



STORMWATER MANAGEMENT

A GUIDE FOR FLORIDIANS



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Florida Department of Environmental Regulation

Stormwater/Nonpoint Source Management
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Cover Photograph:

DER's commitment to stormwater management is demonstrated by its new wet detention system which replaced a traditional drainage system.

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INTRODUCTION

Water flowing over the land during and immediately following a rainstorm is called **stormwater runoff**.

Stormwater runoff from agricultural lands, from lands that are undergoing urban development and from lands which already are developed causes significant problems for landowners in its path, for local governments, and for the waterbodies which ultimately receive it.

As a result of stormwater, sediment fills drainage ditches and channels, causing flooding. The sediment fills rivers, lakes and estuaries, destroying wildlife habitat, degrading water quality, and requiring extensive restoration. High stream velocity causes bank erosion (and more sedimentation downstream) and loss of valuable habitat and property. Areas that once seldom flooded now flood with regularity. Eroded sites must be regraded. Often, new soil must be brought in to replace the soil which has washed away. Sediment must be removed - at great cost - from

culverts, storm sewers and navigable waters to restore their capacity. In addition to sediments, stormwater carries nutrients, heavy metals, oils, greases, pathogens and any other materials that accumulate on the land between rains.

This guidebook has been prepared as a source of general information on urban stormwater management. It is intended for the use of local government officials and others interested in sound planning and design of stormwater management systems. It presents general information on the stormwater problem and how to manage it. Sound planning and good design can create stormwater management systems that are attractive, safe, and efficient, and which provide many different uses and benefits to the community. **It is much easier, and much less expensive, to prevent stormwater problems through proper planning than it is to restore water bodies and rebuild flooded properties.**

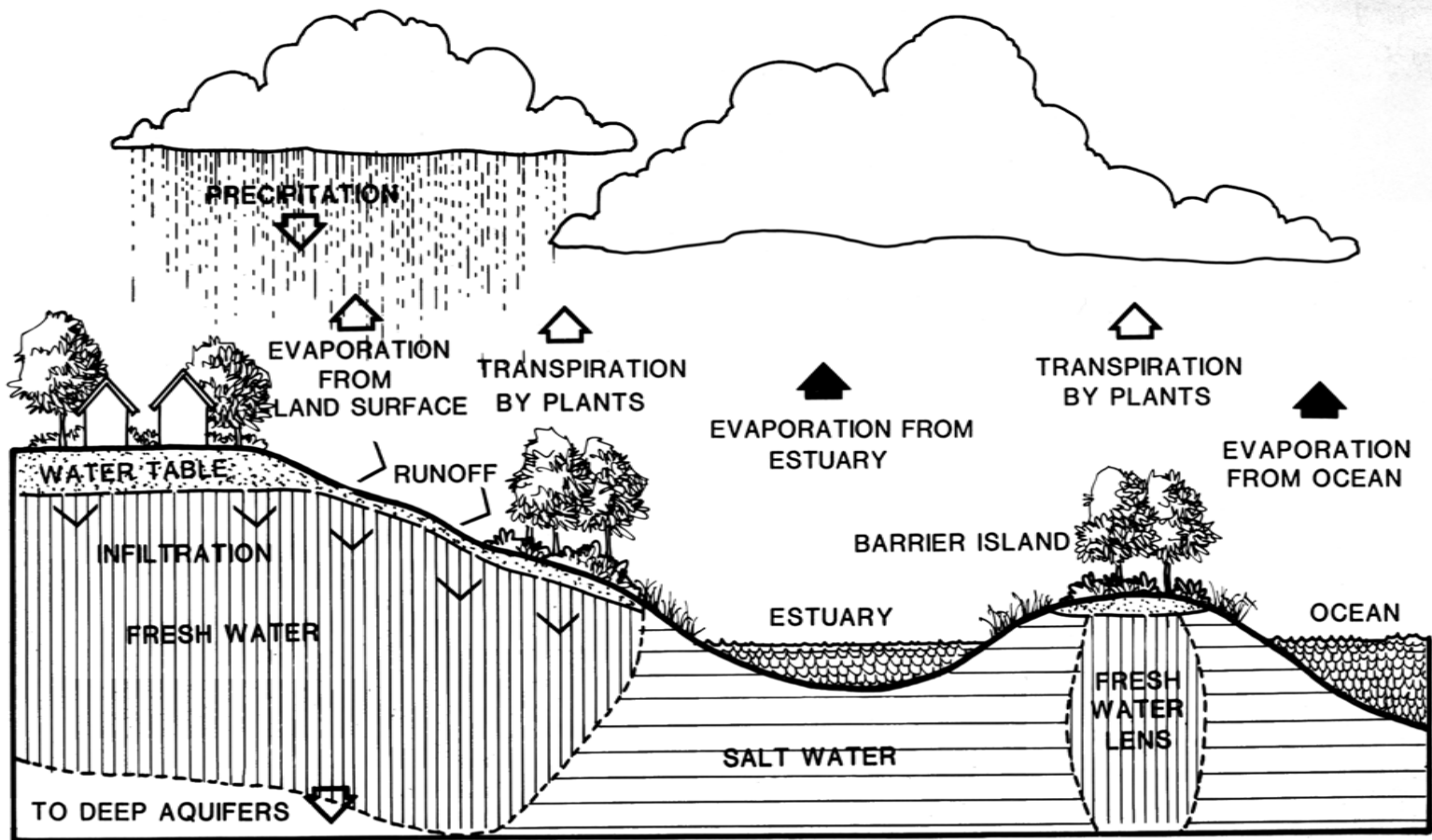


Figure 1: HYDROLOGIC CYCLE

CHAPTER ONE

BACKGROUND

THE IMPORTANCE OF WATER

Water is Florida's lifeblood. Whether it is used for agriculture, industry, recreation, or for drinking, an abundance of clean water is essential for Florida's economy and our quality of life. Florida's rapid growth, and the vulnerability of its surface and ground waters, makes it imperative that its water resources are managed wisely. Fortunately, the Sunshine State receives an abundance of rainfall - 50 to 65 inches from about 120 storms a year. The resulting stormwater, just like treated wastewater, represents a valuable component of our water resources to be recovered and reused.

A. The Hydrologic Cycle

In undeveloped areas, stormwater management is part of the natural environment. The movement of water through the environment, from the clouds to the earth, and back again, is called the **Hydrologic Cycle** (*Figure 1*).

The cycle begins with the sun's energy warming surface waters, causing evaporation. It continues when water vapor rises into the atmosphere, condenses to form clouds, then falls to earth as rain or snow.

When water reaches the ground, it can take three main paths: it can run off the land and collect in

the wetlands, lakes and rivers that eventually flow to the sea; it can infiltrate through the soil, recharging the ground water, or it may be absorbed into the topsoil to be used by plants and eventually returned to the atmosphere through evapotranspiration, which is the evaporation of water from land surfaces plus transpiration, the water given off by the roots and leaves of plants.

Of course, this is a simplified explanation of a very complex natural system - a system that in undeveloped areas maintains a dynamic balance. Natural stormwater systems are in constant change: streams change course, natural erosion occurs, and vegetation and soil permeability change with the seasons. The natural system is thrown out of balance by man-made changes to the land.

The effect of water moving through Florida's diverse water system can differ greatly depending on whether the receiving water is a river, lake, estuary or ground water system. Additionally, Florida's water systems often are interconnected—surface waters become ground waters which can eventually flow back to surface waters. A brief discussion of Florida's various water systems follows to provide a basic introduction to these complex, interrelated systems.

B. The Watershed

A watershed (or drainage basin) is the geographic area from which water in a particular stream, lake or estuary originates (*Figure 2*). All lands in the watershed drain toward the stream, lake or bay and contribute pollutants to these waters. It is important to recognize the connection between our activities on the land within a watershed and the ground water and surface water that flows through it. Everything we do on the land within the watershed ultimately will have an effect on the

water resources of that watershed. It is for this reason that we must begin to manage our land and water resources in a comprehensive, coordinated manner through **Watershed Management**. Watershed management is the integration of land use, infrastructure and water resources throughout an entire watershed.

Watershed boundaries rarely correspond to local government boundaries. As a result, coor-

dination and cooperation among local and regional governments, state government and the private sector is essential for effective water management. If one community limits pollutants or manages its stormwater but others within the watershed do not, then flooding and water quality problems can still result. Those who join the **Watershed Management Team** can work together and effectively solve problems and manage the resources within a watershed.

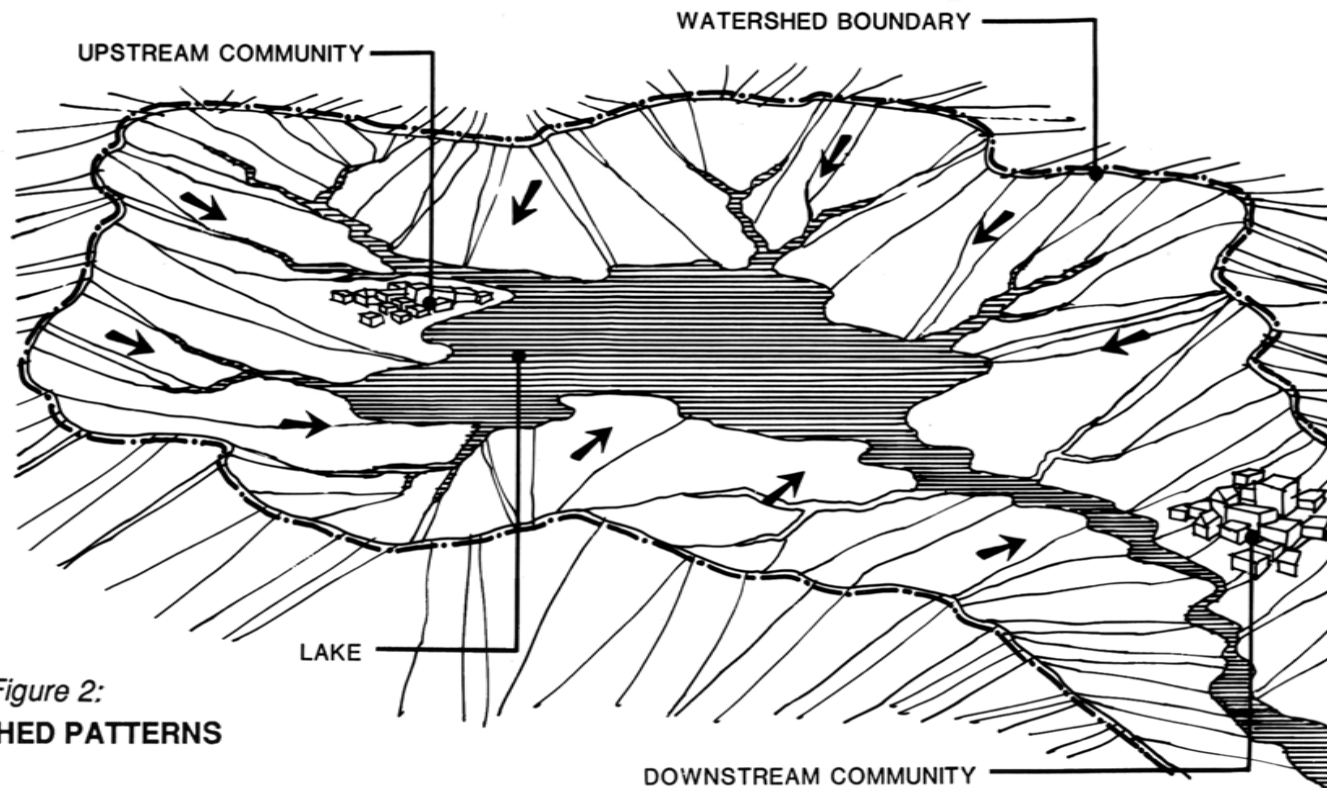


Figure 2:
WATERSHED PATTERNS

C. The River (Lake) System

The characteristics of water and its effects on daily life can be best understood by studying the river or lake basin in which a community is located.

For instance, a small creek running through a neighborhood may appear to be unrelated to the stream that crosses another part of town, but they can be connected. Creeks join to create larger streams, which in turn form still larger ones in a natural drainage network that carries rainwater off backyards, fields, and streets and into rivers or lakes or estuaries. Without this natural stormwater system, land would stay wet or flooded.

As water circulates through a river system it can carry pollutants to downstream parts of the watershed. This is why lakefront or coastal residents may be concerned about the activities of people living some distance upstream from them. Although many miles apart, they all live

within the same watershed, and so can affect one another through their various uses of land and water.

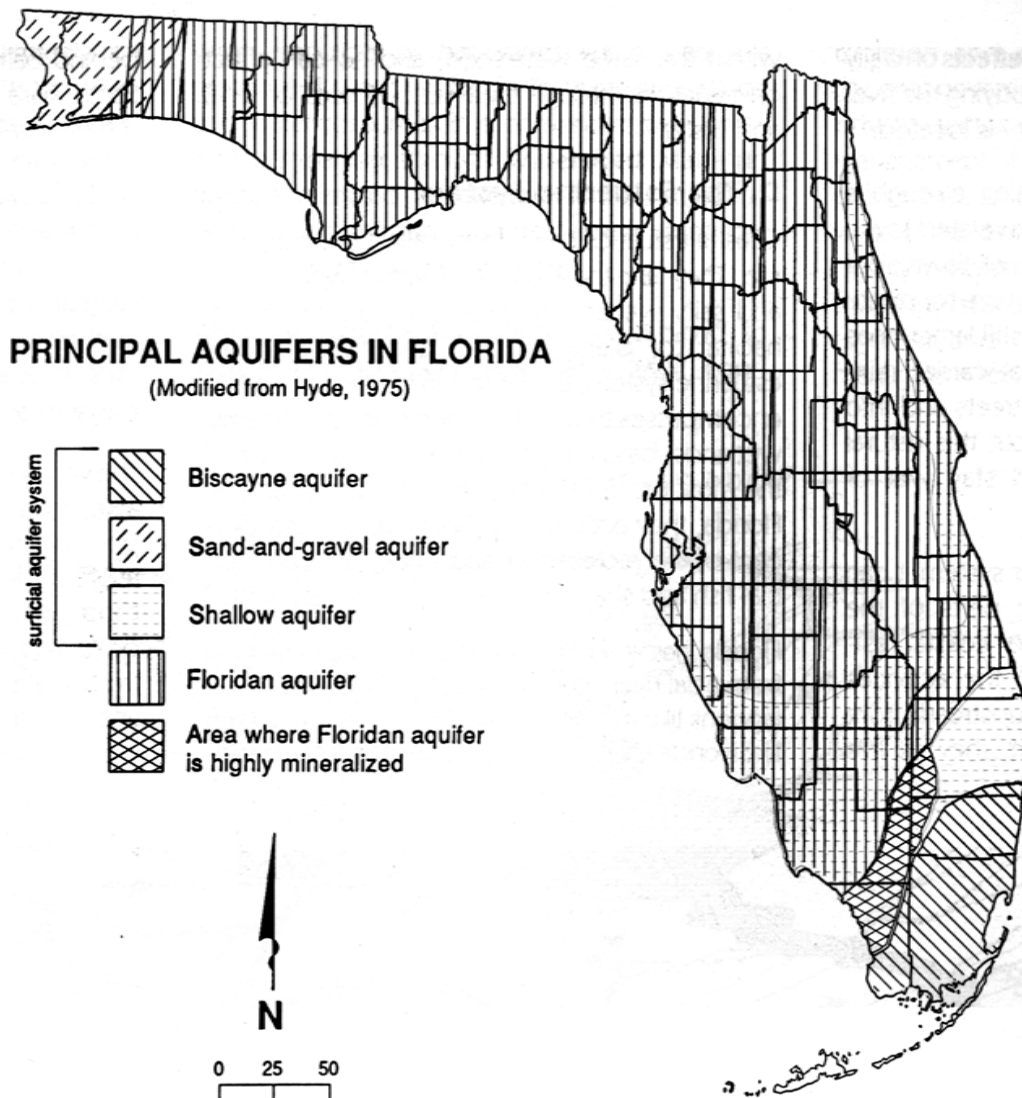
D. The Estuarine System

Coastal estuaries have been called the cradle of life. They are the bodies of water where fresh and salty waters mix, producing a nutrient-rich habitat for plants, animals and fish. Florida's estuarine system, the largest in the United States, encompasses three million acres of tidal streams, wetlands, bays and lagoons. Estuaries are one of the most productive natural systems on earth. In Florida, they account for more than seventy percent of the recreational and important commercial fish and shellfish.

Florida has a wide variety of estuaries, ranging from tidal rivers like the St. Johns River, secluded lagoons like the Indian River lagoon, tropical bays like Florida and Biscayne Bays, and shallow basins






behind barrier islands like Apalachicola Bay and Santa Rosa Sound. All of these estuaries have different salinity patterns, tides, marine life, sediment types and shorelines. The conditions within estuaries are continually changing so the organisms that live in them must be adaptable. The combination of changing salinity, temperatures, and tides, together with shallow water and marsh grasses, provides physical protection and abundant food for juvenile fish and shellfish that use estuaries as nursery areas.

The very functions that make estuaries productive also make them vulnerable to pollutants in stormwater. Just as estuaries efficiently trap and recycle the nutrients that support the estuarine food web, they can also trap and concentrate pollutants. Estuaries can be hurt by too much fresh water, the possible result of urbanization and the increase in stormwater runoff in the estuarine watershed.



PRINCIPAL AQUIFERS IN FLORIDA

(Modified from Hyde, 1975)

- surficial aquifer system
-  Biscayne aquifer
 -  Sand-and-gravel aquifer
 -  Shallow aquifer
 -  Floridan aquifer
 -  Area where Floridan aquifer is highly mineralized



E. The Ground Water System

When water seeps into the ground it is either absorbed by the plants and soil or passes through the soil to become part of the ground water supply. More than 90% of Florida's residents depend on ground water for their drinking water. The sand, gravel and rocks that allow water to collect and move through them are called **aquifers**.

