THE UNIVERSITY OF GEORGIA
COOPERATIVE EXTENSION
Colleges of Agricultural and Environmental Sciences & Family and Consumer Sciences

Land Management

*GEORGIA FARM*A*SYST*

FARM ASSESSMENT SYSTEM

Managing Runoff and Erosion On Croplands and Pastures

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PRE-ASSESSMENT:

Why Should I Be Concerned?

Nonpoint source pollution can be defined as pollution from miscellaneous and scattered sources rather than a specific point. Since it is difficult to recognize and monitor, historically only pollution from point sources has been regulated. Today, we realize that nonpoint sources contribute as much or more of the pollutant load than point sources and must be managed as well. Often, the best method for preventing nonpoint source pollution is to reduce *runoff* and sediment resulting from rainfall on land areas we manage.

Runoff occurs when the rate of rainfall exceeds the rate that soil can absorb it (infiltration). Problems that may arise when too much rainfall runs off the land include increased drought stress to plants, productivity losses, flooding of low-lying areas, and increased soil erosion and transport of other pollutants. Cotton yields from eroded soils in Georgia can be as much as 50 percent less than yields form non-eroded fields. This problem is compounded by the fact that eroded soils will often require increased inputs to sustain desired yields.

Sediment transported to streams and lakes by runoff is the largest single pollutant of surface water. Sediment resulting from soil erosion causes considerable off-farm damage. Sediment can accumulate and fill in stream channels and lakes, disrupt aquatic reproduction and contribute to downstream flooding. It can also clog water filters, damage pumping equipment and shorten the economic life of reservoirs and farm ponds. While soil erosion is a natural process, the actions of man greatly affect the amount of soil eroded by wind and water.

How Does This Assessment Help Protect Drinking Water and the Environment?

- This assessment allows you to evaluate the environmental soundness of your practices relating to your management of croplands and pastures.
- You are encouraged to work through the entire document.
- The assessment asks a series of questions about your land management practices.
- The assessment evaluation uses your answers (rankings) to identify practices or structures that are at risk and should be modified to prevent pollution.
- The runoff and erosion facts provide an overview of sound environmental practices that may be used to prevent pollution.
- You are encouraged to develop an action plan based on your needs as identified by the assessment.
- Farm*A*Syst is a voluntary program.
- The assessment should be conducted by you for your use. If needed, a professional from the University of Georgia Cooperative Extension or one of the other partnership organizations can provide assistance in completing the assessment or action plan.
- No information from this assessment needs to leave your operation.

* *Italicized words are defined in the glossary.*

ASSESSMENT:
Assessing Your Land Management Practices

For each category listed on the left, read across to the right and circle the statement that best describes conditions on your farm. If a category does not apply (for example, you do not have pastures on your farm) then skip those questions. Once you have decided on the most appropriate answer, look above that description to find your rank number (4, 3, 2 or 1) and enter that number in the "RANK" column. The entire assessment should take less than 30 minutes. A glossary is on page 17 to clarify words found in italics throughout this assessment.

RUNOFF AND EROSION CONTROL					
	Low Risk (rank 4)	**Low-Mod Risk (rank 3)**	**Mod-High Risk (rank 2)**	**High Risk (rank 1)**	**Rank**
SITE CONDITIONS					
Land use	Soil is at least 50% covered with vegetation or residue during the entire year.	Soil is at least 50% covered with vegetation or residue most of the year or in forage system.	Annual crops are planted, but soil is never fallow more than 4 months.	Soil is fallow with little residue for periods more than 4 months.	
Soil structure	Open. Soil is very crumbly. No heavy clay layers. No signs of crusting or soil compaction.	Mostly open. Soil is crumbly and doesn't have clay layers that reduce infiltration. Very little soil crusting or compaction.	Slightly dense. Soil breaks into clods. Clay layers are beneath the soil surface. Some soil crusting or compaction.	Dense. Soil breaks into large clods or is difficult to penetrate. Crusting or soil compaction is common and requires tillage.	
Slope	Most slopes are less than 3%.	Most slopes range from 3% to 7% and steeper slope lengths are divided using BMP such as contours, terraces or vegetated waterways.	Some slopes are greater than 7% with some use of BMP.	Most slopes are greater than 7% with little or no use of BMP.	
WATER MANAGEMENT (CROPLAND AND PASTURE)					
Surface runoff (see list of BMP on page 9)	All surface runoff controlled using at least three BMP such as filter strips, vegetated waterways, strip crops or stream side buffer. No direct discharges into streams or unvegetated ditches.	Most surface runoff controlled using more than one BMP. Little runoff directly enters streams or unvegetated ditches.	Some surface runoff controlled using BMP. Less than half of runoff directly enters streams or unvegetated ditches.	Most runoff is not controlled.	
Sub-surface drainage	None used.	Some cropped area is drained using controlled drainage systems that do not impact water quality.	More than half of cropped area is drained, but drainage is controlled and not impacting water quality.	Most cropped area is drained and drainage is adversely impacting water quality.	

*****These conditions are in violation of state and/or federal law***

RUNOFF AND EROSION CONTROL					
	Low Risk (rank 4)	**Low-Mod Risk (rank 3)**	**Mod-High Risk (rank 2)**	**High Risk (rank 1)**	**Rank**
EROSION CONTROL (CROPLAND)					
***Rill* erosion**	No rills are evident in cropland throughout the year.	Rills occur in some years but erosion control plan is used for prevention in most areas.	Small rills are evident at the end of most growing seasons.	Rills that make tillage difficult occur most years.	
Crop rotation	All rotations include a different crop and winter cover each year, and at least one legume is in the rotations.	Crop rotation including a winter cover crop or significant residue is used each year.	Some crop rotation with limited fallow periods or a continuous cropping system with winter cover is used.	Continuous cropping of the same crop more than three years without winter cover or significant residue is used.	
Conservation tillage	Conservation tillage system in place and crops are always planted into at least 30% cover.	Conservation tillage used when possible. Most crops are planted into at least 30% cover.	Tillage or soil preparation in the spring. Less than 15% residue cover after planting.	Preparation in the fall. Less than 10% residue cover after planting.	
Cropping on sloping fields (do not answer for fields less than 3% slope)	Strip cropping used with forage or densely planted crop alternated with row crops planted on contour.	Contour tillage and planting with filter strips, waterways or terraces used to keep slope lengths short.	Contour tillage and planting is used.	Up and down slope tillage and planting is used.	
Critical or highly erodible areas	No areas in any field where erosion occurs regularly, all of these areas are grassed or removed from production.	Some highly erodible areas appear after large rainfall events, but most highly erodible areas are grassed.	Some spots erode in most years, but these discharge into other fields or grassed areas.	Several spots erode regularly every year.	
EROSION CONTROL (PASTURES AND HAYFIELDS)					
Pasture condition	Pastures maintained so forage height is usually greater than two inches. No visible bare spots.	Pastures maintained so forage height is usually greater than two inches. Few bare spots.	Pasture is usually maintained with forage height of less than two inches. Some bare spots.	Pasture is often trampled and dying. Many bare spots.	
Gully erosion	All former gully erosion sites are controlled with no gullies present.	Gully erosion sites are controlled and stabilized with vegetation or proper fill materials.	Gully erosion sites are somewhat controlled and not advancing.	Several gullies exist and appear to be growing each year.	
Livestock access to water	Livestock are fenced out of natural water bodies.	Livestock have access to natural water bodies at a few locations that have erosion control measures in plan.	Livestock have access to natural water bodies but alternate watering sources are available in upland areas.	Livestock have uncontrolled access to natural water bodies.	

