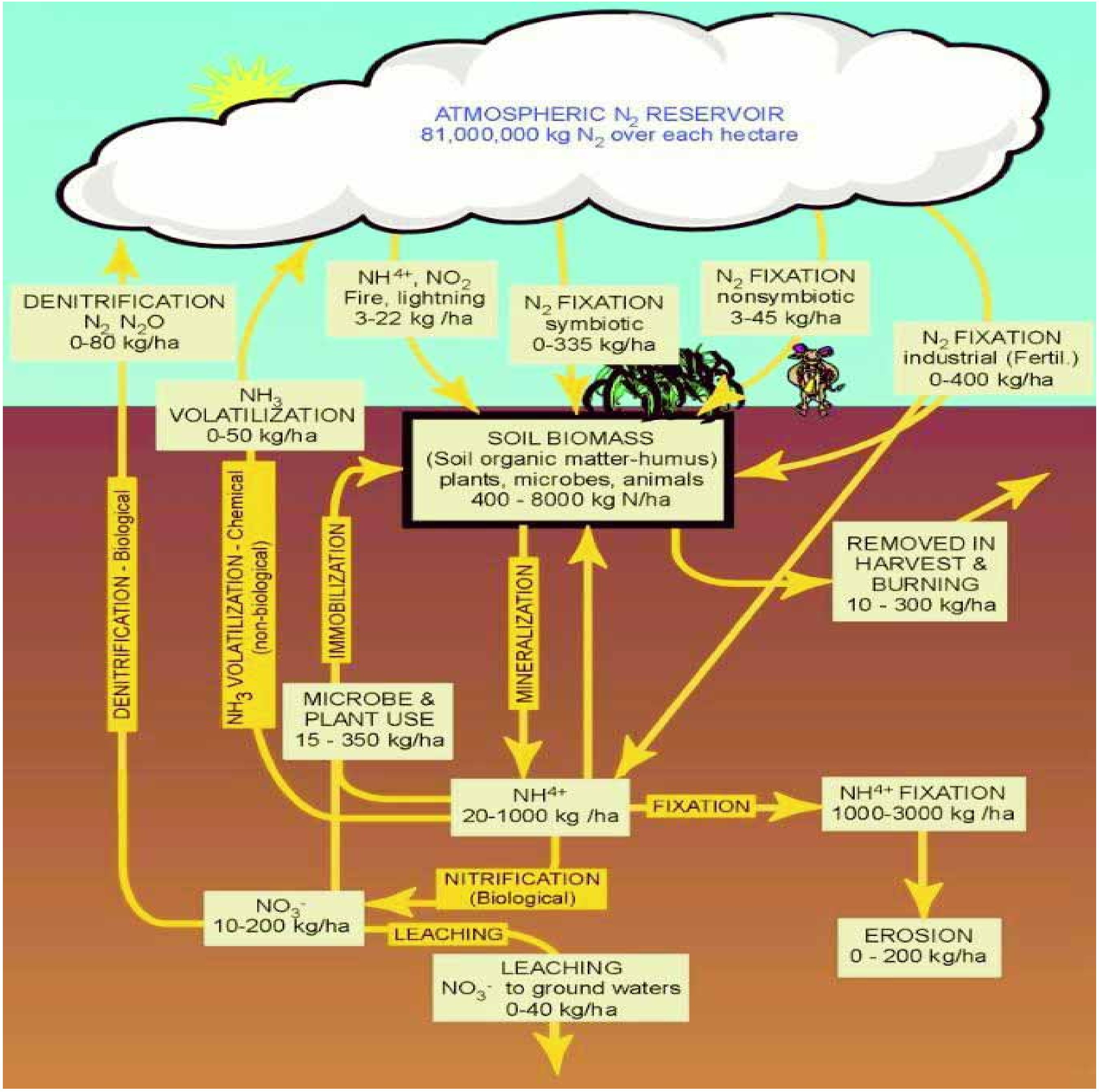
In addition to the factors cited above, the efficiency of N uptake and utilization by the crop depends on the amount of N applied relative to the crop's N requirement. N efficiency is lower in cases where N in excess of the crop requirement is used and the efficiency becomes greatest as the N rate approaches the crop requirement. The IFAS recommended N rates have been determined from field research to represent crop-specific N requirements. Even with the IFAS recommended rates of N, research has shown that some N losses will occur because of the lack of 100% efficiency as described above. For example, potatoes fertilized with the recommended rate of 200 lbs of N per acre in Suwannee County have been shown to only utilize about 100 to 130 lbs of N. Equivalent amounts of N are accumulated in potatoes fertilized with 260 lbs N per acre.

The extra N not used by the crop can leach into the groundwater, especially in deep well-aerated sandy soils. Once N reaches the groundwater, it may be diluted by mixing with incoming, noncontaminated water. However if enough N leaches to the groundwater, the N concentration may increase above the drinking water standard of 10 ppm nitrate-N. Even water with elevated N concentrations below the drinking water standard could be considered a problem. For example, if the water were from a spring that made up the base flow of a river, the N could contribute to excess algae and aquatic weed growth, and could cause an impairment of the water body.

The BMP approach to managing N depends on maximizing N efficiency in the production of crops so that very little N is lost to the environment. This chapter presents those practices which, if implemented on the farm, can contribute to maximizing N efficiency in crop production. In many cases, several practices can be combined to receive the additive benefit of the selected practices.

Optimum fertilization can be accomplished by using the correct amount of fertilizer and applying that fertilizer according to a proper schedule and method of placement in the soil. The goal of fertilizer management is to ensure that applied nutrients benefit crop yield and crop quality, while not negatively impacting the environment. Some growers tend to apply fertilizer in excess of what is needed for best yields, because the extra fertilizer is thought to reduce overall risks associated with crop production. However, this extra fertilizer also represents reduced profits when it only contributes marginally to increased yields or improved quality, and much of it also tends to end up in surface water or ground water. Furthermore, recent research with several vegetable crops and strawberries has documented reduced yields and reduced fruit quality with excess N. In addition, excess N can lead to more disease problems, and can affect tomatoes by increasing the damage from insects such as thrips.

In Florida, water management and fertilizer management are inextricably linked. Changes in one program will almost inevitably affect the efficiency of the other. The goal of proper water management is to keep both the irrigation water and the fertilizer in the crop root zone. Therefore, knowledge of the root zone of a particular crop is needed so that water and fertilizer inputs can be managed properly throughout the season. This chapter includes some of the major nutrient management practices determined from research and grower experience, and also includes irrigation management practices that have been generally effective. This information can be used on vegetable and agronomic crops to ensure that fertilization results in economically viable crop production without serious negative impacts on the environment.



Key References:

(1) Fertilizer Management - Key to a Sound Water Quality Program, http://edis.ifas.ufl.edu/AE023

(2) How Contaminants Reach Groundwater, http://edis.ifas.ufl.edu/SS194

(3) Soil and Fertilizer Management for Vegetable Production in Florida, http://edis.ifas.ufl.edu/CV101

(4) Nitrogen Management Practices for Vegetable Production in Florida, http://edis.ifas.ufl.edu/CV237

(5) Phosphorus Management for Vegetable Production in Florida, http://edis.ifas.ufl.edu/HS105
(6) Commercial Vegetable Fertilization Principles, http://edis.ifas.ufl.edu/CV009
(7) Fertilization of Sweet Corn, Celery, Romaine, Escarole, Endive, and Radish on Organic Soils in Florida, http://edis.ifas.ufl.edu/CV008
(8) UF/IFAS Standardized Fertilization Recommendations for Agronomic Crops, http://edis.ifas.ufl.edu/SS163
(9) Agronomic Crops and Forages, http://jefferson.ifas.ufl.edu/ag_pages/crops_page.htm
(10) UF/IFAS Agronomy Department, http://agronomy.ifas.ufl.edu/AGPUBS.HTML
(11) Fertilization of Agronomic Crops, http://edis.ifas.ufl.edu/AA130

26 SOIL TESTING/SOIL pH

Crop nutrient requirements are related to the maximum amounts of nutrients shown by research to produce optimum economic yields while protecting water quality. It is important to remember that these amounts of nutrients are supplied to the crop from both the soil and the fertilizer. Fertilizers should be applied when a properly calibrated soil test indicates that the extractable amounts of these nutrients present in the soil are below optimum levels.

The most suitable pH range for most vegetables and agronomic crops is between 6.0 to 6.5. It is in this pH range that most fertilizer nutrients, and especially P, are in greatest availability. Too much lime can lead to nutrient deficiencies, especially with *micronutrients*, and can also reduce the accuracy of soil testing programs and resulting fertilizer recommendations. Use of a soil test and a calibrated lime requirement test should result in the correct amount of lime and should also reduce the possibility of over-liming. Many fertilizer materials lower the soil pH, and this should be considered when developing a liming program. From a nutrient BMP standpoint, proper pH management provides for optimum crop growth and better nutrient uptake and utilization by the plant.

Working Definition:

Soil testing is a chemical process by which the concentrations of certain plant nutrients in the soil are determined by laboratory analysis, and the results of the test are used to determine the amount of fertilizer needed.

Key BMP Subcategories:

26A SOIL SAMPLING – *THINGS TO DO: BMP(s)*

√ Contact your county Cooperative Extension Office for complete soil sampling information.

√ Divide your farm into areas for sampling. Separately sample areas with different crop growth, history or patterns, soil color, or lime or fertilizer histories. The sample you collect should represent the average for a uniform portion of the area sampled. If a soil survey or your experience suggests different soil types in a field, collect them separately.

√ Sample between rows to avoid last year's fertilizer bands if practicing conservation tillage.

√ Use the proper sampling tools, such as a sampling tube or soil auger. If it is necessary to use a shovel or trowel, dig a V-shaped hole in the soil 6 inches deep, and slice a 1-inch slab from one side of the hole. Lift out and save the center 1-inch-wide strip of soil.

√ Take a core (with sampling tube) from at least 15 random spots in each area to be tested. Mix together the cores from each field or area and place approximately one pint of the mixed soil in a soil sample bag. One consolidated sample should be submitted for an area up to 20 acres or for a uniform cultural management area.

√ Identify samples by letter or number. Make a sketch or record of where the samples were taken within each area.

√ Use a competent soil testing laboratory that uses calibrated methodologies. Not all laboratories can provide accurate fertilizer recommendations for Florida soils. The Mehlich-1 soil test has been calibrated for sandy soils in Florida.

√ Consult with your county agent if help is needed with interpretation of test results or fertilizer recommendations.

26B SOIL pH AND LIMING – *Things to Do: BMP(s)*

√ Test the soil and have a calibrated lime-requirement test.

√ Maintain soil pH between 6.0 and 6.5 for most crops.

√ Have an irrigation water sample analyzed for total bicarbonates and carbonates annually, and the results converted to pounds of calcium carbonate per acre. Irrigation water from wells in limestone aquifers is an additional source of liming material usually not considered in many liming programs. Include this information in your decision concerning lime.

√ Apply lime in the plowed zone well in advance of the crop in order for the soil reaction to fully take place. The most common liming materials are calcite ($CaCO_3$), dolomite ($CaCO_3MgCO_3$), burnt lime (CaO), dolomitic quick lime ($CaOMgO$) or hydrated lime ($Ca(OH)_2$).

√ Record date, rate of application, materials used, and method of application when applying lime.

Things to Avoid: Potential Pitfalls

X Do not mix soil from contrasting or odd areas (like small wet areas) with your main field sample.

X Do not over-lime. Over-liming and resulting high soil pH can tie up micronutrients and restrict their availability to the crop.

X Do not let the soil pH drop below approximately 5.5 for most crop production, especially where micronutrient levels in the soil may be high due to a history of micronutrient fertilizer and/or micronutrient-containing pesticide applications.

X Do not apply N fertilizer containing ammonium immediately after liming or to soils of pH > 7.5. This will reduce the risk of ammonia volatilization.

X Avoid using large amounts of fast-acting liming materials such as hydrated lime and burnt lime since these can cause severe crop damage if used in excess.

<u>Operation and Maintenance Issues:</u>

■ Keep records of the soil testing results for each field and crop.

<u>Applicable Technical Criteria:</u>

♦ The proper amount of lime to use can be found in the soil-test recommendations by the Florida Extension Soil Testing Laboratory in Gainesville.

- ♦ See the Appendix for more information on the soil testing process.

Other Considerations:

- Liming, fertilization, and irrigation programs are closely related to each other, with an adjustment in one program often influencing another as well. To maximize overall production efficiency, soil and water testing must be made part of any fertilizer management program.
- The element calcium (Ca) is often confused with high pH. Just because Ca is being supplied to the soil, this does not mean the pH will rise. With hi-cal or dolomitic lime, it is the chemistry involving the carbonate ion (CO_3^{-2}) that results in an increase in soil pH, not the addition of Ca.
- Soils normally high in pH, such as the marls and gravelly loams in Miami-Dade county, cannot be economically changed to more suitable pH ranges. On these soil types, band placement of micronutrients is an economical approach to overcoming the effect of high pH.
- One way to overcome high pH is to inject nutrients via drip irrigation so that the nutrients are being applied directly to the root zone. Foliar application of micronutrients is also a suitable application method to reduce any effect the soil might have on micronutrient availability.

Key References:

(1) Soil Testing, http://edis.ifas.ufl.edu/SS156
(2) Producer Soil Test Information Sheet, http://edis.ifas.ufl.edu/SS186
(3) Lime and Liming – A Florida Perspective, http://edis.ifas.ufl.edu/SS161
(4) Producer Soil Test Information Sheet, http://edis.ifas.ufl.edu/SS186
(5) Commercial Vegetable Fertilization Principles, http://edis.ifas.ufl.edu/CV009
(6) IFAS Standardized Fertilization Recommendations for Vegetable Crops, http://edis.ifas.ufl.edu/CV002
(7) Liming of Agronomic Crops, http://edis.ifas.ufl.edu/AA128
(8) UF/IFAS Standardized Fertilization Recommendations for Agronomic Crops, http://edis.ifas.ufl.edu/SS163
(9) Farming for Clean Water in South Carolina, a Handbook of Conservation Practices

27 WATER TABLE OBSERVATION WELLS

A water table observation well is an inexpensive management tool that can be used to provide a visual indication of surficial groundwater levels on soils using elevated water tables for subirrigation. This simple water management tool can be used to optimize soil moisture for crop production while minimizing water use and tailwater discharge. Observation wells, which often have color-coded bars to indicate the optimum water table levels, can also be used to prevent over-irrigation or over-drainage. This applied practice was developed based on in-field water table observations, corroborated by using computer model simulations.

Working Definition:

A water table observation well is a management tool that is used to optimize the soil moisture for crop production while minimizing water use and tailwater discharge from seepage irrigation systems.

Key BMP Subcategories:

27A PLANNING AND INSTALLATION - *Things to Do: BMP(s)*

√ Install observation wells immediately after crop planting, siting them at two locations in each field. Well locations should generally represent the high and low water table elevations within each field.

√ Install observation wells midway between ditches or water furrows, and make sure that wells can be easily viewed for timely monitoring.

√ Install the well casing to a depth so that the top of the reference cap is 9” above the top of the bed.

√ Install additional observation wells if the soil type changes significantly across a field.

27B CALIBRATION, OPERATION AND MAINTENANCE - *Things to Do: BMP(s)*

√ After installation of pipe, allow the water table to stabilize inside the pipe. Measure the distance from the water line to the top of the reference cap. Remove the reference cap to place the float staff into the pipe, and replace the reference cap. Read the float staff level with the top of the reference cap. The number indicated by the float staff, if properly calibrated, should equal the measured distance.

√ Check observation wells frequently (at least daily for non-rainfall days and more frequently during rainfall events) to determine water table status of the field.

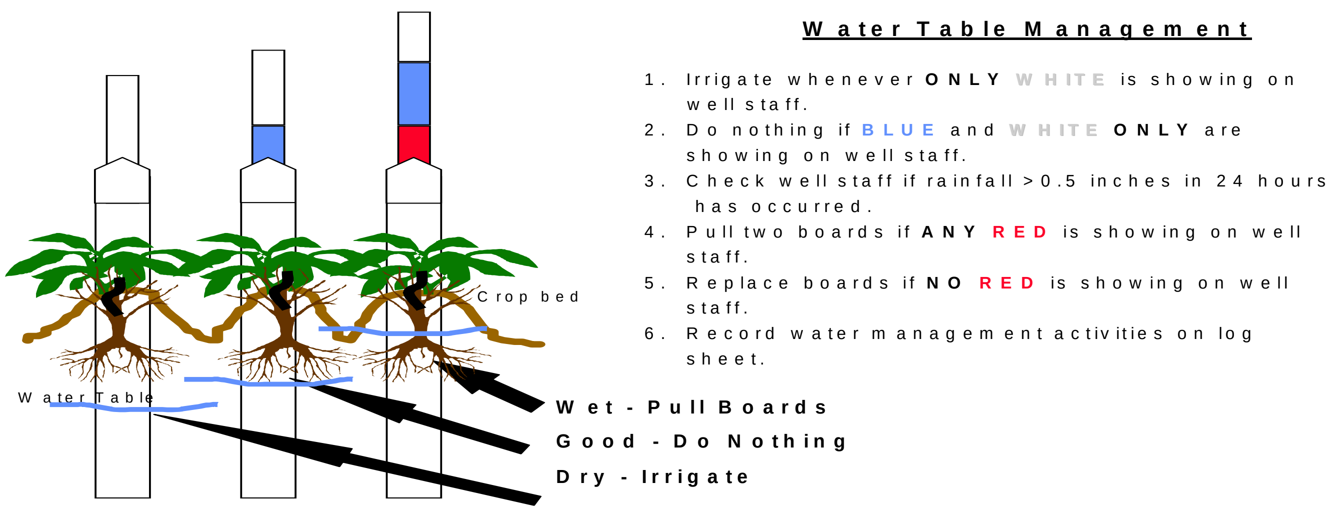
√ Adjust irrigation output or riser boards to keep the water table at an appropriate level for the crop. In general, water table depth should be maintained between 15 and 24 inches below the top of the bed, unless more specific information is available for the particular crop and soil type.

√ Set flashboard riser-boards about 3″ to 6″ above furrow irrigation-water depth or about 12″ to 18″ below the tops of beds, to prevent any overtopping during irrigation.

√ Irrigation should be occurring whenever the float staff is showing ONLY WHITE. Irrigate at a rate that will just maintain water in the furrow ditches nearest the collector ditch without overtopping the riser boards. Irrigation should be turned off or flow rate reduced whenever board overtopping is about to occur or if BLUE is showing on the well float staff.

√ Check observation wells following any rainfall to see if the irrigation should be turned off.

√ If any RED is showing, then normally two boards should be removed from the discharge culvert, with the boards then being replaced when no RED is showing on the staff. For moderate rain events, only one board may require removal.



Other Considerations:

■ To account for variations in water conditions across a field, observe the relative differences between at least two wells installed in various locations around the field.

Key References:

(1) SWET and Mock, Roos and Associates. 1994. Final Report – Phase I: Tri-County Agricultural Best Management Practices Study. Prepared for the St. Johns River Water Management District.
(2) SWET and Mock, Roos and Associates. 1996. Final Report – Phase II: Tri-County Agricultural Best Management Practices Study. Prepared for the St. Johns River Water Management District.

28 PRECISION AGRICULTURE

Precision agriculture, or site-specific crop management, is designed to take advantage of in-field variability, and includes metrics such as: soil fertility, soil moisture content, soil texture, topography, weed/pest populations, plant vigor, soil organic matter, etc. Precision agriculture may be more beneficial on larger, variable fields, and is used to gather information from the field, including crop status, in order to make efficient management decisions. The objectives of precision agriculture are to increase profit, to reduce waste of inputs, and to maintain the quality of the environment. The key technologies used to implement precision agriculture are GPS (Global Positioning System), GIS (Geographic Information System), yield monitoring/mapping, variable rate technology (VRT), remote sensing, soil sampling, and crop scouting/ground truthing. Yield mapping is a crucial first step to implement precision agriculture, as spatial variation of yield is essential to find out what causes high and low yield, and to help recognize other field variabilities.

Working Definition:

Precision agriculture is computer-assisted management of each crop production input (fertilizer, lime, herbicide, seed, insecticide, irrigation**,** etc.) on a site-specific basis to increase profit, reduce waste, and maintain the quality of the environment.

Key BMP Subcategories:

28A PRE-PLANT – *Things to Do: BMP(s)*

- √ Map boundary of production cropland with GPS and create a GIS layer.
- √ Take soil samples to find out nutrient values and other soil characteristics of your field. Soil sampling should be based on 'management unit' rather than purely on a grid system. Refer to the UF/IFAS Nutrient Management fact sheet SL190, Soil Sampling Strategies for Precision Agriculture, http://edis.ifas.ufl.edu/SS402.
- √ Create additional GIS layers for nutrient and soil characteristics, as needed.

28B YIELD MAPPING– *Things to Do: BMP(s)*

√ Commercial yield mapping systems are currently available for some crops, but not all. Most of the systems are sold in a package including GPS, and other necessary components, so consider this before purchasing any software package.

√ Before using a yield monitoring system, try it out beforehand and familiarize yourself with the system.

√ Yield monitors should be calibrated with a known quantity before they are used.

