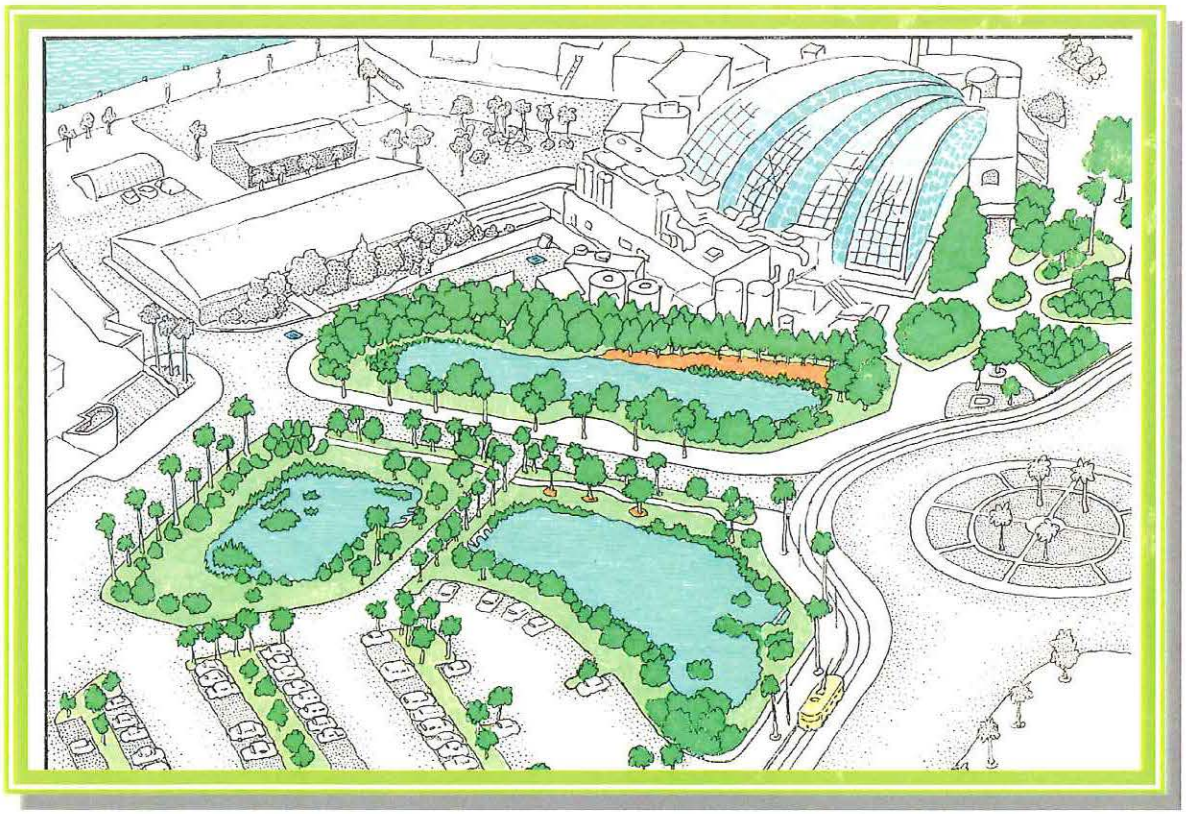
TRAVELING THE STORMWATER TRAIL
SOME FACTS AND FIGURES

WHAT IS STORMWATER?

Stormwater is pure rainwater plus anything the rain carries along with it. In urban areas, rain that falls on the roof of your house, or collects on paved areas like driveways or roads is transported through a system of pipes, swales or other conveyances directly into rivers, lakes and estuaries. In other words, stormwater goes straight from your street to waterways inhabited by fish, frogs, birds and other aquatic animals. It also ends up on bathing beaches and in drinking water reservoirs where it can cause human health problems. Since the mid-1980s, new developments in Florida have been required to treat storm runoff using some type of stormwater management system. Some of these methods are treating stormwater at the Florida Aquarium. They can be seen as you follow the signs along the "stormwater trail" and are explained in more detail in this handout.



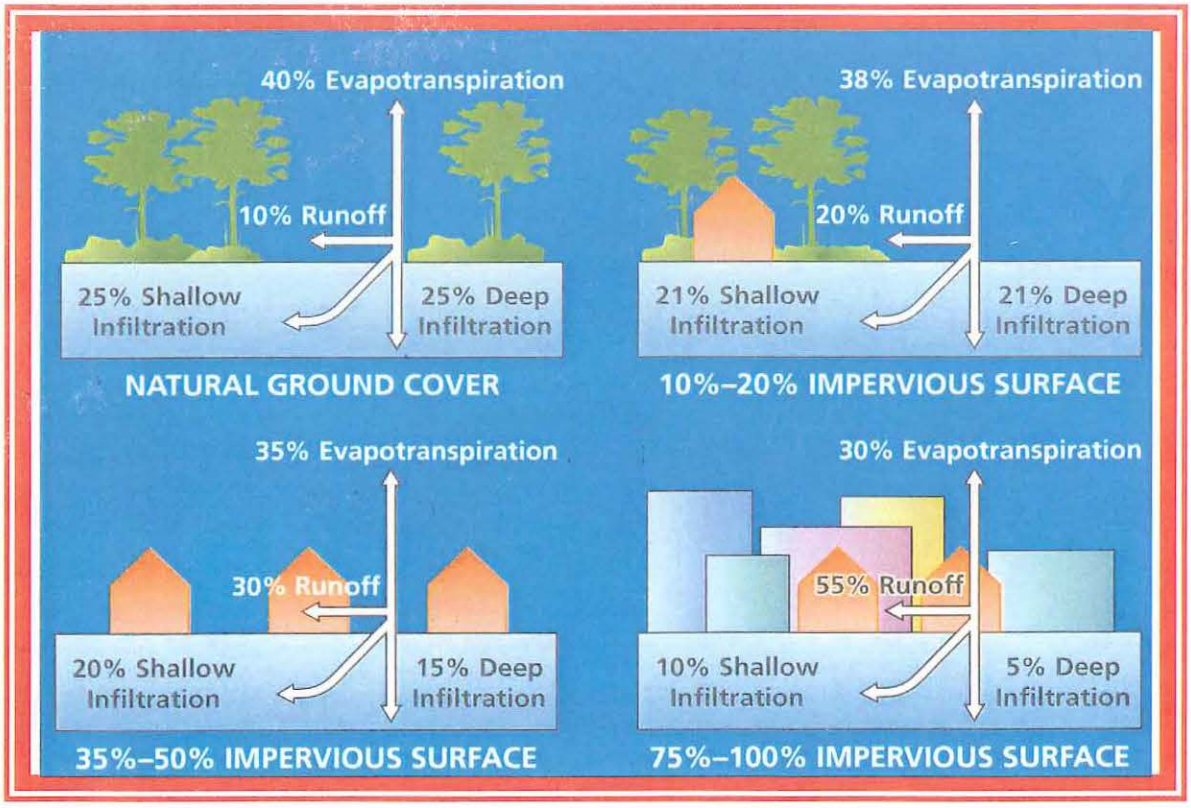
This overview shows, in color, the stormwater ponds and the areas with pre-treatment techniques that can be observed along the "stormwater trail".

WHAT MAKES STORMWATER RUNOFF A PROBLEM?

It has been raining on the earth for a long time, so why has rain only recently become a pollution problem. The answer lies with you and me, our modern technology and the way land is developed.

WHAT HAPPENS WHEN FORESTS ARE TRANSFORMED INTO CITIES?