***These conditions are in violation of state and/or federal law*

RUNOFF AND EROSION CONTROL					
	Low Risk (rank 4)	**Low-Mod Risk (rank 3)**	**Mod-High Risk (rank 2)**	**High Risk (rank 1)**	**Rank**
Animal traffic and feeding areas	All areas where animals congregate are either rotated so that vegetative cover remains year-round or covered.	Most areas where animals congregate are either rotated so that vegetative cover remains year-round or covered.	Areas where animals congregate are not vegetated for significant portions of the year or covered, but drain into vegetated areas and are greater than 100 feet from streams or ditches.	Areas where animal congregate are not vegetated for significant portions of the year or covered and are within 100 feet of streams or ditches.	
DEPOSITION OR OFF-SITE IMPACTS					
Color of water leaving fields after large storms	Clear.	A little cloudy, but it generally looks like water in the streams.	Somewhat cloudy and turbid.	Very cloudy or turbid.	
Deposited sediment	There are no areas in any streams, ditches or fields on the farm where sand or sediment is deposited regularly.	There are some areas near or in fields where sediment accumulates but this is not in a stream or ditch.	There are some spots in streams and ditches on the farm that seem to accumulate sediment.	Several streams or ditches on or downstream from the farm regularly accumulate large amounts of sand or sediment.	
OTHER SOURCES OF EROSION					
Stream banks	Little, if any, stream bank erosion occurring. Buffer strip greater than 25 feet in place on all banks.	Slight stream bank erosion occurring in limited places. Buffer strip of at least 25 feet is in place.	Some erosion occurring along stream banks. Most areas have some buffer strips.	Heavy stream bank erosion in some areas. Some parts of fields or pastures are lost each year.	
Buildings and roads	All buildings have gutters to collect roof water and route it to vegetated areas. Farm roads are paved, graveled or vegetated and do not appear to erode.	Some buildings do not have gutters but are surrounded by vegetated areas. Roads are regularly maintained to reduce erosion.	Uncollected roof water and/or road runoff create some erosion, but excess water from these areas is filtered through fields.	Uncollected roof water and/or road runoff create significant amounts of erosion that directly enter ditches or streams.	

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Number of Areas Ranked ______
(Number of questions answered, if all answered, should total 18)

Ranking Total _____
(Sum of all numbers in the "RANK" Column)

ASSESSMENT EVALUATION:

What Do I Do with These Rankings?

STEP 1: Identify Areas That Have Been Determined to be at Risk

Low risk practices (4s) are ideal and should be your goal. Low to moderate risk practices (3s) provide reasonable protection. Moderate to high risk practices (2s) provide inadequate protection in many circumstances. High risk practices (1s) are inadequate and pose a high risk for causing environmental, health, economic or regulatory problems.

High risk practices (rankings of "1") require immediate attention. Some may only require little effort to correct, while others could be major time commitments or costly to modify. These may require planning or prioritizing before you take action. All activities identified as "high risk" or "1s" should be listed in the recommended action plan. Rankings of "2s" should be examined in greater detail to determine the exact level of risk and attention given accordingly.

STEP 2: Determine Your *Runoff* and Erosion Risk Ranking

The Risk Ranking provides a general idea of how your practices and land use might be affecting ground and surface water, and degrading soil quality.

Use the Rankings Total and the Total Number of Areas Ranked as determined from the questionnaire portion of this assessment to determine the *Runoff* and Erosion Risk Ranking.

RANKINGS TOTAL ÷ TOTAL NUMBER OF AREAS RANKED = RUNOFF/EROSION RISK RANKING

__________ ÷ _______________ = ______________

EROSION RISK RANKING	LEVEL OF RISK
3.6 to 4	Low Risk
2.6 to 3.5	Low to Moderate Risk
1.6 to 2.5	Moderate Risk
1.0 to 1.5	High Risk

This ranking gives you an idea of how your practices and land use might be affecting water and quality. This ranking should serve only as a very general guide, and not as a precise diagnosis since it represents the average of many individual rankings.

STEP 3: Read the Information Section on Reducing Runoff and Erosion

While reading this, give some thought to how you could modify your practices to address your moderate and high-risk areas. If you have any questions that are not addressed in the following portion of this assessment, consult the references in the back of this publication or contact your county Extension agent for more information.

STEP 4: Transfer Information to Total Farm Assessment

If you are completing this assessment as part of a "Total Farm Assessment," you should also transfer your Runoff and Erosion Risk Ranking and your identified high-risk practices to the total farm assessment.

RUNOFF AND EROSION FACTS:

Keys to Reducing Runoff and Soil Erosion

The Nature of Erosion

To reduce soil erosion, understanding the processes and factors that impact soil erosion is required. The impact of a raindrop on the soil surface is like a small explosion sending soil particles in all directions. Once detached, these particles are easily transported by water flowing over the soil surface in a process called sheet erosion. Sheet erosion is not noticeable from looking at water ponding on the soil or from investigating the field after a rainfall, but it does move large amounts of soil.

Where sheet erosion progresses downslope within a field, water concentrates in lower areas forming small, parallel, well-defined channels called rills. Rills may occur in wheel tracks or between plant beds. While soil is primarily detached by raindrop impact, water flowing over a soil surface can also detach soil particles. For example, *rill* erosion can often be seen on the steep side of bedded rows. Soil that erodes from the bed may only move into the row middle and accumulate there or, if enough water is flowing down the row middle, it may advance to the lower end of the rows, resulting in soil loss from the field.