√ Yield maps should be compiled for multiple years in order to determine accurate spatial yield variability.

Things to Avoid: Potential Pitfalls

X Do not use a GPS receiver under trees or close to any structures that might block the GPS signal.

X Avoid rushing; sometimes the differential GPS signal might be temporarily unavailable, so check the quality of the signal often.

<u>Operation and Maintenance Issues:</u>

■ When a new yield mapping system is used, make sure each of the components (moisture sensor, GPS, flow sensor, speed sensor, etc.) work correctly before you collect yield data.

<u>Other Considerations:</u>

● Seek recommendations/information from growers who have already been implementing precision technologies since circumstances vary for each grower.

● Download satellite imagery for your field and incorporate it with your GIS layers. Free satellite imageries can be downloaded from http://www.labins.org and http://www.terraserver.com.

Key References:

(1) The Precision-Farming Guide for Agriculturists, by M. Morgan and D. Ess, Deere & Company, 1997
(2) Global positioning system: http://www.trimble.com/gps
http://www.aero.org/publications/GPSPRIMER/
(3) Geographic Information Systems: http://erg.usgs.gov/isb/pubs/gis_poster/
(4) Variable rate technology (VRT): http://www.precisionag.org/html/ch12.html
(5) Yield mapping: http://www.precisionag.org/html/ch3.html
http://www.deere.com/en_US/ag/servicesupport/ams/yieldmonitor-mapsub2.html/
(6) Remote sensing: http://rsd.gsfc.nasa.gov/rsd
(7) Soil Sampling Strategies for Precision Agriculture, http://edis.ifas.ufl.edu/SS402

29 CROP ESTABLISHMENT

Most vegetable and agronomic crops are planted in the field using direct-seeding methods and/or by transplanting seedlings. Once the initial planting is done, it is critical that the crop have access to water resources to become properly established and grow. The initial delivery of water is generally done prior to planting or bedding. Also, it is important that the proper amount of irrigation water is available to establish sufficient soil moisture around the seedling or seed. This will help to eliminate stress at this critical phase of the plant's growth cycle.

Working Definition:

Crop establishment is the process by which an initial amount of irrigation water is delivered to a seed or seedling in the field to ensure that it will become well established.

29A CROP ESTABLISHMENT – *Things to Do: BMP(s)*

√ Consider weather forecasts and season when planning for crop establishment. Certain storm events can significantly decrease irrigation water needs during particular seasons.

√ Use culverts and risers along farm and field ditches that have significant slope/grade. This allows irrigation water used during crop establishment to be distributed more uniformly throughout the field.

√ Consider using soil moisture determination equipment or techniques such as tensiometers or water table observation wells, so that over-watering of fields is minimized. Tensiometers are extremely difficult to use in the rocky soils of Miami-Dade.

√ Evaluate the different types of soils on your farm. Different soil types will reach proper crop establishment soil moisture levels with differing amounts of irrigation water.

Things to Avoid – Potential Pitfalls:

X Do not leave irrigation pump stations and systems unsupervised during crop establishment. This may lead to excess use and loss of irrigation water.

X Do not irrigate for crop establishment during or immediately after a storm event. Allow infiltration to occur to more accurately determine soil moisture in fields prior to irrigating.

30 DOUBLE CROPPING IN PLASTICULTURE SYSTEMS

Successive cropping of existing mulched beds is a good practice that makes effective use of polyethylene mulch, soil fumigant, and residual (unused) fertilizer. In theory, if nitrogen fertilizer applications and amounts were properly managed for the first season's crop, then there should be negligible amounts of nitrogen remaining in the beds for utilization by subsequent crop(s). Double cropping, which can also include the practice of rotating vegetable crops with non-vegetable cover or forage crops, takes full advantage of the residual nutrients "left over" from previous crops.

Working Definition:

Double cropping is the practice of growing two crops on the same field within a 12-month period.

Key BMP Subcategories:

30A PRE-PLANT – *Things to Do: BMP(s)*

√ Be observant for any nutrient deficiencies in the first crop.

√ Take a representative soil sample in the bed away from any first-crop fertilizer bands.

30B FERTILIZATION - *Things to Do: BMP(s)*

√ Apply an amount of nitrogen equal to the crop's own nutrient requirement as long as nitrogen was not applied in excess of the nutrient requirement for the first crop.

√ Use either drip irrigation or an injection wheel to apply the fertilizer.

√ Inject small amounts of phosphorus by injecting phosphoric acid through the drip system only if required via soil testing.

Things to Avoid: Potential Pitfalls

X Do not add extra fertilizer when planting the first crop with the misconception that this fertilizer will aid growth of the second crop.

X Do not exceed fertilizer recommendations for the first or second crop.

X Do not allow beds to significantly dry-out between the two crops.

Operation and Maintenance Issues:

- Maintain soil moisture between removal of the first crop and planting of the second crop. Small amounts of water applied on a regular basis will help maintain adequate soil moisture, thus helping new plant survival.

Other Considerations:

- Consider using a drip irrigation system. Nitrogen and potassium can be readily injected through the irrigation system to meet the nutrient requirements of the crop. Also, it is easier with drip irrigation to keep the beds moist between the two growing seasons.
- Consider applying white spray paint to black plastic mulch in the fall to help cool the soil for the crop.
- Determine the potassium requirement of the second crop from soil testing if potassium was incorporated in the bed. Otherwise, apply an amount of potassium equal to the crop's nutrient requirement.
- Inject micronutrient(s) only if certain deficiencies are anticipated.

Key References:

(1) Soil and Fertilizer Management for Vegetable Production in Florida, http://edis.ifas.ufl.edu/CV101

(2) Mulching, http://edis.ifas.ufl.edu/CV105

(3) Commercial Vegetable Fertilization Principles, http://edis.ifas.ufl.edu/CV009

(4) IFAS Standardized Fertilization Recommendations for Vegetable Crops, http://edis.ifas.ufl.edu/CV002

(5) Double Cropping Vegetables Grown in Plasticulture in Florida in the BMP Era, http://edis.ifas.ufl.edu/HS165

31 PROPER USE OF ORGANIC FERTILIZER MATERIALS

Waste organic by-products, which include animal manures, composted organic matter and/or sludges, contain nutrients that may enhance plant growth. These materials slowly decompose when applied to the soil and release nutrients for crop uptake. The key to proper use of organic-material fertilizers comes in the knowledge of the nutrient content and the decomposition rate of the materials. Many laboratories offer organic-material analyses to determine specific nutrient contents. Decomposition rates of organic materials in warm sandy soils are rapid. Therefore, there will be relatively small amounts of residual nutrients remaining for succeeding crops. Organic materials are generally similar to mixed chemical fertilizers in that the organic waste supplies an array of nutrients, some of which may not be required on a particular soil. P will build up in soil where manures are used frequently, because all manures contain P.

Tables are also available that describe the average nutrient content of animal wastes. However, the actual nutrient content of manures may vary from one livestock operation to another. Factors that contribute to this variation include: the number of animals per operation, composition of the feed ration, design of the waste management system including the presence of intermixed bedding materials, season of year, animal health, etc. Therefore, it is important that livestock wastes are sampled and analyzed to determine their nutrient concentrations before a sound nutrient management plan can be designed and implemented.

Working Definition:

Organic or natural fertilizers are ones that typically originate from human, plant and animal waste and by-products.

Key BMP Subcategories:

31A SAMPLING – *Things to Do: BMP(s)*

√ Take multiple samples and mix well so that each final sample is representative of the organic material.

√ Final sample should consist of a 1-quart freezer bag, labeled, and kept cool until analyzed.

√ Sample the organic material as near to the time of application as possible.

√ Know both the source and type of material if using sewage sludge. Certain classes of sludge are not appropriate for crop production and may not even be permitted for land application.

31B APPLICATION: *Things to Do: BMP(s)*

√ Determine the organic material's nutrient content by having a laboratory analyze the material for its content of specific nutrients.

√ Base your application rate on the specific nutrient content from the laboratory analysis and on individual crop requirements.

√ Calibrate your spreader so that proper amounts of organic material are applied.

Things to Avoid: Potential Pitfalls

X Do not apply excessive amounts of organic fertilizer materials, since excess nutrients may be released, possibly leading to contamination of nearby water sources.

X Avoid spreading uncomposted animal manure on cropland.

Other Considerations:

- Organic fertilizers supply essential plant nutrients and also serve as a soil amendment by adding organic matter to the soil.
- Organic material increases the moisture-holding capacity of the soil and improves lateral water movement, thus improving irrigation efficiency and decreasing the general "droughtiness" of sandy soils.
- Poultry manure has long been recognized as a desirable source of natural fertilizers, because of its relatively high nitrogen content.
- In areas where phosphorus movement off-site can lead to eutrophication of surface waters, phosphorus rather than nitrogen may be the factor determining application rate of an organic fertilizer material such as animal manure.
- Remain knowledgeable of food safety issues, especially on fresh market crops.

Key References:

(1) Farming for Clean Water in South Carolina: A Handbook of Conservation Practices

(2) Cage Layer Manure: An important resource for land use, http://edis.ifas.ufl.edu/PS005

(3) Poultry Manure as a Fertilizer, http://edis.ifas.ufl.edu/AA205

(4) Soil Organic Matter, Green Manures and Cover Crops For Nematode Management, http://edis.ifas.ufl.edu/VH037

(5) Utilization of Organic Wastes in Florida Agriculture, http://edis.ifas.ufl.edu/AG113

(6) Soil and Fertilizer Management for Vegetable Production in Florida, http://edis.ifas.ufl.edu/CV101

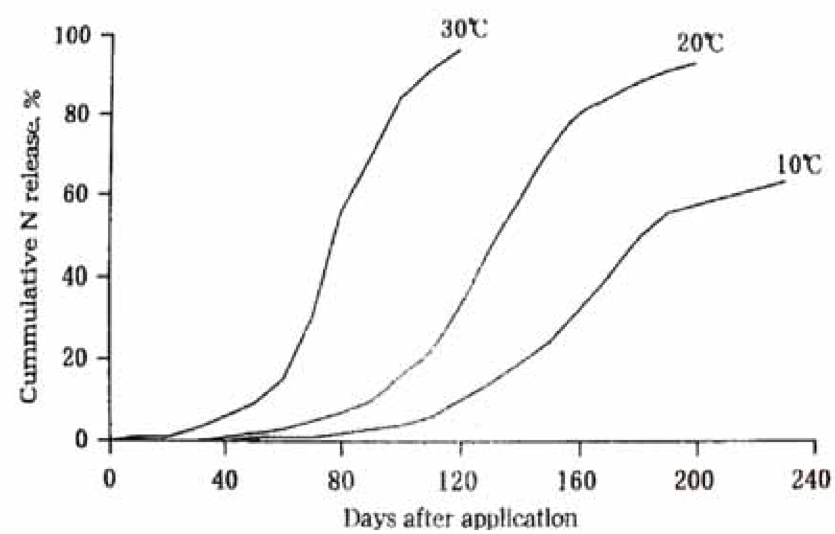
(7) University of Florida North Florida Research Center – Suwannee Valley, http://nfrec-sv.ifas.ufl.edu/

(8) Sampling guide from North Florida Research and Education Center Animal Waste Testing Laboratory, http://nfrec-sv.ifas.ufl.edu/lwtl1.htm

(9) USDA - NRCS Phosphorus Index

(10) UF/IFAS Nutrient Management Series: Computational Tools for Field Implementation of the Florida Phosphorus Index, available for each county. Go to, http://edis.ifas.ufl.edu/TOPIC_SERIES_UF_IFAS_Nutrient_Management

32 CONTROLLED-RELEASE FERTILIZER



Controlled-release fertilizers (CRFs) are an alternative to conventional soluble fertilizers when nutrient release into the environment is of significant concern (and especially nitrate nitrogen). In theory, CRFs allow the grower to better synchronize nutrient release with the crop's nutritional requirement, thereby reducing the risk of leaching between time of application and plant uptake. Most CRFs are in the granular form, but some liquid formulations are also now available.

Due to high manufacturing costs, CRFs have been mainly used in the past with high value ornamental crops or small fruit crops. They are becoming increasingly more popular for some citrus operations. The renewed interest in CRFs for vegetable production has stimulated ongoing research efforts which should increase the amount of available information and grower acceptance.

Working Definition:

Granulated CRFs are sphere-like prills made of a water-soluble fertilizer that degrade based on soil temperature and/or moisture.

Key BMP Subcategories:

32A PLANNING - *Things to Do: BMP(s)*

√ Know your CRF: grade, form of N being released (urea, ammonium, nitrate) and factors influencing time of release (usually soil temperature and moisture level) are all important.

√ Match the CRF's release time with the crop nutrient needs. Consider blending soluble fertilizers and CRFs, and/or blending several CRFs together to ensure adequate and continuous nutrient supply to the crop.

√ Match the release temperature with the actual soil temperature for temperature-based CRFs by using soil temperature records or averaged daily maximum and minimum air temperatures.

√ Plan to monitor crop nutritional status using leaf analysis, sap testing, or both.

32B APPLICATION - *Things to Do: BMP(s)*

√ Apply CRFs as other fertilizers would be applied: with a fertilizer spreader for granulated formulations, by banding (knifing-in), or in the irrigation water for liquid formulations.

√ Incorporate CRFs into the soil after applying.

√ Consider using rates lower than the recommended rate for soluble fertilizers, since the same production results may be achieved as the CRFs are slowly released. Extrapolation from other crops suggests that with appropriate release times, 60 to 75 lbs of N from a CRF will have the same effect on the crop as 100 lbs of N from a soluble fertilizer (urea, ammonium nitrate, 10-10-10).

Things to Avoid: Potential Pitfalls

X Do not exceed the recommended fertilization rate.

X Do not place CRFs on the soil surface.

Other Considerations:

- CRFs with a 1:1:1 ratio provide equal amounts of N, P_2O_5 and K_2O. The application rate of a 1:1:1 fertilizer should be made based on the element (among N, P and K) that is least required based on soil-test recommendations – otherwise, excessive application rates will occur.
- Most coatings and technology of CRF manufacturing are proprietary. Hence, users must rely on and follow the product label.
- Stay updated on CRF-related issues (formulation, cost, recommendations, and other breakthroughs) as new information is continually made available.

Key Reference:

(1) Slow-Release Fertilizer, http://www.ext.vt.edu/departments/envirohort/articles/misc/slowrels.html

(2) Controlled Release Fertilizer-Properties and Utilization, S. Shoji (Ed.), 1999, Konno Printing Co., Sendai, Japan.

(3) Soil and Water Science, Circular 1262, Selected Fertilizers Used in Turfgrass Fertilization, http://edis.ifas.ufl.edu/SS318

33 OPTIMUM FERTILIZATION MANAGEMENT/APPLICATION

Modern vegetable fertility programs are complex in nature, resulting from the interaction of many factors. One important factor is fertilizer cost, which is a large portion of the total crop production expense. Growers are strongly encouraged to refrain from the application of unneeded nutrients, which contributes to inefficient farming and can also lead to water resource contamination. Careful use of fertilizers will save money and prevent unnecessary environmental impacts.

The crop nutrient requirement (CNR) for a crop is determined from field experiments that test the yield response to varying levels of added fertilizer. Current N, P, and K recommendations for vegetables in Florida are supported by more than 40 years of research and on-farm trials.

The fertilization research used to develop the IFAS fertilization recommendations was conducted with modern crop varieties and often on commercial farms in Florida. The "rate" or "amount" of fertilizer recommended is only part of the overall fertilizer management recommendation. Growers are cautioned against focusing only on the amount of fertilizer, and are encouraged to view the recommended rates as a component of the overall nutrient management program for the crop. This chapter outlines those factors important in the overall nutrient management program. Keep in mind that research continues to evaluate BMPs including rates of fertilizer needed as production practices, crop varieties, economics, and environmental protection needs change over time.

To reiterate, BMPs, by definition, must be economically feasible. That said, growers have three basic options in their approach to fertilizer management:

(1) Use IFAS published fertilizer recommendations, which include provisions for supplemental nutrient application(s) or use alternate recommendations supported by other credible research institutions only when regional, site-specific conditions and documented data support this approach;

(2) Use IFAS published fertilizer application recommendations as a general starting point, and if these rates are exceeded, growers are expected to employ additional nutrient and irrigation BMPs to negate possible environmental impacts. These BMPs can be ascertained by using the BMP Assessment Checklist in Appendix A-1; or,

(3) For farming operations in significantly impaired basins caused by nutrients, growers must strictly adhere to all recommendations set forth in the Basin Management Action Plan.

Working Definition:

Optimum fertilization management is the judicious application of fertilizers to meet the crop nutrient requirement without adding excess nutrients.

33A FERTILIZATION RATES - Things to Do: BMP(s)

√ Know the crop nutrient requirement (CNR) for N as specified in IFAS fertilization recommendations or other credible research and target this amount for total crop N fertilization.

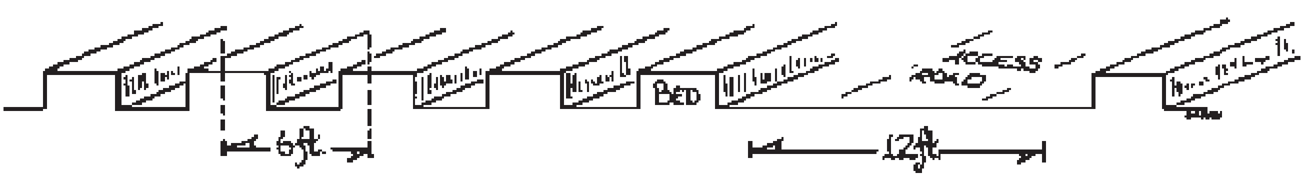
√ Refer to the Linear Bed Foot section in the next paragraph and follow the recommendations.

√ Know the CNR for P, and remember P is not retained on some Florida soils. Refer to the key reference section at the end of this BMP for more information.

√ Set realistic yield goals. Some growers believe that N fertilization is the key to greater yields and, therefore, set yield goals at unrealistic and rarely achieved levels. Once optimum N-fertilization programs (determined by research) have been set, then weather and market conditions usually determine the fluctuations in marketable yield from year to year.

√ Calibrate fertilizer application equipment accurately and make adjustments to the equipment so that the correct amount of fertilizer is applied to the correct portion of the root zone or production bed, nearest the root system.

The University of Florida Extension Soil Testing Laboratory (ESTL) employs the Standardized Fertilizer Recommendation System in which all fertilizer recommendations are expressed in “pounds per acre” (lb/A). These fertilizer rates are based upon typical distances between bed centers for each crop (Table 4 in the Appendix). Table 4 also indicates the typical number of rows of plants within each bed. As an alternative, the use of “pounds per 100 linear bed feet” (lb/100 LBF) as a fertilizer rate assures that an appropriate rate of fertilizer will be applied, regardless of the total number of LBF in the cropped area. The use of lb/A to express fertilizer rate requires an adjustment based upon actual cropped area. The goal is to provide a specific concentration of nutrients to plant roots, since most roots are confined within the volume of soil comprising the bed, and in particular under the polyethylene when using a full-bed mulch system.



33B Linear Bed Foot (LBF) System – *Things to Do: BMP(s)*
Converting from lb/A to lb/100 LBF:

√ Determine the typical bed spacing from Table 4 in the Appendix for the crop.

√ Locate the column containing the recommended fertilizer rate in lb/A in Table 5 in the Appendix.

√ Read down the column until reaching the row containing the typical bed spacing.

√ Use this rate in lb/100 LBF, even in situations where the grower’s bed spacing differs from the typical bed spacing.

33C GENERAL PRE-PLANT FERTILIZER APPLICATION – *Things to Do: BMP(s*)

√ Have a calibrated micronutrient soil test conducted every to 2 to 3 years. Apply micronutrients only when a specific deficiency has been clearly diagnosed.

√ Use a calibrated soil test to determine P fertilizer needs.

√ Broadcast micronutrients when applying P based on soil testing results. Incorporate the micronutrients into the bed area and refrain from “shotgun” micronutrient fertilizer application.

√ Place P in the root zone. Banding is generally considered to provide more efficient utilization of P by plants than broadcasting when soil conditions may reduce P availability such as can occur in organic and calcareous soils.

√ Band or foliarly apply micronutrients, including Fe, Mn, and B, on calcareous soils that tend to fix micronutrients in unavailable forms.

√ Manage N carefully, since N is very mobile in sandy soils. Under non-mulched systems, split- applications of the mobile nutrients must be used to reduce losses to leaching. Up to one-half of the N may be applied to the soil at planting or shortly after that time.

33D PRE-PLANT FERTILIZER PLACEMENT WITH PLASTIC MULCH WHEN USING SUB-SURFACE IRRIGATION – *Things to Do: BMP(s*)

√ Incorporate all P and micronutrients in the bed when using sub-surface (seepage) irrigation. Apply 10 to 20% (but not more) of the N and K with the P. The remaining N and K should be placed in narrow bands on the bed shoulders, the number of which depends on the crop and on the number of rows per bed. These bands should be placed in shallow (2 to 2 ½-inch-deep) grooves. This placement requires that adequate bed moisture be maintained so that moisture capillarity is not broken. Otherwise, fertilizer will not move to the root zone.

33E PRE-PLANT FERTILIZER PLACEMENT WHEN USING DRIP IRRIGATION – *Things to Do: BMP(s*)

√ Incorporate all P, micronutrients, and 20 to 40% of the N and K in the bed.