The next figure shows what happens to the hydrologic cycle as cities grow. When we pave over the land, more rainfall runs off into lakes and streams while less water infiltrates into the ground or evaporates back into the atmosphere. In addition, the process removes natural vegetation and compacts the soil. Pristine natural conditions can never be restored, but stormwater management can mimic natural conditions by constructing wetlands or devising other methods to reduce the volume of runoff and reduce pollution. To do this, every opportunity in the drainage basin should be used to increase infiltration while storing and slowly releasing stormwater. Paved areas and other hard surfaces should be minimized and disconnected from direct discharge into waterways. The "stormwater trail" shows some of the techniques that can be used to incorporate these ideas into urban land development.



When land becomes urbanized storm runoff increases while infiltration into ground water and evapotranspiration decreases.

HOW DOES MODERN TECHNOLOGY CAUSE STORMWATER POLLUTION?

As storm runoff moves through the drainage basin, it picks up and carries away natural and human-made pollutants and deposits them into lakes, rivers, bays and estuaries. Seemingly negligible amounts of chemicals, trash, car residues, air pollution, fertilizers, and other products contribute to stormwater pollution. Anything you put on the land can be picked up by rainfall and carried into waterways. Also, every time an activity disturbs the land the potential for pollution increases. In addition to urban runoff other potential sources of pollution include: agriculture, forestry, grazing, septic systems, recreational boating, construction as well as physical changes to stream channels, and habitat degradation.

Pollution caused by automobile traffic

Improper Use of Fertilizers

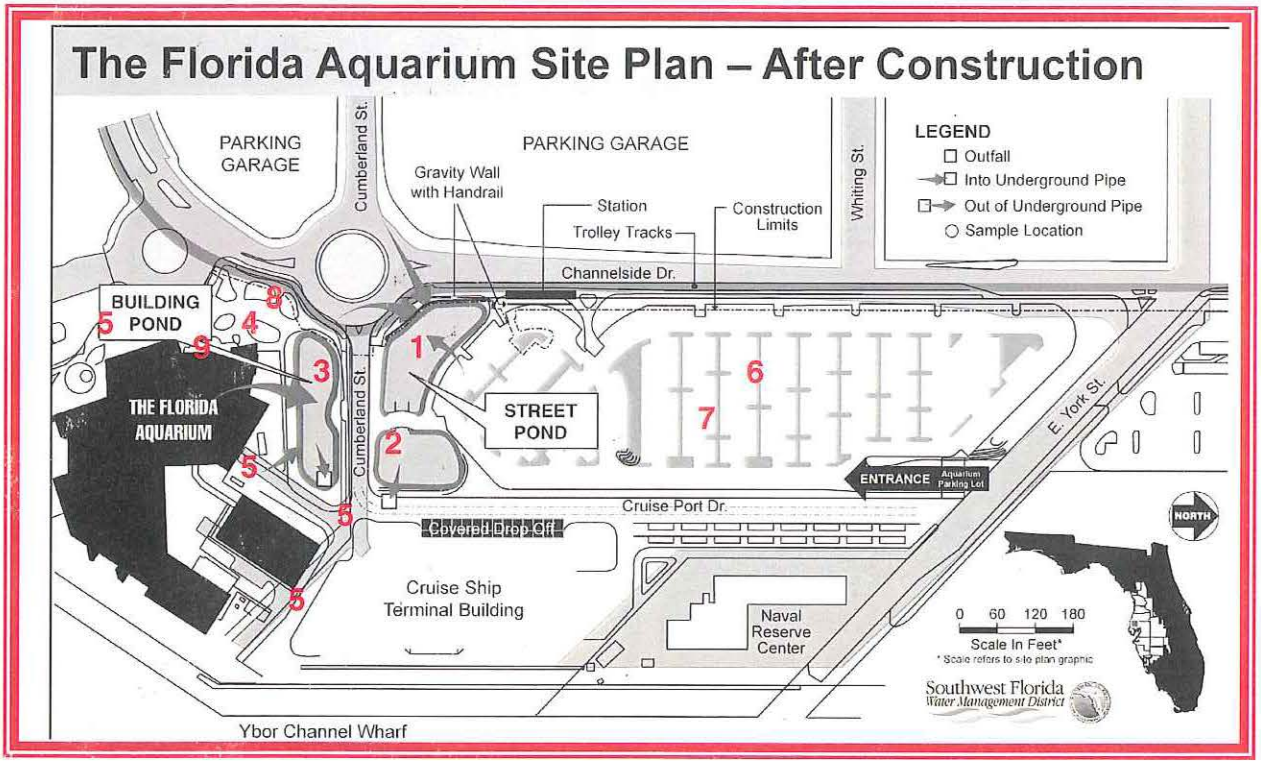
Litter from careless people

Disposing of wastes in storm drains instead of at recycling facilities

Material intercepted by a storm drain insert shows the leaves and debris that are either washed into stormwater drains or disposed of there with blowers used by lawn maintenance personnel.

WHAT CAN BE DONE TO REDUCE STORMWATER POLLUTION?

Many techniques have been developed to reduce stormwater pollutions. Some are seemingly small changes that can be implemented by individuals, but they add up to a considerable improvement in water quality when they are adopted by many individuals. These source control methods emphasize prevention and reduction of excess stormwater flow before it reaches a collection system or receiving waters. Other stormwater techniques require large expenditures of money and are usually implemented by a government either through the permitting process or by using tax dollars. The figure below lists some methods for reducing pollutants and identifies the location where they can be seen as you follow the numbers and travel the stormwater trail. **(Note: At the present time the numbers in this handout do not always correspond to the numbers on the signs and are not necessarily listed in sequential order)**



1. A sedimentation basin for an effluent filtration pond
2. The filtration pond for the effluent filtration system
3. A wet detention pond
4. Bioretention "rain gardens"
5. Drop box inserts (6 of these and not all are shown)
6. Swales (numerous and represented by the gray areas in parking lot)
7. Porous Pavement
8. Native vegetation
9. Rain barrels

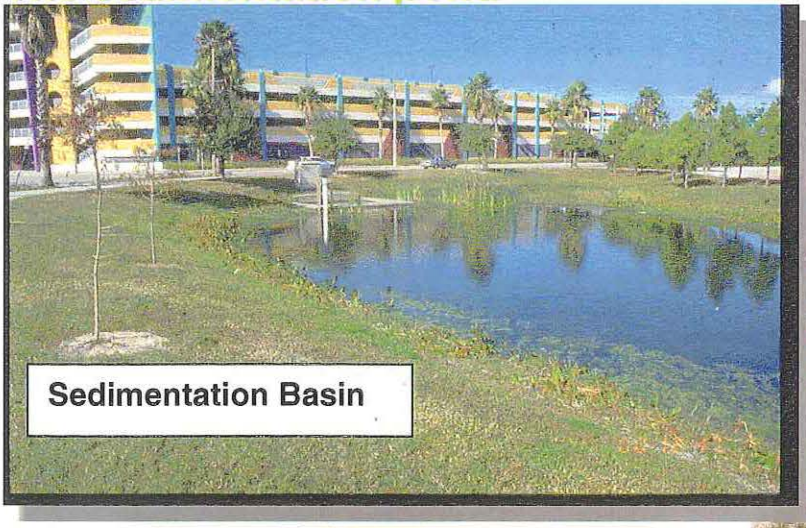
WHAT DOES GOVERNMENT DO TO REDUCE STORMWATER POLLUTION?

Government is helping to reduce stormwater pollution by requiring treatment in new developments and by retrofitting older urban areas using tax dollars from stormwater utilities and/or grant funds from state and federal programs. Some of the methods used to reduce stormwater runoff pollution can be seen along the Florida Aquarium "Stormwater Trail".

1 An effluent filtration pond

This stormwater pond uses a series of techniques for stormwater management. They include: a sediment sump, a sedimentation basin and a pond with an underground filter system. The first line of defense is the sediment sump that collects the heaviest material, which should be removed and disposed of about once a year. Water is further treated in the sedimentation basin before being discharged through equalizer pipes to the filtration pond.