The water level in an unconfined or "water table" aquifer will rise and fall depending upon the amount of water stored in the ground. The recharge of this aquifer occurs by seepage through porous soils when it rains. Although this type of aquifer will recharge relatively easily, pollutants can seep into it just as easily.

A second type of aquifer is called a confined aquifer. It consists of layers of various types of rock (generally limestone in Florida) and clay.

The water in this aquifer moves through the earth under pressure rather than simply by gravity. Recharge to the confined aquifer takes place only in certain areas (recharge zones), so it is less likely to get polluted, unless pollution sources are located in the recharge zones.

The dynamics of ground water movement are complicated. In essence, ground water moves downward, following the slope of the water table (not the land surface) from its highest level to its lowest. The water slowly filters between the rocks and soil of an aquifer, usually at a rate of a few inches a day. This slow movement keeps pollutants from being quickly diluted. Therefore, a well located down-slope from a source of pollution could be contaminated by the ground water flow that still contains concentrated pollutants.

The permeability of soil overlaying an aquifer can also affect pollution. For example, the siting of septic tanks or retention ponds in areas where the water table lies just below very sandy soil can create problems. The porous sand does not retain pollutants as long as other soils do, and it lacks the organic material and microbes that can trap and degrade some pollutants. Areas of Florida with karst geology—land with numerous sinkholes and with underground flow through large cavities in the limestone—are also highly susceptible to ground water contamination, even from stormwater management systems.

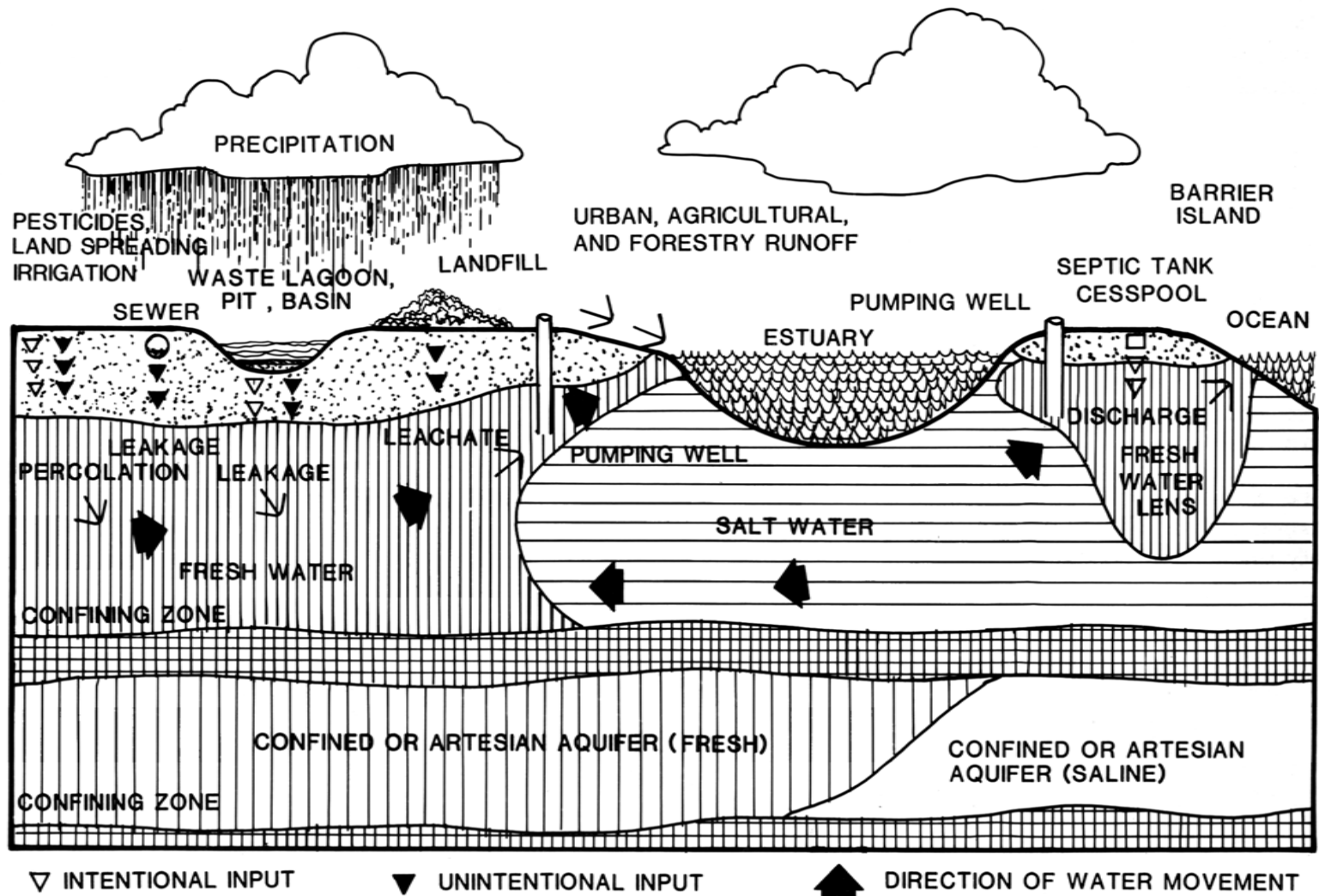


Figure 3:
GROUNDWATER ESTUARINE CONNECTION

F. The Ground Water-Surface Water-Land Connection

To maintain the quality of our lakes, rivers and estuaries, we must recognize the connection between ground waters and surface waters. In many cases, ground water eventually flows into a river, lake or estuary (*Figure 3*) or even becomes surface water such as a spring. Although some of the pollutants in degraded ground water may be dispersed as the water flows through the

aquifer, some pollutants still reach surface water bodies. Movement of contaminated surface water to ground water can also occur by percolation of pollutants from surface impoundments (e.g., pits, ponds, lagoons) into the aquifer underneath. Not only can ground water contamination affect lakes, rivers and estuaries but it is also possible for estuarine waters to flow back

into the underlying aquifer. An example of this is salt water intrusion such as has occurred in Dade County where uncontrolled canal drainage caused declines in fresh water levels allowing salt water to gradually migrate inland.



Little River Spring creates a stream which flows into the Suwannee River and on to the Gulf.



CHAPTER TWO

THE STORMWATER PROBLEM

The volume of stormwater generated by a rain storm depends upon the total amount of rainfall, except that lost by infiltration, transpiration, evaporation, and surface storage. The amount of these losses is a function of climate, soils, geology, topography, vegetative cover and, most importantly, land use.

Changes in land use affect the hydrology of an area in four ways: changes in peak flow charac-

teristics of runoff, changes in runoff volume, changes in water quality, and changes in the hydrologic amenities. The hydrologic amenities are what might be called the appearance or the impression a water body and its adjacent lands leave with the observer. Of all the land use changes that affect an area's hydrology, urbanization is the most important.

A. Effects of Urbanization on Stormwater Quantity

As an area urbanizes, streets, sidewalks, parking lots and buildings cover the soil. In addition, the process removes natural vegetation and compacts the soil. The land's surface becomes more impervious. Rainfall no longer soaks into the ground as readily as before. This causes an increase in runoff and accelerates the speed at which runoff flows (the peak discharge rate) as seen in *Figure 4*.

Historically, the primary concern about stormwater was to remove it from a developed area as quickly as possible after a storm for flood protection. Unfortunately, this led to drainage systems that maximize local convenience and protection, without considering other important factors such as off-site damage from accelerated flow, water pollution, or even the loss of a water resource. Other problems include increased channel erosion and flooding, deposition of sediment, flood plain and channel erosion with a resulting loss of property, wildlife habitat and natural vegetation.

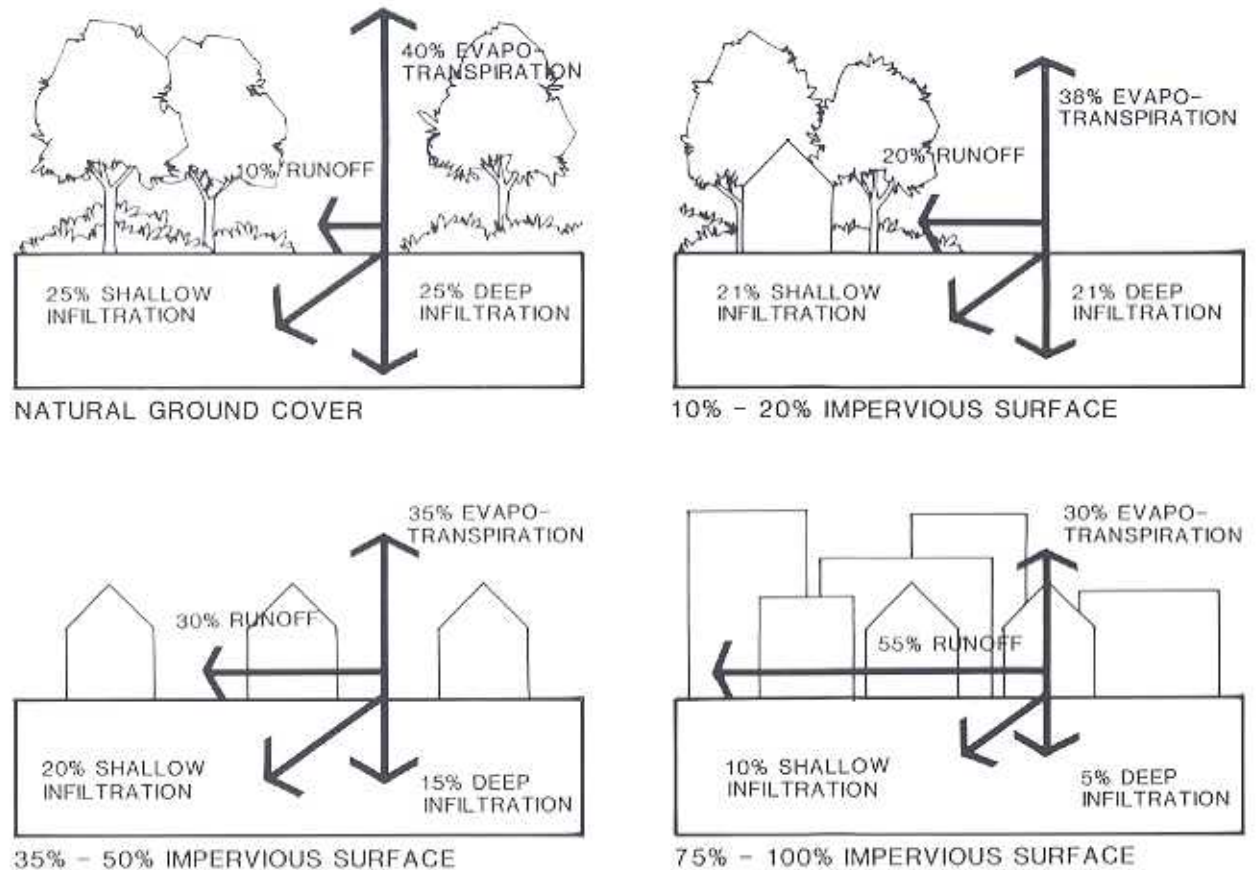


Figure 4:
CHANGES IN RUNOFF FLOWS RESULTING FROM PAVED SURFACES

In an undeveloped area, a natural stream normally adjusts so that its cross section and slope are in approximate equilibrium. Increased volumes and peak discharge rates of stormwater produce drastic changes in the natural stream channel. Eroded banks and frequent flooding are not only unsightly but cause damage to adjacent property and homes. Structures are undermined, homes are damaged, recreational areas are threatened and aesthetic values are destroyed.

Accelerated channel erosion also creates downstream damages by the deposition of eroded sediment. Lakes and reservoirs fill, storm sewers and culverts become clogged causing flooding and areas adjacent to streams and lakes may become covered with mud and debris left after the flood.

Increased stream volumes and velocities associated with the stormwater from urbanized areas produce more frequent floods. Areas that previously flooded only once every five years may flood every year, or several times each year. Flood plain erosion and damage to structures and vegetation increase.

B. Effects of Urbanization on Stormwater Quality

Land use directly affects water quality. In an undeveloped area, natural, physical, chemical, and biological processes interact to recycle most of the materials found in stormwater. As human land use intensifies, these processes are disrupted and everyday activities add materials to the land surface. Leaves, litter, animal wastes, oil, greases, heavy metals, fertilizers, and pesticides are washed off by rainfall and are carried by stormwater to our lakes, rivers and bays. These materials can create high pollutant loadings of:

Sediment which clogs waterways, smothers bottom living aquatic organisms and increases turbidity.

Oxygen demanding substrates which consume the oxygen in water, sometimes creating an oxygen deficit that leads to fish kills.

Nutrients (nitrogen, phosphorus) which cause unwanted and uncontrolled growth of algae and aquatic weeds like hydrilla or hyacinths.

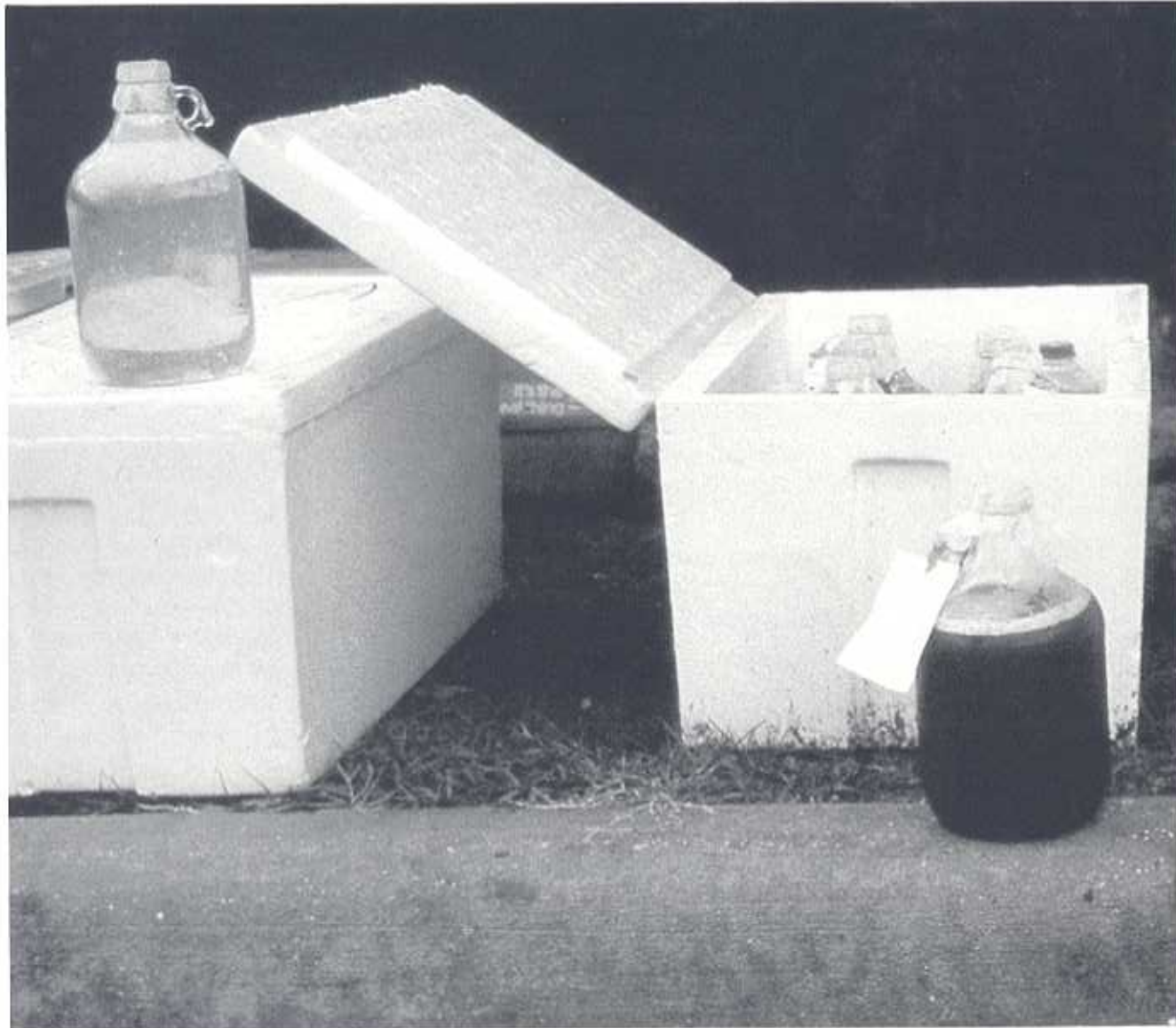
Heavy metals (lead, cadmium, chromium, copper, zinc) which can disrupt the reproduction of fish and shellfish and accumulate in fish tissues.

Petroleum hydrocarbons (oils, greases) which are toxic to many aquatic organisms.

Coliform bacteria and viruses which contaminate lakes and shellfish waters and prevent swimming and harvesting.

Excessive fresh water which changes the salinity of estuaries, alters the types of organisms which live in estuaries, and disrupts this important nursery area.

Stormwater is the major source of pollutants to Florida's lakes, estuaries and streams. Improved stormwater management will reduce pollution loads from new developments and from old stormwater systems that were built primarily for drainage.