√ Apply no more than 20% of the N and K in the bed when using sub-surface irrigation to keep the beds moist.

√ Apply the remaining 60 to 80% of the N and K in increments throughout the cropping season via the drip irrigation system.

33F BARE-GROUND FERTILIZATION – *Things to Do: BMP(s)*

√ Use split applications of the nutrients to reduce losses to leaching.

√ Apply up to one-half of the N and K at planting or shortly after planting. Minimize amounts of N applied at planting which might be subject to leaching before the crop emerges or develops a sufficient root system to capture N in the soil.

√ Apply the remaining fertilizer in one or two applications during the early part of the growing season, or according to specific crop needs.

√ Shut-off valve on applicator equipment so that no fertilizer is applied in the turn row.

33G DRIP IRRIGATION/FERTIGATION DURING THE GROWING SEASON – *Things to Do: BMP(s)*

√ Inject fertilizer more frequently, such as once each day, to reduce the likelihood that nutrients will be leached during a heavy rainstorm or excessive irrigation compared to injecting larger amounts on a less-frequent basis. If the chances for leaching loss are extremely low and soil type permits, then injection once per week should be satisfactory. Knowledge of the crop root zone is important for optimum fertilizer management. It is also important to monitor water application and to understand that fertilizer management is linked to water application practices.

√ When N and K are applied pre-plant in a fertigation program, begin fertilizer injections two or three weeks later. Application rates are determined by crop growth and resulting nutrient demand. Schedules of N and K application have been developed for most vegetables produced with drip irrigation in Florida. For information, consult IFAS document SP170 "Vegetable Production Guide for Florida".

33H SPRINKLER SYSTEM FERTIGATION – *Things to Do: BMP(s)*

√ Fertigate through the sprinkler system for crops with close row spacing, such as leafy greens or corn, rather than for crops such as watermelon.

√ Fertigate only after the root system of the crop has advanced into the inter-row area in order to intercept applied nutrients.

√ Schedule fertilizer applications of N or K with the growth rate of the crop.

33I SUPPLEMENTAL FERTILIZER APPLICATION– *Things to Do:* BMP(s)

√ Manage CNR properly with correct timing and placement of fertilizer to avoid leaching losses.

√ Make a supplemental application of N and/or K, if needed, at this stage of crop development when rainfall exceeds 3 inches in 3 days, or 4 inches in 7 days. In general, apply 30 lbs of supplemental nitrogen per acre of planted cropland or 20 lbs of supplemental potassium (K_2O) per acre of planted cropland if supplemental fertilization is recommended.

√ A supplemental fertilizer application is also allowed when the results of tissue analysis and/or petiole sap testing fall below the sufficiency ranges. The additional amount allowed is 30 lbs/A of N and/or 20 lbs/A of K_2O for bare-ground production. For drip irrigation, double the IFAS recommended weekly drip irrigation rate for N and K_2O for one week.

√ Supplemental fertilizer applications are also allowed for extended crop cycles and harvests. These occur when for economical reasons, a crop is harvested a greater number of times than the number of harvests used for determining IFAS recommendations. When the results of tissue analysis and/or petiole testing are below the sufficiency ranges, an additional 30 lbs/A of N and/or 20 lbs/A of K_2O may be made for each additional harvest for bare-ground production, and an additional peak recommended rate for N and K_2O for drip-irrigated crops, may be used until the next harvest. These provisions allow growers to numerically apply higher fertilizer rates than the 'basic' recommended rates when growing conditions are longer than those used to develop the 'basic' rates.

√ Applying additional fertilizer under these three circumstances is consistent with current IFAS fertilizer recommendations.

Things to Avoid for Any Application System– Potential Pitfalls:

- **X** Do not change the amount of fertilizer used per length of row even if the bed spacings are wider than typically used. Refer to IFAS document Soil and Fertilizer Management for Vegetable Production in Florida, http://edis.ifas.ufl.edu/CV101 .
- **X** Do not make unneeded applications of micronutrients. Indiscriminate application of micronutrients may reduce plant growth and restrict yields because of toxicity.
- **X** Do not over-lime the soil, as this practice can tie-up micronutrients.
- **X** Avoid adding supplemental or side-dress fertilizer to crops immediately before a forecasted storm event of significant magnitude.
- **X** Do not apply fertilizer in bands on the surface of the bed, especially in the area between the tube and the plant.

Operation and Maintenance

- Always store nitrogen-based fertilizers separately in a concrete building with a flame-resistant roof away from solvents, fuels and pesticides. Many fertilizers are oxidants and can accelerate a fire.
- Always store fertilizer in an area that is protected from rainfall in order to prevent contamination of nearby ground water and surface water sources.
- Properly calibrate fertilizer application equipment.

Other Considerations:

- Even though injecting N and K in variable amounts (according to the growth curve) during the season for drip irrigation might be the most efficient approach, there are situations where the injection program can be simplified. For example, on fine-textured soils or where irrigation management is excellent (no leaching), then the seasonal amount of N and K_2O can be applied in equal amounts rather than changing the rate of injection as the crop matures.
- Research has shown that the fertilization frequency, even up to once per week, is not as important as achieving a correct rate of application of nutrients to the crop during a specified period of time. With computer control of drip irrigation systems, some growers find it easy to inject more frequently (even often as once per day).
- In some production systems where soils are relatively high in organic matter, micronutrients, P, and K, it may be possible to grow successful crops with no in-bed fertilizer (i.e. with all fertilizer (N) applied through the drip-irrigation system). This is particularly attractive for areas of the state where growers experience soluble-salt problems. Reducing the amount of dry fertilizer applied in the bed may potentially reduce soluble-salt injury to young seedlings or transplants.
- Excessive moisture can result in fertilizer leaching. Remember that fertilizer and water management programs are linked. Maximum fertilizer efficiency is achieved only with close attention to water management.
- Some crops - including strawberries, tomatoes, and peppers - may benefit from controlled-release fertilizers in the starter (in-bed) fertilizer mixture in order to provide an early-season N supply.
- Fallow flooding to enhance denitrification should be considered if farming vegetable crops on spodosols, especially if excess nitrogen fertilizer may have been applied.

Key References:

(1) Calculating Fertilizer Rates for Vegetable Crops Grown in Raised - Bed Cultural Systems in Florida, http://edis.ifas.ufl.edu/WQ112

(2) Commercial Vegetable Fertilization Principles, http://edis.ifas.ufl.edu/CV009

(3) Soil and Fertilizer Management for Vegetable Production in Florida, http://edis.ifas.ufl.edu/CV101

(4) Phosphorus Management for Vegetable Production in Florida, http://edis.ifas.ufl.edu/HS105

(5) Fertilizer Application and Management for Micro (Drip)-Irrigated Vegetables in Florida**,** http://edis.ifas.ufl.edu/CV141

(6) For current nutrient recommendations for row crops, go to: Vegetable Production Guide for Florida (SP 170), http://edis.ifas.ufl.edu/TOPIC_GUIDE_Vegetable_Production_Guide_for_Florida

(7) UF/IFAS Standardized Fertilization Recommendations for Agronomic Crops, http://edis.ifas.ufl.edu/SS163

(8) For current nutrient recommendations for cotton, peanut, soybeans, and corn, go to: http://edis.ifas.ufl.edu/

(9) A Summary of N, P, and K Research with Tomato in Florida, http://edis.ifas.ufl.edu/CV236

(10) A Summary of N, P, and K Research with Sweet Corn in Florida, http://edis.ifas.ufl.edu/CV235

(11) A Summary of N, P, and K Research with Snapbean in Florida, http://edis.ifas.ufl.edu/CV234

(12) A Summary of N, P, and K Research on Potato in Florida, http://edis.ifas.ufl.edu/CV233

(13) A Summary of N, P, and K Research with Watermelon in Florida, http://edis.ifas.ufl.edu/CV232

(14) A Summary of N and K Research with Muskmelon in Florida, http://edis.ifas.ufl.edu/CV231

(15) A Summary of N, P, and K Research with Pepper in Florida, http://edis.ifas.ufl.edu/CV230

(16) A Summary of N and K Research with Strawberry in Florida, http://edis.ifas.ufl.edu/CV229

(17) A Summary of N and K Research with Eggplant in Florida, http://edis.ifas.ufl.edu/CV228

(18) A Summary of N Research with Squash in Florida, http://edis.ifas.ufl.edu/CV227

(19) A Summary of N, P, and K Research with Cucumber in Florida, http://edis.ifas.ufl.edu/CV226

(20) Nitrogen Management Practices for Vegetable Production in Florida, http://edis.ifas.ufl.edu/CV237

(21) Agronomic Crops and Forages, http://jefferson.ifas.ufl.edu/ag_pages/crops_page.htm

(22) UF/IFAS Agronomy Department, http://agronomy.ifas.ufl.edu/AGPUBS.HTML

(23) Fertilization of Agronomic Crops, http://edis.ifas.ufl.edu/AA130

(24) Soil and Plant Nutrition, http://edis.ifas.ufl.edu/MG091

(25) Nutritional Requirements for Florida Sugarcane, http://edis.ifas.ufl.edu/SC028

34 CHEMIGATION / FERTIGATION

The use of irrigation systems for the application of agrichemicals offers several important advantages over traditional means of application and has become a common practice during recent years. Chemigation is often less expensive than other methods of application and allows chemicals to be applied only as needed and in precise locations and amounts, especially with drip irrigation systems. Chemigation also improves operator safety and reduces the amounts of chemicals required, thereby reducing overall chemical costs. For fertilization, precision application - known as fertigation - follows plant needs more closely than traditional fertilizer methods and helps to reduce nutrient leaching.

It is essential when using any type of fertilizer or pesticide injection system that the water source be protected. State law (Section 487.055, Florida Statutes) requires that backflow/anti-siphon protection be present on all chemical injection systems.

Working Definitions:

Chemigation is the process of chemical application through the irrigation system, while fertigation refers to the application of liquid fertilizer through the irrigation system.

Key BMP Subcategories:

34A IRRIGATION SYSTEM DESIGN FOR CHEMIGATION / FERTIGATION – *Things to Do: BMP(s)*

√ Select equipment that is designed or adapted for the injection of agrichemicals into the irrigation system at a controlled rate.

√ Select irrigation system components that are compatible with the chemicals to be used.

√ Locate the injector so that a minimum amount of water is delivered to the field before the chemical / fertilizer reaches the crop. This will reduce the potential for over-watering and chemical leaching.

√ Design the system to maximize application uniformity and use the appropriate backflow-prevention devices in accordance with Rule 5E-2.030, F.A.C.

√ Determine both the quality of irrigation water and any water quality treatment processes that may be required. Common water quality issues include salinity, algae, bacteria, iron, pH, hardness and turbidity.

34B INJECTION PERIODS AND CALIBRATION – *Things to Do: BMP(s)*

√ If the injection period exceeds the maximum irrigation period, use split applications to prevent over-irrigation and chemical leaching. This may not apply to fumigants.

√ Always know the actual flow rate of the irrigation system being used with the injection system.

√ Calibrate the injection system while the irrigation system is operating, since irrigation-system operating pressures and flow characteristics may influence the injection rate.

34C CHEMICAL MIXTURE and INJECTIONS – *Things to Do: BMP(s)*

√ Depending on the chemical, follow the fertilizer label and apply it either as a precise concentration or as a bulk mass of chemical with (possibly) varying concentration levels.

√ Bring the irrigation system up to operating pressure before adding fertilizer in a non-continuous fashion, such as once per day or once per week.

√ Operate the irrigation system long enough after completion of injection to ensure that complete flushing is achieved. The time necessary for flushing should be based on the time needed for the water to go from the injection point to the farthest point of the irrigation system.

√ Insure that any chemical that is applied through the irrigation system is labeled for such application, and follow all label instructions completely.

34D FERTIGATION WITH DRIP IRRIGATION SYSTEM – *Things to Do: BMP(s)*

√ Begin the fertigation program two or three weeks after planting, if nitrogen and potassium were applied pre-plant.

√ Inject fertilizer on a daily or weekly basis depending on the fertilization and irrigation schedule.

√ For maximum effectiveness, use highly soluble fertilizers. N fertilizer sources include ammonium nitrate, calcium nitrate, various nitrogen solutions, urea and potassium nitrate. K fertilizer sources include potassium nitrate, potassium sulfate, or potassium chloride.

√ Install a drip irrigation system with emitters designed to prevent sediments from settling in the emitters between irrigation, and periodically perform manual flushing or use self-flushing valves at the end of the drip lines.

34E FERTIGATION WITH OVERHEAD IRRIGATION SYSTEM – *Things to Do: BMP(s)*

√ Use fertigation through sprinkler systems mostly on sandy soils that require small yet frequent water applications.

√ Use fertigation through sprinkler systems on crops with close row spacings, such as leafy greens or corn.

√ Begin fertigation only after the crop has developed far enough to ensure that the root system has advanced into the inter-row area to intercept nutrients.

Things to Avoid: Potential Pitfalls

X Avoid excessive irrigation that could cause nutrients to be leached below the root zone.

X Do not inject materials that might clog the irrigation system via chemical precipitation, changes in water temperature, or reaction with the water.

X Do not inject phosphorus or sulfur with calcium, both of which may clog the irrigation emitters.

X Do not use overhead fertigation / chemigation on crops grown on plastic beds.

Operation and Maintenance Issues:

- Include in the maintenance schedule a periodic inspection of the mechanical components and irrigation lines.
- On a regular basis, record the flow rate and pressure delivered by the injector and irrigation pump(s), as well as the energy consumption of the power unit for the irrigation pump.
- Knowledge of water use and pressure can help you troubleshoot problems.
- Check large deviations from the normal operating characteristics of the injection system with a repair specialist.
- Routinely monitor the filtration equipment for clogging and clean as necessary.
- Inject acid, chlorine, or a commercial water-treatment chemical to remove chemical precipitates or organic growth. In low-volume systems, clean the drip lines and emitters as needed to prevent clogging.

Other Considerations:

- Water quality is an important factor to consider in the design or implementation of a chemigation system. Some water sources require chemical additives to prevent bacterial growth or chemical precipitation from clogging the system.
- Concentrated chemical solutions can be advantageous because shorter injection cycles are required to inject the same amount of chemical.
- Phosphorus and micronutrients should generally be applied directly to the soil instead of by injection. These chemicals, in combination with Florida's high calcium-carbonate waters, can result in significant calcium phosphate precipitation.
- Water temperature has a great effect on the solubility of fertilizer solutions. Higher concentrations of N and K can be maintained in solution at higher water temperatures.

Key References:

(1) Injection of Chemicals Into Irrigation Systems: Rates, Volumes, and Injection Periods, http://edis.ifas.ufl.edu/AE116

(2) Microirrigation on Mulched Bed Systems: Components, System Capacities, and Management, http://edis.ifas.ufl.edu./AE042

(3) Fertilizer Application and Management for Micro (Drip)-Irrigated Vegetables in Florida, http://edis.ifas.ufl.edu/CV141

(4) Chemigation and Fertigation, The Irrigation Association, http://www.irrigation.org

(5) Causes and Prevention of Emitter Plugging in Microirrigation System, http://edis.ifas.ufl.edu/AE032

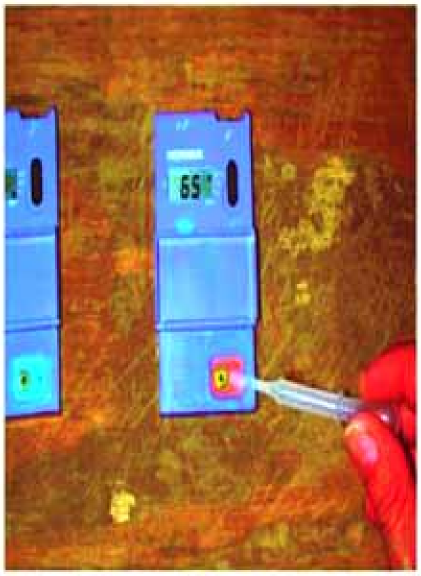
(6) Chemical Injection Methods for Irrigation, http://edis.ifas.ufl.edu/WI004

(7) Commercial Vegetable Fertilization Principles, http://edis.ifas.ufl.edu/CV009

(8) Design of Agricultural Irrigation Systems in Florida, http://edis.ifas.ufl.edu/AE064

(9) ASAE Practice Standard No. EP409.1

35 TISSUE TESTING



Efficient fertilizer management for most crops, and especially long-season vegetable crops, is important to reduce costs, conserve natural resources, and to minimize potential impacts on the environment. These goals can be achieved through optimum management of the fertilizer component, with understanding of the crop's nutrient requirement being one key to efficient fertilizer management. Moreover, timely tissue testing is an equally important tool used in fertilizer management through monitoring the plant's nutritional status, and such testing is also used in diagnosing suspected problems. As a management tool, tissue testing can increase a grower's return by preventing deficiencies that can reduce yield(s), market quality, and profitability.

Working Definition:

Tissue testing is the analysis and diagnosis of the plant's nutritional status based on its chemical composition. It is commonly performed as analyses on dried leaves or dried *petioles* or on sap from fresh petioles, with results compared to recommended nutrient ranges.

Key BMP Subcategories:

35A PLANT SAMPLING – *Things to Do: BMP(s)*

√ Begin sampling soon after the crop is established and continue at regular intervals (weekly or biweekly). Whole-leaf sampling will be most useful early in the season, while later in the season, it can help to point to changes in fertilization practices that are needed for the next season. Fresh petiole sap testing for N and K, practiced regularly throughout the season, can help manage the current crop as well as provide guidance for the next crop.

√ Sample the "*most recently matured leaf*" (MRML). The MRML leaf is the leaf that has most recently turned from a light-green, juvenile color to a darker-green color and has reached full size. For most crops the MRML is the 5th or 6th leaf from the growing tip.

√ Collect enough leaves so that the sample is representative of the crop stand, and that the sample is large enough to perform the required analyses.

√ Remove the same leaf (i.e., *physiological age* and position) from each sampled plant.

√ Collect one *composite sample* from the area exhibiting the disorder and a second sample from otherwise "normal" plants for comparison when trying to diagnose a nutrient deficiency.

√ Separate and properly label the "disorder" sample and the "normal" sample in order to make a valid comparison after analyses.

√ Keep notes on condition of crop and stage of growth, weather, and other variables for future reference.

35B CHOOSING A LABORATORY FOR TISSUE TESTING – *Things to Do: BMP(s)*

√ Select a laboratory that provides interpretations and recommendations based upon test results, which are appropriate for your growing region. The laboratory should be reliable and accredited and also offer a routine turnaround of less than 48 hours.

√ Continue testing with the same laboratory throughout the season in order to avoid significant differences due to variable analytical methods and interpretations.

√ Properly label each sample, provide a matching list, and clearly specify the analysis requested.

35C PREPARATION FOR SHIPPING – *Things to Do: BMP(s)*

√ Be careful not to crush or damage samples during cleansing. In most situations, cleansing is not needed.

√ Blot the samples dry with absorbent paper after rinsing, and air-dry the samples several hours before shipment.

√ Wrap the samples in absorbent paper and place them in a large envelope if a plant analysis kit is not available, and mail immediately.

35D PLANT-SAP QUICK TESTS FOR NUTRIENT ANALYSIS – *Things to Do: BMP(s)*

√ Use these "*quick tests*" in conjunction with routine, whole-leaf foliar analysis. These tests are used for the most mobile nutrients, particularly nitrate-nitrogen and potassium.

√ Some kits read out the nitrogen value as nitrate and some as nitrate-N. Most calibration tables for nitrogen are as nitrate-N values. For kits that read out as nitrates (NO_3), the reading must be divided by 4.43 to find the corresponding nitrate-N value which can then be compared to chart values. Potassium is usually read directly and is expressed in parts per million or mg/l.

√ There are some published values for petiole nitrate-N, but these values are sometimes based on dried petioles and are not directly transformable to fresh sap nitrate-N concentrations. Only fresh petiole-sap nutrient values can be used with fresh petiole sap-testing procedures.

√ Make consistent readings at the same time of day during each sampling event, to minimize variability due to crop water status at the time of sampling.

√ As recommended for foliar sampling, collect the most recently matured leaves, separate leaf blades from petioles, and place petioles (not sap) in a plastic bag on ice if storage is necessary. (Note: petioles can be stored on ice for up to 8 hours or frozen overnight without appreciable changes in the nitrate-N reading.)

√ Calibrate petiole-sap test kits with standards, consisting of known nitrate and potassium solutions available from the test-kit manufacturer.

√ Warm petioles to room temperature before extracting sap so that temperature differences between sap and meter do not affect results.

√ Make the measurement of the pressed sap within one or two minutes of pressing. Otherwise, nitrate readings could change when the sap is exposed to air.

Things to Avoid: Potential Pitfalls

- **X** Avoid plant tissue testing if the crop has received foliar nutrient sprays containing micronutrients or nutrient-containing pesticides.
- **X** Avoid sampling plants damaged by pests, diseases, or other chemicals when trying to monitor the nutritional status of the crop.
- **X** Avoid using tap water to rinse leaf samples, since it can be high in nutrients such as calcium, iron, magnesium, or sulfate sulfur. Use distilled water instead.