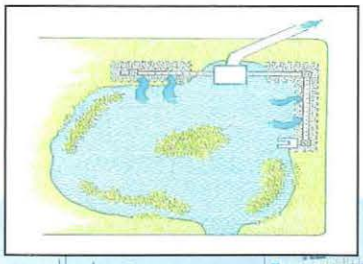
The sedimentation pond



Sedimentation Basin

Concrete Lined Sediment sump

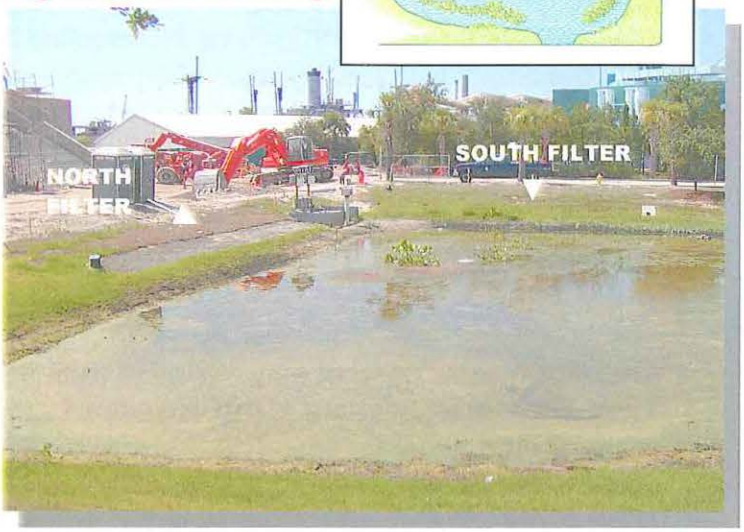
Equalizer pipes connecting the two parts of the pond



2. Effluent filtration (continued)

The Filtration pond

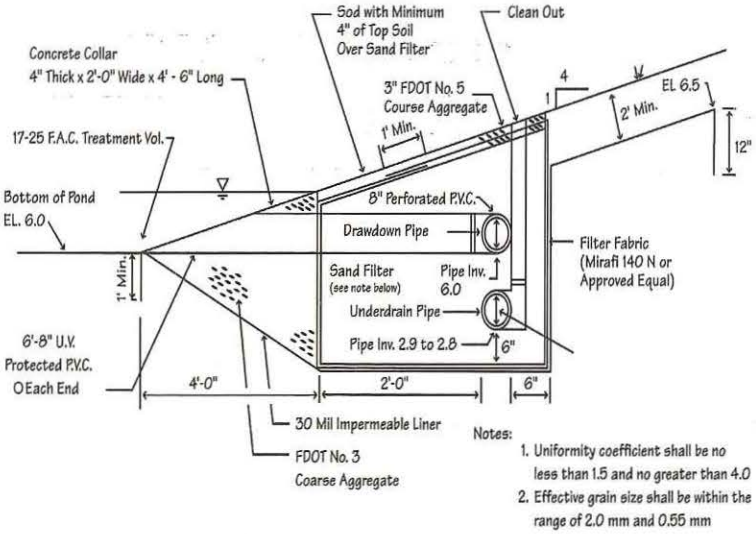
The North Filtration System



The South Filtration System

The filtration pond as it looked during construction of the cruise ship terminal in 2002. The older (south) filtration system uses pipes to deliver water to the underground filters. The newer (North) filtration system is shown to the left of the picture and uses a rock layer over the top of the filter to deliver pond water into the filter. In the pictures the north filter is covered in fabric to protect it from the construction dust and dirt.

Street Pond Underdrain Detail



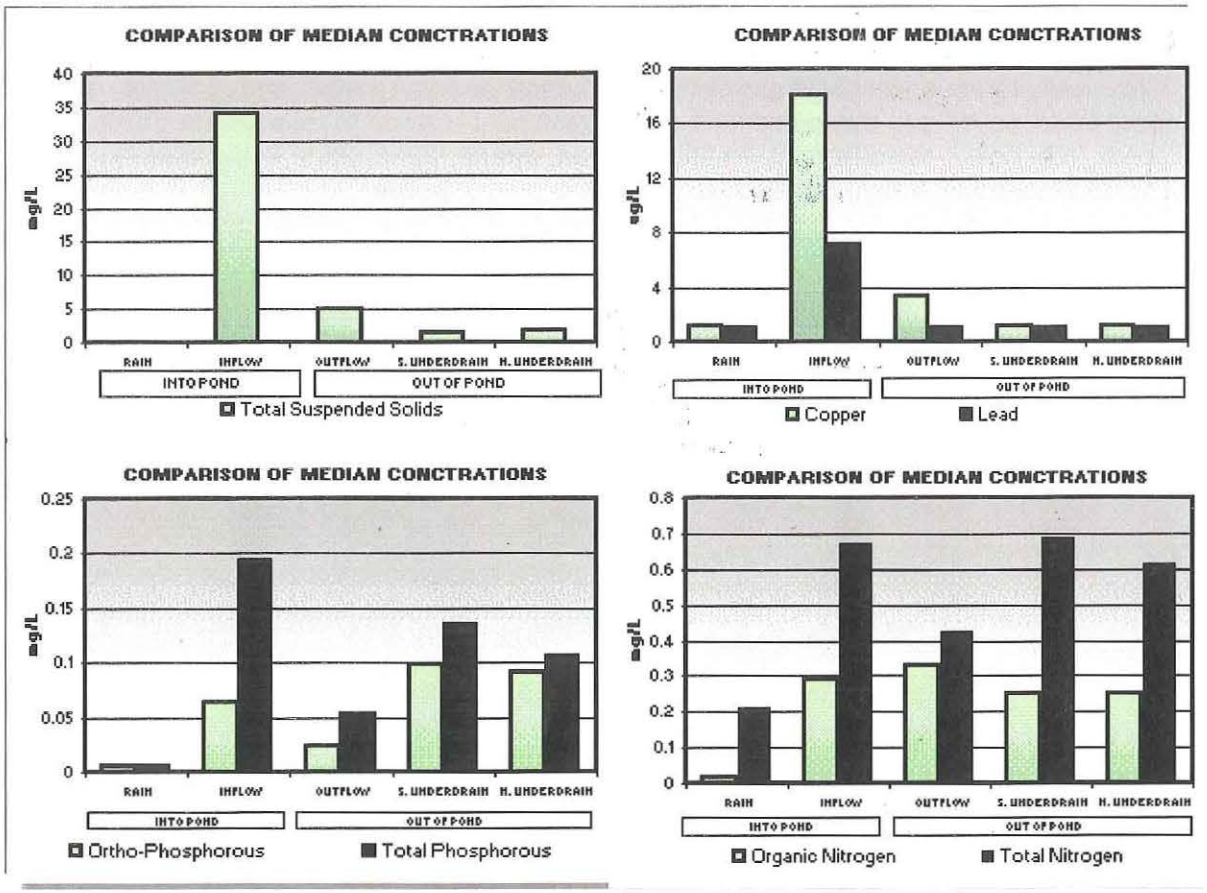
Cross Section of South Underground Filter

Water from the under drain system is seen discharging through the 8" under-drain pipe into the outflow drop box. Also shown is a small weir to measure flow and the tubing to collect water quality samples.

1 & 2 Effluent filtration (continued)

Some Data:

Water quality samples taken of rain falling on the pond, storm runoff entering the pond, and water leaving the pond (over the outfall weir and through the underdrains) indicate the system is effective for removing many of the pollutants of concern. Some of the data are reported in the following figures, which show total suspended solids and metals are greatly reduced by the system. Nitrogen and ortho-phosphorus are more difficult to eliminate, and concentrations are not necessarily lower at the outflow. Except for organic nitrogen, nutrients are measured at lower concentrations flowing over the weir than through the filters. The data demonstrate that the filter is effective for removing particulate pollutants, but does not necessarily remove dissolved pollutants.