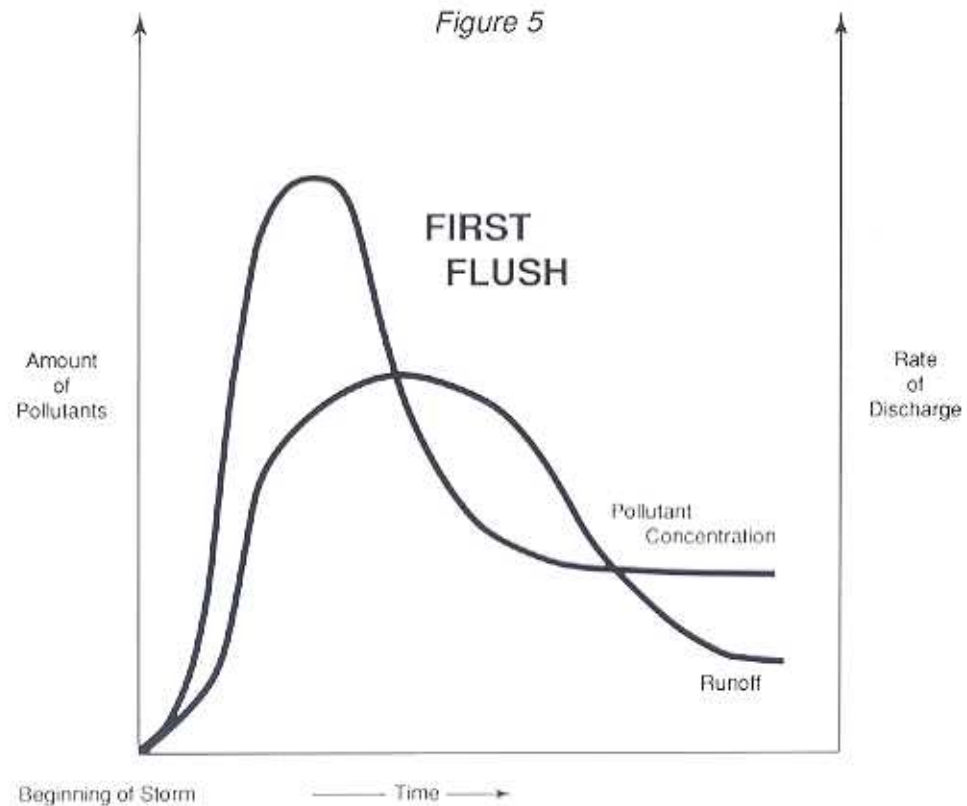
"First Flush" sample (right bottle) contains most pollutants. Later samples (left bottle) are cleaner.

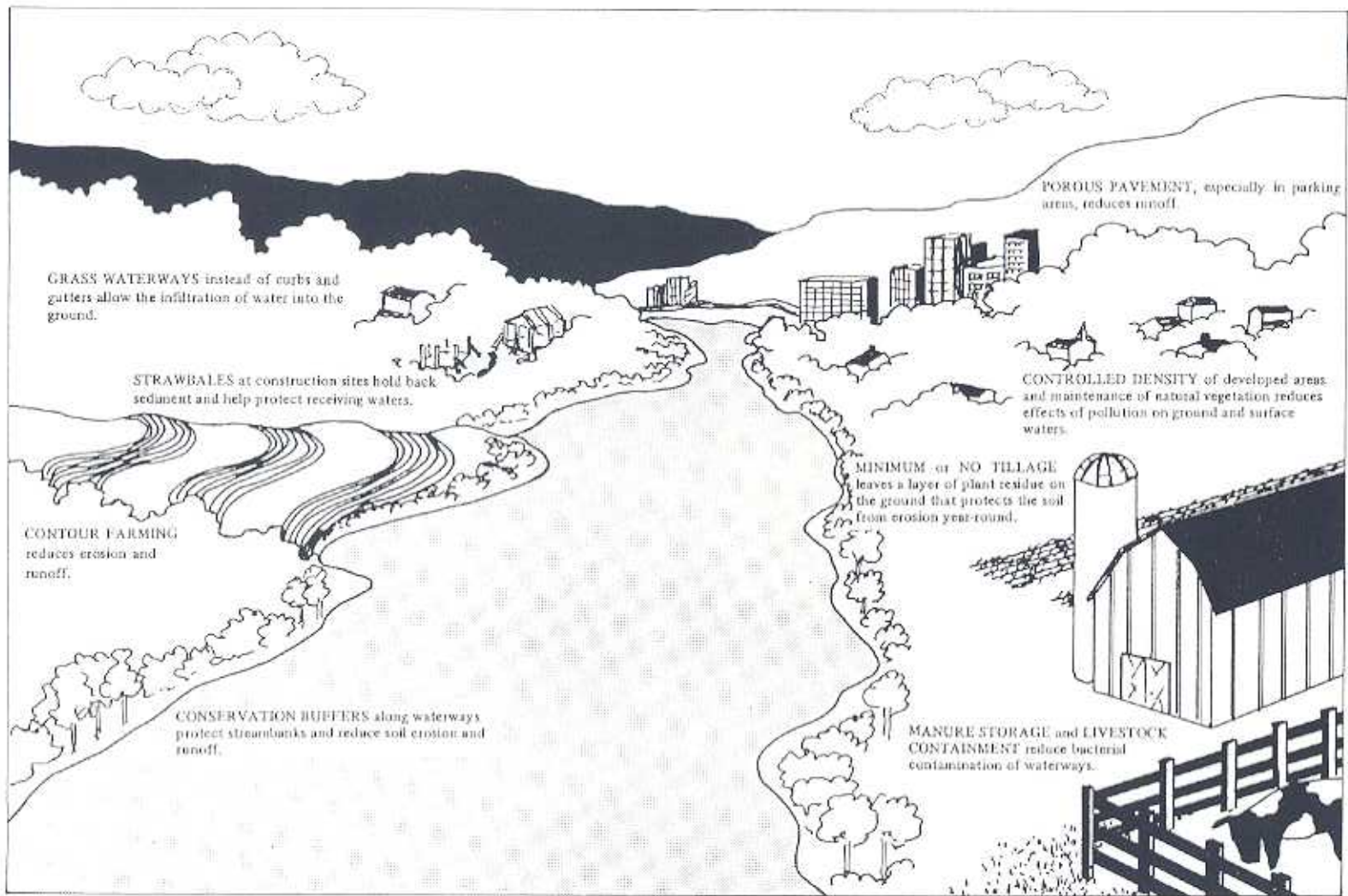
C. The First Flush

Of primary importance to minimizing the effects of stormwater on water quality is the **FIRST FLUSH** (Figure 5). This term describes the washing action that stormwater has on accumulated pollutants in a watershed. In the early stages of runoff the land surfaces, especially the impervious surfaces like streets and parking areas, are flushed clean by the stormwater. This creates a shock loading of pollutants. Studies in Florida have determined that the first one inch of runoff generally carries 90% of the pollution from a storm.

Treatment of the first flush is the key to proper stormwater management, and treatment of the first one inch of runoff from new development is the minimum needed to achieve the desired water quality benefits. In some cases, more than the first inch may need treatment—depending on the

size of the drainage basin, the amount of impervious surface, the type of land use, the type of stormwater management system and, most importantly, the type of receiving water and the desired water quality.





GRASS WATERWAYS instead of curbs and gutters allow the infiltration of water into the ground.

STRAWBALES at construction sites hold back sediment and help protect receiving waters.

CONTOUR FARMING reduces erosion and runoff.

CONSERVATION BUFFERS along waterways protect streambanks and reduce soil erosion and runoff.

POROUS PAVEMENT, especially in parking areas, reduces runoff.

CONTROLLED DENSITY of developed areas and maintenance of natural vegetation reduces effects of pollution on ground and surface waters.

MINIMUM or NO TILLAGE leaves a layer of plant residue on the ground that protects the soil from erosion year-round.

MANURE STORAGE and LIVESTOCK CONTAINMENT reduce bacterial contamination of waterways.

Best Management Practices must be applied throughout a watershed.

STORMWATER AND WATERSHED MANAGEMENT

A. Stormwater Management

Stormwater must be managed to abate the alterations of the hydrologic cycle caused by changes in land use, especially urbanization. An effective **Stormwater Management Program** requires actions to control stormwater to provide:

- Reduction of stormwater pollutants
- Surface drainage and flood protection
- Erosion and sedimentation control
- Enhanced aesthetics and recreational opportunities
- Reuse of this valuable water resource

To achieve these objectives, new developments (or redevelopment projects) should include a stormwater management system which assures that the **Peak Discharge Rate, Volume, and the Pollution Load** of stormwater leaving a site after development are no greater than before development. Chapters Four and Five present addi-

tional information on how a stormwater management system is designed. In addition, new developments must have an erosion and sediment control plan using suitable techniques to retain sediment onsite and minimize the tremendous adverse effects that can occur from improperly managed construction sites.

However, one of the major water quality problems facing Florida is how to reduce the pollution load from old drainage systems that were built solely for flood protection. These systems had one purpose: to convey stormwater away from improved properties as quickly as possible. There was little regard for any environmental effects. It is extremely difficult, and expensive, to correct problems caused by old systems. The solution will take years. Innovative technology, and close coordination with planned infrastructure improvements and urban re-development will be required to solve our stormwater problems.

B. Watershed Management: The Challenge of the Future

We must re-evaluate regulatory approaches to stormwater management to shift the emphasis toward more comprehensive, prevention oriented strategies such as "**Watershed Planning**". Stormwater management is a very important element in watershed planning.

The following comparison illustrates the differences between the usual approach to stormwater management and a comprehensive watershed approach.

1) Usual Approach:

For existing urban development, the usual approach would **address local stormwater problems without evaluating the potential for the runoff control measure to cause adverse effects in downstream areas.** In the case of new urban development, we would delegate stormwater management responsibilities to local land developers and each would be responsible for constructing stormwater management facilities on the development site to maintain post-development

peak runoff and pollution loads from the site at predevelopment levels. There would be little or no consideration of the cumulative effects of the developments with their individual stormwater systems on either the local government stormwater infrastructure or downstream lands and waters.

2) Comprehensive Approach:

This option involves **developing a comprehensive watershed plan**, known as the "master plan", **to identify the most appropriate control measures and the optimum locations to control watershed-wide activities.** The watershed approach typically involves combinations of the following:

- a) overall review of the watershed and its characteristics to assess problems and potential solutions;
- b) strategically locating a single stormwater detention facility (a regional system) to control post-development runoff from several land development projects;

- c) providing stream channel improvements (e.g., removal of obstructions to flow, properly vegetating) where necessary upstream from the stormwater detention facility; and
- d) nonstructural measures throughout the watershed, such as acquisition of parkland and floodproofing to supplement structural control measures.

Watershed management also allows coordination of infrastructure improvements with point and nonpoint source management programs and provides a vital link between land use and water resources management.

While the normal approach to urban stormwater management is relatively easy to administer, it offers several disadvantages. There is greater risk of negative effects, particularly in watersheds that cover several jurisdictions. Insignificant flood protection benefits result from emphasis on the effects of minor flooding. Ineffective runoff

control throughout the watershed is caused by the failure to evaluate locational differences in the benefits of stormwater management facilities. Relatively high local costs for facility maintenance are incurred, as are unnecessary costs associated with the use of small-scale structural solutions rather than large-scale nonstructural solutions which are much cheaper.

Included among the possible negative effects of this piecemeal approach to stormwater management are the following:

- It may only partially solve the major flooding problem(s);
- It may solve flooding problems in the upstream jurisdiction, but create flooding problem in downstream jurisdictions;
- Randomly located detention basins may increase downstream peak flows;
- The program may result in overall prohibitively high maintenance costs for a significant number of runoff control facilities;

- Significant capital and operation/maintenance expenditures may be wasted; and
- The costs of remedial structural solutions likely will be much greater than the costs of a proper management program if it had been implemented in the first place.

The watershed master plan approach offers significant advantages over the piecemeal approach. It promises reductions in capital and operation/maintenance costs and reductions in the risk of downstream flooding and erosion, particularly in multi-jurisdictional watersheds. It offers better opportunities to manage existing stormwater problems and the ability to consider nonstructural measures. Other benefits include an increase in land development opportunities, increased opportunities for recreational uses of runoff controls, potential contributions to local land use planning, enhanced reuse of stormwater, and popularity among land developers. The major **disadvantages** of the **master plan approach** include:

- Local governments must conduct, in advance, studies to locate, and develop preliminary designs for, regional stormwater management facilities;
- Local governments must finance, design, and construct the regional stormwater management facilities before most development occurs and provide for reimbursement by developers over a build-out period that can be many years long.
- In some cases, local governments may have to conduct extraordinary maintenance activities for regional stormwater management facilities the public feels are primarily recreational facilities that merit protection for water quality.

WATER PLANNING

(Proposed)

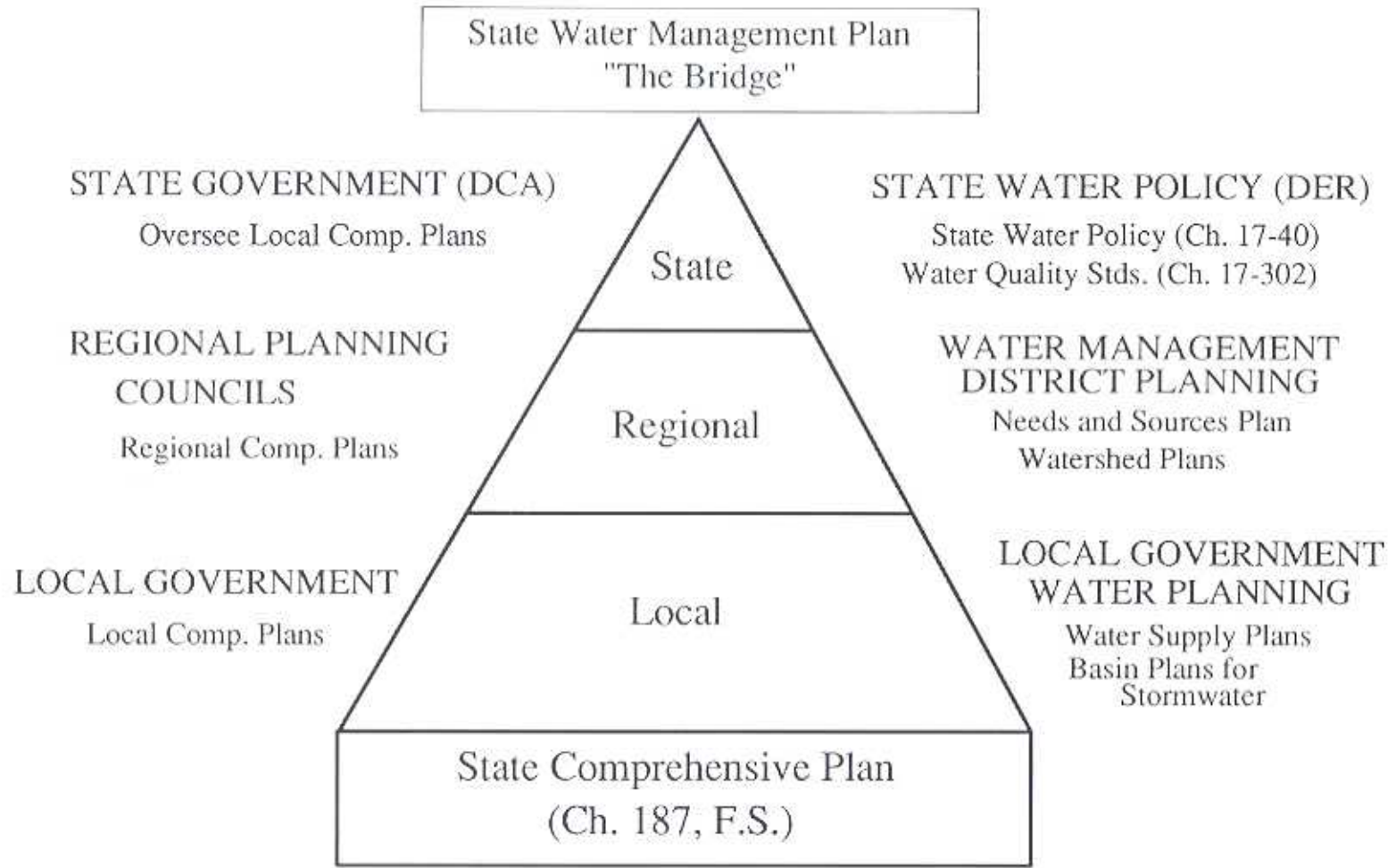


Figure 6: Florida's Water Planning Triangle

C. Florida's Evolving Watershed Management Program

The 1989 STORMWATER LEGISLATION establishes a statewide watershed management framework that relies upon a cooperative effort between the Department of Environmental Regulation, water management districts and local governments. The framework is built upon the integration of the Local Government Comprehensive Planning Act, the State Comprehensive Plan and the Surface Water Improvement and Management Act (SWIM) into a comprehensive watershed management program (Figure 6). The framework is set forth in the State Water Policy, Chapter 17-40, F.A.C.

The legislation designates the Department as the overall lead agency for the watershed management program with specific responsibilities of establishing water quality standards and stormwater treatment requirements and of overseeing the program's implementation by the Water Management Districts and local governments. The Districts will be the chief administrators of the state stormwater regulatory program and will establish watershed specific goals such as the allowable stormwater pollutant loading to a receiving water. As part of the SWIM Program, the Districts have identified priority waters (Table 1) and are developing watershed management goals and plans for these waters.