Gullies are not common on poorly drained flat soils but are evident in every cropped area of the state. The difference between large rills and gullies is that gullies cannot be removed with normal tillage. Farming gullies is costly and dangerous. Gullies form in areas of concentrated flow. They may begin from “dead” plow furrows or water concentrating at outlets of drain furrows or well tracks. This natural pattern of erosion development will continue unless preventative measures are taken before rills are established.

The final form of erosion is stream bank or channel erosion. These processes occur in streams and rivers and move large quantities of sediment downstream. Protecting river and stream banks is very important in preventing this form of erosion. It is important to note that as erosion progresses from sheet to rills, gullies, and streams, the cost of controlling it increases. Often, it costs much less to plant a cover crop or use another *Best Management Practice (BMP)* to control sheet erosion than it would to design and install a water control structure to correct a gullied area or eroding stream bank.

The amount of soil erosion that occurs at a given site is related to five factors:

- Rainfall *erosivity* which is a function of rainfall amount and intensity,
- Soil *erodibility* which is a function of the soil type,
- Slope length and steepness
- Cropping and management of the soil, and
- Any support practices that are implemented.

The amount of rainfall a site receives is primarily a function of geography and is not really affected by agricultural production practices. However, by implementing selected management practices, one can reduce the impact of the rainfall. While the total amount of rainfall a site receives is important, studies show that rainfall energy and distribution have a greater impact on soil erosion. For example, large drops may increase sediment load in *runoff* up to 12 times more than small drops in light rain. Time over which rainfall occurs is also important. An inch of rain in 15 minutes will cause much more *runoff* and sediment loss than an inch spread over three days because more of the rainfall goes into the soil.

Knowledge of rainfall patterns will also allow farmers to insure that soil is protected during the periods when it is prone to large rainfall events. Figure 1 (on the next page) is generally typical of rainfall patterns in Georgia. It shows that rainfall amounts are distributed uniformly throughout the year; however, summer’s rains are usually more intense and create a greater risk of *runoff* and soil loss.

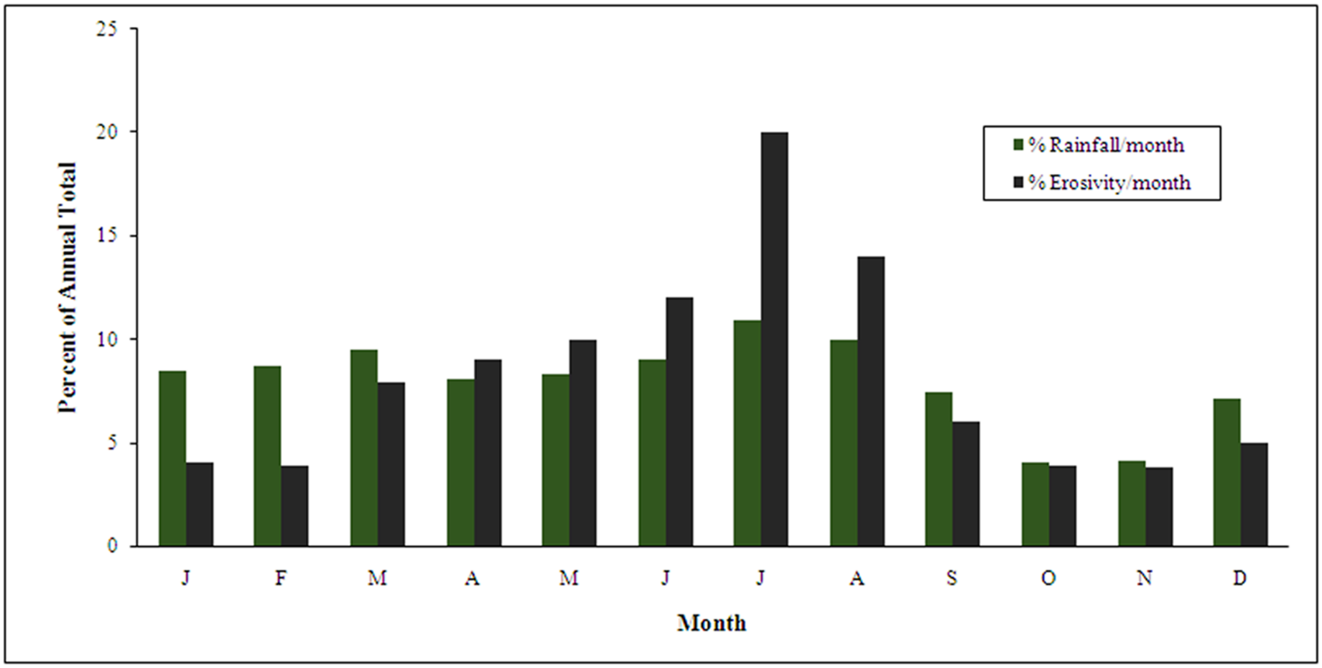

Figure 1. Graph showing the distribution of rainfall and *erosivity* of that rainfall in Douglas, Georgia.

Site Conditions

Cropping and management have a dramatic effect on soil erosion. Land use can impact soil erosion in two ways. First, a vegetative cover increases the amount of water that enters the soil (infiltration) and therefore decreases runoff. Woods and permanent grass and sod areas absorb more rainfall than other land uses. The infiltration is proportionately less based on the cropping practices (see Table 1). Note that under row crop conditions we would expect five to 10 times more runoff and up to 300 times more soil loss than under forested conditions. Second, crop canopy and surface cover or residue act as a buffer between the soil surface and raindrops, absorbing much of the rainfall energy and ultimately reducing soil erosion. Therefore, crops that produce more vegetative cover, have longer growing seasons or produce more residues will generate less soil erosion. Management is also important as tillage can reduce surface cover and residue. No-till and *conservation tillage* systems are effective in maintaining surface cover and reducing soil erosion. Any cropping system that requires less tillage or greater amounts of biomass production, such as perennial systems, will result in less sediment leaving the field.

Soil Structure

Soil type will determine its vulnerability to erosion. Properties affecting soil *erodibility* are texture, structure, organic matter, and the ability to absorb water. Soil containing high percentages of fine sands and silt are normally the most erodible. As clay and organic matter content increases, *erodibility* decreases. While clay acts as a binder or "glue" to reduce erosion, once eroded, clay particles are easily transported off site. Organic matter can also bind soil particles, making them more resistant to erosion. The organic matter of a given soil can be built up over time to produce improved soil structure that will result in less erosion.