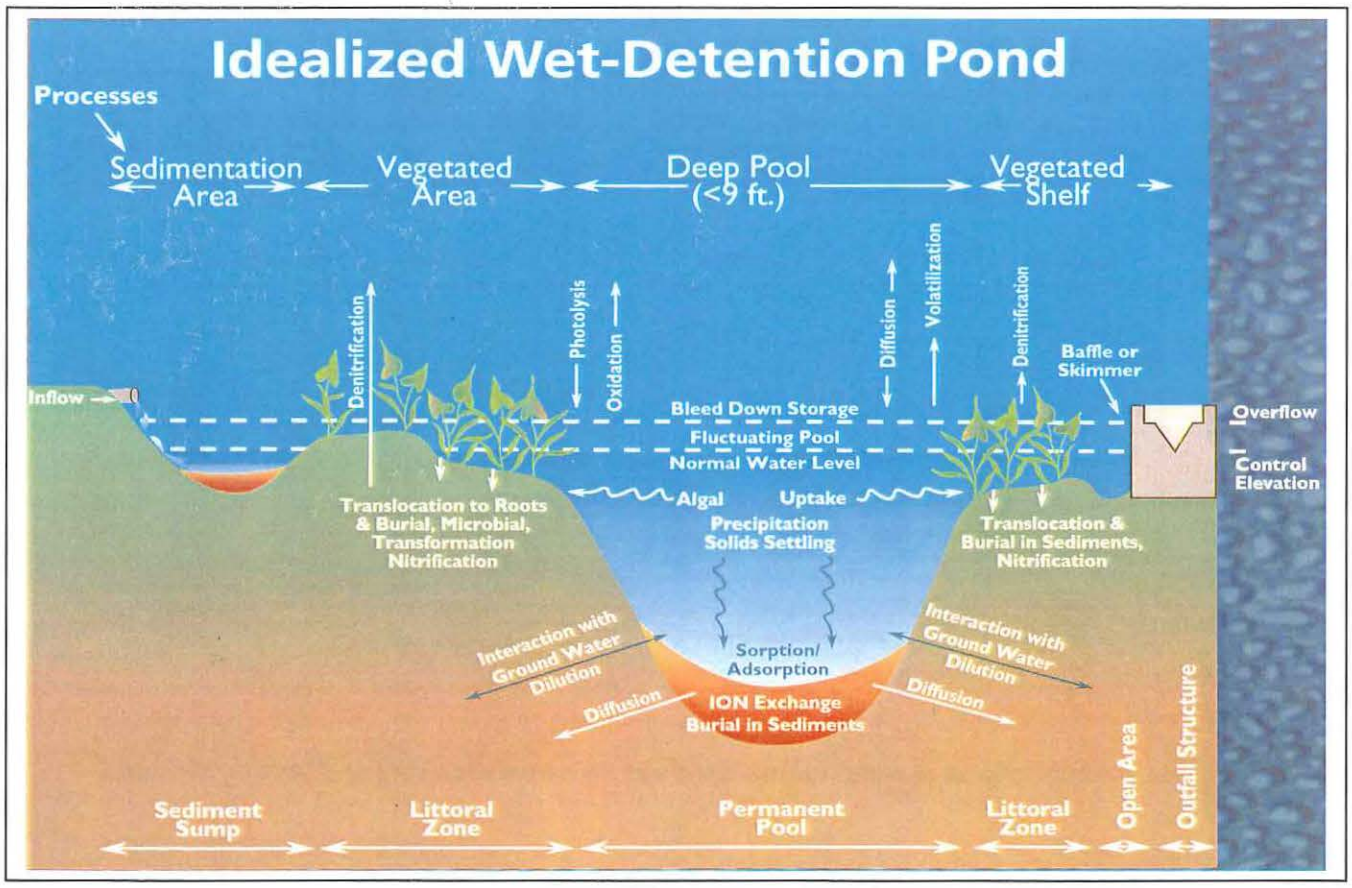


Median concentrations of constituents that were measured entering and leaving the pond

3. Wet Detention Pond

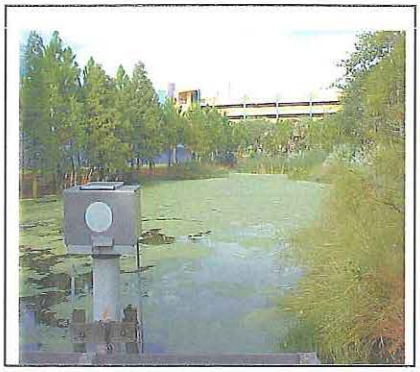
Detention ponds are designed to delay and slowly release storm runoff, thereby reducing the pollutant loads discharged to receiving waters. An important function of ponds is to eliminate the shock load from the "first flush". The "first flush" describes the washing action that stormwater has on accumulated pollutants in the watershed which causes higher concentrations of pollutants in the first part of storms. Since ponds store and delay this first flush, they provide time for increased percolation through the soils, which cleanses the water of most pollutants, augment the groundwater volume and help sustain base flow in rivers and streams.

The following figure depicts some of the processes that take place in ponds, which helps them provide flood control and water quality enhancement. Detention ponds are essentially lakes that consist of various elements designed to reduce pollutants: 1) the permanent water pool (deep pool) stores and treats water between storm events; 2) an overlying zone (fluctuating pool) temporarily stores runoff and slowly releases it over a number of days; and 3) a shallow littoral zone (vegetated shelf) allows wetland plants to biologically remove dissolved stormwater pollutants such as metals and nutrients. An ideal pond would also use some kind of pre-treatment method to remove the gross solids, (i.e. heavy material such as litter, leaves, debris, sand, etc.). In the diagram this is a sedimentation basin, but other methods are also effective.

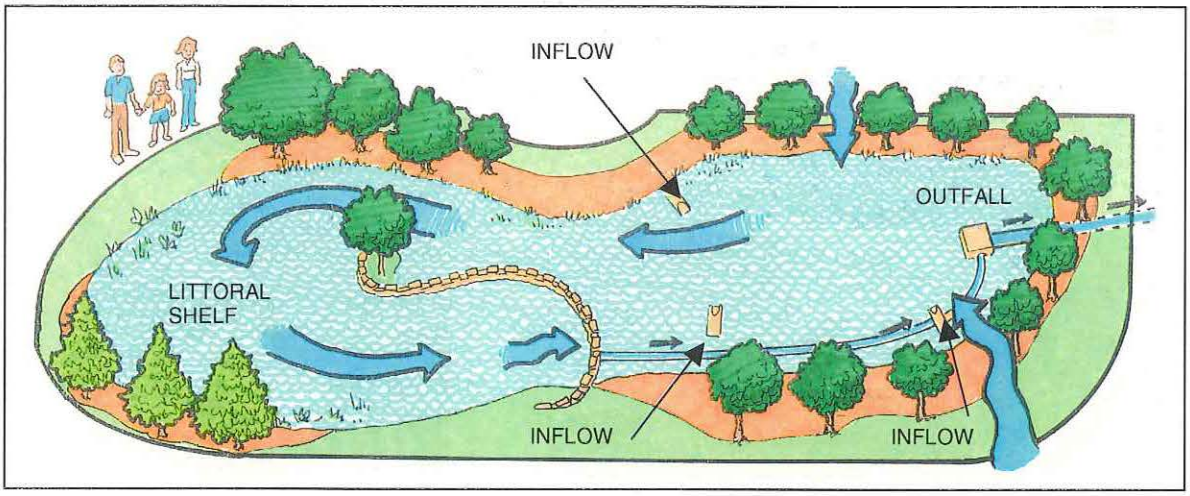


3. Wet Detention Pond (Continued)

The wet detention pond at the Florida Aquarium did not meet all of the desired features of the ideal pond as depicted in the previous figure. Installing pre-treatment skimmer boxes (to be shown later) and re-routing the treatment volume to take advantage of the littoral zone were two methods used to try to improve its pollution removal ability and reduce the amount of floating vegetation on the pond.