Table 1
**Approved Priority Lists and Plans of the
 Surface Water Improvement and Management Program (SWIM)**
 July 1, 1991

<i>NORTHWEST FLORIDA WMD</i>	<i>SOUTHWEST FLORIDA WMD</i>	<i>SOUTH FLORIDA continued</i>
1. Apalachicola River	1. Tampa Bay	14. Corkscrew Swamp
2. Apalachicola Bay/St. George Sound	2. Blue Run (Rainbow River)	15. Naples Bay/Gordon River
3. Lake Jackson	3. Banana Lake	16. Estero Bay
4. Deerpoint Lake	4. Crystal River/Kings Bay	17. Lake Butler
5. Pensacola Bay Area	5. Lake Panasoffkee	18. Alligator Lake
6. St. Marks River	6. Charlotte/Placida Harbor	19. Florida Keys
7. Choctawhatchee Bay	7. Lake Tarpon	20. Pine Island Sound/Matlacha/Ding Darling
8. Choctawhatchee River	8. Lake Thonotosassa	21. Lake Jackson (Osceola Co.)
9. Santa Rosa Sound	9. Winter Haven Chain of Lakes	22. Lake Rosalie
10. St. Joseph Bay		23. Cypress Lake (Osceola Co.)
11. Chipola River	<i>ST. JOHNS RIVER WMD</i>	24. Lake Hatchineha
12. St. Andrews Bay	1. Lower St. Johns Basin	25. Lake Istokpoga
13. Escambia River	2. Indian River Lagoon System	26. Lake Worth
14. Lake Munson	3. Lake Apopka Basin	27. Everglades Holey Land/Rotenberger Tract
15. Merritts Mill Pond	4. Upper Oklawaha River Basin	28. Loxahatchee River
16. Upper Ochlockonee River/Lake Talquin	5. Lake George Basin	29. Rookery Bay/Marco
17. Lake Iamonia		30. Lake Pierce
18. Blackwater River	<i>SOUTH FLORIDA WMD</i>	31. Lake Marian
19. Lake Lafayette	1. Lake Okeechobee/Kissimmee River	32. Lake Trafford
20. Shoal River	1. Biscayne Bay	33. Corbett Wildlife Management Area
21. Yellow River	1. Indian River Lagoon	34. Savannas State Reserve
22. Lower Ochlockonee River/Lake Talquin	4. Everglades National Park/Florida Bay	35. Three Lakes Ranch
23. Lake Miccosukee	5. Everglades Water Conservation Areas	36. Fish Lake (Osceola Co.)
24. Sand Hill Lakes	6. Lake Tohopekaliga	
<i>SUWANNEE RIVER WMD</i>	7. East Lake Tohopekaliga	
1. Suwannee River (Withlacoochee River/Falling Cr)	8. Lake Weohyakapka	
2. Santa Fe River System	9. Caloosahatchee River Estuary	
3. Coastal Rivers Basin (Steinhatchee River)	10. Big Cypress National Preserve	
4. Alligator Lake (Columbia Co.)	11. Lake Kissimmee	
5. Aucilla River (Wacissa River)	12. Everglades East	
6. Waccasassa River	13. Lake Arbuckle	

Bold = Approved Plans



Local Stormwater Utilities provide dedicated funds for solving stormwater problems and educating citizens.

Local governments will play a particularly important role in watershed management.

Using the watershed goals established by the water management districts, local governments will need to develop stormwater master plans that also are based on their adopted comprehensive plan. The stormwater master plan will provide a blueprint for the upgrading of the existing stormwater infrastructure to reduce flooding caused by existing and future land uses and to reduce the stormwater pollutant load discharged to receiving waters as required by the watershed goals. By implementing a **stormwater utility**, a local government will have a **dedicated source of funds** to build the required stormwater infrastructure. Those funds will also allow a community to implement a comprehensive stormwater management program that includes public education and periodic inspection of stormwater systems to assure they are maintained properly.

Development of any comprehensive watershed management program, whether on a statewide or local basis requires maximum cooperation, and a **team approach** between all participating agencies, governments, and private business. Communities are beginning to shift from the current piecemeal to the comprehensive approach. Ultimately the future of Florida's water resources will depend on the extent to which this leadership is followed.

The local government comprehensive plans are a prime opportunity to develop and implement workable Watershed Management Plans. Much of the information needed for a watershed plan will be developed during the comprehensive planning process—watersheds and soils will be mapped, a future land use plan will be developed, an analysis of stormwater systems will be completed, resource management goals will be established, and a capital

improvements plan will be developed. By integrating the land use plan, infrastructure plan, and the capital improvements plan into a watershed management plan, communities will provide a foundation for solving many of their stormwater and land and water resource problems in a cost-effective manner.



Stormwater system creates babbling brook.

CHAPTER FOUR

PRINCIPLES OF STORMWATER MANAGEMENT

The following general principles will help achieve the multiple objectives of stormwater management.

1. **It is much more efficient and cost-effective to prevent problems than to correct them later.** Sound land use planning, based on good site planning principles, is essential as the first, and perhaps the most important step in managing stormwater. All new development plans such as subdivisions, shopping centers, industrial parks, and office centers and redevelopment plans should include a comprehensive stormwater management system.
2. **Every piece of land is part of a larger watershed.** A stormwater management system for each development project should be based on, and support a plan for the entire drainage basin.
3. **Optimum design of the stormwater management system should mimic (and use) the features and functions of the natural**

stormwater system which is largely capital, energy, and maintenance cost free. Most sites contain natural features which contribute to the management of stormwater under the existing conditions. Depending upon the site, features such as natural drainageways, depressions, wetlands, floodplains, highly permeable soils, and vegetation provide natural infiltration, help control the velocity of runoff, extend the time of concentration, filter sediments and other pollutants, and recycle nutrients. Each development plan should carefully map and identify the existing natural system. "Natural" engineering techniques should be used as much as possible to preserve and enhance the natural features and processes of a site to maximize the economic and environmental benefits. Natural engineering is particularly effective when combined with open spaces and recreational use of the site, or in developments that use cluster techniques. Design should seek to improve the effectiveness of natural systems, rather than to negate, replace, or ignore them.

4. **The volume, rate, timing and pollutant load of stormwater after development should closely approximate the conditions which occurred before development.** Two overall concepts must be considered: To the greatest extent possible, the perviousness of the site should be maintained, and the rate of runoff should be slowed. Stormwater management systems should use **Best Management Practices (BMPs)** that maintain vegetative and porous land cover and which include on-site storage. These systems will promote infiltration, filtering, and slowing of the runoff.
5. **Maximize-on-site storage of stormwater.** Provision for storage can reduce peak runoff rates; aid in ground water recharge; provide settling of pollutants; lower the probability of downstream flooding, stream erosion and sedimentation; and provide water for other beneficial uses. Where practical, the "blue-green" approach to development which includes lakes and open space should be used. It inherently provides storage, environmental protection and enhancement of community amenities.
6. **Stormwater runoff should never be discharged directly to surface or ground waters.** Runoff should be routed over a longer distance, through grassed swales, wetlands, vegetated buffers and other areas designed

to increase overland "sheet" flow. These systems increase infiltration and evaporation, allow suspended solids to settle, and help remove pollutants **before** they are introduced to Florida's waters.

7. **Stormwater management systems, especially those that emphasize the use of vegetation, should be planned, constructed and stabilized in advance of the facilities that will discharge into them.** This principle is frequently ignored, causing unnecessary off-site effects, extra maintenance, reworking of grades, revegetation of slopes and grassed swales, and extra expense to the developer. The stormwater management system, including erosion and sedimentation controls, should be constructed and stabilized at the start of site disturbance and construction.
8. **The stormwater management system must be designed beginning with the outlet or point of outflow from the project.** The downstream conveyance system should be evaluated to ensure that it has the capacity to accept the design discharge without adverse downstream effects. It may be necessary to stabilize the downstream conveyance system, especially near the stormwater system outlet. Another common problem is a restricted outlet, which causes stormwater to back up and exceed the storage capacity of the collection

and treatment system, resulting in temporary upstream flooding. This may lead to hydraulic failure of the system, causing resuspension of the pollutants or expensive repairs to damaged structures or property. In such circumstances it is advisable to use more than one outlet or to increase the on-site storage volume.

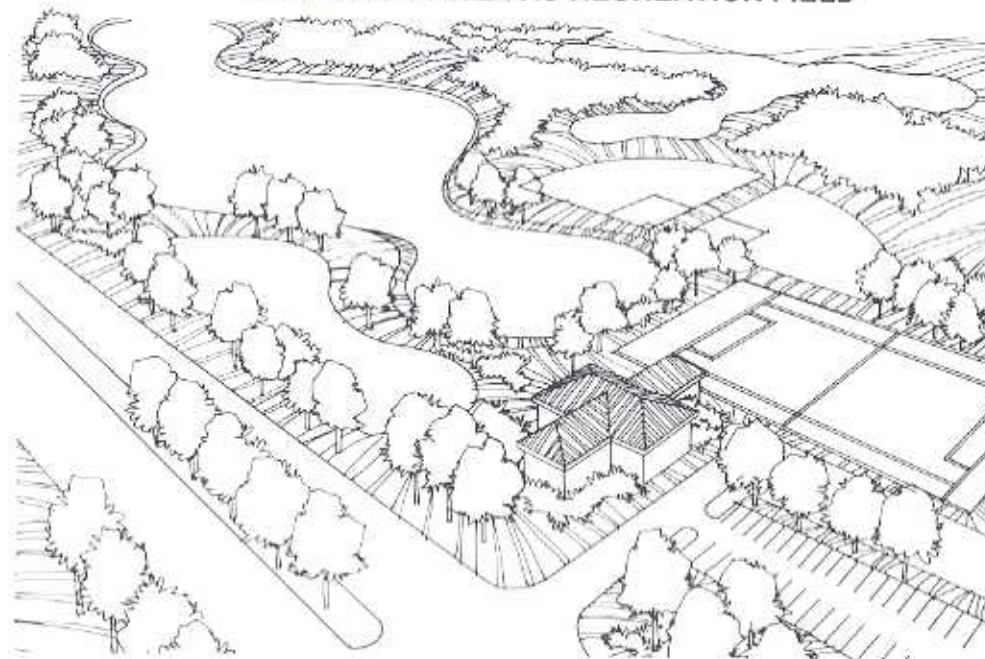
9. **Whenever possible, construct the components of the stormwater management system on the contours that follow the natural topography.** This will minimize erosion and stabilization problems caused by excessive water velocity. It also will slow the runoff, allowing for greater infiltration and filtering.
10. **Stormwater is a component of the total water resource. It should not be discarded casually but should be used to replenish those resources.** Stormwater represents a potential resource that is out of place. Its location determines whether it is a liability or an asset. With the water quantity and quality problems that face Florida, we must consider stormwater as an asset. Treated stormwater has many beneficial uses. It may be used for irrigation (farms, lawns, parks, golf courses), recreational lakes, ground water recharge, industrial cooling and process water, and other nonpotable domestic uses.

11. **Whenever practical, multiple-use temporary storage basins should be an integral component of the stormwater management system.** All too often, storage facilities planned as part of the system are conventional, unimaginative ponds which are aesthetically unpleasing. Recreational areas (ballfields, tennis courts, volleyball courts), greenbelts, neighborhood parks, and even parking facilities provide excellent settings for temporary storage of stormwater. Such areas are not usually used during periods of high rainfall, and the ponding of stormwater for short periods does not seriously affect their primary uses.

12. **Storage areas should be designed with curving shorelines.** Curving shorelines increase the length of the shore and create development opportunities if a blue-green concept of permanent lakes is being used. The increased shoreline also provides more space for the growth of littoral vegetation to provide more pollutant filtering and a more diversified aquatic habitat.

13. **Vegetated buffer strips should be retained in their natural state and should be created along the banks of all water bodies.** Vegetated buffers prevent erosion, trap sediment, filter runoff, provide public access, enhance the site amenities, and function as a

RETENTION AREA AS RECREATION FIELD



floodplain during periods of high water. They also provide a strip along a shoreline which can accept sheet flow from developed areas and help to minimize the adverse effects of untreated stormwater.

14. **THE STORMWATER MANAGEMENT SYSTEM MUST BE MAINTAINED.** Failure to provide proper maintenance reduces the pollutant removal efficiency of the system and reduces the system's hydraulic capacity. Lack of maintenance, especially to vegetative systems

which may require re-vegetating, can increase the pollutant load of stormwater discharges. The key to effective maintenance is the clear assignment of responsibilities to an established agency such as a local government or an organization such as a homeowners association, and regular inspections to determine maintenance needs. **Stormwater system designers should make their systems as simple, natural and, maintenance free as possible.**

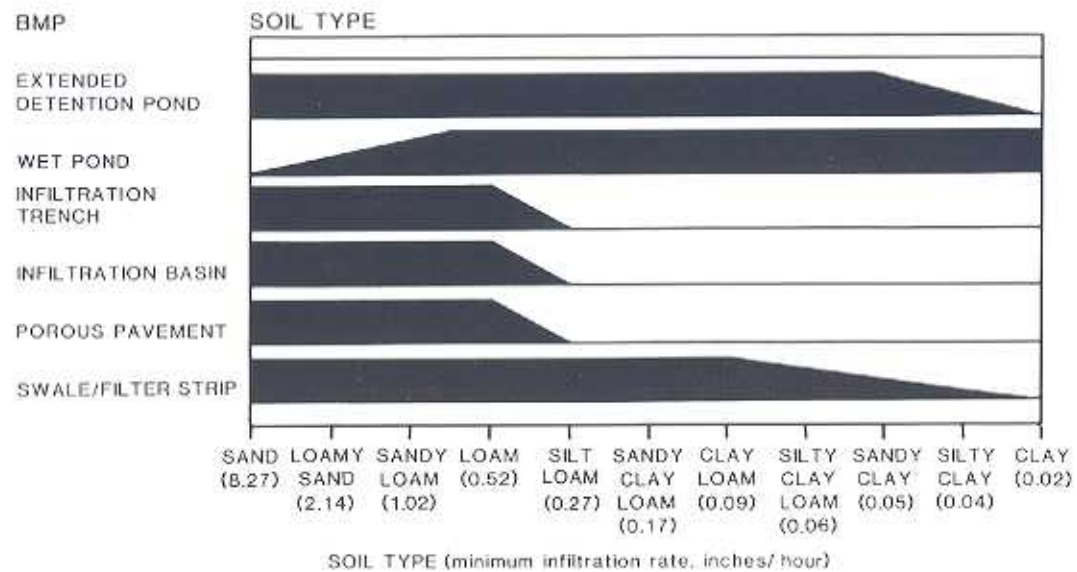
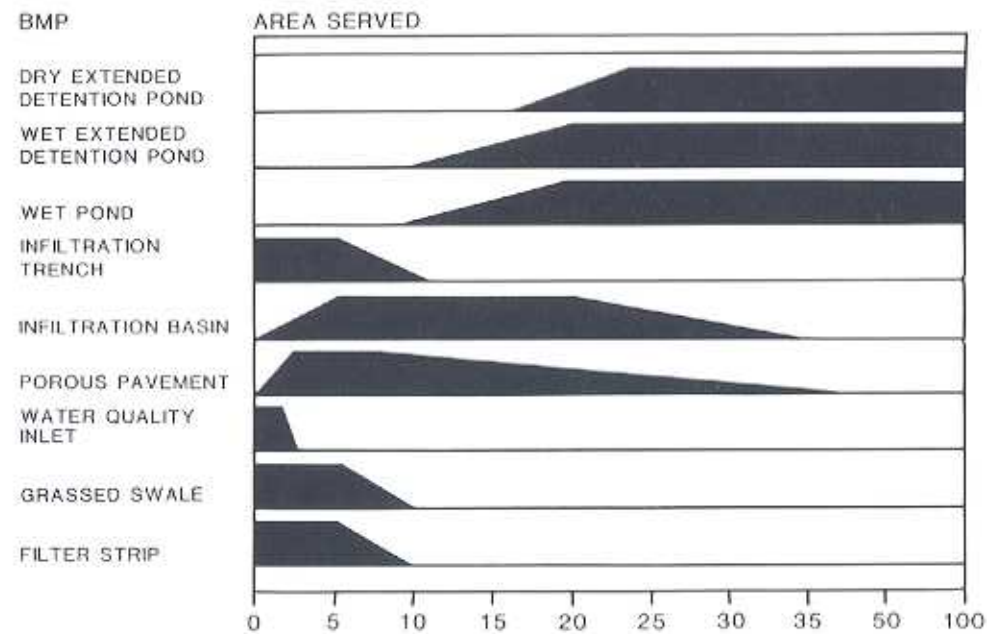


Figure 7:
BMPs FOR DIFFERENT SOIL TYPES



LEGEND:



Figure 8:
BMPs FOR DIFFERENT WATERSHED SIZES

CHAPTER FIVE

STORMWATER MANAGEMENT PRACTICES

The control measures discussed in this chapter are intended to serve as basic models and perhaps to stir the imagination of all who are involved with land development—landowners, developers, contractors, engineers, architects, landscape architects, and the government officials who develop and implement stormwater management programs. The suggested approach is to minimize the adverse effects of stormwater through a coordinated system of source controls. Source controls emphasize prevention and reduction of nonpoint pollution and excess stormwater flow before it reaches a collection system or receiving waters.

Source control is the central theme of the various stormwater management methods or **Best Management Practices (BMPs)**. The term Best Management Practice refers to that practice which is used for a given set of conditions to achieve satisfactory water quality and quantity enhancement at a minimum cost. Chapter 6 of the Florida Development Manual: A Guide to Sound Land and Water Management (DER, 1988) contains an extensive discussion of the use, design, construction and operation of a

wide variety of stormwater management and erosion and sediment control BMPs.

To achieve the desired objectives of flood and water quality protection, erosion control, and improved aesthetics and recreation, a stormwater management system must be an integral part of site planning for every project. Although the basic principles of stormwater management remain the same, each project presents slightly different problems. The many variations in climate, soils, topography, geology, and the planned land use require site-specific design. Each site has its natural attributes that influence the type and configuration of the stormwater management system. For example, sandy soils suggest the use of infiltration practices such as retention areas integrated into a development's open space and landscaping, while natural low areas and isolated wetlands offer opportunities for detention and wetland treatment. *Figure 7* summarizes a number of BMP types according to their feasibility for different soil types. Likewise, the size of the watershed dictates appropriateness of BMPs, as illustrated in *Figure 8*.