Infiltration rate of a soil determines runoff amount and corresponding erosion. In general, sandy soils can absorb from 0.50 to greater than 2.0 inches of rainfall per hour while most clay soils can only absorb 0.50 inches per hour or less. In addition, rainfall may cause soil "*crusting*" on freshly prepared seedbeds. Soil particles tend to seal soil pores and reduce infiltration. When this happens, only a small part of the rain soaks in and the rest runs off the field. This may increase irrigation demands. Irrigation water may also run off the field under this condition. This may require another irrigation soon to avoid crop stress, thus increasing the cost of production. *Compaction* can further reduce infiltration, resulting in even greater soil erosion.

Table 1. Runoff and Erosion Rates
(based on the land use or cover as a ratio of runoff expected in permanent grass or forest areas)

	Runoff Ratio	Erosion Ratio
Perennial Grass or Forest	1.0	1.0
Pastures	1.5 - 4.0	1.3 - 8.0
Small Grains	3.3 - 5.0	10.0 - 120.0
Conservation Tilled Crops	2.5 - 5.0	20.0 - 150.0
Row Crops with Tillage	5.0 - 10.0	60.0 - 30.0

Slope and Slope Lengths

Historically, reducing slope steepness and length have been the primary means of erosion control. Since the dawn of agriculture, man has known that longer and steeper slopes produce more soil erosion and has used methods such as the construction of levies and terraces to reduce slope length and steepness. More recently, practices such as strip cropping and vegetated waterway construction have been used to reduce runoff velocities and effective slope length. The main reason longer and steeper slopes produce more erosion is that the water flowing downhill accumulates energy that dislodges and transports more soil particles. Methods that can slow the flow velocity or reduce the amount of water flowing over the surface will also reduce soil erosion.

Soil loss can also be reduced using cultural practices such as contouring, strip cropping and constructing of terraces. As runoff and accompanying sediment leaves fields, it constantly moves over different surfaces where the rate and volume of movement are affected. Any time this movement is slowed, it causes sediment to be dropped out or deposited along the water course. Heavy vegetation, flatter slopes, depressions, swamps, wetlands, ponds and sediment retention structures all cause sediment deposition and prevent water quality degradation. Terraces are engineered structures designed to reduce effective slope and slope length by dividing a long slope into a series of smaller steps. The less sloping land that is created increases infiltration and reduces flow velocities and concentrations by routing excess water across the slope rather than down the slope. While terraces are expensive to establish and maintain and remove area from production, they are highly effective at reducing erosion. They have been used for thousands of years and are especially effective on steep slopes. Contact your NRCS or county extension agent for more information on establishing terraces.

Water Management

Runoff is the portion of precipitation that makes its way toward streams, channels, lakes or oceans, and is the primary cause of water pollution. Therefore, it is important to understand how it is created and which factors influence a reduction in erosion caused by runoff.

Before runoff can occur, rainfall must satisfy the demands of evaporation, infiltration and surface or plant storage. Runoff will only occur when the rainfall rate exceeds the rate of infiltration. After the infiltration rate is met, water begins to fill soil surface depressions. As depressions are filled, runoff begins. Often, tillage can be used to increase infiltration and roughness of a soil surface, resulting in less runoff; however, soil *crusting* that occurs during the first few rainfall events negates the benefits. A better approach is to increase the roughness and infiltration rate using crop residues and organic matter additions, as these practices result in long-term benefits.

Table 2. Best Management Practices for Controlling Runoff and Erosion

BMP	Description	Cost Install/Maintain	Mode of Action
Buffer Zone	Undisturbed or planted vegetative strip around a site or bordering a stream.	Med/Low	Filters/removes sediment and stabilizes banks.
Check Dam	Small temporary barrier constructed across a swale, drainage ditch or area of concentrated flow.	Med/Med	Short-term measure. Reduces low velocity, deposition of sediment.
Conservation Tillage	Planting and cultivating crops with less tillage to maintain at least 30% residue cover on the surface.	Med/Low	Increases infiltration and soil quality and protects soil from raindrop impact.
Contour Farming	Planting across the slope rather than up and down the slope.	Low/Low	Increase infiltration and reduces flow velocities.
Cover Crops and Crop Rotation	Planting crops in the winter or sequences of crops resulting in more soil coverage.	Low/Low	Improves soil quality and reduces periods of soil exposure to rain.
Critical Area Planting	Removing highly erodible areas from production by planting them to permanent cover.	Med/Low	Stabilizes highly erodible areas.
Filter Strips	Strips of grass planted around a site or bordering a stream.	Med/Low	Filters sediment from runoff.
Diversion	Ridge of soil constructed above, across or below a slope.	Med/Low	Reduces slope lengths. Routes runoff to stable outlets.
Level Spreader	Outlet device constructed across the slope where concentrated runoff is discharged at low velocity into vegetated areas.	High/Med	Converts concentrated runoff into sheet flow that can infiltrate the soil or be filtered.
Sediment Barrier	Temporary structure made of silt fence, sand bags, straw bales or other filtering material.	Low/Med	Converts concentrated runoff into sheet flow that can infiltrate the soil or be filtered.
Sediment Basin	Basin or pond created to collect sediment.	High/Med	Holds runoff temporarily to trap sediment.
Strip-cropping	Planting alternating strips of crops and small grains or forage across the slope.	Low/Low	Forage or grain strips are used to filter sediment from runoff from the cropped area.
Stream Bank Stabilization	Use of readily available plant materials to prevent, restore, maintain or enhance stream banks.	High/Low	Filters/removes sediment and stabilizes banks.
Terracing	Earthen embankment constructed across the slope to collect runoff.	High/Low	Reduces slope length and flow concentration.
Vegetated Waterway	Waterway that is shaped or graded and stabilized with vegetation.	High/Med	Removes runoff on stabilized surface.

Surface Runoff and BMP's

Best Management Practices (BMPs) refer to a combination of practices determined to be effective and economical approaches to preventing or reducing pollution generated by nonpoint sources. BMPs can be structural, as in the construction of terraces, dams, ponds or fencing, or they can be cultural, like crop rotation, nutrient management and *conservation tillage*. Both types of BMPs require good management to be effective in reducing the generation or delivery of pollutants from agricultural activities. Preventive practices such as these are the most practical approaches to reducing nonpoint source pollution.

While most BMPs for erosion control use one of the factors discussed above to reduce erosion, some BMPs use other mechanisms to reduce the impact of a pollutant. To become a pollutant, the soil must be detached and transported to a water body. For example, using a small pond to collect sediment before entering a stream is an example of reducing pollutant transport.