Applicable Technical Criteria:

- ♦ Nutrient sufficiency ranges for Florida vegetables have been published in “Special Series SSVEC-42”, *Plant tissue analysis and interpretation for vegetables crops in Florida*, by Hochmuth et al. (1991). This is available from all County Extension Offices.

Operation and Maintenance Issues:

- ■ Store test kits and chemicals in a protected place within the proper temperature range as specified by the manufacturer.

Other Considerations:

- ● Tissue testing may also be used to diagnose a suspected nutritional deficiency, toxicity or imbalance.
- ● Individual plants, even side-by-side, may have different nutritional status. Therefore, by sampling a sufficiently large number of plants, the effect of this error due to inherent variability should be minimized.
- ● It is preferable to include a soil sample together with a tissue sample when submitting samples to a diagnostic lab, since the soil sample may indicate other factors - such as pH - that may influence crop growth, nutrient availability, and uptake.
- ● Use reputable labs or other sources for interpretation of lab results. Interpretation guidelines should be based on actual field research, not on “typically observed” or historical lab databases.

Key References:

(1) Plant Tissue Test Information Sheet, http://edis.ifas.ufl.edu/SS182

(2) Plant Analysis Handbook II (Athens, Georgia)

(3) Plant Petiole Sap-Testing for Vegetable Crops, Circular 1144, http://edis.ifas.ufl.edu/CV004

(4) Plant Tissue Analysis and Interpretation for Vegetable Crops in Florida, SS-VEC-42

(5) Reference Sufficiency Ranges for Plant Analysis in the Southern Region of the United States, Southern Cooperative Series Bulletin #394, http://www.agr.state.nc.us/agronomi/saaesd/scsb394.htm

36 WATER SUPPLY

Proper water management planning must consider all uses of water, ranging from the source of irrigation water to a plant's water use requirements. It is important to differentiate between crop water requirements and irrigation water requirements. Crop water requirements refer to the actual water needs for *evapotranspiration* (ET) and plant growth, and primarily depend on crop development and on other factors that are closely related to climatic demands. Irrigation requirements are primarily determined by crop water requirements, but also depend on the characteristics (efficiency) of the irrigation system. It is extremely important that the irrigation system be designed properly so that the crop will get the proper amount of water at the right time. This will help maximize both crop yield and profit, while preventing wasteful water applications.

Working Definition:

Water supply is the practice by which water is taken from a reliable source and delivered to a crop via a distribution system.

Key BMP Subcategories:

36A WATER SOURCE – *Things to Do: BMP(s)*

√ Know the quantity and quality of the water source before designing and installing an irrigation system. This is particularly important if you intend to use a drip or sprinkler system. Water-quality analyses are performed at a number of private labs, as well as at the University of Florida's (IFAS) Extension Soil and Water Testing Laboratory in Gainesville.

√ Reduce seepage losses on reservoir-supplied sources by lining dikes with impermeable soils (typically clays) or man-made synthetic liners; or, by properly compacting the reservoir dikes and building a core trench underneath.

√ Minimize evaporative losses by covering the water surface; however, this is only practical for tanks or small reservoirs. Evaporative losses from field-scale reservoirs can be reduced by designing and constructing reservoirs with smaller surface areas and greater depths.

√ Consider using pipelines instead of open channels to convey irrigation water. This will avoid both seepage and evaporative losses during conveyance.

√ Reduce irrigation water losses from open-channel conveyance systems by lining the channels and controlling unchecked vegetative growth in the channel.

36B BACKFLOW PREVENTION – *Things to Do: BMP(*s)

√ Ensure that the water source does not become contaminated. Florida law, county and municipal codes generally require backflow prevention assemblies on all irrigation systems injecting chemicals into irrigation water. Appropriate backflow prevention should include the following setup:

1. A check valve upstream from the injection device to prevent backward flow.
2. A low-pressure drain to prevent seepage past the check valve.
3. A vacuum relief valve to ensure that a siphon cannot develop.
4. A check valve on the injection line.

Key References:

(1) Chemical Injection Methods for Irrigation, http://edis.ifas.ufl.edu/WI004
(2) Causes and Prevention of Emitter Plugging In Microirrigation Systems,http://edis.ifas.ufl.edu/AE032
(3) Design Tips For Drip Irrigation of Vegetables, http://edis.ifas.ufl.edu/AE093
(4) Design of Agricultural Irrigation Systems in Florida, http://edis.ifas.ufl.edu/AE064
(5) Efficiencies of Florida Agricultural Irrigation Systems, http://edis.ifas.ufl.edu/AE110
(6) IFAS Extension Bulletin 217
(7) IFAS Extension Bulletin 248, Backflow Requirements When Using Public Water Supplies
(8) Design of Agricultural Irrigation Systems in Florida, http://edis.ifas.ufl.edu/AE064
(9) Microirrigation on Mulched Bed Systems: Components, System Capacities, and Management, http://edis.ifas.ufl.edu/AE042

37 TAILWATER RECOVERY

Tailwater recovery systems are installed to conserve water and improve water quality by collecting and re-using irrigation water or rainfall that runs off the surface of farm fields. Because of their additional ability to intercept subsurface lateral flow above a spodic horizon, where present, they are becoming increasingly popular among farmers in high seasonal groundwater table environments. Also, tailwater-recovery systems help protect and preserve fresh water resources, and mitigate critical water quality and water supply issues.

Working definition:

Tailwater recovery is the practice of collecting, storing, and re-using water for irrigation.

Key BMP Subcategories:

37A TAILWATER RECOVERY - *Things to Do: BMP(s)*

√ A tailwater recovery system typically consists of collection and storage components (ditches, ponds) and also delivery components (pump stations, pipes).

√ Consider the runoff volume and rate, as well as the water control level in the tailwater pond, when determining the proper size of the storage facility.

√ Also consider the size of the tailwater recovery system, including variables such as land available, gravity drainage, number of fields and their acreage, and the source and quality of the irrigation water.

√ Consider tailwater recovery systems for seepage and flood irrigation systems, rather than for low-volume irrigation systems.

√ Locate the tailwater recovery system at the low end of a field(s), so that water collection can be done by gravity.

√ Consider ”rainwater harvesting” based upon your farm’s geographical location. Certain areas of the state may yield significant quantities from stormwater runoff and/or surficial aquifer contribution.

37B WATER QUALITY CONSIDERATIONS – *Things to Do: BMP(s)*

- √ Tailwater recovery systems may require additional filtering infrastructure, depending on the quality of the water being captured, the type of irrigation system being used, and the type of crop being grown.
- √ Offsite seepage from the tailwater recovery system should be controlled and managed properly, especially if the system is expected to receive chemical-laden waters. Control may be in the form of dike compaction, natural-soil liners, soil additives, commercial liners, drain tile, or other approved methods.
- √ If disease incidence is an issue, refer to the “Tailwater Reuse and Waterborne Plant Pathogens” BMP within this chapter.

Applicable Technical Criteria:

- ♦ Equip tailwater recovery ponds with inlets designed to protect the collection and storage facilities from erosion. Additional sediment sumps should be installed as needed.
- ♦ The capacity of tailwater recovery systems shall be determined by analysis of the expected runoff rate, the planned storage pond capacity, and the irrigation application rate(s) if the recovery pond is to supply irrigation water.
- ♦ Tailwater recovery systems should be designed for structural integrity, using the appropriate, 24-hour storm frequency design, if the system will be directly accepting rainfall.

Operation and Maintenance:

- ■ Clean and re-grade all collection components periodically to maintain structural integrity and functionality.
- ■ Check and remove debris as necessary from trash racks and structures to assure proper operation.
- ■ Inspect or test all pipeline and pumping station components and *appurtenances*, as applicable, to ensure their long-term operation.
- ■ Maintain proper vegetative cover and regrade dikes and berms as necessary to maintain structural integrity and insure proper functioning of the system.

Other Considerations:

- ● Irrigation scheduling and related management practices should be reviewed once tailwater recovery systems are implemented.
- ● The stored tailwater should be analyzed for nutrient content and then correct the crop’s fertigation program accordingly.
- ● Nutrient and pest management measures should be planned to limit chemical-laden tailwater as much as practical. Chemical-laden water can create a potential hazard to wildlife, and especially to any waterfowl that are drawn to the ponded water.
- ● Protection of system components from large storm events and excessive sedimentation should be considered.
- ● Downstream flows and/or wetland hydrology may be reduced in some instances, so analyze these variables, if applicable.

Key References:

(1) USDA-NRCS FOTG Practices Irrigation System (Tailwater Recovery) - Code 447, Irrigation Storage Reservoir - Code 436, and Irrigation Regulating Reservoir - Code 552, http://www.nrcs.usda.gov/technical/efotg
(2) ASAE Practice Standard No. EP408.2

38 TAILWATER REUSE AND WATERBORNE PLANT PATHOGENS

As competing demands for water resources grow and permitted water quantities decrease, tailwater recovery systems provide growers with an alternative and viable water source. Unfortunately, the water collected from fields may also contain disease-causing fungal spores and bacteria. These diseases can infect plants and can cause severe economic losses to tomatoes, peppers, eggplants, cucumbers, squash, melons, citrus and numerous other vegetable and fruit crops.

Working Definition:

Waterborne pathogens are microscopic organisms capable of causing plant diseases that can freely spread to non-infected plants through the medium of water.

Key BMP Subcategories:

38A PLANNING AND DESIGN ISSUES - ***Things to Do: BMP(s)***

√ Consider deeper tailwater recovery ponds, as they promote the dilution, settling, and deterioration of disease-causing spores.

√ Consider deep plowing prior to seedbed formation if *double cropping* with a susceptible host crop.

38B IRRIGATION PRACTICES - ***Things to Do: BMP(s)***

√ Replace overhead irrigation with drip systems where possible (plant surfaces must be wet at least 2 hours before *Phytophthora* can infect a susceptible plant).

√ When using tailwater in drip irrigation systems, place drip tape a reasonable distance from plant stems and keep irrigation cycles as short as possible without causing moisture stress.

38C WATER PROCESSING/DISINFECTION- ***Things to Do: BMP(s)***

√ Dilute tailwater earmarked for reuse with fresh water to lower disease concentrations.

√ Consider technology such as:

1. Slow Sand Filtration
2. Exposure to Ultraviolet Light

3. Chlorination/Bromination
4. Ozonation

√ Consider using chlorine disinfectant on tailwater when growing high value vegetable crops in order to minimize risk.

38D STRATEGIES TO REDUCE RISK - *Things to Do: BMP(s)*

√ For vegetable crops highly susceptible to *Phytophthora* (blight), *Pythium* (damping-off & root rot), and/or *Xanthomonas* (bacterial leaf spot) spp., consider disinfecting tailwater when using closed-pipe systems.

√ Use *resistant plant varieties* listed in the Key References citation at the end of this section.

√ Use only high quality, disease-free transplants and fungicide treated seeds, when appropriate.

√ Follow IFAS fertilizer recommendations and avoid excessive amounts of nitrogen, which may contribute to rapid vegetative growth, thus weakening the plants.

√ Mature healthy plants are less susceptible to waterborne pathogens, so try to avoid tailwater use on seedlings and young plants.

√ Alternate non-host crops to reduce residual pathogen populations in the soil.

√ Practice rigorous field sanitation; remove volunteers, diseased fruits, and plants.

√ Refer to the IPM section of the Pest Management Chapter of this manual for other strategies.

Things to Avoid: Potential Pitfalls

X Avoid saturated soil conditions and excessive surface moisture.

X When possible and practical, avoid planting dates that encourage diseases.

X Avoid handling wet plants in the field. Disease spores can also be transported to the infection sites by dew, splash, or other water droplets.

<u>Applicable Technical Criteria:</u>

♦ In ponds holding 16 million gallons (approximately 2 million cubic feet) of water or greater, pumping from the middle depths of the pond reduces the risk of transporting disease spores (which settle to the bottom of the pond) and motile spores (which tend to swim near the surface of the water).

<u>Operation and Maintenance Issues:</u>

■ Use soil testing to avoid over-fertilizing.

■ Laser-level fields to eliminate low-lying and standing water areas.

Other Considerations:

● Raised beds promote good drainage and lower disease risk.

● Plastic mulch reduces disease incidence by preventing foliar and fruit contact with the soil, and eliminates splash from the soil surface to plants.

Key References:
(1) Circular 1222- Nitrogen Management Practices for Vegetable Production in Florida, http://edis.ifas.ufl.edu/CV237
(2) Treating Irrigation Water to Remove Plant Pathogens, http://zoospore.okstate.edu/nursery/managing/treat/index.html
(3) Dr. Sharon L. von Broembsen, Department of Entomology and Plant Pathology, Oklahoma State University
(4) New Approaches to Control Plant Pathogens in Irrigation Water, http://ohioline.osu.edu/sc173/sc173_13.html
(5) Harry A.J. Hoitink and Matthew S. Krause, Ohio State University
(6) Vegetable Varieties with Resistance to Various Diseases, http://www.imok.ufl.edu/plant/pubs/docs/v_resist.htm

39 IRRIGATION SYSTEM MAINTENANCE AND EVALUATION

The uniformity of water application and efficiency of an irrigation system tends to decrease over time because of aging, weathering, and component breakdown unless proper system maintenance is performed. The goal of irrigation system maintenance is to maintain and maximize system performance. Maintenance programs vary according to the type of irrigation system. For example, maintenance of flood or seepage systems may be limited to a pre-season operational check of pump stations and ditches. Maintenance programs for pressurized pipe systems generally involve filtration, chlorination/acidification, flushing, repair or replacement of clogged emitters, and observation. Irrigation systems that are managed efficiently help ensure crop uniformity, conserve water, and reduce operation and maintenance costs.

Working Definition:

Irrigation maintenance and evaluation is a management plan designed to maintain irrigation system components in good working condition, so that the entire system can perform according to design specifications.

Key BMP Subcategories:

39A GENERAL IRRIGATION MAINTENANCE – *Things to Do: BMP(s)*

- √ Determine and record the design operating values. Know your level of irrigation system efficiency, defined as the ratio of the volume of water delivered by the irrigation system and available to the crop, compared to the volume of water that this system extracts from a source (e.g., well, pond, etc.).
- √ Periodically check system uniformity, defined as the degree to which an irrigation system can apply equal amounts of water throughout different locations in a field. Improper maintenance can decrease system uniformity.
- √ Establish a documented maintenance schedule that should include inspection of the mechanical components and irrigation lines, as well as monitoring of the pump and power unit. This can be done by keeping written records of performance and maintenance actions.
- √ Record the flow rate, pressure delivered by the pump, and energy consumption of the power unit frequently enough to gain an understanding.

√ Use flow meters or pressure gauges to determine existing operating parameters and to properly manage the irrigation system.
√ Test water quality at least once each year, since changes in water quality parameters can affect maintenance requirements and frequency.
√ Clean and maintain filtration equipment, so that it operates at optimum pressure ranges.
√ Regularly check control valves, pressure regulators, leaks on seals, gaskets, and fittings and pressure relief valves for proper operation.

39B SUB-SURFACE (SEEPAGE) IRRIGATION MAINTENANCE- *Things to Do: BMP(s)*
√ Maintain the pump and well in good condition.
√ Clean ditches and canals as needed; remove debris and control weeds.
√ Maintain water-level control structures, and contact an Agricultural Engineer concerning any tailwater issues.

39C OVERHEAD IRRIGATION SYSTEMS (SOLID SETS, TRAVELLING GUNS, LINEAR MOVES, CENTER PIVOTS) MAINTENANCE –*Things to Do*: BMP(s)
√ Follow manufacturer's maintenance recommendation for all motors, engines, pumps and other moving parts.
√ Sprinkler nozzles should be inspected for wear and malfunction and replaced as necessary.
√ Contact an Agricultural Engineer or a Mobile Irrigation Lab technician to consider an evaluation of the irrigation system and/or possible tailwater recovery.

39D DRIP IRRIGATION SYSTEMS MAINTENANCE- *Things to Do: BMP(s)*
√ Use filters compatible with drip irrigation (200 mesh or equivalent) and water source.
√ Consider using chemical treatment to prevent emitter plugging due to microbial growth and/or mineral precipitation. Chlorination is the most common method for treating bacterial slimes. Since bacteria can grow within filters and chlorination may create iron-hydroxide precipitates, chlorine injection should be done prior to filtration. Be very careful about the concentration of chlorine as it can damage the crops if the concentration is high enough.
√ Acid can be used to lower pH of irrigation water to reduce the potential for chemical precipitation and to enhance effectiveness of the chlorine injection. Acid can be injected in much the same way as fertilizer; however, extreme caution is required.
√ Scale inhibitors, such as *chelating* and *sequestering agents*, are available for use in microirrigation systems to prevent plugging.
√ Flush the drip irrigation lines regularly to minimize sediment build up. A regular maintenance program of inspection and flushing will help significantly in preventing emitter plugging.
√ Flush all fertilizer (when fertigating) prior to shutting the irrigation system down. Flushing can be accomplished manually by opening the end of each lateral, or by using automatic flushing end-caps on the laterals.

39E MOBILE IRRIGATION LAB (MIL)- *Things to Do: BMP(s)*
√ MIL services are available free of charge and provide an irrigation system evaluation with recommendations regarding system upgrades, irrigation scheduling, and other maintenance items. Contact your local NRCS District Conservationist for the MIL closest to your location.

Key References:

(1) Causes and Prevention of Emitter Plugging in Microirrigation systems, http://edis.ifas.ufl.edu/AE032
(2) Efficiencies of Florida Agricultural Irrigation Systems, http://edis.ifas.ufl.edu/AE110
(3) IFAS Extension Bulletin 217, http://edis.ifas.ufl.edu
(4) IFAS Extension Bulletin 248, Backflow Requirements When Using Public Water Supplies, http://edis.ifas.ufl.edu/
(5) Agricultural Engineering Fact Sheet AE-73, Potential Impacts of Improper Irrigation System Design, http://edis.ifas.ufl.edu/
(6) Design of Agricultural Irrigation Systems in Florida, http://edis.ifas.ufl.edu/AE064
(7) Microirrigation on Mulched Bed Systems: Components, System Capacities, and Management, http://edis.ifas.ufl.edu/AE042
(8) NRCS Conservation Standard, Irrigation System (Sprinkler), Code 442 and Well Decommissioning, Code 351, http://www.nrcs.usda.gov/
(9) ASAE Standard Practice No.: S395, S436.1, S447, and EP458.
(10) IFAS Extension Bulletin 265, Field Evaluation of Microirrigation Water Application Uniformity, http://edis.ifas.ufl.edu/AE094
(11) IFAS Extension Bulletin 247, Efficiencies of Florida Agricultural Systems, http://edis.ifas.ufl.edu/AE110
(12) The Irrigation Association, http://www.irrigation.org
(13) Florida Irrigation Society (FIS), http://www.fisstate.org/features.htm
(14) USDA NRCS Irrigation Web Page, http://www.wcc.nrcs.usda.gov/nrcsirrig/

40 IRRIGATION SCHEDULING

Irrigation scheduling consists of a collection of technical procedures developed to forecast the timing and amount of irrigation events. Often, irrigation scheduling decision-making is not based solely on technical procedures, but also on local experience and other limitations introduced by water delivery techniques and irrigation system infrastructure. Technical approaches to irrigation scheduling are complex because they require an understanding of many factors, including: crop water needs, soils, climate, irrigation method(s), management objectives, and regulatory constraints. All irrigation scheduling methods are ultimately based on one of two approaches: (1) Monitoring soil and/or plant water status, or (2) Determining a soil water budget that forecasts irrigation scheduling events based on estimated water depletion in the root zone.

Bear in mind that random irrigation using only the "feel and appearance" method (applying a pre-determined amount of water when the soil feels dry or when the crop begins to wilt) is likely to result in reduced yields because of crop water deficits and/or nutrient leaching resulting from excessive irrigation. Also, Florida's sandy and course-textured soils have low water holding capacities and generally cannot store more than a few days worth of a crop's water needs.

Working Definition:

Irrigation scheduling is a planning and decision-making tool that the farm manager uses to best determine a crop's irrigation water needs.

Key BMP Subcategories:

40A MONITORING SOIL AND PLANT WATER STATUS – *Things To Do: BMP(s)*

√ Consider the available soil moisture content as part of the crop's water needs.

√ Use tensiometers, capacitance sensors or electrical-resistance gypsum blocks, or other proven devices to monitor soil moisture.

√ If *soil water tension* (SWT) devices are used to determine soil moisture content, try to maintain SWT within the recommended range for the crop. For vegetable crops, this range is generally between 8 centibars (field capacity for typical Florida coarse sands) and 10-15 centibars. Also, evaluate the irrigation system's ability to deliver water in a timely fashion when managing SWT's upper range.

√ If tensiometer SWT or other soil moisture indicator devices are used, test and calibrate prior to installation, and place in representative areas of the field.

√ Allow SWT to fluctuate within the recommended range. If SWT consistently remains near field capacity, over irrigation and nutrient leaching will likely occur.

√ Install tensiometers in stations of two when soil depth allows. Place one sensor 6 inches below the top of the bed and the other sensor 12 inches below the bed surface. Place devices between plants in a row. This provides an opportunity to observe soil-water movement in the root zone. For shallow soils, follow the local recommendations of the Extension office.