Best Management Practices can be classified into two broad categories - Nonstructural and Structural. Nonstructural controls are those which are intended to improve stormwater quality by reducing the generation and accumulation of potential stormwater pollutants at or near their sources. Nonstructural controls are the first line of defense and include practices such as land use planning and management, wetlands and floodplain protection, public education, fertilizer and pesticide application control, solid waste collection and disposal, street cleaning and "good housekeeping" techniques on construction sites. They are prevention oriented and very cost-effective. Structural controls are those which are used to control the stormwater volume and peak discharge rate, as well as reducing the magnitude of pollutants in the discharge water through physical containment or flow restrictions designed to allow settling, filtration, percolation, chemical treatment or biological uptake. These practices typically are land intensive, require proper long term maintenance and can be costly, especially in already urbanized areas.

A. BMP Treatment Train

A stormwater management system might be considered as a **BMP treatment train** in which the individual BMPs are the cars. Generally, the more BMPs that are incorporated into the system, the better the performance of the treatment train. Although the different BMPs will be discussed



individually, they often work together as part of a total system.

As noted, the careful design of stormwater management systems should be an integral part of development planning. Stormwater management is not—or should not be—an afterthought, and there are many opportunities to integrate stormwater controls into the open space and landscape elements of development. Creative and imaginative design can produce stormwater management systems that not only function properly but also are aesthetic amenities, reduce

maintenance, offer recreational opportunities, wildlife habitat, irrigation, and fire protection. All too often, inadequate or improper design and construction of stormwater systems have produced unsightly and unsafe facilities that do not perform well and which quickly become maintenance problems. Public acceptance of such projects is understandably poor, and the entire concept of stormwater management suffers as a result. **BMPs should not be big muddy ponds.**

B. On-Line Versus Off-Line BMPs

On-line BMPs temporarily store runoff before they discharge to surface waters. These systems capture all of the runoff from a design storm. They primarily provide flood control benefits. Water quality benefits are secondary.

Off-line BMPs divert the first flush of polluted stormwater for treatment and isolate it from the remaining stormwater, which is managed for flood control. Off-line retention is the most effective water quality protection BMP, since the diverted first flush is not discharged to surface waters but is stored to be gradually removed by infiltration, evaporation and evapotranspiration.

Figure 9 is a schematic of an off-line treatment system in which a **smart weir** directs the first flush of stormwater into the infiltration area until it is filled. The remaining runoff is routed to the detention facility for flood control.

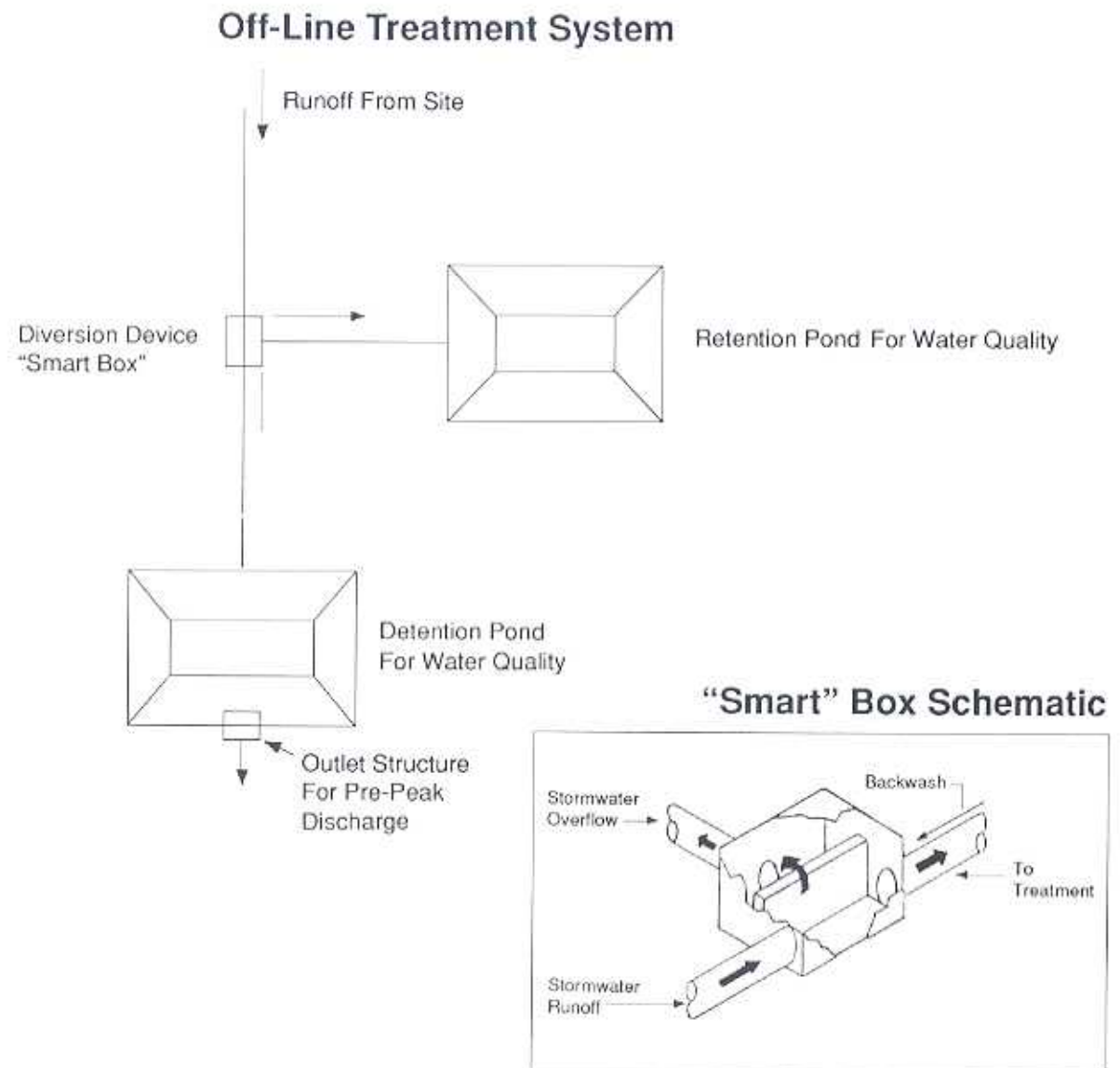


Figure 9: SCHEMATIC OF "DUAL-POND" OFF-LINE TREATMENT SYSTEM



Off-line systems can be designed so that they are integrated with the site's landscaping thus providing an amenity instead of a potential detraction.



C. The Importance of Vegetation

Vegetation provides several benefits in managing stormwater (*Figure 10*). It absorbs the energy of falling rain, preventing erosion, and maintains the soil's capacity to absorb water, promoting infiltration. It slows the velocity of runoff, reducing peak discharge rate.

Vegetation is especially important in reducing erosion and sedimentation during construction. By phasing and limiting the removal of vegetation, and by decreasing the area that is cleared and limiting the time bare land is exposed to rainfall, sedimentation at construction sites can be reduced by up to 90%. If large areas of land must be cleared at once, those areas upon which construction will not occur within 7 days should be mulched and seeded to provide immediate temporary cover. Special consideration should be given to the maintenance of vegetative cover on areas of high erosion potential, such as erodible soils, steep or long slopes, stormwater conveyances, and the banks of streams.

Stormwater BMPs which use vegetative cover include overland sheet flow, grassed swales and channels, infiltration areas, and grassed discharge or flow areas for roof drainage. All are particularly suited to residential, transportation and recreational developments, but also can be used in commercial and industrial sites.

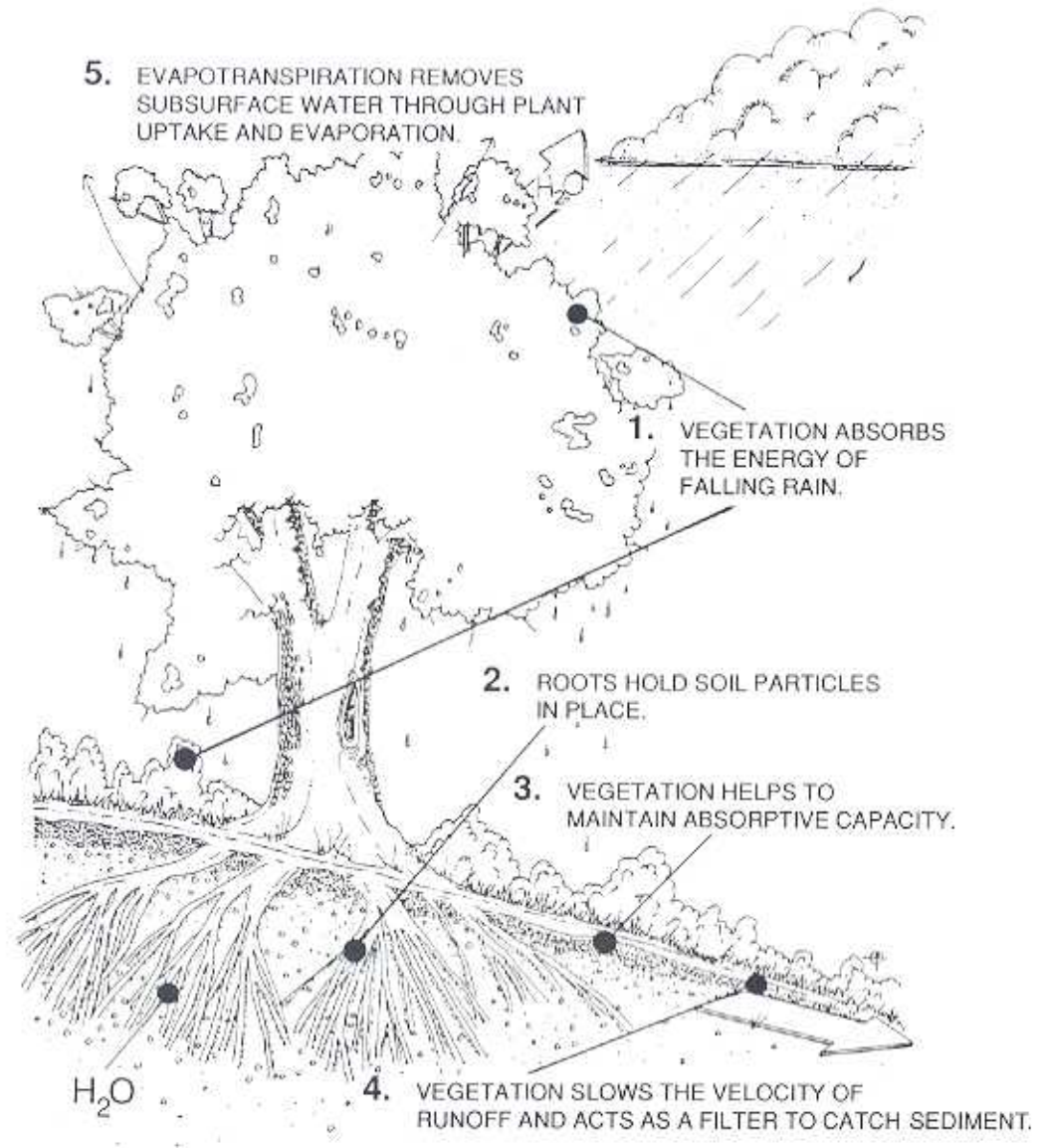


Figure 10: EROSION CONTROL BY VEGETATION COVER

The amount and nature of topsoil and vegetation are important factors that affect infiltration of stormwater. A thick layer of topsoil with dense sod provides excellent natural infiltration. Any area under development that is to be revegetated should be covered by an adequate layer of topsoil. The original topsoil at the site should be removed and stockpiled for reuse to provide a minimum of four inches over areas that have a porous sub-soil. In areas of heavy clay, six to eight inches of topsoil will provide proper plant growth and create absorbent soil.

D. Infiltration (Retention) Practices

In an undeveloped area, infiltration is a natural part of the hydrologic cycle. A certain part of precipitation is absorbed into the ground, replenishing the ground water and feeding trees and other plants. **Retention BMPs retain stormwater on-site, allowing it to infiltrate into the ground or to evaporate.** These practices reduce the volume of stormwater, and are the most effective for reducing stormwater pollution since, typically, the first flush is not discharged to surface waters. By reducing the volume of stormwater, infiltration also helps reduce the effects of stormwater on estuaries which are vulnerable to too much fresh water.

The amount of infiltration depends primarily on the soil. Successful use of infiltration requires appropriate site conditions to assure that the stormwater will infiltrate within 24 to 72 hours. Coarse-grained sandy soils have excellent infiltration capacity. As soils begin to contain higher amounts of fine-grained clays and silts, their infil-

tration capacity diminishes. To protect ground water from contamination, the seasonal high water table and bedrock should be at least three feet beneath the bottom of the retention practice. In areas where limerock is near the surface and sinkholes are common, special precautions must be taken to protect the ground water.



Infiltration Practice: Directing roof runoff to grassed areas.

In areas with appropriate site conditions, off-line infiltration BMPs should be used where possible. Typical retention BMPs include grassed swales (often with check dams), retention basins, infiltration areas, and infiltration trenches. With imaginative design and proper installation, retention practices can effectively meet the challenges of aesthetics, safety, maintenance and effectiveness. However, as with any portion of a development project, good solutions do not happen by themselves. They must be carefully planned as part of the entire development.

Off-line infiltration can be easily incorporated into landscaped and open space areas such as natural or excavated grassed depressions, recreational areas, and even landscaped parking lot islands. Some retention practices can be designed as landscaped rock gardens or picturesque creek beds. Lawns, especially on waterfront property, can be designed to store runoff for a short time. Since retention areas frequently are designed to remain dry when not in use, they can often provide multiple uses—stormwater management during wet weather and recreational, open spaces or parking during dry weather.

Dry Retention Basins or Areas

Nearly every land use in a developing area can effectively and economically incorporate on-site, off-line retention into its design. If site conditions will not allow total infiltration of the first flush, then parts of the first flush can be infiltrated as pretreatment before the stormwater enters a wet detention or wetland treatment system for final treatment.

On a small scale, lawns, parking lot islands, and small landscaped areas all can be used to store stormwater and allow it to infiltrate. Such areas are especially appropriate as elements of a **BMP treatment train** where raised storm sewer inlets are placed in the retention area allowing some treatment before excess stormwater is routed to a detention facility.



On a larger scale, retention areas can be designed into the open spaces of an entire development or park system. Orlando has been very creative in using this concept to modify older stormwater systems and reduce the pollutant loading to the city's downtown lakes. Proper design of these retention systems can insure successful, useful and attractive results. During dry periods, large retention areas can serve as parks or community recreation areas.

Side slopes of infiltration areas should be gentle enough to mow and should be properly shaped to blend with the surrounding topography. When intended for recreational use, side slopes can provide an amphitheater for spectator seating on grassy banks. Banks can also serve to contain balls in the playing area, avoiding the need for a fence.

Good vegetative cover and proper drying are extremely important in the design and development of multiple-use retention and recreation facilities. The basin floor must be properly graded (two percent slope—more on poorly drained soils) to provide adequate surface drainage and yet must allow appropriate recreational use and avoid low spots that might remain wet. In some situations, underdrains may be needed to promote infiltration and to help eliminate standing water. By eliminating the possibility of standing water, problems of weeds, algae and mosquitos can be avoided and the multiple uses of the stormwater system can be realized.

The natural characteristics of the site must be respected and used properly. In many situations, the appropriate appearance of BMPs will be crisp and clear with a certain quality of sophistication. In other instances, especially in parks or residential developments, retention areas can be effectively created in naturalized or wooded areas, further reducing maintenance.

With sensitive placement, imaginative design, careful construction and appropriate landscaping, stormwater retention facilities can effectively protect property and water quality and still be an aesthetically satisfying part of the community environment.



Proposed spreader swale at Al Coith Park (Orlando).

Grassed Swales

Swales, or grassed waterways, are one of the oldest stormwater BMPs, and have been used along streets and highways for years. A swale is:

1. a shallow trench which has side slopes flatter than three feet horizontal to one foot vertical;
2. contains areas of standing or flowing water only after a rainfall;
3. planted with or has vegetation suitable for soil stabilization, stormwater treatment, and nutrient uptake;
4. designed to take into account the soil erodibility, soil percolation, slope, slope length, and drainage area so as to prevent erosion and reduce the stormwater pollutant load.

Traditionally, swales are used primarily for stormwater conveyance, and are considered an on-line practice. As with other retention practices, the effectiveness of pollutant removal depends on the volume of stormwater that can be infiltrated through the filtering vegetation and into the soil.

Used alone, swales must percolate 80% of the runoff from a three-inch rainfall within 72 hours to provide proper water quality benefits. However, this is often impossible because of soil or slope, and the greatest utility of a swale is as

a pretreatment conveyance system to reduce pollutants before the stormwater enters a retention and detention basin, or a wetland. **Swales should be seen as an important component of a BMP treatment train.**



One way to improve the effectiveness of pollutant removal and the infiltration capability of a swale is to place small check dams along the swale, or to use raised driveway culverts to cause stormwater to pond, slowing the runoff

and holding it—allowing some to soak into the ground and be filtered by vegetation. On high speed highways, safety must be considered, and a maximum water depth of about 1.5 feet and flow line slopes on the check dams of 1 vertical/

20 horizontal are recommended. Along residential streets and lower speed highways, steeper flow line berm slopes (1:6) are acceptable. *Figure 11* is an example of a swale with a cross block.