When selecting BMPs, a systematic approach should be used to ensure that the selected practice will solve the problem. The most effective plan will probably consist of several different BMPs that target different mechanisms. Finally, if a BMP is not economically feasible and well suited for the site, it should not be selected. Consider all costs, including effects on yield, production and machinery costs, labor and maintenance, and field conditions. Often, effective BMPs will become a problem if all costs are not considered before implementation. The list of BMPs in Table 2 should be helpful in devising a plan to reduce soil erosion. Many of these BMPs are discussed in more detail in later sections. More information on design and use can be obtained through any of the Farm*A*Syst support agencies. In addition, the Georgia Soil and Water Conservation Commission has a great resource on many agricultural BMPs on the web at http://www.gaswcc.org/docs/ag_bmp_Manual.pdf.

Even with the best BMPs, some surface runoff will occur. Since all water flows downhill, the total amount of surface runoff going past a given point will increase as you move downhill. As runoff concentrates in rills and gullies, its erosive force and ability to transport pollutants continues to increase. Often structural practices such as terraces, diversions, grassed waterways, sediment basins, subsurface drainage or even farm ponds can be used to control the flow of water and protect water quality. While these practices are often costly to install, they usually have production and aesthetic benefits in addition to their environmental benefits.

A grassed waterway is a natural or constructed channel, usually broad and shallow, planted with perennial grasses or legumes to protect soils from erosion by concentrated flow. These waterways serve as conduits for transporting excess rainfall and diverted runoff from fields or pastures without excessive soil erosion. The vegetation also acts as a filter to remove suspended sediment and some nutrients. Grassed waterways require careful maintenance and periodic reshaping, especially after large or intense storms. Performing maintenance regularly is important. Concentrated flow conditions can lead to rapid gully formation if minor washouts are left unchecked. If you have certain areas that seem to erode almost every year, you should definitely consider converting these to grassed waterways.

Use of sediment basins or small farm ponds is another important way of preventing off-farm pollution. A sediment basin is a barrier or dam constructed across a waterway to reduce runoff velocity causing sediment deposition. Small sediment basins require regular sediment removal while larger basins can almost appear to be a pond and may support fish and wildlife. A well-placed pond can collect all farm runoff and have a positive impact on water quality. It acts as a detention basin by removing sediment and nutrients from the flow and reducing the volumes of flow occurring at peak conditions. It can also filter many nutrients if aquatic vegetation or fish are used. Finally, ponds can act as a buffer between the farm and the external environment.

Subsurface Drainage

Georgia's water quality benefits from the fact that most crop production areas do not require a high degree of subsurface drainage. Subsurface drainage systems usually consist of perforated piping used to artificially lower the water table and dry out soils that normally are wet. While the benefits of subsurface drainage are substantial on soils that have poor natural drainage, these systems do put water quality at risk. Since they rapidly drain shallow groundwater and usually discharge it as concentrated flow, any pollutants in shallow groundwater, such as nutrients or pesticides, bypass normal filtering processes that occur in soil. If you do have subsurface drainage, then it is important for you to know the quality of water that you are draining. Also, it is more important for you to use proper amounts of nutrients and pesticides since over-applications will probably result in elevated levels in drainage system discharge. Recent research indicates that *controlled drainage systems* (systems where drain water is held in ditches over the winter) improve water quality and crop production. Discharge pipes or ditches must also be designed in a manner that does not result in increased stream bank erosion.

Erosion Control (CropLand)

Erosion processes and BMPs for improving water quality were discussed previously. These questions refer to specific practices that have proven effective at reducing soil erosion in Georgia.

Rill Erosion

Rills are defined as parallel shallow channels resulting from concentrated flow of runoff water. They are like small gullies; however, rills can be removed through normal tillage operations. It is important to recognize *rill* formation because they are a "telltale" sign of significant sediment loss and will grow into gullies if left unchecked. They are most noticeable at the end of the growing season since they develop over time between tillage operations. Studies have shown that productivity is reduced in areas that are prone to *rill* erosion. While tillage can remove rills, they will often erode again unless other BMPs are used to prevent upslope runoff. Simple monitoring of your fields during the growing season will help you recognize where rills are regularly occurring and may help you develop strategies for addressing problem areas.

Crop Rotation

Cropping practices and rotations have a dramatic effect on soil quality, runoff and erosion, and nutrient and pesticide loss. By simply changing practices or crop sequence, you can substantially reduce erosion and improve productivity. Crop rotations involve a planned sequence of changing crops grown on a particular field. A typical rotation often involves a year or two of high-value crops such as peanuts, corn or cotton followed by a grass or *legume* such as soybeans, small grains or hay. Crop rotations not only reduce erosion by improving soil properties, but they also provide increased cover during certain times within the growing season to lower the overall erosion rate. In addition, rotations can be used to reduce or control nematodes, insects and diseases. Including a non-host crop in the rotation can prevent the buildup of certain pests associated with continuous crop production, resulting in less pesticide use. Finally, when legumes are used in a rotation, nitrogen formed by fixation can reduce the amount of nitrogen supplement required for the subsequent crop. This is a great example of a BMP that makes both economic and environmental sense.

Cover crops are often used to protect the soil surface during the winter and early spring. Besides being an effective and economical BMP, *cover crops* will also improve soil quality over time if tillage is also reduced. Most croplands are only used 50 to 75 percent of the year for production of a winter and/or summer crop. The remainder of the time, croplands lie idle. In addition to controlling erosion by blanketing the soil, when tillage is reduced, *cover crops* can also add organic matter, thus increasing soil quality and holding the soil in place. Legumes, grasses and grains commonly grown as *cover crops* in Georgia include crimson clover, winter rye and wheat.

Conservation Tillage

Soil disturbance or tillage is the primary reason that agricultural fields produce more erosion than other land uses. It exposes the soil surface to rainfall that detaches soil particles, increases soil *crusting* that causes greater runoff, and decreases vegetation at the soil surface. In addition, soil *compaction* from tillage causes substantial reductions in productivity.