Pond from outfall showing monitoring equipment



A schematic of the pond shows how runoff enters the pond through three pipes (black arrows) near the outfall structure. A diversion wall and a return pipe were installed to force the water that originally exited through the bleed down pipe to flow through the littoral zone to provide for additional treatment before discharge through the outfall structure.

3. Wet Detention Pond (Continued)

Picture of the outfall weir shows water discharging through the bleed down orifice in the figure at right. Note skimmer around the outside of the weir structure to hold back floating pollutants such as oils, greases and floating algae.

Littoral shelf (on left) during the dry season

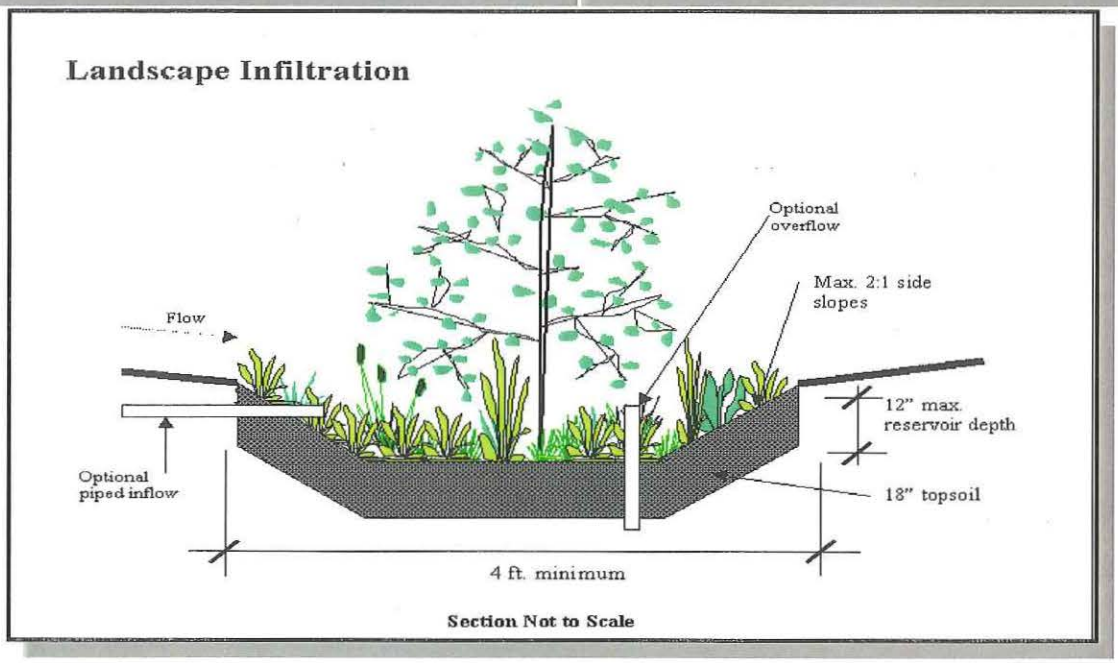
Installing diversion structure

4. Bioretention "Rain Gardens"

Storm treatment ponds work best if stormwater has had an opportunity to be detained and the flow reduced by the conveyance system upstream. Using the concept of a treatment train where opportunities exist in the drainage basin for runoff to infiltrate not only prolongs the life of ponds but also reduces runoff pollution. Pre-treatment gardens are one method for accomplishing this goal. These types of gardens are small depressions in the landscape that are used to store and infiltrate storm runoff before it reaches the pond. Several of the gardens near the entrance to the Aquarium serve this function.

Bioretention garden with trees

A closer look shows the thick litter layer to absorb water



4. Bioretention "Rain Gardens" (Con't)

8. Landscape with Native Plants

Landscaping with native plants is effective because when plants are chosen to match the conditions in your yard, they require no fertilizers and once established they do not need much pampering or water. The ideas in the entrance garden at the Aquarium show native plants that are suitable for landscaping your yard.

Reasons to reduce the size of your lawn and plant trees and shrubs instead.

Properly selected trees and shrubs absorb up to 14 times more rainwater than a grass lawn & they don't require fertilizer according to the Alliance for Chesapeake Bay.

In addition, trees and woody plants provide the services depicted in the figure to the left.

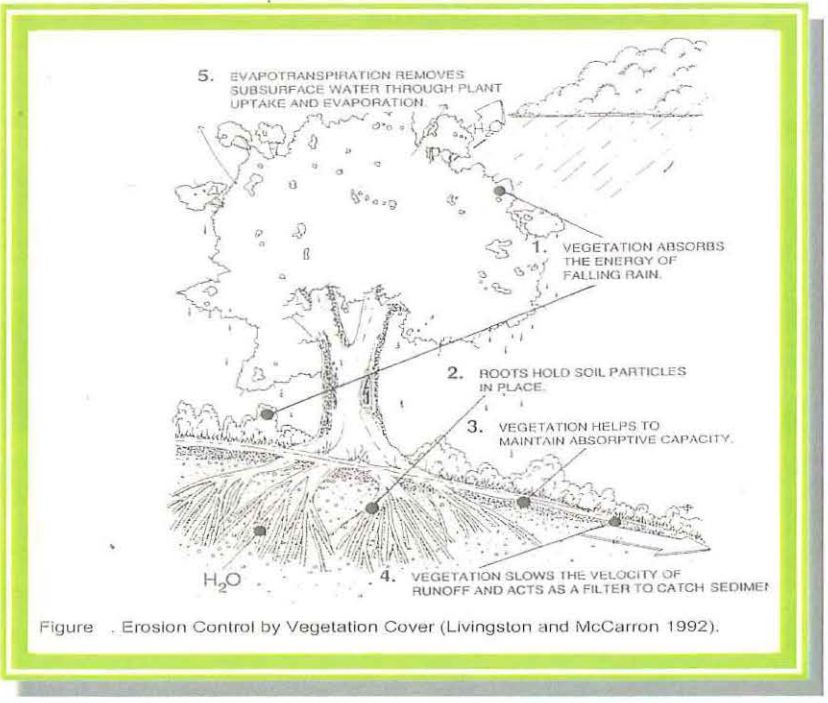
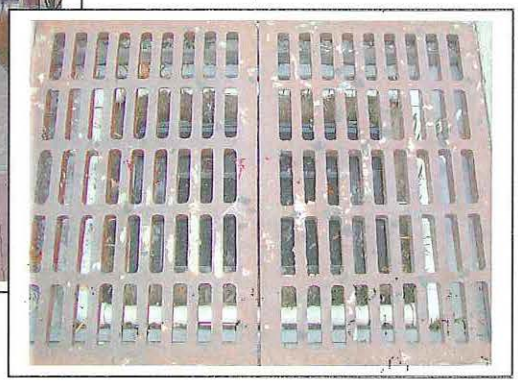
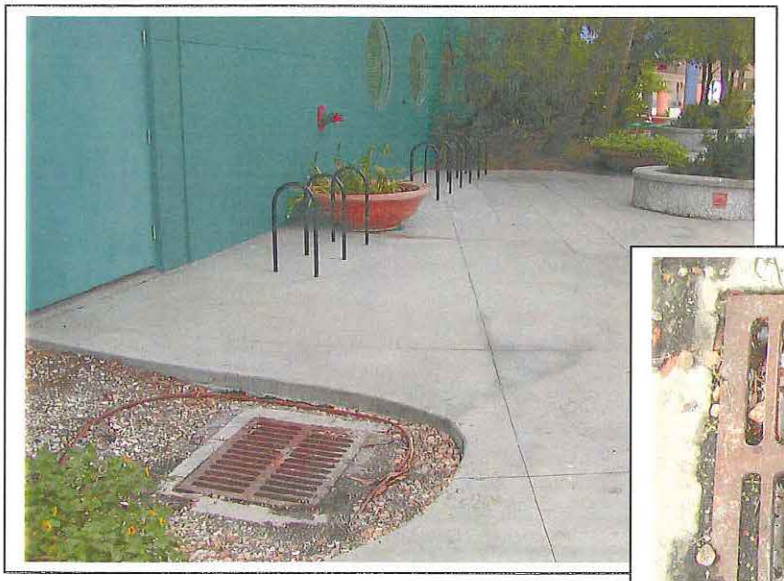


Figure . Erosion Control by Vegetation Cover (Livingston and McCarron 1992).