Figure 11:
SWALE WITH CROSS BLOCK

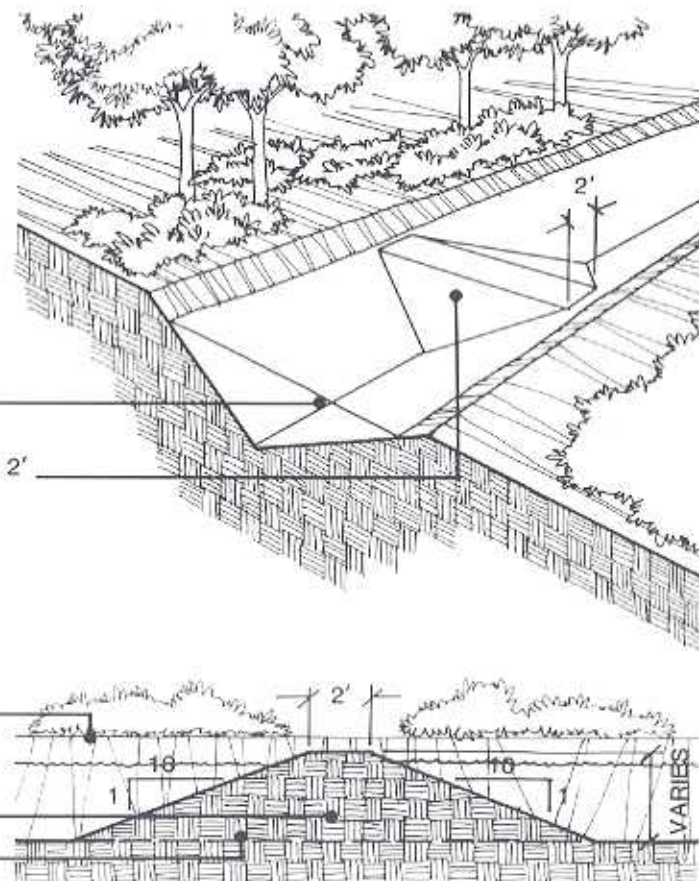
SWALE FLOW LINE

SOD ENTIRE BERM AND EXTEND SOD 2' MINIMUM EITHER SIDE

TOP OF BANK

COMPACTED SOIL MATERIAL TO SUPPORT SOD

SWALE FLOW LINE



The feasibility of swales depends on land use and site characteristics. Considerations such as on-street parking, and small lots with numerous driveway culverts may be a limiting factor. On the other hand, parkways, boulevards, collector streets and streets in large-lot subdivisions may all benefit from using swales.

Maintenance requirements for swales will not be significantly greater than those for a normal lawn. However, public education is essential, especially for residents who live in developments served by swales. Residents need to be informed about the benefits provided by their swale so they take pride in maintaining it and do not fill it in. Residents need to know that leaves, limbs and other vegetation, along with debris and oil should not be disposed of in the swale. If this occurs, the pollutants in these materials will be delivered to downstream waters and a benefit of the swale would be lost.

Many local governments require curb and gutter systems and prohibit swales. Such policies should be reviewed to determine why they were established and if they can be modified to help reduce stormwater management costs and water quality degradation. If curb and gutter sys-

tems are used, curb cuts should be used wherever grassed areas are adjacent to the road to allow some infiltration and treatment of the stormwater. An effective treatment train can be formed by using a curb cut in association with a raised storm sewer inlet which ultimately conveys the runoff to a retention or detention system.



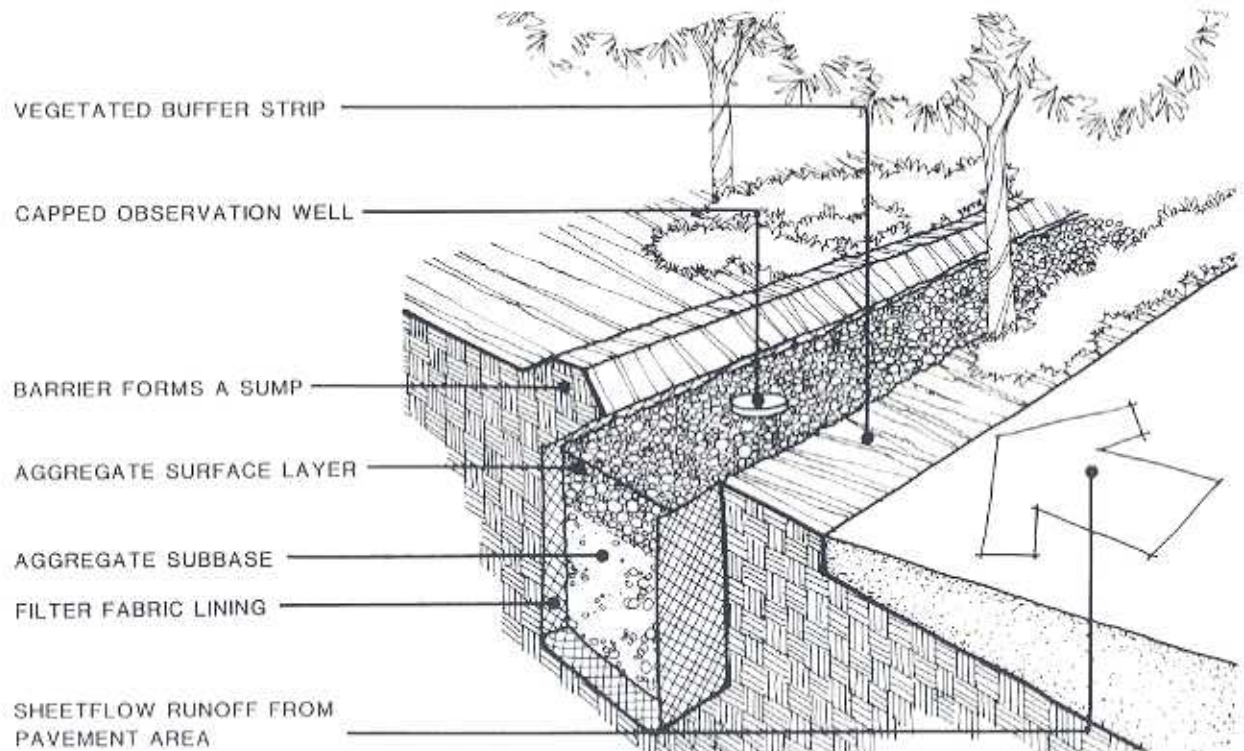
Infiltration Trenches

In many urban areas, land costs are so prohibitive that infiltration basins are not feasible. In such cases an off-line **infiltration trench** can be the primary component of the treatment train. This BMP consists of a long, narrow excavation ranging from 3 to 12 feet in depth (depending on stormwater volume, soil and water table conditions) which is backfilled with stone aggregate, allowing for the temporary storage of the first flush stormwater in the voids between the aggregate material. Stored runoff then infiltrates into the surrounding soil.

To prevent ground water contamination, trench bottoms should be at least four feet above the seasonal high water table. Another important consideration for infiltration trenches is to use the treatment train concept to maximize water quality benefits, reduce maintenance requirements, and prevent the physical clogging of these systems by sediment, leaves and other materials. Limestone aggregate should not be used since it has a tendency to cement together, thus reducing the void space in which the stormwater is stored.

Infiltration trenches can be located on the surface or below the ground. **Surface trenches** receive sheet flow runoff directly from adjacent areas after it has been filtered by a grass buffer. Surface trenches typically are used in residential areas where smaller loads of sediment and oil can be trapped by grassed filter strips that are at least 20 feet wide. While surface trenches may be more susceptible to sediment accumulations, their accessibility makes them easier to maintain. Surface trenches can be used in highway medians, parking lots and in narrow landscaped areas.

INFILTRATION CHANNEL



Underground trenches can accept runoff from storm sewers and can be applied in many development situations, although discretion must be exercised with their applicability. To prevent clogging, pretreatment is essential. Inlets to underground trenches must include trash racks, catch basins and baffles to reduce sediment, leaves, other debris, and oils and greases. Maintenance or replacement of underground trenches can be very difficult and expensive, especially if they are placed beneath parking areas or pavement.

The most commonly used underground trench is an **exfiltration system** in which runoff is diverted into an oversized perforated pipe placed within an aggregate envelope. The first flush of stormwater is stored in the pipe and exfiltrates out of the holes through the gravel and into the surrounding soil. The City of Orlando has installed many exfiltration systems throughout downtown to reduce stormwater pollution of its lakes. Routine maintenance consists of vacuuming debris from the catch basin inlets and, if needed, using high pressure hoses to wash clogging materials out of the pipe.



Orlando Streetscape Project Exfiltration Trench



E. Detention Practices

Unfortunately, variations in soil, water table and geologic conditions throughout Florida preclude the exclusive use of infiltration practices in many locations. These locales often have slowly percolating soils, high water tables, and flat terrain typical of the "flatwoods" area of Florida. In such areas, permanently wet detention systems and wetland treatment systems are likely to be the preferred BMPs. The concept of the stormwater treatment train is especially applicable to detention systems. The use of swales, landscape infiltration areas, and perimeter swale/berms for pretreatment will greatly improve the pollutant removal effectiveness, aesthetics and longevity of a detention system.

Detention systems are storage areas that maintain a planned permanent level of water even after stormwater discharge has ceased. These permanent lakes and ponds, if properly planned and constructed, provide multiple benefits including improved property values. They provide "lake-front" property, possibilities for recreation and wildlife habitat, water for irrigation and fire protection, and even a source of fill. Detention systems also provide flood protection and very good removal of stormwater pollutants.

Figure 12 illustrates the basic components of a wet detention system that is used for flood control and water quality enhancement. Essentially, a wet detention "lake" consists of a permanent water pool, an overlying zone in which the design runoff volume temporarily increases the depth while it is stored and released at the allowed peak discharge rate and a shallow littoral zone in which wetland plants biologically remove dissolved stormwater pollutants such as metals and nutrients. During storms, runoff replaces "treated" waters which were detained within the permanent pool after the previous storm. Wet detention lakes are often used in series, with swale interconnections.

Technical design criteria for detention systems have been established by the Department of Environmental Regulation and the water management districts. These criteria address general concerns that are important to safe, efficient operation of such systems including: evaluation of runoff hydrographs for storms of various size and frequency; determination of level of flood protection, rate of stormwater release; design requirements to maximize pollutant removal; provisions for maintenance; and provisions for emergency overflow to protect adjacent and downstream properties.

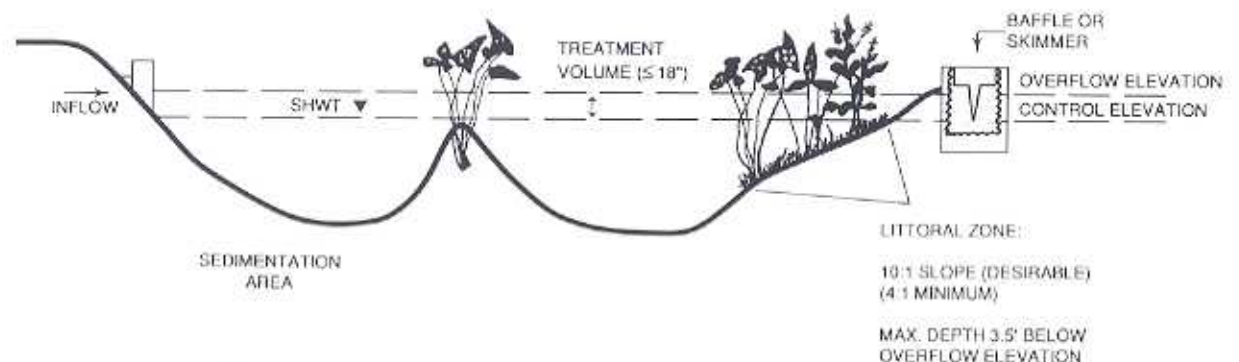


Figure 12: TYPICAL WET DETENTION COMPONENTS

Once the technical requirements have been established, they must be translated into physical reality through competent design and construction. The same set of technical requirements can be met through a traditional engineering solutions or through creative design with full appreciation for aesthetic, maintenance, safety and multiple use considerations.

The solution shown at right illustrates several important elements in the design of detention systems. The permanent water pool is bordered by a stone edge capped by a concrete coping to give a refined appearance that blends with its landscaped surroundings. The first level of stormwater control is provided within the borders of stone and concrete coping. For storage capacity required by more intense storms, the lawn area surrounding the permanent pond is carefully graded to contain additional runoff. The final level of control is provided by an emergency overflow swale designed to convey stormwater from a very large, infrequent storm, more severe than the design storm, safely away from improvements susceptible to damage.

The entire appearance of this example is aesthetically pleasing, provides recreational opportunities and has been skillfully integrated into the overall landscape design of this urban setting. Because of the rock and concrete edging, bank erosion and maintenance are not problems, and the overflow area of the facility is simply maintained as lawn.

Detention systems can be designed to fit almost any new development. Depending on the nature of the land use, the detention lakes can be refined and sophisticated or natural and somewhat wild. As illustrated by the examples presented in

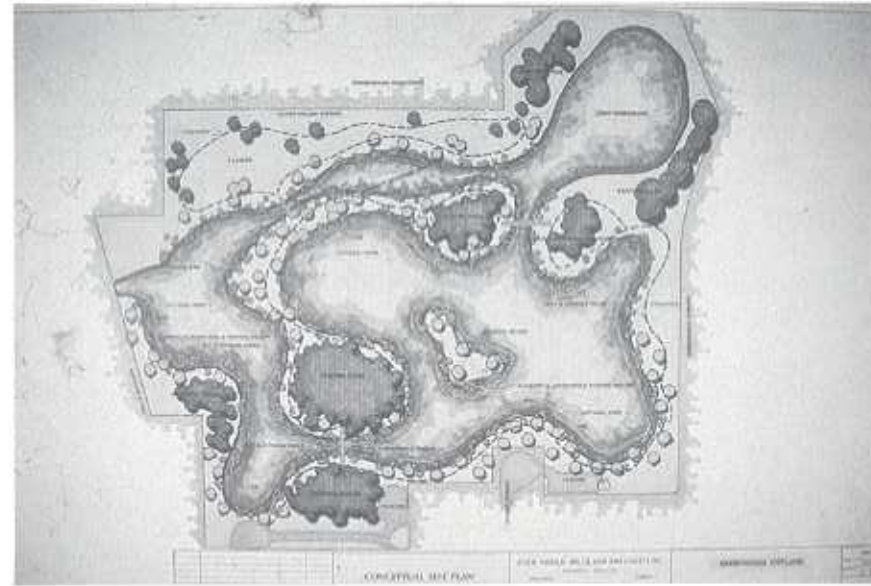
this section, the problems of safety and maintenance as well as the considerations of aesthetic quality and multiple use can be effectively controlled through sound planning and careful design.



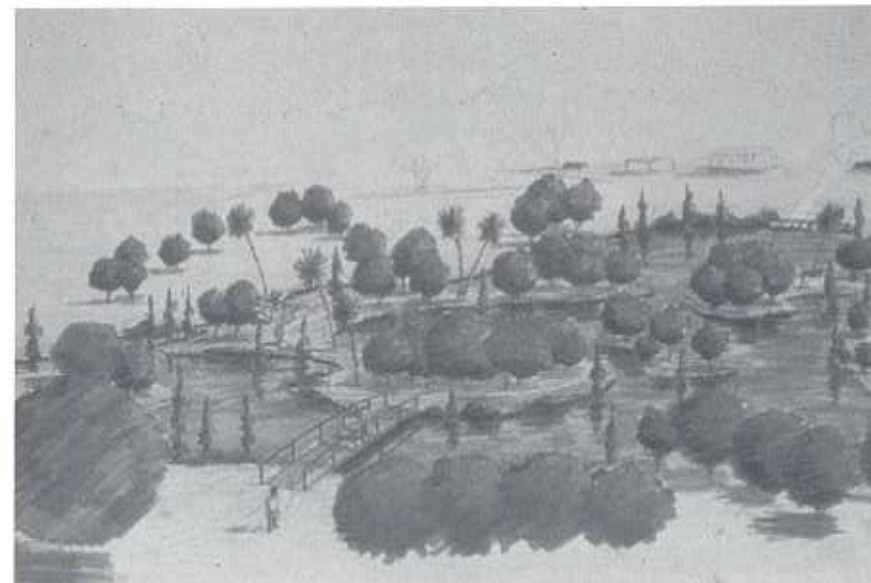


Regional detention systems can be established to provide stormwater management for several projects within a watershed. In addition, regional facilities can provide for water quality enhancement and flood protection for existing stormwater problems and, if located and designed as part of an overall stormwater master plan, they can also address stormwater management needs associated with future development. Regional facilities also offer many advantages such as economy of scale for construction and operation costs and greater overall effectiveness.

In addition to their stormwater management benefits, regional detention systems also can provide much needed recreational and open space benefits in the urban environment. As part of its Southeast Lakes Watershed Project, the City of Orlando constructed a very creative detention system called the Lake Greenwood Urban Wetland. Besides being an innovative stormwater treatment train, the system also provides an attractive urban wetland and recreational area.