Many Georgia row crops can be produced using *conservation tillage,* which is generally considered the most effective single practice for reducing erosion and sediment transport. *Conservation tillage* is a means of planting and culturing crops with minimum soil disturbance. It can include no-till, strip till, ridge till and mulch till systems. In *conservation tillage*, at least 30 percent of the soil surface is covered with a cover crop or crop residue immediately after planting. Crop residues, including old plant stalks and leaves, dissipate rainfall energy and protect the soil surface from water and wind erosion. It also creates a rougher soil surface that reduces flow velocities and increases surface storage and infiltration. The amount of tillage needed with *conservation tillage* varies with soil type and crop. The key in conservation tillage systems is obtaining a suitable growing environment that is weed-free and non-compacted without burying large amounts of residue beneath the soil surface. New equipment for tillage and planting has been extremely helpful. In-row subsoilers are especially valuable for summer crops like soybeans, cotton and corn in Georgia.

The most common approach to *conservation tillage* in Georgia is to grow a winter small grain, harvest it, spread the residue and then use special *conservation tillage* planters to plant directly into the small grain residue. *Conservation tillage* has been shown to reduce surface soil temperature by as much as 30 degrees Fahrenheit and runoff by as much as 95 percent over that of conventional tillage. On average, *conservation tillage* reduces soil loss by 50 to 95 percent. Actual amounts are often directly related to the amount of residue left on the soil surface.

Although research results have shown that *conservation tillage* in Georgia can increase yields, most farmers feel the compacted clay layers beneath their fields must be broken by some type of plowing. While yields may decline during the initial season, natural processes such as insect, animal and worm activity and the accumulation of organic matter will begin to negate the effects of compacted clay layers. Studies have indicated that *conservation tillage* yields can be greater than conventional tillage. There are several farmer-led *conservation tillage* groups established in Georgia and these will often be your best source of information on these technologies.

Cropping on Sloping Land

Farming steep slopes creates a higher risk of soil erosion as surface storage and infiltration is reduced and runoff is more likely to concentrate and form rills or gullies. There are several BMPs that should be used if you are planting on steeper slopes.

Contour farming allows crops to be cultivated across the slope rather than up and down the slope. It reduces soil erosion and increases infiltration by providing hundreds of small dams or ridges. This diverts flow and slows runoff to prevent soil erosion. Contouring requires little management or investment and is often easy to implement. Soil loss reductions can range from 30 to 80 percent. Tilling with the contour or cross-slope is easier with chisel plows or offset discs than with a moldboard plow.

Strip cropping alternates strips of small grain crops or grasses with strips of row crops contoured to the land. The small grain or forage acts as a filter strip that slows runoff, increases infiltration and traps sediment, while ridges formed by contoured rows dam water flow and reduce erosion. Although this BMP requires slightly more management and labor, it is highly effective in fields that are susceptible to soil erosion. This also offers the advantage of creating a crop rotation that will include high-value crops each year.

Terraces and diversions can also be used on steep or long slopes. A terrace is an earthen embankment or ridge and channel constructed across the slope to reduce sediment in runoff water. A diversion or "hillside ditch" is a channel with a supporting ridge on the lower side constructed across the slope to divert water and control runoff. Both of these practices are helpful because they slow down the runoff by encouraging flow across the hillside rather than down the steeper hill slope. Both practices are usually used in conjunction with ditches or grass waterways to carry runoff to the field outlet or a natural waterway within the field.

Critical or Highly Erodible Areas

Critical areas are those sensitive to water quality problems or areas that cannot usually be stabilized by ordinary conservation treatment and if left unmanaged can cause severe erosion problems. Examples of critical areas susceptible to erosion include hillsides, dikes, levees, cuts, fills, and denuded or gullied areas where vegetation is difficult to establish. Theses areas will become recurring problems spots if they are put into pasture or crop land. Areas in the immediate vicinity of wellheads should be left out of production to insure that pollutants do not enter drinking water. All streams, rivers, lakes, ponds, and other water bodies in Georgia are more sensitive to environmental pollutants than the land that surrounds them. By managing the area around these water bodies more intensively, many conditions that may lead to surface or groundwater contamination can be prevented.

The area immediately surrounding a stream or lake can also be used to remove sediment or nutrients from runoff or shallow groundwater before it reaches areas where it becomes a pollutant. Filter strips are grass, shrubs or other close-growing vegetation intended to remove sediment or pollutants from runoff. They are normally planted in an area where water will pass over them as sheet flow. The vegetation slows the water, allowing solids to settle out and become trapped in the vegetation. Filter strips have been found to reduce sediment, nitrogen, phosphorus and other pollutants, and can be effective around feedlots, tilled fields, pastures and any other pollutant sources.

Vegetative buffer strips established along the edge of a waterway can stabilize fragile banks suffering from erosion and prevent streams or drainage ditches from being filled with sediment. Waterway surroundings and ditch banks are susceptible to degradation and erosion if not properly protected from agricultural practices and adverse seasonal conditions. Grassed cover protects the soil and holds the banks, which helps to prevent soil accumulation within the watercourse. Wooded strips are known to retain up to 90 percent of the sediment from agricultural land.

Other benefits of vegetative buffer strips include the following:

- Stabilizes watercourse banks,
- Provides a sediment filter or barrier to surface water flow,
- Prevents water warming (a benefit for fish and aquatic life),
- Filters nutrients from agricultural land and prevents them from reaching groundwater or waterways,
- Creates habitats for wildlife,
- Provides a natural windbreak, depending on the vegetative species utilized, and
- Increases land value.

In Georgia, several programs are available to assist you in establishing vegetative buffers. For example, the Conservation Reserve Program (CRP) will provide you with cost sharing and rental payments for acreage that you use to protect water quality. Contact NRCS or FSA for more information on these programs.

Erosion Control (Pastures or Hayfields)

Although areas used for pasture and forage production have a low potential for pollution due to an abundance of soil cover and relatively low amounts of chemical and nutrient input, if improperly managed they can contribute significant amounts of nonpoint source contamination. Grasslands or pastures are essential to almost any livestock operation. They provide nutrition for livestock and food and cover for wildlife. Well-managed grasslands protect valuable soil resources and improve water quality. The fibrous root systems of healthy grasses hold soil in place, preventing erosion and off-site contamination.

Pasture Condition

Keys to maintaining adequate and sustainable pastures must be recognized. Plant selection is critical. The plant must be adapted to both the soil and climate to ensure adequate cover throughout the year. Determining proper *stocking rates* that will not damage the vegetative cover and result in increased soil erosion is also essential. Controlling animal traffic can help to prevent bare spots that could lead to the formation of rills and gullies. Weeds may be a problem in some pastures; however, proper grazing management and fertilization should reduce weed problems. When pasture renovation becomes necessary, no-till or other *conservation tillage* practices that minimize erosion should be used.