5. Drop Box Inserts (Skimmer boxes)

Drop box inserts (also called grate inlet skimmer boxes) are a pre-treatment method that can be used in built-up urban areas where land is at a premium. These devices collect the gross solids before they reach the collection system and pond. Gross solids are large size particles that include litter, debris, sediments, road break down products, leaves, seeds, grass clippings and other material larger than 64 microns. Six drop box inserts were installed at the Aquarium to reduce the amount of pollution being discharged to the wet detention pond. These are scattered throughout the drainage basin. Examples can be seen near the entrance to the Aquarium.

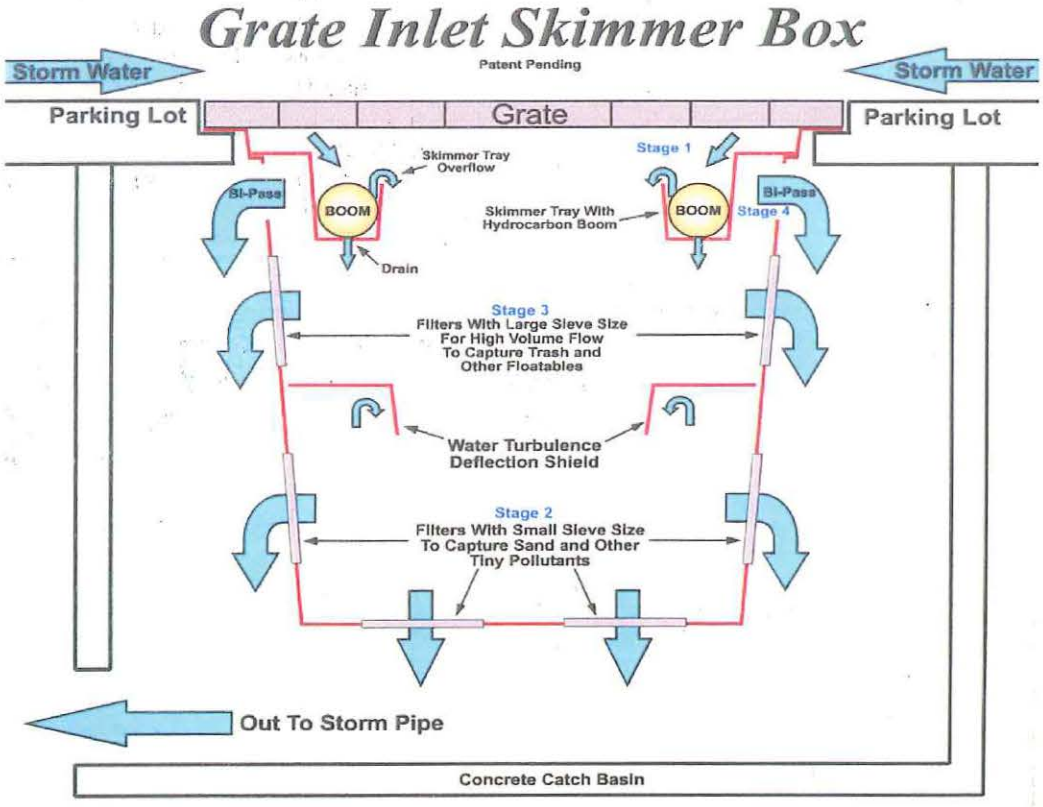




5. Drop Box Inserts (Skimmer boxes) Continued

Before installing drop box insert
With protective grate partially remove

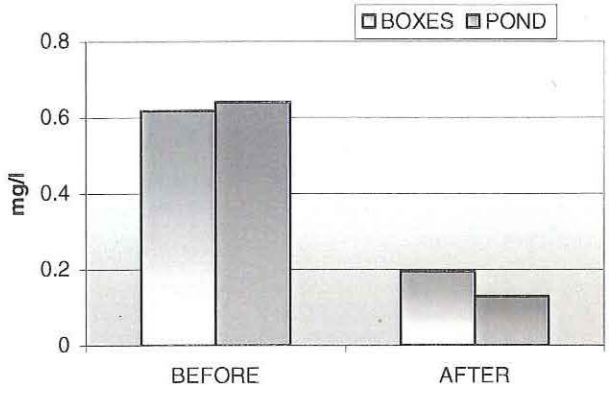
After installing drop box insert
and before grate put back on



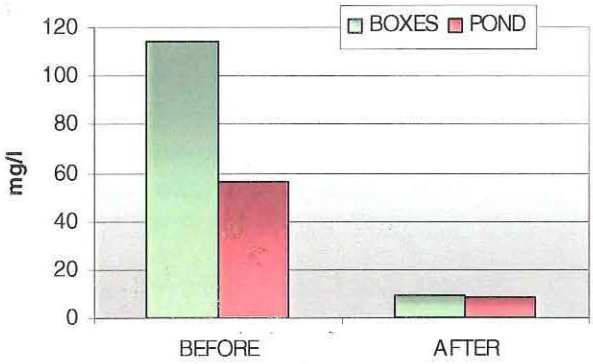
The pictures show the installation of a skimmer box and the diagram is a schematic of how one works.

5. Drop Box Inserts (Skimmer boxes) Continued

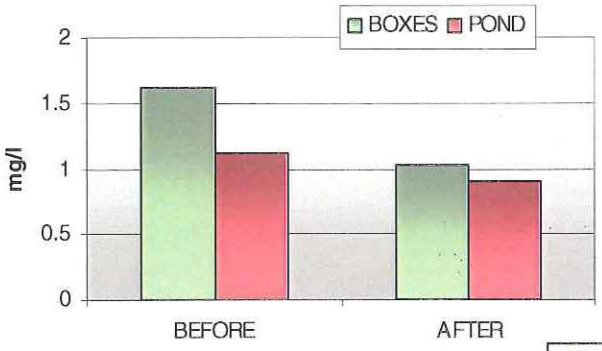
TOTAL PHOSPHORUS
Before and after skimmer box inserts installed



TOTAL SUSPENDED SOLIDS
Before and after skimmer box inserts installed



TOTAL NITROGEN
Before and after skimmer box inserts installed

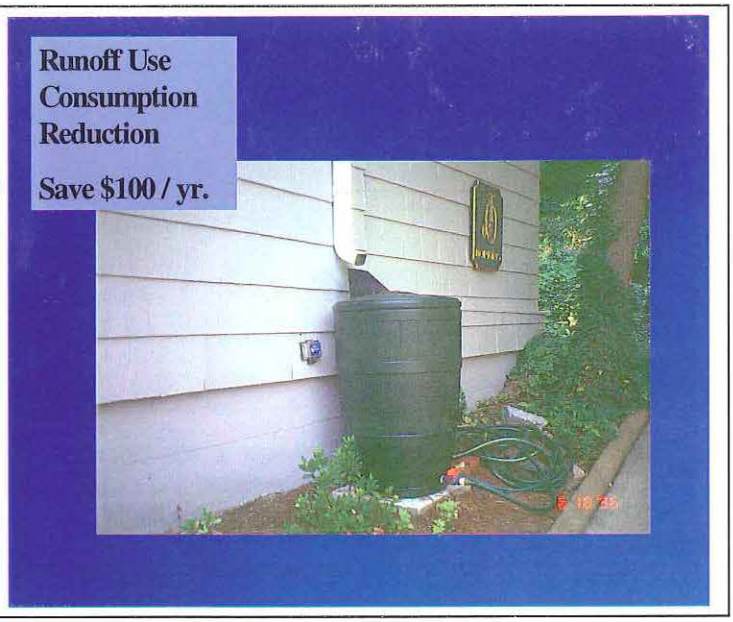


Some preliminary data taken from water in the bottom of the drop boxes and at the outflow of the pond before and after the inserts were installed. (Data taken before the inserts were installed also included dust and dirt from the port construction activity and final results may be different).