√ Keep irrigation events smaller than the amount of water than can be stored in the root zone. When irrigation needs are greater (during long, warm days when the crop is near harvest), irrigation application should be split into 2 or 3 daily applications.

40B FORECASTING CROP WATER NEEDS – *THINGS TO DO: BMP(s)*

√ Manage irrigation and fertilization together, especially if liquid fertilizer is being applied through the irrigation system. Poor irrigation management negatively affects a well designed fertilization program.

√ Try to determine daily crop evapotranspiration (ETc) using proven methodologies, such as actual reference evapotranspiration (ETo), historical ETo, class A pan evaporation, or empirical computer models when no other estimates are available. For information on which is the best methodology to apply on your farm, consult IFAS Bulletin AE260 "Principles and Practices of Irrigation Management for Vegetables", http://edis.ifas.ufl.edu/CV107.

√ Consider both irrigation system efficiency and uniformity when estimating water needs using the ETc methodology. Contact an Agricultural Engineer or a Mobile Irrigation Lab technician to determine those values for your irrigation system.

√ Use totalizing water meters or equivalent measuring devices to determine how much water is actually applied to an irrigated area of predetermined size.

√ Keep records of irrigation amounts applied and total rainfall received.

40C IRRIGATION SCHEDULING AND OTHER APPLICATIONS – *THINGS TO DO: BMP(s)*

√ Consider computer-model assisted irrigation scheduling as it has been used successfully in commercial farming for over 20 years. These models can increase irrigation effectiveness, improve irrigation efficiency, and result in less total water use.

√ Minimize application losses due to evaporation and wind drift by irrigating early in the morning or late in the afternoon, or when cloud cover is significant and wind speed is minimal.

√ Consider the rainfall contribution to crop water needs, especially when crops are grown on bare ground. When impervious plastic mulch is used, surface storage and infiltration is reduced and rainfall contributes less to crop water needs. When sub-surface irrigation is used, maintain the water table at the lowest practical level where soil moisture will still be available in the root zone.

√ When irrigation events have been missed due to unforeseen circumstances, do not try to "catch up" by applying a large irrigation amount. Instead, gradually restore soil moisture and continue to monitor soil moisture content.

Things to Avoid – Potential Pitfalls:

X Avoid irrigations that fully replenish soil moisture when the probability of rainfall is high. Instead, practice *deficit irrigation*, in such situations.

- X Avoid irrigation events that exceed the soil water holding capacity of the wetted area. When irrigation amounts larger than the water holding capacity of the wetted area are needed, then irrigation water should be applied in two or three events (split applications).

Operation and Maintenance:

- ■ Irrigation systems should be checked periodically for efficiency and water application uniformity. A uniformity of 80% or greater is recommended before fertilizer injection through a microirrigation system.
- ■ The irrigation system should be well maintained and operated at the highest irrigation efficiency and uniformity that is practicable.

Other Considerations:

- Monitor water quality regularly or retrieve data from other agencies that monitor water quality. Water used in microirrigation systems should be tested for hardness (calcium carbonate), hydrogen sulfide, iron and manganese, pH, and TDS, to prevent clogging. In addition, surface water used in microirrigation systems should be tested for organic material.
- Soil moisture may also be monitored with time-domain reflectometry, electrical conductivity probes, remote sensing of canopy reflectance, and other technologies. However, recommendations based on these techniques are not generally available at this time.
- If research information is available, use the *water-release curve* of each soil type when measuring volumetric soil water content in order to determine the corresponding SWTi .
- If your soils are conducive, consider performing a dye test to determine the actual wetting zone and water holding capacity of the soil where the root zone is.

Key References:

(1) ASAE Standard EP458, December 1994

(2) Irrigation Scheduling for Water & Energy Conservation in the 80's, ASAE Publ.23-81, Am. Soc. Agric. Engr., St. Joseph, MI.

(3) Fertilizer Application and Management for Micro (Drip)-Irrigated Vegetables in Florida, http://edis.ifas.ufl.edu/FR031

(4) Principles and Practices of Irrigation Management for Vegetables, http://edis.ifas.ufl.edu/CV107

(5) Water Use and Irrigation Management of Agronomic Crops, http://edis.ifas.ufl.edu/AA131

(6) Basic Irrigation Scheduling in Florida, http://edis.ifas.ufl.edu/AE111

(7) Irrigation Scheduling with Evaporation Pans, http://edis.ifas.ufl.edu/AE118

(8) Efficiencies of Florida Agricultural Irrigation Systems, http://edis.ifas.ufl.edu/AE110

(9) Field Evaluation of Microirrigation Water Application Uniformity, http://edis.ifas.ufl.edu/AE094

(10) Tensiometers for Soil Moisture Measurement and Irrigation Scheduling, http://edis.ifas.ufl.edu/AE146

(11) Tensiometer Service, Testing and Calibration, http://edis.ifas.ufl.edu/AE086

(12) For additional information on irrigation design and other irrigation-related topics, go to http://edis.ifas.ufl.edu

(13) FAO 56 - Crop Evapotranspiration, Food and Agricultural Organization, www.wcc.nrcs.usda.gov/nrcsirrig/Handbooks_Manuals/handbooks_manuals.html or www.fao.org/icatalog/inter-e.htm

(14) USDA - NRCS Practice, Irrigation Water Management, Code 449, http://www.nrcs.usda.gov/

(15) ASCE, Evaporation and Irrigation Water Requirements, www.pubs.asce.org/.

41 FROST AND FREEZE PROTECTION

Protecting crops from occasional frost and deadly freezes is a challenge for winter vegetable growers in central and south Florida. Options available include sprinkler irrigation, soil banking, and establishment of row covers or cover crops. Each method has application in certain areas for specific crops. The proper application of frost and freeze quantities will reduce inadvertent water quantity impacts.

Working Definition:

Frost and freeze protection consists of various methods to protect plants from cold temperatures and the associated damage to plant tissues.

Key BMP Subcategories:

41A FROST AND FREEZE PROTECTION - *Things to Do: BMP(s)*

√ Water freezes at 32° F, but most fleshy plant tissues freeze at lower temperatures (approximately 28° F). Therefore, it is important to know the specific threshold temperature and its minimum duration at which your crop will freeze. In general, start the irrigation system if the weather prediction is showing continuous drop in temperature or as soon as the air temperature drops to 30^{0}F.

√ Monitor air temperatures and wind speed on each farm and on a regional basis using television, radio reports and/or an internet site (e.g., using the Florida Agriculture Weather Network (FAWN) accessed at http://fawn.ifas.ufl.edu.

√ Use soil banking (covering the crop with soil) for crops such as potatoes, which have large energy reserves in the seed piece which enable it to grow out from the soil covering.

√ Early melons, sweet corn, or beans may be planted in a small trench in which the seedlings are protected somewhat from frost by the surrounding soil mass. Exercise caution when doing this on poorly drained soils.

√ Row covers (crop covers) can be used for frost and freeze protection. Depending on the thickness of the cover, protection down to 25° F may be possible.

√ Sprinkler irrigation systems can be used to take advantage of the *latent heat* of fusion that is released when irrigation water is changed from liquid to ice. Water must be continuously provided to protect the plant, as long as the air temperature is below 32º F (ice must be kept wet continuously at 32º F). Enough water must be used to compensate for all heat losses. Remember that sprinkler irrigation is less effective under windy conditions.

√ Monitor crop nutritional status after repeated frost protection since mobile nutrients may have been leached or their oxidation state may have changed.

41B IRRIGATION SYSTEM DESIGN FOR FROST PROTECTION - *Things to Do: BMP(s)*

√ Design the irrigation system for high uniformity of water application. Remember that wind adversely affects the uniformity of water applied through an overhead sprinkler system.

√ It is recommended that the sprinkler pattern overlap each adjacent sprinkler pattern down and between the laterals for frost protection. The spacing of the sprinklers must be closer in areas where high winds are frequent.

√ Temperature, humidity, and wind speed all affect the rate of water application necessary for cold protection. Water applied at too low a rate can cause more damage than no protection during a freeze. Use sprinkler head nozzle sizes that minimize application rates, but maximize coverage area. In general, higher application rates are required for *advective freezes*. See Tables 6 and 7 in Appendix for specific application rates.

Things to Avoid: Potential Pitfalls

X Do not allow critical irrigation system components to freeze.

X Avoid over-application and potential offsite runoff, by not initiating irrigation events too soon, or continuing protection after temperatures rise above 32 ºF and until all the ice has melted.

Other Considerations:

♦ Formation of a "milky-white" ice without icicles, and incomplete coverage of the plant suggests too low a rate of water application. Clear ice and icicles are usually an indication of successful cold protection.

♦ Row covers currently cost $750 to $1000 per acre, and most materials can be used for at least two or more seasons.

Key References:

(1) Row Covers for Commercial Vegetable Culture in Florida, http://edis.ifas.ufl.edu/CV201

(2) Row Covers for Growth Enhancement, http://edis.ifas.ufl.edu/CV106

(3) Cold Protection by Irrigation: Dew Point and Humidity Technology, http://edis.ifas.ufl.edu/CH054

(4) Sprinkler Irrigation for Cold Protection, University of Florida, Cooperative Extension Service Institute of Food and Agricultural Sciences, Circular 348

(5) Use of Water in Florida Crop Production Systems, http://edis.ifas.ufl.edu/AE036

(6) Principles and Practices of Irrigation Management for Vegetables, http://edis.ifas.ufl.edu/CV107

42 WATER CONTROL STRUCTURE

A structure for water control may serve many functions but is typically installed to control stage, discharge, distribution, and/or direction of water in open channels. This practice may be applied as part of a conservation management system to improve water quality and thereby protecting other natural resources. This practice applies wherever a permanent structure is needed to control irrigation and/or drainage.

Working Definition:

A water control structure is a structure designed to convey water, control the direction or rate of flow, and/or maintain a desired water surface elevation and includes applications such as a culvert and riser combination.

Key BMP Subcategories:

42A PLANNING - *Things to Do: BMP(s)*

√ Plans should specify the locations, grades, dimensions, materials, and hydraulic and structural requirements for the proposed structures.

√ Culverts and risers should meet strength and durability requirements of the site.

√ Consider the flotation of culverts and risers to prevent buoyancy problems.

42B CONSTRUCTION AND DRAINAGE - *Things to Do: BMP(s)*

√ Remove all brush, trees, stumps, fence rows, and other objectionable items so that they will not interfere with construction or proper functioning of the structure.

√ Place backfill material over culvers and risers in horizontal layers and compact with manually directed compaction equipment, as necessary.

√ Conduct construction operations so that erosion and sedimentation are minimized. This may involve the use of silt fences, hay bale barriers, temporary vegetation, mulching, etc.

√ Prevent seepage along the culvert through proper compaction, anti-seep collars, or other devices.

√ Ensure that culverts and risers have a leveled or inclined grade in the direction of flow and are installed on stable foundations.

Things to Avoid: Potential Pitfalls

- **X** Avoid creating flood conditions by using appropriately sized structures.
- **X** Avoid using these structures to raise the water table prior to significant storm events, as this may increase the stormwater runoff potential.

Applicable Technical Criteria:

- ♦ Water control structures installed in an open channel should be designed to accept and discharge no more than the channel capacity.
- ♦ Structures should be constructed of durable materials with a life expectancy equal to the planned life of the project.

Operation and Maintenance Issues:

- ■ An operation and maintenance plan should be prepared for each structure site.
- ■ The structure should be inspected periodically to ensure that it functions as planned.
- ■ Repair or replace structure materials that have deteriorated, as needed.

Other Considerations:

- ● Where conditions make it difficult to establish vegetative cover, consider using non-vegetative materials such as gravel, geoweb, gabions, or other types of protection.
- ● Structures may trap sediment and other pollutants carried by runoff. Employment of the Sediment Basin BMP should also be considered in conjunction with this BMP.
- ● Where structures are used for irrigation or drainage systems, use the structure to optimize crop rooting depth via water table control.
- ● Structures for water control can also increase the application efficiency of subirrigation (seepage) systems.

Key References:

(1) USDA-NRCS Practice Standard, Structure for Water Control, Code 587, http://www.nrcs.usda.gov/technical/efotg

WATER RESOURCES MANAGEMENT

Florida’s water resources are majestic jewels comprised of 320 known springs, vast wetland areas, 13 major rivers, 7,800 lakes, estuaries, lagoons, coastal marshes, and three primary underground aquifers. Most of these ecosystems are interconnected and depend upon a seasonal inflow of fresh water. Water is equally important to the farming community as it is the “lifeblood” or all living processes. Chemically speaking, the water molecule is crucial in driving photosynthesis, whereby carbon dioxide and water are brought together within plants and algae to form complex sugar molecules and oxygen gas. Without continued adequate supplies of freshwater, Florida agriculture and eco-tourism will both suffer economic loss, much to the detriment of the state.

Florida has annual rainfall amounts that average approximately 53 inches per year statewide. Unfortunately, these rainfall events do not always occur when needed, as evidenced by the summer wet season in tropical South Florida. During this rainy period, many vegetable crops are “idled” creating virtually no on-farm demand for water. Such situations have resulted in the need for agriculture to better manage its water resource via irrigation and stormwater management systems. The need for increased management of the state’s water resources continues to grow, not only because of rainfall variability patterns but also because of increasing demand by other user groups.

Since its inception, Florida’s agricultural industry has used varied forms of irrigation and stormwater management systems. Such systems have evolved into more comprehensive and effective systems, especially as the need for more efficient systems increases. The water resources BMPs outlined in this chapter are intended to update the industry on the most common irrigation and stormwater management techniques available at this time. The development of BMPs is an on-going process. Therefore, it is expected that agricultural water resources techniques will continue to evolve and change; history has shown that such trends exist.

43 FLOOD PROTECTION

The state of Florida averages approximately 53 inches of rain per year. This value tends to decrease as you move towards the central and southeastern parts of the state, and to increase as you move towards the northwestern part of the state. In addition to its variability by location, rainfall events are not spread evenly throughout the year. Rainfall tends to concentrate during the summer months, especially in the central and southern areas of the state. In addition to this geographic and seasonal variability, there is also variability in the type of crops that are grown throughout the state. Because of these compounding factors, it is important that farmers implement a flood protection plan that best suits their own unique situation.

Working Definition:

Flood protection involves several proactive steps that a farmer needs to take in advance of farm field construction to identify if a site has appropriate “natural” flood protection and, if not, what criteria and tools should used to meet the flood protection needs of the farm.

Key BMP Subcategories:

43A STORM EVENT PLANNING – *Things to Do: BMP(s)*

√ Determine the maximum storm size for which you want to provide protection for your crop. An example might be a storm that would produce 8 inches of rainfall in a single day.

√ Consider all factors before making this decision: economics (the higher the storm protection, the higher the cost to provide that protection), land availability, and internal natural features such as creeks, rivers, ponds, or wetlands.

√ Equate the level of storm/flood protection you choose as you would in choosing an insurance policy.

43B FARM/FIELD LOCATION AND CROP TYPE – *Things to Do: BMP(s)*

√ Locate and map the specific area where you want to grow your crop. The proposed location may have attractive features such as wells or appropriate soil types, but also may be deficient with respect to flood protection.

√ Contact your local county or water management district to obtain maps (FEMA, FIRM) or other information germane to flooding issues at the location you are considering.

√ Contact your local county or water management district to obtain maps that show the elevation of the location you are considering, and how that elevation compares to low-lying areas within the vicinity of the site such as ponds, creeks, rivers, or wetlands.

√ Contact your local NRCS District Conservationist to obtain information about the soil types for the location you are considering. The District Conservationist can identify those soil types that are historically prone to flooding or standing water.

√ Determine the crop type and the time/season it is to be grown since crops have different flood protection requirements, depending on their level of tolerance to standing water or to excessive soil moisture content.

43C FARM/FIELD INTERNAL FEATURES – *Things to Do: BMP(s)*

√ Evaluate the natural and/or manmade features of the proposed location. If the location you are considering has the proper internal elevation and drainage characteristics, you may not need to provide any additional protection for your crops.

√ Use the following key features in order to make your determination: storage capacity, size, and elevations of existing ditches, ponds, creeks, rivers, and wetlands. The size, layout, and elevations of the proposed fields will also need to be considered during this analysis.

43D DESIGN AND CONSTRUCTION – *Things to Do: BMP(s)*

√ Consult with a public or private agricultural engineer to discuss your flood protection needs and considerations, especially if you are farming on marginal lands. Such engineers should be qualified to provide an appropriate stormwater runoff analysis for your site.

√ For a listing of qualified engineers, contact local farmers, the USDA-NRCS, the Florida section of the American Society of Agricultural Engineers (ASAE), or the Florida Engineering Society (FES).

***Things to Avoid: Potential* Pitfalls**

X Do not farm a location without knowing its affinity to flood, especially when growing sensitive crops.

X Do not underestimate the influence that stormwater can have on the quality and productivity of your crop. Stormwater may not only harm crops, but also create short and long-term soil losses, erosion problems, and downstream pollution.

Other Considerations:

- Evaluate how your flood protection plan may affect the flow of stormwater on neighboring properties.

Key References:

(1) NRCS Conservation Standard, Drainage Water Management, Code 554 and, Runoff Management System, Code 570

(2) Water Management Districts ERP Manuals, Basis of Review, Appendices

(3) ASAE Standard No. EP302.4

(4) Florida Engineering Society Directory and Guide

44 PONDS/RESERVOIRS AND DITCHES

Wet detention ponds or reservoirs are the "heart" of a stormwater management system. They provide the means to temporarily store farm runoff generated from a storm, and then release it in a way that will not cause flood impacts to the farm and its neighboring properties. They also provide very good removal of particulate matter depending upon the degree of adsorption and pollutants. Depending on ground elevations, water table, farming practices, and soil types, runoff can be stored either below ground (in ponds) or above ground (in reservoirs). Ditches are not only used for irrigation purposes, but also direct runoff to ponds/reservoirs and allow for *treatment train* management of stormwater and irrigation water within the farm.

Working Definition:

Ponds/reservoirs are below or above ground earthworks which are used to provide water quality benefits and flood relief to internal farm fields by capturing stormwater runoff. Ditches are excavations of land below ground that allow stormwater runoff to be collected and routed to ponds/reservoirs.

Key BMP Subcategories:

DRAINAGE AND IRRIGATION STRUCTURES – *Things to Do: BMP(s)*

Ponds/reservoirs generally require drainage/irrigation structures to allow farm runoff to enter or to leave. Depending on ground elevations, water table, farming practices, and/or soil types, water will enter and leave ponds/reservoirs and ditches via gravity or pump structures. The following is a list of such structures and their associated BMP(s):

44A PUMP FACILITIES – *Things to Do: BMP(s)*

√ Provide the proper fuel tank spill containment infrastructure as needed.

√ Use low-cost automated pump "on" and "off" float switches, when possible. This will allow internal water management and protection to occur, even when farm hands are absent.

√ Operate and maintain pumps according to manufactures' recommendations.

- √ Provide the appropriate trash and debris retainers/filters where the pump(s) will operate. This will maximize pump lifetime and minimize pump failure due to obstructions.
- √ Use a flap gate or an upward pipe extension to avoid water coming back onto the farm fields, when the maximum water level in the pond is above the pump discharge pipe.
- √ Operate and inspect the pump occasionally during the dry season, to maximize pump lifetime and minimize repairs.

44B CULVERTS – *Things to Do: BMP(s)*

- √ Maintain culverts free of any debris by inspecting them regularly. This will allow maximum use of the drainage capacity of the culverts.
- √ Use a sediment sump in the ditch that provides water to the culvert if blockages or constrictions are mostly due to sediments.
- √ Choose a culvert type and material that best fits your own specific needs. For example, squashed culverts rather than circular culverts for low crossings; and polyethylene culverts rather than aluminum culverts for ease of handling. Refer to culvert or pipe manufacturers specifications for more information.
- √ Use the appropriate amount of soil placed over the culvert to ensure its long-term structural integrity.
- √ Install any new culvert in a ditch at least 6 inches above the ditch bottom to allow for ditch sedimentation.
- √ Allow for proper culvert extension past the ditch crossing or dike bank to minimize culvert blockages and constrictions.

44C FLASHBOARD RISERS/SCREWGATES – *Things to Do: BMP(s)*

- √ Use risers or screwgates on culverts, when you need to manage drainage or irrigation water on your farm, particularly if ditches or open water ponds/reservoirs are key to this management function. The steeper your farm field grade, the greater the number of risers or screwgates will be needed.
- √ Try to use screwgates when managing high water levels (above 4’ to 5’). These gates will be easier to open and close under those water level conditions.
- √ Use a board thickness in risers that will not lock the board in the riser when it swells. A maximum board length of 3’ is recommended for ease of use in the riser.
- √ Weight or tie down the end of the culvert that has a riser or screwgate in order to avoid floatation problems.

44D SEDIMENT SUMPS – *Things to Do: BMP(s)*

- √ Use sediment sumps in ditches when the ditch bottom is too steep and the velocity of the water creates erosion in the ditch.
- √ Construct a sediment sump at the entrance to a pond/reservoir if the pump or ditch carrying the water has sediments in it. In most instances, sediment sumps will be required if pumps are being used.
- √ Stabilize or line the sump banks and bottom with a filter fabric, rock and/or vegetation. This will maintain the integrity of the sump and minimize further movement of sediment out of the sump and downstream.
- √ Remove sediment buildup from the sump on a regular basis to maximize the useful life of the sump.