Properly designed rotational grazing systems may improve pastures and often increase productivity. Long-term persistence of forage species is increased when proper grazing heights are used to manage cattle access to a pasture. Proper grazing heights vary by forage species with creeping species sustaining closer grazing than upright bunch-type species. Once defoliated, forages need time to accumulate energy reserves and initiate new growth before being grazed again. When management allows a rest period, by either stocking method or grazing pressure, pasture plants tend to maintain more vigorous growth. *Stocking rates* on pastures should be low enough to maintain a minimum plant cover. While this varies with plant species, usually heights of 3 to 4 inches are recommended. Continuous, close grazing may weaken the stand, exposing the soil surface to sunlight and eroding forces of rainfall, allowing the opportunity for weeds to invade.

Gully Erosion

Since pastures usually have adequate cover in Georgia, gullies are a prime source of sediment in most systems. It is essential to understand how excess water is drained from fields and pastures. Often this can be observed following large rainstorms. Find locations where runoff concentrates and watch these areas for *rill* development. If rilling occurs, these areas should be smoothed and stabilized with vegetative cover before gullies are formed. It is often more expensive to repair gullies than prevent them. If gullies are advancing, they cause water quality problems and represent a loss in productivity since valuable land is being washed downstream. While using fill dirt and re-establishing vegetation on these areas can be used to reclaim some gullies, often BMPs such as drop spillways, diversions, vegetated waterways or other flow control structures will be required. One final word of caution: Gullies should not be used as farm dumps. Remember, the gully was formed by large amounts of water washing over the area. Whatever is put in this area may be washed further downstream.

Livestock Access to Water

Animal access to surface waters also represents a possible source of water contamination. Manure deposited directly in or adjacent to streams pollute the water, but the livestock also reduce streamside vegetation by foraging or trampling and disturbing sediment on the stream bank and bed. This increases erosion and decreases the buffering capacity of the streamside vegetation. Stream and waterway protection can be accomplished by limiting livestock access and stabilizing stream banks. Livestock exclusion is the use of fencing or other barriers to prevent cattle from having access to streams, rivers and lakes. This BMP eliminates manure and sediment deposited directly in the stream from animals and establishes a "buffer" zone.

Vegetation established along the edges of the stream buffers the banks from channel erosion as well as the erosion caused by animal traffic. The main drawbacks of livestock exclusion are the removal of land, water and shade from the pastured area, and the costs associated with establishing and maintaining fences.

An alternative to building fences for total exclusion of livestock is the development of alternate watering facilities. Research has shown improvements in water quality by simply supplying a watering tank or trough at selected locations away from the stream or water body. When given a choice, cattle will usually drink from the closest source of water. Therefore, alternate water sources reduce the total amount of time cattle spend in the water and traveling to and from the water. One study showed that stream bank erosion was reduced by 77 percent and concentrations of other pollutants were reduced by 90 percent due to an off-stream watering source. In other words, off-stream watering sources were clearly an effective BMP. Also, offering livestock a clean, alternate watering facility reduces the risk of transmitting disease organisms.

If cattle must have access to pastures on both sides of a stream, *stream crossings* should be constructed. *Stream crossings* can either function as a bridge using a culvert or fencing to prevent cattle access to the water. Also, they can simply reinforce areas with low slopes that make it easier for cattle to get up and down the banks without creating erosion problems. *Stream crossings* have recently been constructed using geotextile fabrics and packed stone. These crossing may go unnoticed to most people, but can have a significant impact on water quality protection.

Animal Traffic and Feeding Areas

When livestock congregate around supplemental feeding areas, mineral feeders and water troughs, these *heavy use area*s pose both environmental and production challenges. Livestock waste accumulation, loss of vegetation, reduced drainage and increased soil erosion are all reasons to properly manage these areas. The amount of animal waste accumulation in an area is determined by the number of animals and amount of time the animals are there. Trampling effects in high traffic areas can result in loss of vegetation, reduced drainage, soil erosion and mud holes. In combination, these factors threaten animal health and soil and water resources. Additionally, muddy areas around commonly used supplemental feeding and watering sites are a management nuisance to producers. Unmanaged heavy use areas are particularly evident during winter months when saturated soil conditions exist.

Mineral feeders, hay rings, water supplies, lick tanks and other supplements should be spaced out individually in the pasture to avoid creating single multi-use areas frequented by livestock. Site selection criteria should include drainage and proximity to wells and surface water. Resource rotation and attention to placement is an effective and inexpensive way to minimize negative environmental impacts, decrease pasture degradation, and prevent large commonly used loafing areas.

A practice known as *heavy use area protection* stabilizes areas that are frequently used by livestock. Heavy use area protection should be considered around water troughs, hay rings, mineral feeders and livestock lanes. *Heavy use areas* are typically protected by (1) grading and leveling the area to provide for drainage and prevent ponding of water, (2) removing undesirable materials to design specifications, (3) placing geotextile over the treatment area, and (4) spreading graded aggregate base (GAB) stone to a minimum depth of 6 inches over the treatment area. Including grading, materials and installation, the approximate cost for *heavy use area protection* is $1 to $1.25 per square foot. Once installed, these areas should be maintained by routine inspection scraping, proper redistribution of animal wastes and additions of crusher run stone, as needed.

Deposition or Off-site Impacts

Deposited sediment and murky or turbid water running off your fields are indications that erosion is occurring in upslope areas. These indicators should be used to measure the impact that your upland BMPs are having and improve your practices when necessary.

Color of Water Leaving Fields After Large Storms

Sediment concentrations in rivers and streams range from 100 to 50,000 parts per million (ppm) with occasional concentrations as high as 500,000 ppm. Sediment carried within flowing water is often measured as “suspended solids.” Since heavier soil particles settle out of water quicker than light particles, large sand particles are often deposited as soon as they enter a river or stream. Small particles such as silt and clay are often carried much further downstream until the flow reaches a lake or pond. Turbidity, a measure of the light that can pass through water, is an indirect measure of sediment since suspended solids often make the water appear cloudy. While both turbidity and suspended solids affect the aesthetic quality of water, neither have a direct impact on human or animal health. If your water is running red or cloudy in north Georgia and murky in south Georgia, then it is probably carrying significant amounts of your topsoil off of your property.

Deposited Sediment

Like turbidity, deposited sediment indicates that soil erosion is occurring upslope. Since heavier particles settle first and since sand does not hold much water, these areas of deposition may look like sandy areas in a field and are usually less productive. Another problem is that the sand is being removed from more productive areas of the field and leaving denser, often clayey subsoil that is also less productive. This is how soil erosion, in general, lowers your overall soil quality and negatively impacts your production. While deposition indicates that a least some particles are not leaving your farm and affecting downstream water quality, it also indicates that more upslope erosion control may be required to sustain productivity.