Lake Greenwood Urban Wetland
(Conceptual Views)

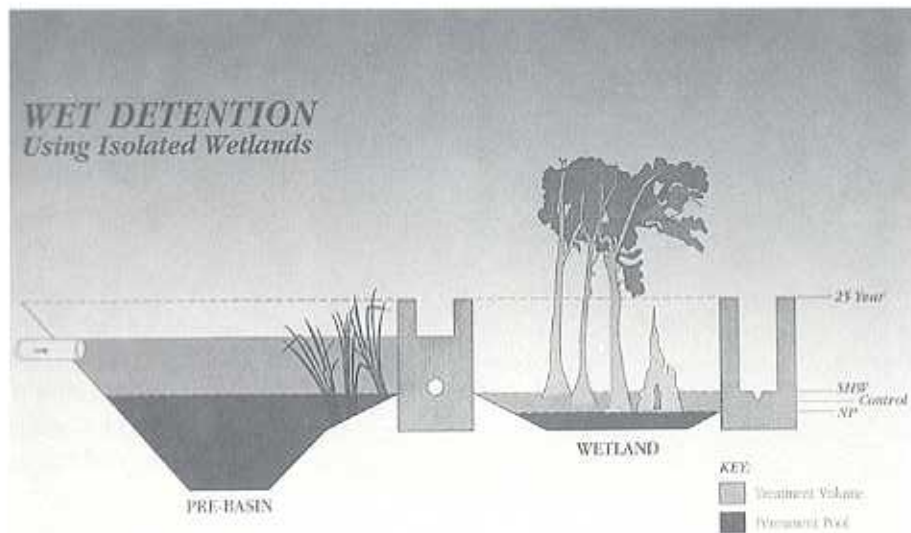


Lake Greenwood Before Redesign



Lake Greenwood After Redesign





Conceptual Design



Pretreatment Pond



Wetland Treatment System



Swale Discharge From Wetland

F. Wetland Stormwater Systems

The contributions of wetlands to a high quality environment are substantial and irreplaceable. Wetlands help improve water quality by trapping sediments, filtration and adsorption of pollutants, and natural flood protection through water storage and conveying flows. Wetlands are nature's kidneys.

The incorporation of wetlands into a comprehensive stormwater management system provides a way to achieve many objectives—flood protection, water quality enhancement, reduced operation and maintenance, aesthetic buffer, development amenities, enhanced wetland value, and wetland preservation and enhancement. However, the use of wetlands for stormwater management is neither a panacea nor a refined science.

In 1984, the Florida Legislature authorized the use of certain wetlands for stormwater management if the ecological values of the wetlands were protected or restored. Wetlands that have been ditched and drained and which are connected

to state waters by such a ditch may be used for stormwater management. These wetlands have been damaged. Typically they are dry and upland plants are invading and replacing wetland plants. Using these kinds of wetlands for stormwater management revitalizes them and provides valuable new fish and wildlife habitat and aesthetic benefits. Isolated wetlands that are intermittently connected and which flow to other waters when ground water rises above the land surface also may be used for stormwater management. This program has helped to preserve wetlands that otherwise would have been destroyed or damaged during development, while helping to provide effective stormwater management.

In designing stormwater management systems that incorporate wetlands, the stormwater treatment train concept is essential. Pretreatment practices such as swales, off-line landscape infiltration or a pretreatment pond are needed to reduce oil, grease and sediment loads to protect the wetland filter—the vegetation, sedi-

ment and microorganisms—that treats the other stormwater pollutants. The pretreatment pond also provides stormwater storage and attenuates peak discharges to help protect the hydroperiod of the wetland. The hydroperiod—the duration that water stays at various levels—determines the form, function and nature of the wetland. It must be preserved or restored.

Careful attention to detail is essential in the design of wetland stormwater systems. The BMPs in the treatment train must be carefully planned to work together to convey and pretreat stormwater. To protect the hydroperiod, the allowable high-and-low water levels in the wetland must be skillfully determined from field indicators. A distribution system that assures sheet flow of stormwater through the wetland must be designed to avoid channelized flow and to assure maximum contact of the stormwater with the wetland's vegetation, sediment, and microorganisms. Imaginative planning and design can create a stormwater system that is attractive, effective, and nearly self-maintaining.

G. Detention with Filtration

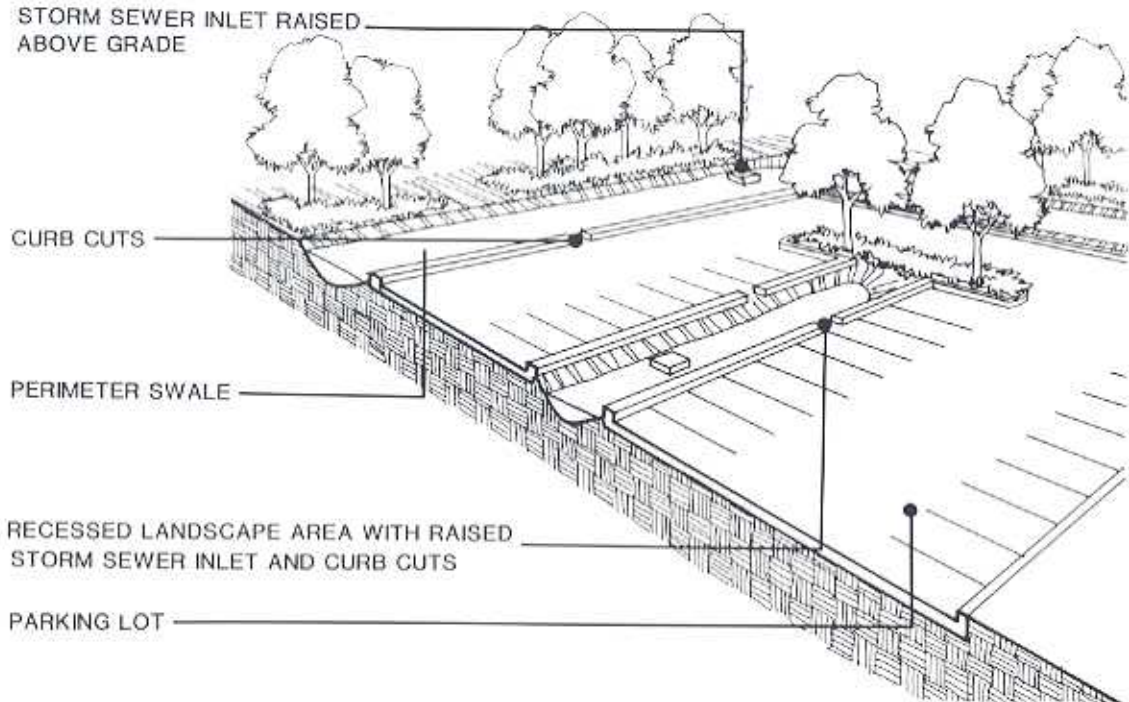
A BMP commonly used in Florida since 1982 is detention with filtration in which stormwater is held in a detention system and then is discharged through a filter. The filter removes particulate pollutants but does not remove dissolved pollutants and, therefore, is of limited value for protection of water quality. Typical filter systems have included bottom or side bank sand or natural soil filters. Recently, more exotic techniques such as multi-media filters composed of alum sludge or activated charcoal have been tried to improve the ability of a filter to remove dissolved pollutants. The Japanese garden filter shown to the right was built as part of the Lake Eola restoration project but, like other filters, it suffers from design and operation problems.

Difficulties associated with the design, construction and, most importantly, the maintenance of stormwater filters has led the Department of Environmental Regulation to deemphasize use of these systems. Experience shows that it is not a question of whether a filter will clog, but when—and then who will maintain it. Wet detention systems with planted littoral zones should be used rather than detention with filtration. However, where wet detention systems are impractical such as on small sites, sodded bottom filters are an acceptable alternative. The importance of vegetation cannot be over-emphasized for both enhanced treatment and minimum maintenance.



H. Parking Lots

Parking lots are one of the largest generators of runoff and polluted stormwater. These vast paved deserts generate stormwater after every storm. Many parking areas, such as for shopping centers are rarely completely filled with cars. This suggests that local regulations specifying parking requirements might need revision, while our design of parking lots could use greater imagination. The grassed parking lot at Tampa Stadium is a good example of a creative solution.



Another creative design is to recess landscaped islands so they are small retention and pretreatment areas. Placing a raised storm sewer inlet in the landscape island helps filter heavy metals, oils and greases. The raised inlet allows some retention and infiltration of the first flush before the stormwater is routed to a detention system. Using a curb cut allows the stormwater to flow into the landscape island easily.



POROUS CONCRETE is another innovative BMP with widespread applicability for parking areas. Paving with porous concrete allows water to percolate into the underlying soil. By using porous concrete, a parking lot can remain pervious and act as a large retention area, thereby reducing stormwater volume, peak discharge rate and pollutant load. In addition, porous concrete eliminates water pockets and provides a safer, skid resistant surface.

However, porous concrete is only feasible and cost effective on sites with gentle slopes, permeable soils and relatively deep water table and bedrock levels. When properly designed and carefully installed, porous concrete has load bearing strength and longevity similar to that of conventional concrete. The design and installation of porous concrete should be done only by a professional team of engineers and contractors who are familiar with its properties. Routine inspection and maintenance is essential to preserve the high infiltration rate of porous concrete paving. The surface should be routinely checked after a prolonged storm for evidence of debris, ponding of water, clogging of pores or other damage. Regular vacuum sweeping should be performed to prevent clogging of the porous

parking surface. High pressure steam cleaning may be needed annually. During construction it is essential that sound erosion and sediment control practices be used to keep sediment off the pervious pavement and prevent clogging.

If properly designed, installed and maintained, pervious concrete provides a cost-effective, viable solution to parking lot stormwater management problems.



I. Alum Treatment

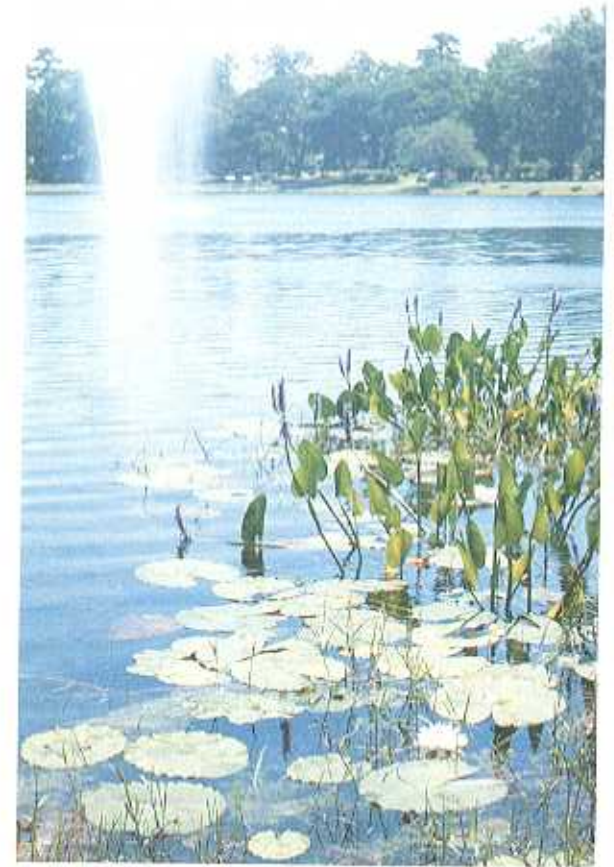
Aluminum sulfate (alum) has been used to clarify potable water supplies, remove phosphorus from wastewater, and to inactivate phosphorus in lake sediments. Injection of liquid alum inside storm sewers to treat stormwater represents another innovative, cost-effective BMP with widespread application, especially to reduce stormwater pollutant loads to urban lakes.



The first application of this technique was in the 1986 restoration of Lake Ella in Tallahassee. Lake Ella is a 13-acre shallow lake whose 160 acre watershed is intensively developed. The lack of available land, and heavy clay soils prevented the use of traditional BMPs to reduce stormwater pollutant loads to the lake.

The Lake Ella stormwater management system consists of flow meters which measure stormwater flowing in the storm sewers, and injectors which periodically add a predetermined dose of alum to the stormwater as it moves through the storm sewer. As the alum mixes with stormwater, it produces a small floc which attracts suspended and dissolved pollutants. The pollutants become bound to the floc, which settles and becomes incorporated into the lake's sediments. An added benefit is that the alum floc attracts pollutants within the lake water itself and removes them also.

The system has successfully removed more than 90% of the stormwater pollutants and Lake Ella's water quality and clarity is outstanding. Lake Ella is once again a heavily used recreational area for Tallahassee residents.



The City of Orlando also used alum injection on a project that demonstrates how a commitment to environmental quality and coordination of retrofitting with a new project can provide multiple benefits and substantial cost savings. The City was building a new arena for its expansion franchise in the National Basketball Association. A traditional stormwater management system using underground exfiltration systems was designed to treat the runoff from the 42 acres associated with the new arena and its surrounding parking areas. The cost of constructing this system was estimated at over \$2 million. Because of its past experiences with stormwater management, the City felt that alternative options, namely, a regional approach to stormwater management, were available that could provide additional benefits for less cost. A desirable benefit was retrofitting the existing drainage system that flowed through the project area and discharged untreated stormwater from the 305 acre basin into Lake Dot which is located directly in front of the new arena. The City constructed an alum injection system that incorporates a dual feed system - one for alum for treatment, and a second for sodium hydroxide to maintain desirable pH levels in Lake Dot - at a cost of \$450,000.



J. Maintenance of Stormwater Systems

The ultimate success of any stormwater management program depends on proper maintenance. If a system is not properly maintained, the possibility of failure and subsequent downstream damage is very real. Sooner or later, damage will result and the investment in management facilities will have been wasted.

Continuing maintenance should be incorporated into the planning and design of stormwater management systems. Along with the consideration of who is ultimately responsible for maintenance, design decisions concerning safety, soil conditions, topography, watershed size, land use, slope of vegetated banks and overall effectiveness all have a bearing on system maintenance. Proper handling of these elements during design and construction can minimize maintenance activities and costs associated with stormwater management.

Traditionally, well designed and constructed systems on industrial and commercial sites generally receive maintenance. One reason for this is that the organization responsible for planning, design and construction is also responsible for maintenance. These facilities are often intended to provide a major site amenity and, as such, require maintenance on the same basis as does lawn and building care.

However, stormwater systems for residential developments generally have not received much maintenance. In most cases a property owners association is legally responsible for maintenance, but does not have the technical ability or the money to do the job. While these facilities should be designed and built to allow as much owner maintenance as possible, the ultimate responsibility for continuing maintenance should be a local government's. Stormwater

systems are part of the public infrastructure just like roads or water systems, and they should be maintained in the same way. Proper easements for all stormwater management facilities must be required, with easements recorded to insure adequate access for maintenance. Easement requirements typically are found within the state stormwater criteria.

Finally, methods to finance the required maintenance must be a part of the overall stormwater management program. The potential for major downstream damage and degraded water quality from uncontrolled stormwater makes financing the maintenance of stormwater facilities as important to the community as road and bridge maintenance or sanitary and safety services.



CHAPTER SIX

STORMWATER REGULATORY PROGRAMS

In the past, the problems caused by increased stormwater runoff were borne by downstream property owners and governments. However, court decisions have established that the responsibility and cost for correcting stormwater problems rests with the developer who created the problem, or with the local government which permitted the development without appropriate stormwater management. Landowners, developers, contractors, and local governments must realize the consequences of development on the master stormwater system and provide appropriate controls.

Damages caused by stormwater are physical and visual, environmental and economic, and the cost of correcting the damage always is high. Since prevention of stormwater problems through sound site and watershed planning is far easier than correcting them, stormwater requirements have been implemented by several levels of government.

A. Federal NPDES Stormwater Permitting

Section 402(p) of the 1987 Federal Clean Water Act requires the U.S. Environmental Protection Agency (EPA) to establish National Pollutant Discharge Elimination System (NPDES) stormwater permits. This permitting program, to be administered in Florida by the EPA, is being phased in between 1989 and 1992. It will require certain local governments to obtain permits for their existing stormwater (drainage) systems and require permits for stormwater from certain industrial activities. This includes all construction projects that will disturb five or more acres of land, government owned landfills, power plants, airports, vehicle maintenance facilities and wastewater treatment plants (over 1 MGD flow). The greatest burden will be on local governments which are liable for the pollutants discharged from their stormwater systems into Florida waters and which will be responsible for developing a long term, comprehensive program to reduce the pollutant loading from their systems.

The EPA published final regulations for the NPDES stormwater permitting program on November 16, 1990. Recognizing the need to address stormwater on a watershed basis, the Department and EPA determined that all local governments within a county having a population over 100,000 must be included in the program to achieve the desired level of stormwater pollutant load reductions necessary to keep Florida's rivers, lakes and estuaries healthy. *Table 2* lists counties which, together with their municipalities and the Florida Department of Transportation, must submit permit applications. In addition, once the 1990 census is certified, the counties (and their municipalities) listed in *Table 3* will also have to apply for an NPDES stormwater permit.

Table 2

Counties Required to Apply for NPDES Stormwater Permits at Present
(and all municipalities within)

Broward	Orange
Dade	Palm Beach
Duval	Pinellas
Escambia	Polk
Hillsborough	Sarasota

Table 3

Counties Required to Apply for NPDES Stormwater Permits in Near Future
(and all municipalities within)

Alachua	Collier	Leon	Pasco
Bay	Hernando	Manatee	Seminole
Brevard	Indian River	Martin	St. Lucie
Charlotte	Lee	Okaloosa	Volusia

Local governments should begin immediately to use their comprehensive plans to develop an inventory of their stormwater management systems and to determine their stormwater infrastructure deficiencies. This information will be needed to develop the stormwater master plan required under both this federal program and the state's growth management program.

B. State Stormwater Permitting

The state Stormwater Rule, Chapter 17-25 Florida Administrative Code, was implemented by the Department of Environmental Regulation in February 1982. The rule requires all new developments, redevelopment projects, and most

modifications of stormwater systems to use appropriate BMPs to treat the first flush of stormwater, and to remove at least 80% of the annual average pollutant load. Stormwater discharges to Outstanding Florida Waters must be treated to remove 95% of the annual pollutant load.

Since its adoption, the Stormwater Rule has been revised several times to keep pace with the rapidly changing state of the art in BMP design and effectiveness. However, the most significant change to the state stormwater program occurred with the passage of the 1989 stormwater legislation. **This bill recognized the importance of a**

comprehensive approach to stormwater management throughout an entire watershed and of the need for a coordinated watershed management team approach involving DER, the water management districts and local governments.