44E WEIRS AND ORIFICES – *Things to Do: BMP(s)*

√ Use weirs and/or orifices when water levels in ditches and ponds/reservoirs do not have to be managed on a daily or weekly basis.

√ Use weirs and/or orifices when discharge needs to be controlled based on water depth.

√ Use weirs and/or orifices when erosion and sedimentation in ditches and ponds/reservoirs are an issue. Weirs and orifices can be very effective in reducing erosion.

√ Consider building weirs and orifices out of concrete so that their lifespan and integrity are greatly increased. Also, consider using aluminum culverts and risers as well.

√ Consult an agricultural engineer for the appropriate size of weir and/or orifice necessary to meet your needs.

44F BERMS OR DIKES – *Things to Do: BMP(s)*

√ Build berms or dikes in ditches/ponds/reservoirs that are high enough and wide enough to contain the volume and level of water needed to irrigate or protect your crop. Consider the types of soils as some soils are not conducive to proper dike/berm structural integrity, leading to failure and potential flooding.

√ Use compaction techniques and flatten bank slopes when building dikes that will contain more than 2 feet of water over a period of several weeks or more.

√ Use the proper clearance, known as freeboard, between the maximum water level in the pond/reservoir and the top of the dike. Improper clearance can create dike erosion and eventual failure from the waves generated during high wind.

√ Use wave breaks such as rock piles or vegetation in the pond/reservoir so that dike erosion from wave action is avoided or minimized.

√ Remove any brush or trees from dikes, since their roots can create seepage areas across the dike and lead to potential dike failure.

√ Monitor and maintain grass cover on dikes and berms. Dikes that are properly vegetated and properly mowed can be accessed by vehicles or heavy equipment, and can therefore be maintained on a more frequent basis.

√ Consult an agricultural engineer concerning the size and type of berms/ditches necessary to meet your drainage/irrigation needs.

Things to Avoid: Potential Pitfalls

X Do not build ponds/reservoirs and ditches without having a good knowledge about how stormwater or irrigation water moves in the areas you are planning to farm.

X Do not build berms/dikes or ditches in or near naturally occurring regional flood-prone areas such as creeks or swamps, as they will likely fail or cause unwanted off-site hydrologic changes.

Key References:

(1) Design of Small Canal Structures, U.S. Bureau of Reclamation, http://ogee.do.usbr.gov/fmt/wmm/

(2) USDA - NRCS Practices: Stream Channel Stabilization - Code 584, 322, Dike - Code 356, Drainage Water Management - Code 554, Grade Stabilization Structure - Code 410, Open Channel - Code 582, Pond - Code 378, Rock Barrier - Code 555, Sediment Basin - Code 350, Structure for Water Control - Code 587, Surface Drainage (Field Ditch) - Code 607, Surface Drainage (Main or Lateral) - Code 608, Underground Outlet - Code 620, Vegetative Barrier - Code 601, and Vertical Drain - Code 630, http://www.nrcs.usda.gov/technical/efotg

45 FARM POND

Ponds can serve many functions on a farm. Farm ponds can provide water for livestock as well as wildlife, can be used as a source of irrigation water for crop lands, and can be used as a management tool to maintain or improve water quality on the farm. If properly designed, the pond can serve many purposes and can also aesthetically enhance the landscape of the farm.

Working Definition:

A farm pond is a water feature with a limited watershed, typically constructed by excavating a pit in order to intercept the existing groundwater table.

Key BMP Subcategories:

45A POND PLANNING - ***Things to Do: BMP(s)***

- √ Check with federal, state and local authorities for any applicable permit requirements before beginning pond construction.
- √ Perform a thorough site and soils check before construction to be sure that the location is suitable. Check with your local Soil and Water Conservation District if further assistance is needed.
- √ Plan the shape and form of ponds, excavated material, and associated plantings according to their surroundings and to their function.
- √ Install soil conservation measures in surrounding farm fields to prevent sedimentation impacts.
- √ Divert runoff from barnyards or feed lots away from the pond, or at a minimum install *Filter Strips* to help treat and convey the runoff.

45B POND CONSTRUCTION AND ESTABLISHMENT – ***Things to Do: BMP(s)***

- √ Seed or sod as necessary in order to prevent erosion of exposed soil surfaces, embankment areas, spillways, borrow areas, and other disturbed areas.
- √ Construct the pond during the dry season, if practicable.

Things to Avoid: Potential Pitfalls

- **X** Avoid constructing farm ponds in waterbodies, wetlands, or over *karst* topographical features.
- **X** Avoid spreading spoil material in wetlands and/or floodplains.
- **X** Avoid excessive excavation depths that may penetrate the *aquitard*.

Applicable Technical Criteria:

- ♦ Excavated pit ponds that are not used for water supply purposes should be constructed by excavating no greater than 14 feet deep, have a “footprint” equal to or less than 1 acre in size, and be set back a minimum of 25 feet from wetland areas.
- ♦ Stabilize side slopes with at least a 4 foot horizontal run to 1 foot vertical rise (4:1), as appropriate.
- ♦ If constructing a watershed pond, contact local Soil and Water Conservation District staff to determine any potential impacts to surrounding property, historical (water) flow rates, and/or on-site jurisdictional wetland areas.

Operation and Maintenance Issues:

- ■ Inspect the pond periodically, and especially after heavy rains, to determine whether it is functioning properly or if repairs are needed.
- ■ Maintain vegetative cover of the pond embankment by mowing or burning as needed. Remove uncontrolled nuisance or exotic species from the pond.
- ■ Consider fencing to protect the public, especially when constructed with steep side slopes adjacent to highly urbanized areas.

Other Considerations:

- ● Ponds have the potential for multiple uses. Storage requirements for each purpose should be considered to ensure an adequate water supply for all intended uses.

Key References:

(1) USDA-NRCS Conservation Standard, Pond, Code 378, http://www.nrcs.usda.gov/technical/efotg
(2) Farming for Clean Water in South Carolina: A Handbook of Conservation Practices
(3) Aquascaping: Planting and Maintenance. IFAS Circular 912

46 FIELDS AND BEDS

Fields and beds, an integral part of farming, also play a role in stormwater management. The alignment, length, and slope of a field/bed, and the type of bed, each have an effect on the amount of stormwater runoff retained or discharged from the field. Moreover, these variables can also have an effect on the amount of irrigation water that can be used by the crop in the field.

Working Definition:

Fields and beds are the key farm production areas where crops are grown. While ponds/reservoirs are the heart of a stormwater management system, fields and beds are the arteries.

46A ROW MANAGEMENT – *Things to Do: BMP(s)*

√ Consider using contour farming in northern Florida to address both drainage needs and sedimentation/erosion issues on significantly sloped fields.

√ Evaluate row length and field slope prior to farming a field. While drainage may improve as the slope/grade increases, it may also decrease in some areas as row length increases.

√ Evaluate the soil and crop type in your field, prior to farming. Row length and alignment can be affected by a variety of factors. Sandy soils generate less runoff than silty soils and can limit water conveyance along row beds.

46B LAND LEVELING – *Things to Do: BMP(s)*

√ Re-grade fields that historically have not drained well or that have existing sedimentation/erosion issues. These re-grading activities can significantly improve stormwater management.

√ Determine the natural slope/grade of your field(s) prior to land leveling. Leveling excessively steep or flat fields may not be cost-effective when trying to meet stormwater and/or erosion control requirements.

√ Consult the Land Leveling BMP in the Erosion Control and Sediment Management chapter of this BMP manual.

46C BEDDING AND MULCHING – *Things to Do: BMP(s)*

√ Consider your crop type and growing season when deciding whether to use bedding and plastic mulch. Minimize these in-field practices during the rainy season, so that stormwater management can be maximized.

√ If bedding and plastic mulching are necessary, minimize the time between completion of farming and removal of the mulch, particularly during the rainy season; also, maximize the use of other stormwater BMPs listed in this manual.

√ If plastic mulch is used during the rainy season, maintain the lowest water levels in ditches, ponds, and reservoirs to maximize the amount of storage available for the additional runoff generated from this impervious mulch material.

√ If double cropping practices are used with plastic mulch, try to use a fall-spring rotation rather than spring-fall rotation, to minimize runoff from your fields. This will depend on your farm's climate patterns.

√ If plastic mulch is used, consider using efficient underground or bed (e.g., drip) irrigation to reduce irrigation water runoff by applying this water under the mulch and directly to the root zone of the plant. Refer to the Nutrient and Irrigation Management Chapter and the Plasticulture Farming chapters of this BMP manual for more information.

Things to Avoid – Potential Pitfalls:

X Do not use plastic mulch during the rainy season for fields that drain onto neighboring properties, especially if they do not drain to any internal pond/reservoir, or natural depression. Runoff from those plastic mulched fields could cause flooding impacts to neighboring properties.

X Do not leave plastic mulch on the field once the final crop has been harvested, as it can exacerbate runoff problems.

Key References:

(1) USDA-NRCS Conservation Standards, Contour Farming - Code 330, Cover Crop - Code 340, Deep Tillage - Code 324, Filter Strip - Code 393, Grassed Waterway - Code 412, Land Smoothing - Code 466, Mulching - Code 484, Precision Land Forming - Code 462, Row Arrangement - Code 557, Stripcropping (Contour) - Code 585, Subsurface Drain - Code 606, and Terrace - Code 600, http://www.nrcs.usda.gov/technical/efotg

(2) ASAE Standard No. S268.4

47 PLASTICULTURE FARMING

Polyethylene or plastic mulch has been used commercially on vegetable production in Florida for over forty years, with the vast majority used in South and Southwest Florida on tomatoes, peppers, eggplants, strawberries, and cucurbits. The primary benefits of using plastic mulch include water conservation through moisture retention, weed growth inhibition, early yield opportunities, precision fertilizer application and reduced leaching, decreased soil compaction, reduced fruit rot and the benefit of having a soil fumigant chamber to aid chemical fumigation application. There are some potential negative aspects of using plastic mulch, as well, and these must be weighed in terms of risk versus benefit. Three potential negative aspects include flooding impacts to sensitive adjacent downstream properties, mulch removal and disposal, and having to purchase and use special equipment such as a bed press/fumigator and mulch layer to facilitate installing the mulch material.

Because of the differences between crop production with plastic mulch and conventional crop production, the requirements for water quality protection differ. Irrigation system selection is a critical component when performing this evaluation. Usually, drip irrigation tubing is placed underneath the plastic mulch to more precisely provide water and nutrients to the crop; however, in some cases, overhead sprinkler irrigation is also used (e.g., frost/freeze protection on strawberries). Because of the compounding effects of using plastic mulch with certain types of soils and irrigation systems, use of mulch can substantially increase the amount of runoff. Implementing the following BMPs should help to preclude potential impacts to the water resources when plasticulture farming.

Working Definition:

Plasticulture farming involves the cultivation of primarily vegetable crops on raised beds covered with impervious polyethylene mulch material.

Key BMP Subcategories:

47A PLANNING CONSIDERATIONS - *Things to Do: BMP(s)*

√ Use visual inspections, topographic maps, soil manual hydrologic group designations and basic survey equipment to identify areas where laying plastic mulch may be problematic.

47B WATER QUANTITY MANAGEMENT - *Things to Do: BMP(s)*

- √ Maximize the use of all existing internal depressional areas which can act as temporary catchment ponds to receive and store farm field runoff prior to discharging offsite.
- √ Utilize contour farming to reduce flooding at the edge(s) of the farm and in offsite downstream areas, when applicable.
- √ If contour farming is not practical, maximize the use of rows that are laid out across applicable steeper field slope(s).
- √ Incorporate assorted tillage practices such as deep plowing, sub soiling or ripping that minimize the development of *tillage* or *plow pans*. Be cautious about impacting the spodosol layer.
- √ Maximize the use of inter-row cover crops such as grasses or legumes to reduce runoff when not in conflict with an ongoing IPM program.
- √ Construct internal above ground storage areas when economically feasible and route field runoff to these areas prior to discharging offsite.

47C WATER QUALITY MANAGEMENT – *Things to Do: BMP(s)*

- √ Maximize the use of existing internal depressional areas which can act as biological filters to treat farm field runoff prior to discharging offsite.
- √ Utilize contour farming areas to slow down farm field runoff in order to minimize potential sedimentation and erosion impacts to downstream water resources, when applicable.
- √ If contour farming is not practical, maximize the use of rows that are laid out across applicable steeper field slope(s) to also slow down runoff.
- √ Incorporate assorted tillage practices such as deep plowing, sub soiling or ripping that minimize the development of *tillage* or *plow pans*. Be cautious about impacting the spodosol layer.
- √ Maximize the use of inter-row cover crops such as grasses or legumes to provide additional biological treatment when not in conflict with an ongoing IPM program.
- √ Construct internal above ground storage and/or tailwater recovery ponds when economically feasible and route field runoff to these storage areas prior to discharging offsite.

47D SPECIAL ENGINEERING CONSIDERATIONS – *Things to Do: BMP(s)*

- √ The amount of water quantity and water quality benefits obtained from the implementation of any of the above BMPs will vary from location to location. Consult with an agricultural engineer if you wish to more clearly quantify those benefits.

Things to Avoid: Potential Pitfalls

- **X** Avoid leaving plastic mulch on abandoned farm fields after the harvest of the last crop in order to prevent possible inadvertent flooding impacts during the onset of the rainy season.
- **X** Avoid burning or disposing of used plastic mulch in a manner inconsistent with all applicable laws and regulations.

<u>Applicable Technical Criteria:</u>

- ♦ Perform an engineering analysis that consists of volume and peak discharge rate calculations on well drained (Hydrologic Group A) soils, especially when slopes exceed 1%.

Operation and Maintenance Issues:

- Control undesirable weed species that become established through holes in the polyethylene mulch by hand weeding and/or spot spraying of herbicides.

Other Considerations:

- Consider the implementation of soil conservation measures in plasticulture farm fields or other areas that contribute flow in order to minimize sediment loss and maximize water quality protection.

Key References:

(1) UF, IFAS Circular 805

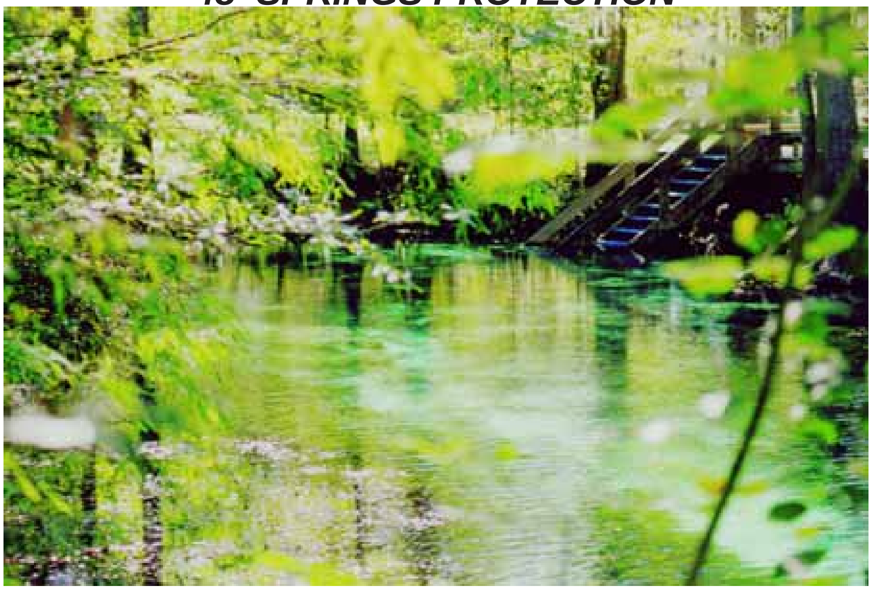
(2) Virginia Cooperative Extension, "Protecting Water Quality Best Management Practices for Row Crops Grown on Plastic Mulch in Virginia".

(3) SWFWMD, AGSWM Permanent Farming Standards

(4) American Society of Agricultural Engineers

(5) USDA-NRCS Conservation Practice Standards, Deep Tillage - Code 324, Contour Buffer Strips - Code 332, Cover Crop - Code 340, and Constructed Wetland - Code 656

48 SPRINGS PROTECTION



For centuries, Florida's springs have drawn people and animals to their crystal clear waters and pristine habitats. In fact, Florida has more first-magnitude springs than any other state, and perhaps the highest concentration of fresh water springs in the world. From the tourist attraction of Weeki Wachee Springs to the lucrative business of bottled water, springs are major contributors to Florida's economy. Springs and spring-fed rivers are also major contributors to Florida's water supply. Springs have been called "windows to the aquifer", reflecting the health of our ground water resources, and along with sinkholes are direct conduits to the Floridan aquifer. Over the past 50 years, intense population growth and development have substantially increased demands on Florida's ground and surface water supplies, while natural buffer zones protecting (spring) recharge areas have been converted to more intensive uses. Over-pumping the Floridan aquifer has diminished and in some cases even stopped the flow of major springs. Since the 1970's, water quality in many springs has declined, as well. Some springs are also at risk from nutrients from fertilized fields, home lawns, and golf courses. Recognizing the value of Florida springs, in 2001 the Florida Legislature passed the Florida Springs Initiative authorizing funds (to the Florida Department of Environmental Protection) to investigate the status of Florida springs and strategies to protect them. A prime component of these protection strategies is the creation of agricultural BMPs addressing water quality and off-site discharges. With the implementation of BMPs, springs should improve over time.

Working Definition:

A spring is a surface water body created by the natural emergence of ground water flowing to the earth's surface.

Key BMP Subcategories:

48A SOIL PREPARATION AND MANAGEMENT- ***Things to Do: BMP(s)***

√ Employ conservation tillage techniques on agricultural production areas that contribute surface water directly to springs, functional sinks, or other conduits.

√ Practice all applicable Erosion Control and Sediment Management BMP measures contained in this manual.

√ Create and maintain conservation buffer setbacks for springs, spring runs, functional sinks, or other conduits.

48B WATER RESOURCES MANAGEMENT – *Things to Do: BMP(s)*

√ Develop and follow an Irrigation Management Plan, as appropriate, as referenced in this manual.

√ Follow the Wellhead Protection BMP criteria in the Conservation Practices and Buffers chapter of this manual.

Things to Avoid – Potential Pitfalls:

X Do not over irrigate crops as this may leach nutrients into underground spring conduits.

X Eliminate direct runoff to adjacent surface waters using tailwater recovery, diversions and/or other techniques.

<u>Applicable Technical Criteria for First Magnitude (>100 cubic feet per second) Springs:</u>

♦ Develop an Irrigation and Nutrient Management Plan that includes FDACS Interim Measures and/or IFAS fertilizer application rates.

♦ Use Integrated Pest Management (IPM). See the IPM section of this manual.

♦ Create and maintain a 100-foot buffer setback from springheads and spring runs. Also, maintain an average 50-foot buffer setback from functional sinks and sinkholes.

♦ Employ conservation tillage on production areas that contribute surface water directly to springs, spring runs, functional sinks, and sinkholes.

♦ For irrigation wells located within the spring recharge basin, follow the Wellhead Protection BMP criteria contained within this manual.

Other Considerations:

● If crops are produced within a springs recharge basin, locate them as far as possible from the springhead and/or other sink features.

Key References:

(1) Protecting Florida's Springs, Land Use Planning Strategies and Best Management Practices.

(2) Agrichemical Handling & Farm Equipment Maintenance, http://www.dep.state.fl.us/water/strmwater/pubs.htm.

(3) Circular 1222- Nitrogen Management Practices for Vegetable Production in Florida, http://edis.ifas.ufl.edu/CV237

SEASONAL OR TEMPORARY FARMING OPERATIONS

Seasonal or temporary farming is really nothing more than practicing the age-old art of crop rotation. Before the advent of petrochemicals, which includes synthetic crop protection chemicals, many vegetable farmers had no choice but to rotate crops and allow certain fields to lay fallow. This rotational period not only allowed farmers the opportunity to “break” disease cycles which infested crops, but also gave them the opportunity to plant high residue cover crops and employ other organic farming practices in order to improve overall soil health and tilth.

Today, farming conditions and practices have been modified somewhat given the ready access to agrichemicals, urban encroachment pressures, and agricultural land valuation issues. This is especially true in Florida. Nonetheless, in the central peninsular and panhandle regions, beef cattle operations continue to thrive as there are nearly 5 million acres that are managed as improved pasture. Given the economic realities of farming, many of these cow/calf operations have more recently diversified to include seasonal row crop farming, sod production, and other land management strategies to support wildlife habitat for ancillary hunt leases.

The BMP that follows recognizes this integrated use amongst some Florida farmers and thus promotes sequenced temporary farming activities on farm fields for a limited time period.

49 SEASONAL OR TEMPORARY FARMING OPERATIONS

Seasonal or temporary farming operations are environmentally compatible land uses, and their position and overall role in the landscape helps to maintain Florida's wilderness heritage. In fact, some farmers in South, Southwest and North Florida agricultural production regions still practice the art of *rotational farming*. Oftentimes, agricultural operations are fully integrated and produce a seasonal row crop, winter pasture/cover, high-residue cover crop, and/or manage for strategic habitat improvements. Many of these practices work in concert with one another and the natural systems. Besides rotational farming, field flooding - another seasonal or temporary farming practice - is readily used in South Florida for pest management. The use of this practice can also benefit waterfowl and create wildlife habitat. Much of the agricultural land in South and Southwest Florida is managed for cattle grazing. As such, ranching and *silviculture* have both been recognized as low-intensity agricultural uses and are highly compatible with maintaining Florida's natural systems. When properly managed, temporary farming operations that diligently maintain a year-round vegetative cover help to increase the organic matter content of Florida's sandy soils, thus benefiting soil and water properties overall.