9. Rain Barrels

According to the Low Impact Development center, a home owner can save $100 per year by using a rain barrel for roof runoff. The more rain barrels, the more money you can save, and you save valuable water and reduce pollutants as well.

See the end of this report for the web addresses for stormwater treatment ideas.



6. Landscape Swales and Depressions

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

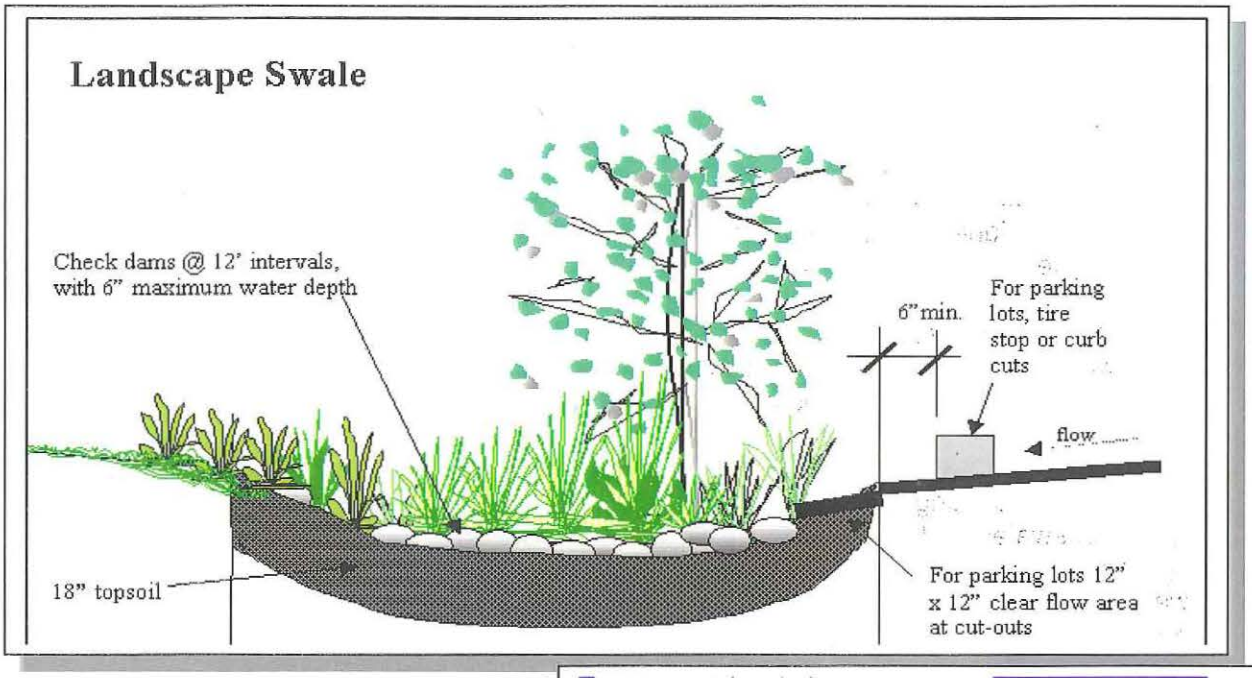
- A shallow trench, which has side slopes flatter than three feet horizontal to one foot vertical.
- Contains areas of standing or flowing water only after a rainfall.
- Planted with or have vegetation suitable for soil stabilization, stormwater treatment and nutrient uptake.
- Designed to take into account the soil erodibility, soil percolation, slope, slope length and to reduce the stormwater pollutant load.

Swales alone are usually not sufficient to reduce pollutants to acceptable levels, but used with other retention practices they are effective for pre-treatment. They are best incorporated into the design as one component in a series of best management practices.

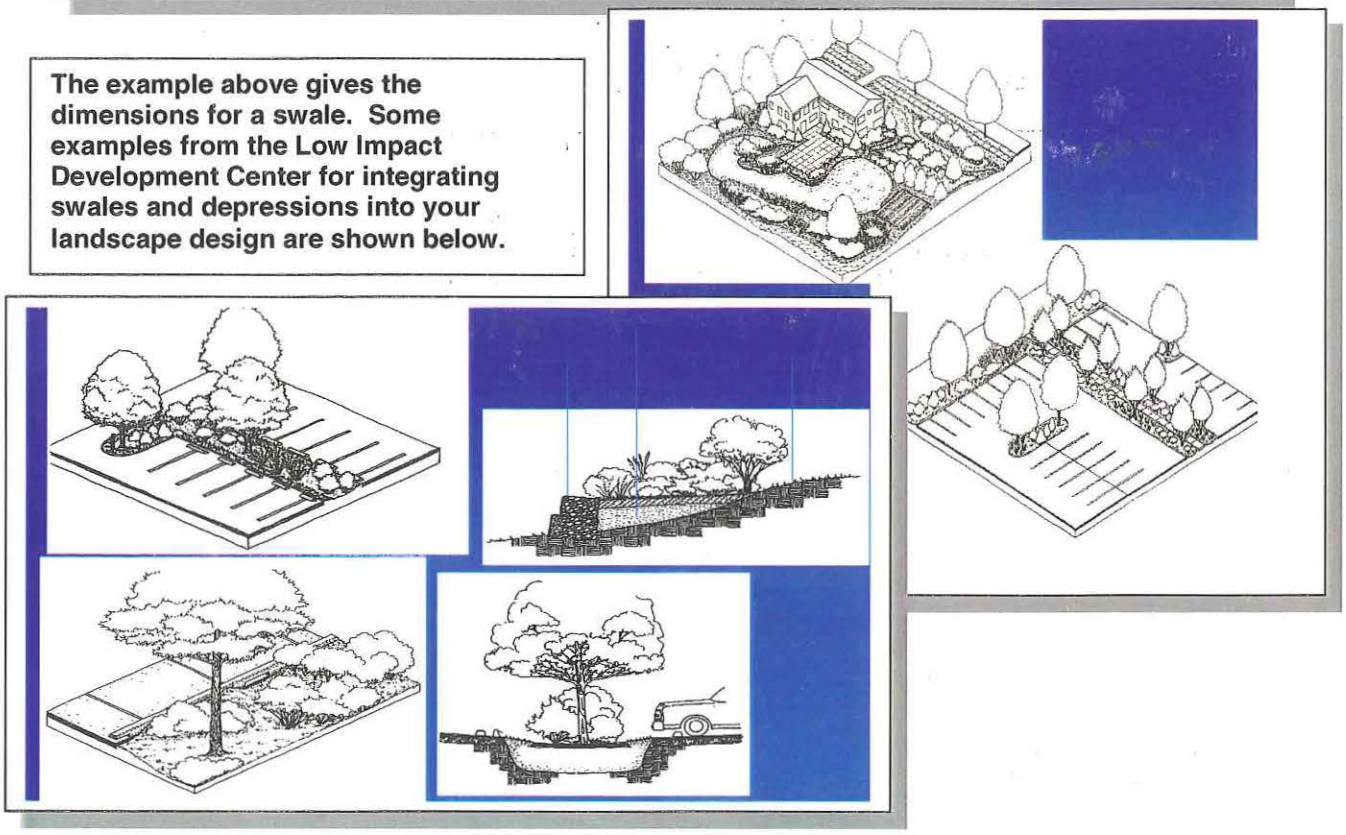
Originally the parking lot at the Aquarium was an advanced design that used a series of gardens, swales and strands as part of the conveyance system before stormwater reached a wet detention pond. Some of the original system is still in operation, but the water is now routed for final treatment into an underground vault that is out of sight and not part of the tour. The original parking lot design was studied for two years to evaluate the effectiveness of the system and to test different paving types. A complete report of the results is available from the Southwest Florida Water Management District and a ten-page paper can be downloaded from their web site.