As a result, State Water Policy (Chapter 17-40, F.A.C.) was revised in December, 1990 to establish within Section 17-40.420, the overall goals and institutional framework for the state's stormwater management program. These goals include retaining sediment onsite during construction; trying to assure that the stormwater peak discharge rate, volume and pollutant loading from a site are no greater after development than before the land use change; and reducing the stormwater pollutant loading from older drainage systems so that receiving waters will maintain or be restored to good water quality levels.

Each of the water management districts (except the Northwest Florida Water Management District which is currently developing rules in Chapters 40A and 40A-40) has implemented Management and Storage of Surface Waters rules to assure that stormwater is properly managed to prevent flooding problems and other negative effects on water resources. These rules can be

found in Chapter 40B-4 (Suwannee River Water Management District), Chapters 40C-4, 40C-40 and 40C-42 (St. Johns River Water Management District), Chapters 40D-4 and 40D-40 (Southwest Florida Water Management District) and Chapters 40E-4 and 40E-40 (South Florida Water Management District). These rules must be consistent with the goals set forth in State Water Policy. This ensures consistent and equitable administration of the stormwater program throughout Florida.

To provide for permitting efficiency and to assure comprehensive stormwater management, the Department is delegating its stormwater quality permitting program to the water management districts. To date, the South Florida Water Management District and St. Johns River Water Management District have received full delegation, and the Southwest Florida Water Management District and the Suwannee River Water Management District have received partial delegation. In the Florida panhandle, all stormwater quality permitting currently is conducted by the Department. For further information on the delegation of stormwater permitting to the water management districts or to learn which projects are permitted by the Department or by a District, call the Stormwater Management Section of the Department of Environmental Regulation in Tallahassee (904/488-0782).

C. Local Government Stormwater Permitting

Many local governments have adopted stormwater regulations to protect their citizens from flood damage, and to protect local water quality. Local regulations must be consistent with State Water Policy and the state and water management district rules and should not duplicate state permitting programs.

As a minimum, local government land development codes should ensure that all projects that will create and discharge stormwater, especially to state waters or to local government stormwater systems, have received a state stormwater permit or exemption before a local building permit is issued. This will help to assure that the stormwater is properly treated before discharge to the local government system and will reduce the local government liability for polluting receiving waters. Hopefully, these regulations integrate stormwater, landscaping and tree protection requirements and coordinate onsite stormwater controls with the local government stormwater master plan and level of service. The City of Tallahassee's Environmental Management Act is an excellent example of such an ordinance.

Table 4

Watershed Management: A Step by Step Guide

1. **Delineate and map watershed boundary and the sub-basins within the watershed**
2. **Inventory and map natural stormwater conveyance and storage systems**
3. **Inventory and map man-made stormwater conveyance and storage system.**
 - This includes all ditches, swales, storm sewers, detention ponds, retention areas, and includes information such as size, storage capacity, and age.
4. **Inventory and map land use by sub-basin**
5. **Inventory and map detailed soils by sub-basin**
6. **Establish a clear understanding of water resources in the watershed**
 - Analyze water quality, sediment, and biological data
 - Analyze subjective information on problems (such as citizen complaints)
 - Evaluate water body use impairment—frequency, timing, seasonality of problem
 - Conduct water quantity assessment—low flows, seasonality
7. **Inventory pollution sources in the watershed**
 - Point sources—location, pollutants, loadings, flow, capacity, etc.
 - Nonpoint Sources—type, location, pollutants, loading, etc.
 - land use/loading rate analysis for stormwater
 - sanitary survey for septic tanks
 - dry flow monitoring to locate illicit discharges
8. **Identify and map future land use by sub-basin**
 - Conduct land use loading rate analyses to assess potential effects of various land use scenarios
9. **Identify planned infrastructure improvements—5 year, 20 year**
 - Stormwater management deficiencies should be coordinated and scheduled with other infrastructure or development projects.
10. **Analysis**
 - Determine infrastructure and natural resources management needs within each watershed
11. **Set resource management goals and objectives**
 - Before corrective actions can be taken, a resource management target must be set. The target can be defined in terms of water quality standards; attainment and preservation of beneficial uses; or other local resource management objectives.
12. **Determine pollutant reduction (for existing and future land uses) needed to achieve water quality goals.**
13. **Select appropriate management practices (point source, nonpoint source) that can be used to achieve the goal**
 - Evaluate pollutant removal effectiveness, land owner acceptance, financial incentives and costs, availability of land operation and maintenance needs, feasibility, and availability of technical assistance
14. **Develop Watershed Management Plan**
 - Since the problems in each watershed will be unique, each watershed management plan will be specific.
 - However, all watershed plans will include elements such as:
 - Existing and future land use plan
 - Master stormwater management plan that addresses existing and future needs
 - Wastewater management plan including septic tank maintenance programs
 - Infrastructure and Capital Improvements Plan

WHAT LOCAL GOVERNMENTS CAN DO

Local governments are the key to solving Florida's stormwater management problems because of the intimate relationship between land use, infrastructure, and stormwater management. Since local governments determine land use, zone property, and issue building permits, their commitment to sound watershed management is essential. Watershed Management involves coordination between land use, infrastructure, and water resources management in a well-planned, integrated program that protects the quality of life in the most economical fashion. The stormwater management liability borne by local government strongly implies a need to develop comprehensive stormwater management programs that will help to prevent problems in a cost effective manner. It is important to remember that successful watershed management requires an integration of nonstructural, preventive approaches (e.g., land use management, source controls) with structural approaches (e.g., BMP implementation).

A. Develop a Watershed Management Plan

The **Local Government Comprehensive Planning Process** offers a unique opportunity to obtain much of the information that is needed for a local government to develop and implement **Watershed Management Plans**. As shown in *Table 4*, the steps taken to develop a watershed plan are similar to those undertaken in the comprehensive planning process. In fact, a thorough, well done comprehensive plan can be a watershed management plan. In their planning process local governments should inventory their existing infrastructure, develop appropriate maps and atlases (such as maps of storm sewer systems), conduct level of service analyses, determine needs and problem areas and then, based on future land use, develop and implement their master plan to meet their needs for infrastructure.

B. Implementation of the Watershed Management Plan

The implementation of a watershed management plan, especially recommendations about reconstruction of infrastructure such as the modification of existing stormwater systems to reduce their pollutant loads, requires a stable funding source over as much as 25 years. Frequently, stormwater management can be integrated with other infrastructure improvements such as road widening or urban redevelopment while water quality improvements can be coordinated with modified flood protection for the existing stormwater system. Even the development of new parks or recreation areas can be used to address stormwater management needs. The watershed management program should include the following elements to help assure successful implementation.

Local Ordinances

Implementation of the watershed management plan (or Comprehensive Plan) will be achieved primarily by the adoption of **Land Development Regulations**. These will include administrative procedures, concurrency management systems, zoning classifications and requirements, subdivision regulations, and supplemental regulations that are needed to assure that the objectives of the watershed management plan are met. Supplemental regulations typically include stormwater management, well-head protection,

landscaping, tree protection, septic tank siting and maintenance. These supplemental regulations also should include requirements for various source controls such as open space, natural areas, buffer zones, and even nutrient and pesticide management. Parking requirements represent an area where significant benefits can be realized by minimizing the number of parking spaces or the amount of impervious surface by promoting the use of alternatives such as pervious concrete, turf block or even grass parking using special subgrade materials that provide bearing strength. **It must be stressed that maximum benefits are realized only if these ordinances are integrated, allowing maximum use of nonstructural preventive controls and promoting use of the BMP treatment train throughout the site planning process.**

The Land Development Regulations should not duplicate state permitting requirements but should ensure that appropriate state and federal permits are obtained before a building permit is issued. Specific criteria which complement but are more restrictive than state requirements should be included, if needed, to meet Comprehensive Plan or local resource management objectives. For example, a local government in a karst area should adopt stormwater criteria that help prevent contamination of ground water

through the porous soils and rock or sinkholes characteristic of such regions.

Public Education

Educating the public about stormwater, BMPs, and how our everyday activities can add to the nonpoint source and stormwater problem is a continuous need, not only to reduce the effects of these pollution sources, but to gain citizen support for local environmental management programs.

The public should understand that fertilizing lawns and then heavily watering the lawn causes the fertilizer to run off, creating nutrient problems in local waters as well as losing the benefits of the fertilization. They also should know how a swale works, and what benefits it provides. They need to understand that swales and storm sewers are not receptacles for grass clippings, tree limbs or other debris, and that used oil and debris should not be dumped into these conveyances since these materials are soon carried to nearby lakes or rivers. Programs can be undertaken to stencil storm drains "DUMP NO WASTES--DRAINS TO LAKE (RIVER, ESTUARY)" to alert the public to the relationship of these drains to water quality problems.

Pamphlets can be inserted into utility bills to help educate citizens about stormwater management. Informative materials have been developed by the Department, water management districts and local governments to help educate the public. Slide shows and other technical assistance is available from the Department and the water management districts.



Funding - The Stormwater Utility - An Innovative Source of Money to Get the Job Done

The largest obstacle to solving Florida's stormwater management problems is the lack of adequate financial resources.

To effectively implement a stormwater management program, local governments need money that is dedicated exclusively to stormwater. An innovative alternative for stormwater management financing is the creation of a **stormwater utility** which relies on user fees rather than the government's limited general tax revenues. The utility system is user-oriented, with costs allocated according to the services received. Parcels of land are assessed a charge based on runoff characteristics. Charges typically are determined according to a parcel's size and its percent of impervious (paved) area. Adjustments can be built into the system for properties which use appropriate BMPs to manage their runoff. Thus, user charges are related to a given parcel's stormwater contribution in excess of that contributed in the natural state.

The stormwater utility concept is not new. It has been used by several communities in the western United States since 1969. In Florida, the City of Tallahassee implemented the state's first stormwater utility in 1986, with single family residents paying \$1.00 per month. Today, over thirty-five other communities have implemented stormwater utilities, and many others are in the process of adopting one (Table 5). Recognizing

Table 5

Florida Stormwater Utilities

IMPLEMENTED		ERU RATE	UNDER CONSIDERATION	
1	TALLAHASSEE	\$5.00	1	ESCAMBIA CO./PENSACOLA
2	GAINESVILLE	\$3.75	2	PALM BAY
3	OCALA	\$2.00	3	SANIBEL
4	DAYTONA BEACH	\$1.75	4	GULFPORT
5	PORT ORANGE	\$3.00	5	VOLUSIA COUNTY
6	PORT ST. LUCIE	\$3.33	6	MANATEE COUNTY
7	MIAMI	\$2.50	7	PINELLAS COUNTY
8	OAKLAND PARK	\$1.00	8	EUSTIS
9	ORLANDO	\$3.00	9	NEW SMYRNA BEACH
10	ALTAMONTE SPRINGS	\$2.25	10	CASSELBERRY
11	WINTER PARK	\$3.50	11	ST. CLOUD
12	MOUNT DORA	\$3.00	12	BAY COUNTY/PANAMA CITY
13	EDGEWATER	\$3.00	13	COCOA
14	ST. PETERSBURG	\$4.50	14	ROCKLEDGE
15	TAVARES	\$3.00	15	ORANGE CITY
16	DUNEDIN	\$3.00	16	SEMINOLE COUNTY
17	KISSIMMEE	\$2.00	17	ORANGE COUNTY
18	HOLLY HILL	\$0.50	18	NAPLES
19	S. DAYTONA	\$1.00	19	MELBOURNE
20	ORMOND BEACH	\$2.50	20	MARTIN COUNTY
21	LARGO	\$1.50	21	PALM BEACH COUNTY
22	DELAND	\$2.00	22	HOLLYWOOD
23	CAPE CORAL	\$2.50	23	NEW PORT RICHEY
24	SARASOTA COUNTY	\$3.50	24	ATLANTIC BEACH
25	BREVARD COUNTY	\$3.00	25	BROOKSVILLE
26	HILLSBOROUGH COUNTY	\$1.00		
27	CLEARWATER	\$3.00		
28	W. PALM BEACH	\$3.50		
29	JACKSONVILLE BCH.	\$3.00		
30	DELRAY BEACH	\$2.25		
31	CLERMONT	\$3.00		
32	TITUSVILLE	\$3.00		
33	COLLIER COUNTY	\$3.50		
34	DADE COUNTY	\$2.50		
35	FT. MYERS	\$3.00		
36	LEON COUNTY	\$1.68		
37	LAKE MARY	\$3.00		
38	SANFORD	\$3.00		
			26	DUVAL COUNTY
			27	LAKE COUNTY
			28	VERO BEACH
			29	BOCA RATON
			30	HIALEAH
			31	BROWARD COUNTY
			32	FT. LAUDERDALE
			33	LEESBURG
			34	BELLE GLADE
			35	CITRUS COUNTY
			36	POLK COUNTY
			37	WINTER HAVEN
			38	LAKE WALES
			39	OVIEDO
			40	MAITLAND
			41	FT. MEADE
			42	MADISON
			43	LAKELAND
			44	LEE COUNTY
			45	APOPKA
			46	BOYNTON BEACH
			47	TARPON SPRINGS
			48	TAMPA

the need for integrated stormwater management throughout a watershed, Dade County recently

enacted the first county-wide stormwater utility that also includes twelve of its municipalities.

A successful financing program for each community must be based on that community's needs. However, a high degree of public acceptance and government confidence has been demonstrated for establishing a stormwater utility program which integrates the following components:

Phase Out General Fund Contributions - Allows a gradual transition to a full utility, usually over a five-year period.

Adopt a Stormwater Ordinance - The ordinance identifies the duties of the local government, the users and developers; establishes the legal framework and fee structure; establishes the stormwater management goals, policies and standards, and sets up an operating permit system to assure that privately owned facilities continue to function properly.

Prepare Stormwater Master Plan - A comprehensive stormwater master plan is needed to guide near-term and long-term stormwater system improvements and determine costs.

Establish a User Fee System - User charges are set at rates sufficient to cover the utility's annual operation, maintenance, capital and debt service requirements.

Establish a Developer Contribution System - Developer contributions represent a source of capital for constructing new stormwater management facilities. Methods include:

Subdivision dedications that require the developer to construct stormwater management facilities and dedicate them to local government,

Fees-in-lieu-of that require developers to pay an impact fee for the capital improvements needed to serve the development or pay a portion of the cost for a regional facility that will serve the development,

Availability charge that recover a debt service charge on a previously constructed facility which will serve the new development.

Establish a Permit Fee System - While revenue from a permit fee is minimal, the system establishes control on all proposed stormwater projects, thus facilitating compliance with the master stormwater plan.

C. Operation and Maintenance of the Stormwater System

While Florida's stormwater regulatory program has helped to minimize adverse effects of stormwater and has led to the construction of stormwater management facilities, a major problem is how to assure that the facilities, once they are properly constructed, are being maintained. Staffing limitations have prevented the Department of Environmental Regulation or delegated water management districts from conducting inspections and emphasizing compliance and long-term maintenance. Local government assistance is needed to help assure that the tremendous investment in stormwater management infrastructure continues to provide benefits. Since most of these systems discharge into local government stormwater system, it is imperative to make sure that they function properly to minimize liabilities to the local government.

Local governments can help to inspect stormwater systems during construction. They already have building inspectors who travel to development projects to conduct various inspections. If properly trained, these inspectors could greatly improve the effectiveness of Florida's stormwater program. Training programs for local government inspectors hopefully will be developed by the Department and water management districts in the near future.

Local governments can also help to assure that stormwater systems are properly maintained. Stormwater systems need to be thought of as part of the community's infrastructure just like its roads, water and wastewater systems. The City of Orlando uses its code enforcement powers to assure that needed maintenance is performed. The City of Altamonte Springs has considered using Occupation License renewal as a means of



assuring that stormwater systems serving commercial properties are properly maintained. Before an Occupational License can be renewed the stormwater system is inspected by the City Engineer's Office which makes sure the system has been maintained and is operating properly. Most recently, as part of a thorough revision of its Environmental Management Ordinance and the implementation of its stormwater utility, the City of Tallahassee implemented a stormwater operation permit system that requires regular maintenance of the stormwater system and periodic renewal of the operating permit. Currently, the Department is working with the Florida Water and Pollution Control Operators Association to develop a standardized curriculum and certification program for local government stormwater maintenance staff.

D. Intergovernmental Coordination

Since stormwater does not recognize political boundaries it is essential that local governments within a watershed work together to develop and implement their stormwater master plan. Coordination with the Department, water management districts, and the Department of Transportation is also needed as is cooperation with the private sector. **THE WATERSHED MANAGEMENT TEAM NEEDS YOU!**

CONCLUSION

Proper stormwater management is vital to the health of Florida's economy and our quality of life. Properly designed stormwater management is a practical, feasible and desirable element in urban development and redevelopment. Stormwater can be controlled in conjunction with development of any site. The particular control strategy should be tailored to fit the needs of the individual project by sound selection of appropriate BMPs, good technical and aesthetic design, and quality construction and maintenance.

Effective watershed management programs must be based upon the big C's of watershed management:

1. **COMPREHENSIVE** management of land use, water resources and infrastructure throughout a watershed
2. **CONTINUITY** of stormwater and watershed management programs over a long period of time will be required to solve these problems
3. **COOPERATION** between state and local governments, cities and counties, the public and private sectors and all of our citizens is essential to prevent and solve problems
4. **COMMUNICATION** is essential to educate ourselves about how we are all part of the problem and how we can and must be part of the solution
5. **COORDINATION** of stormwater retrofitting to reduce pollutant loading with other infrastructure improvements or redevelopment is needed for cost-effective implementation and to maximize benefits
6. **CREATIVITY** in both BMP technology and in our approach to solving complex problems is vital
7. **COMMITMENT** to solving these problems so our children will have a bright future (JUST SAY NO TO STORMWATER POLLUTION) will depend upon putting our money where our mouths are.

This guidebook has presented a variety of approaches to control stormwater. We hope it will be a resource of ideas and will stimulate imaginative new solutions to our watershed management problems.

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