Cow/calf operations with periodic rotations of crops should follow the criteria set forth in this chapter; furthermore, during cattle-grazing periods, owners are strongly encouraged to follow the BMP practices enumerated in the "*Water Quality Best Management Practices for Cow/Calf Operations".* Farmers not engaged in cow/calf operations, yet meeting the seasonal farming thresholds outlined in this BMP, are also encouraged to follow the criteria described below.

Working Definition:

Seasonal or temporary farms include planned and sequenced agricultural activities on relatively small project areas for a limited time period. These farms, following completion of crop harvest, generally practice hydrologic restoration (return to predevelopment conditions) and cover cropping.

Key BMP Subcategories:

49A CROP PLANNING AND DESIGN ISSUES - *Things to Do: BMP(s)*

√ Grow crops in a planned, regular scheme and select crops adapted to the local climate and soil conditions. Certain crops such as watermelon, potato, and other vegetable crops are particularly suited when used in conjunction with a rotation and/or renovation of cattle pastures.

√ Select crops that are economically feasible and that produce enough biomass to help reduce soil erosion by water and/or wind.

√ Select crops that can beneficially add organic matter to the soil. Be aware of the carbon to nitrogen (C:N) ratio of any residue being incorporated into the soil. In general, materials that have a C:N ratio higher than 20:1 may temporarily immobilize inorganic nitrogen and produce nitrogen deficiencies in subsequent crops.

√ Grow nitrogen-fixing crops (legumes) immediately prior to or interplanted with nitrogen-depleting crops when crop rotations are designed to add nitrogen to the system. (See Table No. 3 at the end of this BMP for typical nitrogen-fixing crops for Florida).

√ Alternate crops to break the pest cycle (i.e., nematodes and soil-borne diseases) and to allow for the use of a variety of Integrated Pest Management control strategies. Pay particular attention to plant pathogenic host crops.

49B CROP CYCLE AND FALLOW REQUIREMENTS - *Things to Do: BMP(s)*

√ Follow all relevant BMPs, but especially the Conservation Crop Rotation and/or Cover Crop BMPs contained in this manual.

√ Follow the farming rotation interval, including the prescribed *fallow* period(s) referenced in the table below.

Crop Duration	Rotation Interval	Fallow/Cover Crop Requirement
Two-Year Period*	Five-Year Period	High Residue Cover
Three-Year Period**	Five-Year Period	High Residue Cover

*****Denotes a limitation to farm no more than two seasons (spring and fall) per year.
**Denotes a limitation to farm no more than one season (preferably spring) per year.

√ Limit the amount of plastic mulch, if applicable, to no more than 25% of the planned project or cropping area. Farm operations exceeding this threshold will be required to comply with the criteria set forth in the Water Resources chapter of this manual.

√ Abide by the appropriate wetland setbacks as referenced in the Wetlands Protection BMP in the Conservation Buffers chapter of this manual. Certain encroachments may be allowed, when approved by FDACS in advance, as long as these temporary discharge features are no closer than 15 feet landward of receiving isolated wetland areas.

√ If soil tests show a losing organic matter trend, then follow USDA-NRCS' residue index recommendation(s).

√ Limit ditch depths to a maximum of 24", except in cases where approved farm field rim ditches are also used for irrigation purposes and have negligible impacts on adjacent water resources.

√ If farming in closed drainage basins, consult an agricultural engineer for design assistance.

49C ABANDONMENT (END OF SEASON) STANDARDS - *Things to Do: BMP(s)*

√ Restore all agricultural surface water management system features to equivalent, pre-development, hydrologic conditions.
√ Abide by prescribed crop rotation periods and minimum fallow requirements.
√ Keep careful, permanent records of crop history.

49D TEMPORARY FIELD FLOODING - *Things to Do: BMP(s)*

√ Continually monitor water levels at the site to be aware of water loss through infiltration and/or evaporation.
√ Take a representative water quality sample to determine nutrient levels of the water. It is important to consider nutrient levels prior to selecting water management options, as high nutrient waters should be recirculated to adjacent crop fields.
√ If an impoundment is created, routinely monitor the berms for integrity.
√ Keep good records of flooded field duration, levels, and water quality analyses.

Things to Avoid: Potential Pitfalls

X Avoid replanting agronomic and/or vegetable crops on recently harvested fields growing the same crop (or of the same botanical family), because of potential disease/pest carryover issues.

<u>Operation and Maintenance Issues:</u>

■ Use soil testing and follow the recommendations to avoid over fertilizing, especially after planting a legume.
■ Remove plastic mulch, if applicable, within 30 days after harvest of the last crop in order to avoid inadvertent adverse water resource impacts.
■ Agricultural crops can be packed directly into shipping containers in the field or transported to a shaded facility to maintain product quality and to facilitate sorting, grading, and packing operations prior to transport for sale. Sediment removal can be accomplished either mechanically or hydraulically. If hydraulic means are used, water quality concerns should be addressed through the use of a Sediment Basin BMP or other applicable practices, and the offsite discharge of wash water should be avoided when possible as this activity may require permits under Florida Law.

Other Considerations:

- Incorporate crop residues into the soil to increase infiltration, reduce runoff, and improve soil moisture holding ability.
- Soil compaction can also be reduced by adjusting crop rotations to include deep-rooted crops that are able to extend to and penetrate any compacted soil layers, as well as avoiding crops that require field operations when the soils are wet.
- When legumes are planted, use an appropriate inoculant for the legume type.

Key References:

(1) USDA-NRCS Practice Standard, Conservation Crop Rotation, Code 328, http://www.nrcs.usda.gov/technical/efotg

(2) Farming for Clean Water in South Carolina – A Handbook of Conservation Practices

(3) Crop Rotations for Vegetables and Row Crops, http://www.ncatark.uark.edu/~steved/rotation.html

(4) Cultural Control for Management of Vegetable Pests in Florida, http://www.imok.ufl.edu/LIV/groups/cultural/pests/insects.htm

(5) Southwest Florida Water Management District, Agricultural Ground and Surface Water Management Program

Some plants have the ability to "fix" or convert atmospheric nitrogen to a usable form and assimilate this compound via plant physiologic processes. These plants commonly referred to as legumes, rely on bacteria that colonize root nodules and generate ammonia under (chemically) reducing conditions. Nitrogen fixation by legumes can range from 25 to 75 pounds of nitrogen per acre in a natural ecosystem, and to as much as several hundred pounds per acre in a designed cropping system. Listed below are categories of leguminous plants, arranged by their common names.

TABLE NO. 3

Grain Legumes	Forage Legumes
Common Beans	Alfalfa
Peanuts	Clovers
Cowpeas	Vetches
Soybeans	Sun Hemp
	Perennial Peanut
	Aeschynomene
	Begarweeds
	Hairy Indigo
	Sesbania
	Lupine

GLOSSARY

Adsorption – The process by which chemicals are held on the surface of a mineral or soil particle.

Advective freeze - This occurs when a cold air mass moves over an area, also known as an “arctic blast”.

Appurtenances - A supplementary component.

Aquifer – A soil or rock formation that contains ground water and serves as a source of water that can be pumped to the surface.

Aquitard - A layer of rock having low permeability that stores groundwater but delays its flow.

Base flow – The ground water contribution to runoff that comes from springs or seepage into a stream channel.

Biomass - The total mass or amount of living organisms in a particular area or volume.

Broadcast – To spread fertilizer evenly over the entire soil surface and, usually, thoroughly incorporate it. The broadcast method for bedded vegetable production involves broadcasting the fertilizer in a 3- to 4-foot swath in the bed area only.

Chelating – A process by which a molecule can form several bonds to a single metal ion.

Chemigation – The process of transporting chemicals to the root zone, the aerial part of the plant, or both via the irrigation system.

Chemical mixing center (CMC) – A permanently located pesticide and herbicide mixing and loading facility which is designed to provide a place where spill-prone activities can be performed over an impermeable surface that can be easily cleaned and permits the ready recovery of spilled materials.

Composite sample – A composite sample is a collection of individual samples obtained at regular intervals. Each individual sample is combined with the others in proportion.

Conveyance capacity – The amount of flow (generally expressed in cubic feet per second) that a canal/ditch can carry based on the size, shape, slope, and condition of the canal/ditch.

Crop nutrient requirements – The total amounts of plant nutrients needed by a crop for maximum productivity in most situations. This amount is supplied by a combination of native soil fertility, and added by fertilizers.

Damping-off - A disease, mostly of young plants or seedlings caused by water-loving fungi, mostly Pithium species. The organisms typically attack plants under stress due to low temperature and overly wet conditions in the field.

Deficit irrigation - Irrigation management that results in applying slightly less than optimum amounts of water to a crop. Typically used to achieve large savings in water applied with minimal reductions in crop yield, and sometimes practiced to increase concentrations of sugars in certain vegetable crops.

Denitrification – Microbial conversion of nitrate to gasses (N_2 and N_2O) under anaerobic conditions.

Diluent - An agent used to make a mixture less concentrated.

Double cropping – Successive cropping of existing mulched beds. The practice makes effective use of both the polyethylene mulch and the fumigant.

Earthen plugs – An obstruction in a canal/ditch that generally consists of localized compacted and vegetated soil, which allows total or partial obstruction of flow in that canal/ditch.

Evapotranspiration – The combined process of water evaporation and the loss of water from plants.

Fallow - To be left uncultivated or unplanted.

Fertigation – Application of fertilizer to crops by injecting nutrients through the irrigation system, specifically during drip irrigation.

Fixation - Reduction into a solid or nonvolatile form.

Foliar fertilization - Applying (spraying) plant nutrients to the leaves of plants to supply part of the plant's nutrient requirements. Foliar fertilization works best for curing deficiencies of micronutrients, such as Fe, Mn, B, etc.

Forb - A non-grasslike herbaceous plant, a broad-leaved herb.

Green manure - A term given to plants that are grown to benefit the soil.

Hydraulic drawdown – The amount by which the water level in an aquifer or water table is further lowered, when the water from that aquifer or water table is continually removed by man-made means (pumps, canals/ditches).

Hydrologic conditions – The status of water-related parameters in an area; those parameters are typically rainfall, and water levels above (ponds/lakes/reservoirs) and below (aquifers) ground.

Hydroperiod - Period of time during which soils, waterbodies and sites are wet.

Jurisdictional wetlands – A wetland that has been determined to be subject to state or federal regulatory jurisdiction. For most cases at the federal level, the USACOE has jurisdiction over wetland regulation. However, if the wetland occurs on agricultural land, the wetland is regulated by the NRCS. In Florida, FDEP and the WMDs have jurisdiction over wetland related activities.

Karst - A geologic formation consisting of porous limestone containing deep fissures and sinkholes and characterized by underground caves and streams.

Latent heat of fusion - A source of heat provided when water changes to ice.

Lateral flow – The movement of water below ground along or parallel to a soil layer.

Legumes - A plant of the Leguminosae (also called Fabaceae) family, with the characteristic ability to fix atmospheric nitrogen in root nodules. Legumes help maintain soil fertility and provide nutritious food for wildlife and/or livestock. Examples include clover, alfalfa, lespedezas, field beans, and peas.

Macronutrients - Essential plant nutrients required in large quantities. The six macronutrients are nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), and sulfur (S).

Micronutrients – Essential plant nutrients required in small quantities. The micronutrients include iron (Fe), boron (B), chlorine (Cl), copper (Cu), manganese (Mn), zinc (Zn), and molybdenum (Mo). In most cases there is a fine line between sufficient amounts and toxic amounts of these nutrients.

Most-recently-matured leaf - The leaf on a branch or vine that has reached its approximate maximum size and has begun to change from its juvenile light-green color to a more dark-green coloration.

Nitrogen fixation - The process by which atmospheric nitrogen gas (N_2) is converted into ammonia compounds. The ammonia is subsequently available for many important biological molecules such as amino acids, proteins, vitamins and nucleic acids.

Nurse tanks - Tanks of clean water transported to the field to fill the sprayer.

Outfall ditches – The ditch or ditches in a farm that ultimately allow water to leave the farm. Internal farm ditches are typically connected to this canal/ditch.

Petiole – The stalk attaching the leaf blade to the stem.

Physiological age - Term used to describe the stage of growth of a plant based on identifying developmental stages, such as “vegetative”, “reproductive”, “early flower buds”, “early vine growth”, “first blossoms”, “1-inch fruits”, “early pod set”, “mature seeds”, etc, rather than an age based on calendar dates.

Planting bed - The general area of the field where plants will be placed, typically used in conjunction with soil raised in rows above the plane of the field.

Plastic mulch - Thin manufactured film material made typically of polyethylene used to cover the formed planting bed in a vegetable field and through which the seeds or plants are placed. Plastic mulch comes in various widths, colors, and thicknesses, and is used to warm the soil, speed crop

Portable mixing center – Portable mixing centers are another option for preventing contamination of mixing and loading sites. Some are little more than a very durable version of a child's wading pool, while others are made of interlocking steel sections with a custom fitted liner and built in a custom fitted liner and built in sump. There are also many other variations.

Quick tests – Test kits which analyze plant sap and have been calibrated for N and K for several vegetables in Florida. The kits offer speed of analysis and are accurate enough for on-the-spot monitoring of plant nutrient status.

Resistant-plant varieties - Special varieties of crops that have been developed through breeding to ward off attack from diseases or insects. These varieties may require few pesticides in their growth and production.

Rill – A long and narrow trench or cut at the soil surface, typically generated by the rapid movement of water along that surface.

Rip-rap – Large, loose angular stones that serve as a permanent erosion-resistant ground cover.

Riparian – Belonging or relating to the bank of a river or stream; of or on the bank.

Row covers – Flexible, transparent, or semitransparent materials used to enclose single or multiple rows of plants with the objective of enhancing crop growth and yield by increasing soil and air temperature and reducing wind damage.

Rotational farming - The practice of regularly changing the type of crops grown in a field.

Row tunnels – Polyethylene or polypropylene hemispherical materials placed over the plants in a row and secured in place.

Sequestering agent - A chemical compound used to tie up undesirable ions, keep them in solution, and eliminate or reduce the normal effects of the ions.

Sheet flow – The flow of water, usually initiated from a rainfall event, where the soil surface became saturated and the accumulated water, in puddles, begins to flow in rather thin layers across the land surface.

Silviculture - The art, science, and practice of establishing, tending, and reproducing forest stands with desired characteristics.

Soil water tension – The magnitude of the suction (negative pressure) the plant roots have to create to free soil water from the attraction of the soil, and move it into the root cells.

Spoil – The soil material obtained from excavating an area to construct such works as canals/ditches and/or ponds. This material is typically used to build berms and/or dikes along or in the vicinity of the excavation site.

Spodosol - A soil type characteristic of moist climates, with dense subsurface layers of organic matter, aluminum and iron. In Florida, these soils are common in poorly drained flatwoods.

Swale – A shallow curve-shaped excavation, typically used to collect and route water runoff to a ditch.

Temperature Inversion - A stable atmospheric condition characterized by an increase in air temperature with an increase in height above the ground until at some height a barrier of cold air is met.

Tillage or Plow Pan - A compacted zone in the soil caused by routine use of tillage implements such as discs and plows.

Tilth – The physical condition of soil: how easy it is to till, its fitness as a seedbed, and how well seedlings and roots can penetrate it.

Topographic maps – Detailed, graphic representation of the land surface elevations of a region.

Twin-row cropping systems - A vegetable cultural practice where two rows of a crop are grown on one planting bed. Pepper and strawberry are two crops commonly grown in this fashion.

Water bar - A ditch or hump constructed diagonally across trails or roads to reduce soil erosion by diverting surface water runoff into adjacent ditches or vegetation.

Water-release curve - A graphical presentation of the amount of water in a soil profile under various suction levels.

Zone of influence - The distance an area of defined recharge to the well.

APPENDICES

VEGETABLE PRODUCTION BEST MANAGEMENT PRACTICES CHECKLIST

I. INTRODUCTION

The following checklist is designed to assist vegetable growers statewide in identifying the most appropriate Best Management Practices (BMPs) for their specific site and growing conditions. This checklist is to be employed after going through the BMP Decision Tree flowchart process on the preceding pages and is only used by vegetable producers who double crop and/or are using fertilizer rates in excess of the IFAS recommended rates. The results of this assessment should be kept on file and reviewed annually to document implementation of BMPs, and to determine whether further practices may be necessary. Providing the voluntary information requested below will help the farm manager select BMPs that are appropriate for their specific farm operation.

Grower Information: Please fill in all applicable lines below.

A.) Property Owner: ______________________________

B.) Farm Name: ______________________________

C.) County: ______________________________

D.) Tax ID Number: ______________________________

Section: ______________________________

Township: ______________________________

Range: ______________________________

E.) Farm acres: ______________________________

F.) Crops grown: ______________________________

G.) General Soils Characteristic: ______________________________

H.) Describe Bed Preparation: ______________________________

I.) Irrigation Method: Drip Seep Overhead Other None

J.) Pump Capacity Outflow in gallons per minute: ______________________________

Note:
A **YES** answer for any survey question indicates that the farm conforms to the referenced BMPs. A NO answer indicates that the referenced BMPs might improve the environmental performance of the farm, but implementation of all BMPs will generally not be required. Review BMPs listed for questions that were answered NO. Select specific BMPs from those indicated by a **NO** answer that are appropriate for application to the farm. BMPs that are scheduled for implementation should be listed in Section IV.

Use the comment section at the end of this document to explain why certain BMPs from questions that were answered **NO** will not be implemented. The comment section can also be used to elaborate on any items or questions that may be unclear or ambiguous, or to explain particular farm conditions. Comments should be referenced to the specific section and question number of the survey. N/A may be used if the question or section does not apply to a particular farm.

II. NUTRIENT AND IRRIGATION MANAGEMENT

Farm Evaluation Date: ____________

Question	Yes	No	BMP No.
Irrigation Practices			
1) Did you have the irrigation water quality analyzed before designing and installing your irrigation system?	☐	☐	36
2) Have both the irrigation system's efficiency and uniformity been determined?	☐	☐	39
3) Has a documented maintenance schedule been established?	☐	☐	39
4) Do you have a modified irrigation schedule that is based on evapotranspiration, rainfall events, fertigation, tensiometers or other devices?	☐	☐	40
5) Do you use a water table observation well or other device(s) as a management tool if using seepage irrigation?	☐	☐	27
Nutrient Practices:			
6) Has standard whole-leaf or petiole fresh sap plant tissue testing been initiated?	☐	☐	35
7) Are you using precision agriculture to assist with crop production?	☐	☐	28
8) Do you have a soil survey on record for your farm?	☐	☐	14
9) Is there a confining layer, for example a spodic horizon, on your farm?	☐	☐	14
10)If you use organic or natural fertilizers, do you have samples analyzed for nutrient content?	☐	☐	31
11)Do you regularly test the soil to determine the soil pH and the concentration of available plant nutrients? If your soil has a low ability to adsorb P, use the Phosphorus Index which can be found at http://www.fl.nrcs.usda.gov/technical/tools.html	☐	☐	14, 26
12)Do you use the results of the soil testing to determine the amount of fertilizer needed to meet the crop nutrient requirements?	☐	☐	26, 33
13)If fertigating, do you inject small increments frequently?	☐	☐	33, 34
14)For growers who are not using fertigation, do you apply supplemental applications of N and/or K only after rainfall exceeds 3 inches in 3 days or 4 inches in 7 days based on crop stage?	☐	☐	33
Double Cropping (If applicable)			
15)Do you sample the soil after the first crop to determine the residual nutrient concentration?	☐	☐	26, 30
16)Do you modify fertilizer use to account for the second crop?	☐	☐	30, 33
Bare-Ground:			
17)Are you using split applications of nutrients to reduce losses to leaching?	☐	☐	33
18)Do you use controlled-release fertilizer?	☐	☐	32
Reservoir Systems:			
19)Do you have water control structures on your farm?	☐	☐	42
20)Can the present system of canals, ponds, and/or ditches be used to provide water storage capacity?	☐	☐	44
21)Are you using tailwater recovery?	☐	☐	37, 38
22)Do you have a water management district permit for the construction and operation of a surface water management system?	☐	☐	7, 15, 16, 21, 22, 43, 44, 45

III. CONCLUSION AND RESOLUTION:

Assessment conducted by (print name): ______________________________

Signature: ______________________________

Farm representative (if different from above): ______________________________

Signature: ______________________________

Date: ______________________________

Comments:

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IV. BMPS TO BE IMPLEMENTED

BMPs selected from those indicated by NO answers that farm management team agrees to implement including the year of anticipated implementation.