Other Sources of Erosion

The goal of this assessment is to address erosion on croplands and pastures; however, no discussion of erosion is complete without at least mentioning a couple of other major sources of soil erosion.

Stream Banks

Stream channels and banks should be protected to reduce erosion. Often this can be accomplished using vegetation; however, at times structural measures such as rock riprap may need to be used. Generally, livestock should never have unlimited access to any body of water, but when necessary the areas should have dense vegetation, smooth stable slopes and firm surfaces. If your farm has areas where stream banks are nearly vertical or the land is occasionally sloughing off into the stream, you may want to contact the NRCS or State Soil and Water Conservation Commission for some assistance in stabilizing these banks.

Buildings and Roads

Another common area for excessive soil erosion is around buildings and along roads. Most agricultural buildings do not have gutters to collect and distribute rainwater from the roof. This often results in the development of a ledge of soil directly beneath the roof edge. Soil loss in this area can be substantial. For example, if the soil drop-off on a ledge averages about 1 foot, then on a typical poultry house (500 ft long), more than 40 tons of soil have been displaced or lost. Displaced soil may be in downslope pastures and fields or in drainage ditches and streams. On some buildings, this could also lead to structural failure as the building foundation is exposed and undercut. The best methods for controlling this type of erosion are to either use gutters to collect roof water and divert it to vegetated areas or to place a 2- to 3-foot-wide strip of gravel around the perimeter of the building.

Roads and traffic areas can also be sources of large amounts of sediment. Generally, areas that are going to support vehicular traffic should be paved or graveled. Not only will this reduce erosion, but it should also increase vehicle life and save time. Roads should be located in well-drained areas and be crowned to shed water. Ideally, runoff along farm roads should be diverted into vegetated fields rather than collected in roadside ditches. If ditches are used, then water control structures should be used to ensure that discharge is not creating erosion problems.

GLOSSARY:

Best Management Practices (BMPs): A combination of practices determined to be effective economical approaches to preventing or reducing pollution generated by nonpoint sources.

Conservation Tillage: Tillage that reduces crop residue incorporated into soil. Conservation tillage leaves 30 percent or more of the soil surface covered with residue immediately after planting.

Contour Tillage and Planting: Crop rows are planted following the slope of the land.

Compaction: Packing of the soil, reducing pore space. Compaction is usually caused by heavy equipment and is best controlled by limiting traffic and unnecessary vehicle weight.

Controlled Drainage Systems: Subsurface drainage systems that retain drained water in drainage ditches or other impoundments for further natural treatment processes during certain periods of the year.

Cover Crops: A crop grown in rotation with regular crops, primarily for ground cover rather than harvest.

Crusting: Formation of a less permeable surface layer of soil that limits infiltration.

Erodibility: Susceptibility of a soil to erosion.

Erosivity: Erosive potential of rainfall; it takes into account both total amount and intensity of rainfall.

Heavy Use Area: An area frequented by livestock and in which animals tend to linger and congregate, such as areas used to provide supplemental feed, minerals, and water. Heavy use areas are protected by establishing vegetative cover, surfacing with suitable materials or installing needed structures.

Legume: Plant species that fixes nitrogen.

Perennials: Plants that grow again each year from plants grown the previous year.

Rill: An area where overland flow has concentrated and begun to cut into the soil surface. By definition, a rill is the stage before gully formation and can be removed through normal tillage practices.

Runoff: Water that has not moved into the soil but moves across the soil or another surface.

Stocking Rate: Number of animals grazed per unit area, for example, animals per acre.

Stream Crossing: A trail or travel way constructed across a stream to allow livestock or equipment to cross with minimal disturbance to the stream and aquatic environment.

ACTION PLAN:

An action plan is a tool that allows you to take the needed steps to modify the areas of concern as identified by your assessment. The outline provided below is a basic guide for developing an action plan. Feel free to expand your plan if you feel the need for detail or additional areas not included. Consult the list of references at the end of this publication if additional assistance is needed to develop a detailed action plan.

Area of Concern	Risk Ranking	Planned Action to Address Concern	Time Frame	Estimated Cost

REFERENCES:

CONTACTS AND REFERENCES			
Organization	**Responsibilities**	**Address**	**Phone Number**
Agricultural Pollution Prevention (AgP2)	Questions regarding pollution prevention practices that can save you money.	BAE Department, UGA Driftmier Engineering Center Athens, GA 30602	706-542-9067
County Extension-UGA	Information about management of crops, pastures and livestock.	Local County Extension Office	Check your local telephone directory blue pages under "County Government."
Georgia Conservation Tillage Alliance	Technical assistance regarding conservation tillage.	Local alliances throughout the State	706-542-8084
Georgia Environmental Protection Division	Nonpoint source pollution and water quality.	4220 International Pkwy. Suite 101 Atlanta, GA 30603	404-675-6420
Georgia Soil and Water Conservation Commission	Best Management Practices and implementation of erosion and sediment control activities in Georgia.	4310 Lexington Road P.O. Box 8024 Athens, GA 30603	706-542-3065
USDA-Natural Resource Conservation Service	Technical assistance and federal cost share programs on conservation practices.	Local county or multi-county field office	Check your local telephone directory blue pages under "U.S. Government."

PUBLICATIONS:

State Soil and Water Conservation Commission
P.O. Box 8024
Athens, GA 30603

- Agricultural Best Management Practices for Protecting Water in Georgia
- A Georgia Guide to Controlling Erosion with Vegetation: Establishing and Maintaining Vegetation on Erosive Sites
- Guidelines for Stream Bank Restoration
- Field Manual for Erosion and Sediment Control in Georgia

University of Georgia Cooperative Extension
Athens, GA 30602

USDA Natural Resources Conservation Service, Local Field Office

- Conservation Practice Standards, Field Office Technical Guide

The Georgia Farm Assessment System is a cooperative project of the Pollution Prevention Assistance Division, Georgia Department of Natural Resources, the University of Georgia, College of Agricultural and Environmental Sciences, Cooperative Extension, the State Soil and Water Conservation Commission and the USDA, Natural Resources Conservation Service.

This bulletin is a revision of "Managing Runoff and Erosion on Croplands and Pastures" developed by Dr. Mark Risse.

Learning *for* Life

Bulletin 1152-15 **Revised March 2009**