Parking lot showing planted swale to the left and the basins without a planted swale on the right. Most parking lots are built without a planted swale. (Close up views) ⟶

6. Landscape Swales and Depressions (continued)



The example above gives the dimensions for a swale. Some examples from the Low Impact Development Center for integrating swales and depressions into your landscape design are shown below.



7. Porous Pavement

The use of porous pavement is another method that can be used to infiltrate rain runoff. It is a permeable pavement surface with an underlying stone reservoir that temporarily stores surface runoff before it infiltrates into the subsoil. According to the Stormwater Center Fact Sheet, it needs to meet the following site conditions:

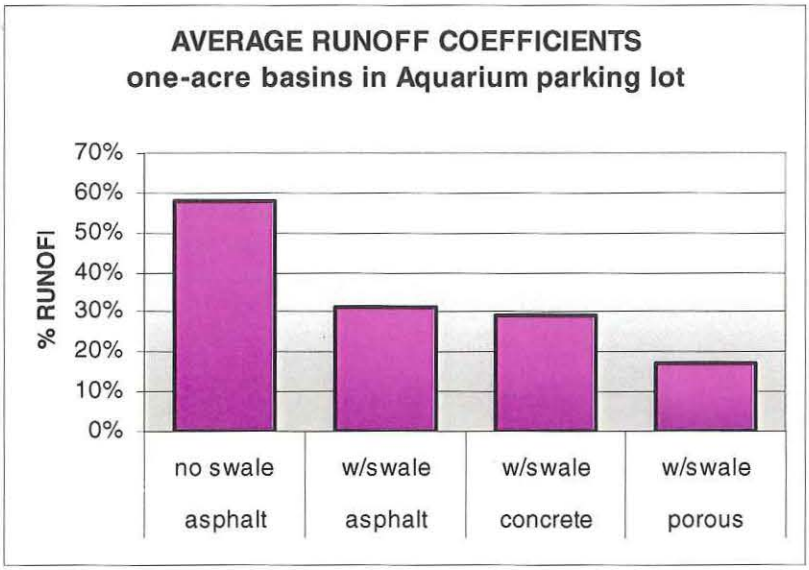
- Soils need to have a permeability between 0.5 and 3.0 inches per hour
- The bottom of the stone reservoir should be completely flat so that infiltrated runoff will be able to infiltrate through the entire surface.
- It should be located at least 2 to 5 feet above the seasonally high groundwater table, and at least 100 feet away from drinking water wells.
- It should only be used on low traffic or overflow parking areas.

The porous paved parking areas at the Aquarium met these criteria, and it was found to be effective when used in conjunction with swales and gardens as seen from the data below.

Swale entering drop box. Also shows garden areas & monitoring equipment

Porous Paving with planted swale

Data show that on average about 60% of the rain falling on the basin with garden areas (but no swale) ran off, while only 30% in the basin paved in asphalt or concrete ran off, and 17% of the rain falling on the basin with porous pavement ran off. All the basins are exactly alike with swales and garden areas except the one with no planted swale.



WHAT CAN YOU DO AS AN INDIVIDUAL TO REDUCE STORMWATER POLLUTION?

Although you may think that the small amount of pollution you cause is of no consequence, when the entire population is added together, we are a major cause of pollution today. Some of the things you can do as an individual have been discussed by the Environmental Protection Agency and are summarized below. EPA suggests that you take a close look at practices around your house that may be contributing to polluted runoff. The following are some specific tips to help you become part of the solution rather than part of the problem.

Household Chemicals

- Select less toxic chemicals to use around the house, or even better use non-toxic substitutes, and buy only what you expect to use.
- Do not pour unwanted chemicals down the drain; take them to collection centers and never pour unwanted chemicals on the ground.
- Use low-phosphate or phosphate-free detergents.
- Use water-based products when possible.
- Never spray pesticides indiscriminately.

Landscaping and gardening

- Select plants that have low requirements for water, fertilizer and pesticides
- Minimize grassed areas which require high maintenance
- Preserve existing trees and desirable understory plants.
- Incorporate grass swales and bioretention gardens in your landscape design.
- Install gravel trenches along driveways and patios.
- Restore bare patches in your lawn to avoid erosion.
- Leave lawn clippings on your lawn to recycle nutrients.
- Compost your yard trimmings and use as a soil amendment.
- Spread mulch on bare ground to minimize erosion and runoff
- Test your soil before applying fertilizers and calibrate your applicator often.
- Keep storm gutters and drains free of leaves since they leach nutrients.

Water Conservation

- Use low-flow faucets, shower heads and toilets and repair leaks.
- Don't hose down driveways or sidewalks.
- Take short showers instead of baths.
- Wash your car only when necessary and use a bucket to save water.
- Do not overwater your lawn and garden and use slow-watering techniques such as trickle irrigation or soaker hoses.
- Use rain barrels under roof drains and re-use later to water plants.

Other areas where you can make a difference

- Clean up after your pets.
- Deposit litter, including cigarette butts, in an appropriate container.
- Recycle used oil and antifreeze by taking it to a recycling center
- Keep your car in good repair so that it doesn't leak fluids or deposit residues.
- Educate yourself and become involved in planning & zoning decisions.

Acknowledgements

Many of the ideas in this handout were taken from the following publications:

Livingston, Eric and Ellen McCarron. 1992. Stormwater Management: A Guide for Floridians.

Goo, Robert. 1991. Do's and Don't Around the Home.
http://www.epa.gov/owowwtr1/NPS/dosdont.html

Alliance for the Chesapeake Bay, Inc. 2003. More Examples of What You Can Do to Prevent Nonpoint Source Pollution From the Alliance for the Chesapeake Bay.
http://www.epa.gov/owow/nps/abc.html

Rushton, Betty. 2001. Florida Aquarium Parking Lot: A Treatment Train Approach for Stormwater Management.
http://www.swfwmd.state.fl.us/ppr/reports/files/9ICUD.pdf

Low Impact Development Center
http://lowimpactdevelopment.org

Stormwater Center. 2001. Porous Pavement Fact Sheet. 2001.
http://www.stormwatercenter.net

This project, including the signage along the "Stormwater Trail" and the preparation of this report has been funded in part by a Section 319 Nonpoint Source Management Program grant form the U. S. Environmental Protection Agency (US EPA) through a contract with the Stormwater/Nonpoint Source Management Section of the Florida Department of Environmental Protection. The total estimated cost of the project is $302,300 of which $181,575 was provided by the US EPA. The project also included water quality and hydrology monitoring for the stormwater ponds and water quality monitoring to test improvements. The Southwest Florida Water Management District and the Florida Aquarium provided in-kind services and matching funds.