____

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V. OTHER BMPs USED BUT NOT CONTAINED IN THE MANUAL

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____

Best Management Practices Effectiveness Summary*								
Best Management Practices	Resource Concerns							Relative Cost
	Surface Water Quality					Ground Water Quality		
	Nutrients	Sediments	Pesticides	BOD	Salinity	Nutrients	Pesticides	
Management Practices								
Irrigation Management	H	H	H	L	H	M	M	M
Nutrient Management	H	--	L	M	--	H	--	L
Pest Management	--	--	H	--	--	--	H	L
Springs Protection	M	M	M	M	--	H	M	L
Vegetative and Tillage Practices								
Conservation Crop Rotation	M	H	M	--	M	M	M	T
Conservation Tillage	M	H	M	L	--	--	--	M
Contour Farming	M	H	M	M	--	--	--	T
Cover Crops	M	M	M	L	--	M	L	M
Field Borders	M	M	M	M	--	--	--	L
Filter Strips	M	H	M	M	--	--	--	L
Grassed Waterways	M	M	M	L	--	--	--	H
Plasticulture Farming	M	1	M	--	--	M	M	H
Riparian Buffers	M	M	M	M	--	--	-	
Structural Practices								
Diversions/ Terraces	L	M	L	L	--	--	--	H
Grade Stabiliztion	L	M	--	L	--	--	--	H
Reservoirs Ponds & Ditches	H	H	M	H	--	H	L	
Sediment Basins	M	H	M	M	--	--	--	M
Temporary Erosion Control	M	H	M	M	--	--	--	L/M
Water Table Control	M	H	M	H	--	--	--	M

H (high), M (medium), L (low), -- (little to no effect); T (primary cost is time)

*Adapted from Ohio State University Extension Fact Sheet AEX-464-91and Farming for Clean Water in South Carolina. 1 - Effects may be positive or negative depending on management techniques.

Candidate BMP Checklist

Instructions: Using the Florida Vegetable and Agronomic Crops Best Management Practices Checklist, check "**Yes**" for all BMP's currently practiced and "**No**" for BMPs not currently implemented. For those BMPs that will be implemented in future years, enter the year you plan to initiate the BMP in the "year" column. Enter N/A in the "year" column if the practice is not applicable to your operation or if it conflicts with other BMPs that have been implemented.

PESTICIDEMANAGEMENT

Yes	No	Year	BMP
		____	1. Integrated Pest Management
		____	2. Pesticide Mixing and Loading Activities
		____	3. Spill Management
		____	4. Pesticide Application Equipment Washwater and Container Management
		____	5. Pesticide Equipment Calibration

CONSERVATION PRACTICES AND BUFFERS

Yes	No	Year	BMP
		____	6. Well Head Protection
		____	7. Wetlands Protection
		____	8. Grassed Waterways
		____	9. Filter Strips
		____	10.Field Borders
		____	11.Riparian Buffers
		____	12.Contour Farming
		____	13.Land Leveling
		____	14.Soil Survey

EROSION CONTROL AND SEDIMENT MANAGEMENT

Yes	No	Year	BMP
		____	15.Sediments Basins
		____	16.Access Roads
		____	17.Critical Area Plantings
		____	18.Diversions/Terraces
		____	19.Temporary Erosion Control Measures
		____	20.Raised bed Preparation
		____	21.Grade Stabilization Structures
		____	22.Ditch Construction and Maintenance
		____	23.Conservation Tillage
		____	24.Cover Crops
		____	25.Consrvation Crop Rotation

NUTRIENT AND IRRIGATION MANAGEMENT

YES	NO	YEAR	BMP
		______	26.Soil Testing/Soil pH
		______	27.Water Table Observation Wells
		______	28.Precision Agriculture
		______	29.Crop Establishment
		______	30.Double Cropping in Plasticulture Systems
		______	31.Proper Use of Organic Fertilizer Materials
		______	32.Controlled-Release Fertilizers
		______	33.Optimum Fertilization Management/Application
		______	34.Chemigation/Fertigation
		______	35.Tissue Testing
		______	36.Water Supply
		______	37.Tailwater Recovery
		______	38.Tailwater Reuse and Waterborne Plant Pathogens
		______	39.Irrigation System Maintenance and Evaluation
		______	40.Irrigation Scheduling
		______	41.Frost and Freeze Protection
		______	42.Water Control Structures

WATER RESOURCES MANAGEMENT

Yes	No	Year	BMP
		______	43.Flood Protection
		______	44.Ponds/Reservoirs and Ditches
		______	45.Farm Ponds
		______	46.Fields and Beds
		______	47.Plasticulture Farming
		______	48.Springs Protection

SEASONAL OR TEMPORARY FARMING OPERATIONS

Yes	No	Year	BMP
		______	49.Seasonal or Temporary Farming Criteria

NOTICE OF INTENT TO IMPLEMENT
VEGETABLE AND AGRONOMIC CROPS
BEST MANAGEMENT PRACTICES MANUAL

In accordance with Florida Statute 403.067(7)(c)2 and Rule 5M-8.004 F.A.C., the following information is hereby submitted as proof of my intent to implement Best Management Practices for Vegetable and Agronomic Crops in Florida. Multiple parcels and associated property tax identification numbers may be listed on one NOI. If parcels are owned in more than one county, then one NOI should be submitted for each county with the list of associated property tax identification numbers on each NOI. Use an additional sheet if necessary.

Land Owner____

Leaseholder____

Authorized Local Contact____

Local Contact Address____

Local Contact Telephone____

Farm Name____

Total Number of Enrolled Acres____

County____

Property Tax ID Number/s
From Property Appraiser

____

____

____

____

____

Complete the Candidate BMP Checklist and use the results to fill out the Notice of Intent to Implement. Submit the complete Notice of Intent to Implement to the Department of Agriculture and Consumer Services at the address below. **Keep the completed grower checklist in your files along with a copy of your completed Notice(s) of Intent.** You must complete the grower checklist and submit the Notice of Intent to Implement and maintain these on file and have them available for inspection by the Department if you wish to receive a presumption of compliance with state water quality standards. A submitted Notice of Intent to Implement is also a requirement to be eligible for some sources of BMP cost share funding.

____ ____________________
Signature of Farm Owner or Leaseholder Date

Mail the complete form to: FDACS- OAWP
1203 Governor's Square Boulevard, Suite 200
Tallahassee, Florida 32301

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Table 4. Typical Bed Spacings for Vegetables Grown in Florida used in IFAS fertilizer Recommendations.

Vegetables	Typical Bed Spacing[1] (ft)	Rows of Plants Per Bed
Broccoli	6	2
Muskmelon	5	1
Cabbage	6	2
Pepper	6	2
Cauliflower	6	2
Summer Squash	6	2
Cucumber	6	2
Strawberry	4	2
Eggplant	6	1
Tomato	6	1
Lettuce	4	2
Watermelon	8	1

[1]Spacing from the center of one bed to the center of an adjacent bed. To calculate amount of 100 LBF per acre for "typical bedspacing": 43560 sq. ft. per acre divided by the "typical bed spacing" and then finally divided by 100.

Table 5. Conversion of Fertilizer Rates in lb/A to lb/100 LBF.

Typical Bed Spacing (ft)	Recommended Fertilizer Rate in lb/A (N, P_2O_5, or K_2O)									
	20	40	60	80	100	120	140	160	180	200
	Resulting Fertilizer Rate in lb/100 LBF (N, P_2O_5, or K_2O)									
3	0.14	0.28	0.41	0.55	0.69	0.83	0.96	1.10	1.23	1.37
4	0.18	0.37	0.55	0.73	0.92	1.10	1.29	1.47	1.65	1.84
5	0.23	0.46	0.69	0.92	1.15	1.38	1.61	1.84	2.07	2.30
6	0.28	0.55	0.83	1.10	1.38	1.65	1.93	2.20	2.49	2.76
8	0.37	0.73	1.10	1.47	1.84	2.20	2.57	2.94	3.30	3.78

Table 6. Application Rates Recommended for Cold Protection Under Different Wind and Temperature Conditions[1].

	WIND SPEED (MPH)		
MINIMUM TEMPERATURE EXPECTED	0 TO 1	2 TO 4	5 TO 8
	APPLICATION RATE (inches/hour)		
27 F	0.10	0.10	0.10
26 F	0.10	0.10	0.14
24 F	0.10	0.16	0.30
22 F	0.12	0.24	0.50
20 F	0.16	0.30	0.60
18 F	0.20	0.40	0.70
15 F	0.26	0.50	0.90

[1] Ext. Circular 287, Florida Agricultural Extension Service.

Table 7. Precipitation Rate for Selected Nozzle Capacities and Sprinkler Spacings

	GALLONS PER MINUTE/SPRINKLER								
SPRINKLER	2	3	4	5	6	8	10	12	15
SPACING (ft.)									
30 X 30	.21	.32							
30 X 40	.16	.24	.32						
40 X 40		.18	.24	.30					
40 X 50		.14	.19	.24	.29				
50 X 50		.12	.16	.20	.24	.32			
50 X 60			.13	.16	.19	.26	.32		
60 X 60				.13	.16	.21	.27	.32	
60 X 70					.14	.18	.23	.28	.34

SOIL TESTING PROCESS

Often the benefits of a soil test are assumed. The soil testing process comprises of four major steps and understanding each one clearly will increase the reliability of the process tremendously. The steps in the soil testing process are -i) soil sampling, ii) sample analysis, iii) interpretation of test results, and iv) nutrient recommendations.

Soil Sampling: Soil samples need to be representative of the field and soil types and the soil analysis results will be only as good as the sample submitted is. Samples collected from areas that differ from typical characteristics of the area should be submitted separately and should not be consolidated with the primary samples. Using management zone (area on the farm that is managed similarly) as a guiding factor to collect and consolidate samples is strongly recommended to optimize the resources. Consult the IFAS Extension Fact Sheet SL190* for further information on soil sampling strategies.

Sample Analysis: The soil samples that are submitted to the testing laboratories undergo a series of physical and chemical processes that are specific to the soil types, crops, and management regimes. Once the soil samples are homogenized through grinding and/or sieving, a precise volume of the sample will be extracted for plant nutrient through an extraction procedure. The following standard methods are followed at the IFAS Soil Testing Laboratories for different soils in Florida-

a) Mehlich-1 extraction - this method is performed on all acid-mineral soils up to a soil pH of 7.3.
b) AB-DTPA extraction - this method is performed on alkaline (calcareous) soils with a pH of 7.4 and above.
c) Water extraction - this method is used for extraction of P in all organic soils.
d) Acetic acid extraction - this method is performed on all organic soils for extraction of K, MG, Ca, Si, and Na.

Therefore, it is extremely important that procedures used at the laboratories are well understood before submitting the samples since most BMPs are tied to the standardized procedures used by the labs at the landgrant universities in the state such as UF/IFAS. Similarly it is also very important to note that the IFAS laboratory does not offer any test for N since there is no reliable test for plant available N under Florida conditions. N recommendations are based on crop needs based on research literature. More information regarding the procedures used at the IFAS Extension Soil Testing Laboratory in Gainesville can be found in the extension publication, Circular 1248*.

Interpretation of Test Results: The primary goal of state laboratories in offering the soil testing service is to provide interpretation to the soil test results based on soil test-crop response trials and field calibration of the test results with the optimum economic yields of the various crops. Economic yield returns to added nutrients cannot be obtained once the test results are interpreted as ‘High’ resulting in no recommendation for that particular nutrient. The interpretations provided are specific to the soil and crop type.

Current interpretation tables can be obtained from either SL 189* or SL 129* - IFAS extension factsheets.

Nutrient Recommendations: Nutrient recommendations based on soil test results are formulated based on the optimum economic crop response to an added nutrient to the soil. Current nutrient recommendations for common agronomic and horticultural crops grown in Florida can be found in extension factsheets SL 129* and Circular 1152*.

*Mylavarapu, R.S. and W.D. Lee. 2002. Soil Sampling Strategies for Precision Agriculture. SL 190. Soil and Water Science, Cooperative Extension Service. IFAS, p. 4. edis.ifas.ufl.edu/ss402.

*Mylavarapu, R.S. and E.D. Kennelley. 2002. UF/IFAS Extension Soil Testing Laboratory Analytical Procedures and Training Manual. Soil and Water Science, Circular 1248, Cooperative Extension Service, IFAS, p. 19.

*Mylavarapu, R.S. 2002. The Process of Standardized Nutrient Recommendation Development for Successful Crop Production and Environmental Protection. SL 189, Soil and Water Science, Cooperative Extension Service, IFAS.

*Kidder, G., C.G. Chambliss, and R. Mylavarapu. 2002. UF/IFAS Standardized Fertilization Recommendations for Agronomic Crops. SL129, Soil and Water Science, Cooperative Extension Service, IFAS. p. 9.

Hochmuth, G.J. and E.A. Hanlon. 2000. IFAS Standardized Fertilization Recommendations for Vegetable Crops. Cooperative Extension Service, p. 8.

INCENTIVE PROGRAMS FOR AGRICULTURE

The implementation of improved agricultural management practices can reduce nonpoint sources of pollution, conserve valuable soil and water resources, and improve water quality. The implementation of these management practices can also be expensive and, in some cases, may not be economically feasible for agricultural producers. To reduce the financial burden associated with implementation of selected practices, several voluntary cost-share programs have been established. These programs are designed to conserve soil and water resources and improve water quality in receiving water bodies. The following sections are intended to provide basic information regarding each of the primary federal, state, and regional programs. Sources of additional information have also been included, and growers are encouraged to contact the identified agencies or organizations for current information regarding each program.

I. Major Programs Administered by USDA's Farm Services Agency (FSA):

Conservation Reserve Program (CRP): This program encourages farmers to convert highly erodible cropland or other environmentally sensitive lands to vegetative cover including grasses and/or trees. This land-use conversion is designed to improve sediment control and provide additional wildlife habitat. Program participants receive annual rental payments for the term of the contract in addition to cost-share payments for the establishment of vegetative cover.

Conservation Reserve Enhancement Program (CREP): CREP uses a combination of federal and state resources to address agricultural resource problems in specific geographic regions. This program (which is not limited to highly erodible lands) is designed to improve water quality, minimize erosion, and improve wildlife habitat in geographic regions that have been adversely impacted by agricultural activities.

For further information on CRP and CREP, including eligibility criteria, please contact your local USDA Service Center. Information is also available on the Internet at www.fsa.usda.gov.

II. Major Programs Administered by USDA's Natural Resources Conservation Service (NRCS):

Environmental Quality Incentives Program (EQIP): EQIP provides financial assistance (up to 75% cost share and 90% for new and limited resource farmers) to farmers for the implementation of selected management practices. Practices eligible for EQIP cost share are designed to improve and maintain the health of natural resources and include nutrient management, pest management, and erosion control. The 2002 Farm Bill made numerous improvements to the program and significantly increased available funding. *For current information on this program, please contact your local NRCS office.*

Emergency Conservation Program (ECP): The ECP provides financial assistance to farmers and ranchers for the restoration of farmlands on which normal farming operations have been impeded by natural disasters. More specifically, ECP funds are available for restoring permanent fences, terraces, diversions, irrigation systems, and other conservation installations. The program also provides funds for emergency water conservation measures during periods of severe drought.

Small Watershed Program (PL-566): Although not directly related to the Farm Bill, the Small Watershed Program works through local government sponsors to help participants solve natural resource problems in watersheds of 250,000 or fewer acres. Technical and financial assistance is available for flood prevention, sediment control, water supply, water quality, fish and wildlife habitat enhancement, and wetlands creation and restoration.

Stewardship and Forestry Incentive Programs: The Stewardship and Forestry Incentive Programs provide technical and financial assistance to encourage non-industrial, private forest landowners to keep their lands and natural resources productive and healthy. These programs have recently been merged to create the Forest Land Enhancement Program. Qualifying land includes rural lands with existing tree cover or land suitable for growing trees, which is owned by an individual, group, association, corporation, Indian Tribe, or other legal private entity. To be eligible, landowners must have a management plan and own 1000 or fewer acres of qualifying land.

Wetlands Reserve Program (WRP): WRP is a voluntary program designed to restore wetlands. Program participants can establish easements (30-year or perpetual) or enter into restoration cost-share agreements. In exchange for establishing a permanent easement, the landowner usually receives payment up to the agricultural value of the land and 100 percent of the wetland restoration cost. Under the 30-year easement, land and restoration payments are reduced to 75 percent of the perpetual easement amounts. In exchange for the payments received, landowners agree to land use limitations and agree to provide wetland restoration and protection.

Wildlife Habitat Incentives Program (WHIP): The Wildlife Habitat Incentives Program provides financial incentives for the development of fish and wildlife habitat on private lands. Program eligibility requires that landowners develop and implement a Wildlife Habitat Development Plan. Participants enter multiyear (5 –10 year) agreements with USDA-NRCS.

For further information on these programs, including eligibility criteria, please contact your local USDA Service Center. Information is also available on the Internet at the following web sites: www.nrcs.usda.gov, www.fsa.usda.gov, www.fs.fed.us.

III. State and Regional Incentive Programs:

Tri-County Agricultural Area - Water Quality Protection Cost Share Program (TCAA-WQPP): This voluntary program has been available since the year 2000 and is administered by the SJRWMD with the assistance of the FDACS – Office of Agricultural Water Policy. The goal of the program is to reduce agricultural nonpoint source discharges and, thereby, improve water quality in the Lower St. Johns River. Program goals are to be achieved through the implementation of agricultural BMPs that can improve water quality. Potato and cabbage producers in a three-county area (Putnam, Flagler, and St. Johns counties) are eligible for the program. To receive cost-share payments, participants must enter a five-year agreement with the District. Annual cost-share payments are based on the practices selected and the level of participation. Eligible practices have been adopted under an Interim Measures Rule and are fully described in the “TCAA-WQPP

Applicant's Handbook" which is available from the District at the address below. Potato and cabbage producers in the region are encouraged to contact the SJRWMD at the following address for further information:

P.O. Box 1429
Palatka, Florida 32178
(904) 329-4426
1-800-451-7106
http://sjr.state.fl.us/

Alternative Water Supply Construction Cost-Share Program: This program is administered by the SJRWMD, and is available throughout the district's 19-county jurisdictional area. The program pays up to 50% of the costs of selected construction projects, and is available to local governments, utilities, industrial, agricultural, and other public and private water providers and users. The goal of the program is to conserve surface and ground water resources through the construction of reuse systems. Applications for the annual cost-share program are evaluated and ranked by the Alternative Water Supply Program Advisory Committee. Evaluation criteria and application instructions are provided in the "Alternative Water Supply Construction Cost-Sharing Application Package", which is available upon request from the SJRWMD. The deadline for applications is usually in early December, and contracts for selected projects are generally executed by June of the following year. Agricultural projects selected for funding have included detention ponds, horizontal wells, and canal systems that allow water to be captured and recycled on-site. For more specific information on this program, please contact the SJRWMD at the address above.

Suwannee River Partnership: Significant efforts to address elevated groundwater nitrate levels in the Middle Suwannee River Area began in the early 1990s with the initiation of a NRCS "land treatment project" under the authority of Public Law 566. Since that time, the area has also been designated as a priority area under EQIP. In 1998, the Suwannee River Basin Nutrient Management Working Group was organized to coordinate the implementation of water quality BMPs in the region. With the assistance of NRCS, FDACS, the SRWMD, the University of Florida, and the Soil and Water Conservation Districts, poultry and dairy operations in the Middle Suwannee Basin are establishing nutrient management plans and implementing BMPs that are specifically designed to address nitrate leaching. Row crop farmers may also be provided assistance under this program. For further information on the Suwannee River Partnership, please contact NRCS at (386)362-2622, or the FDACS Office of Agricultural Water Policy at 1-800-226-1066.

FARMS Program: Under the auspices of a Memorandum of Agreement between FDACS and the SWFWMD, the Facilitating Agricultural Resource Management Systems (FARMS) program began in 2002. FARMS is a demonstration BMP cost-share reimbursement program that involves both water quantity and water quality aspects. Currently, the FARMS program is available to growers in the Upper Myakka River, Shell Prairie Joshua Creek watersheds, and the eight county Southern Water Use Caution Area. For further information, contact SWFWMD or FDACS staff at 1-800-320-3503.

Clean Water Act State Revolving Fund Program (SRF): Established in 1989, the SRF is administered by the Florida Department of Environmental Protection. The Fund provides growers with low interest loans for BMPs associated with agricultural stormwater runoff pollution control activities. “Preconstruction loans” are available for the planning and engineering costs associated with activities prior to construction. Agricultural projects are also eligible for loans and loan amendments to finance the construction of pollution control practices that include technical services and the cost of equipment. Priority for funding favors small projects. For additional information, contact the Bureau of Water Facilities Funding at (850) 245-8358.

FDACS Field Offices Contact List

The Florida Department of Agriculture and Consumer Services, Office of Agricultural Water Policy (OAWP), has field staff strategically located throughout the state to assist growers with BMP programs. Many of these individuals are co-located in various offices within the five regional water management districts. The contact information appears below, and it can also be accessed via the Office of Agricultural Water Policy's web page which is www.floridaagwaterpolicy.com .

Location	FDACS Ag-Team Telephone Number
Northwest Florida Water Management District	850-482-9914
Suwannee River Water Management District	386-362-1001, ext. 3023
St. Johns River Water Management District	386-329-4812
Southwest Florida Water Management District	941-377-3722, ext. 6556
South Florida Water Management District	863-462-5881
OAWP Tallahassee Office	850-488-6249