Options for Achieving Enhanced Stormwater Removal to Meet the New Statewide Stormwater Rule

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ERD
Water Quality Engineering

Stormwater Rule History

- State Water Policy Rule
  - Adopted in 1981 – first in US
  - Effective in February 1982
  - Technology based rule with 4 key components
    - Performance standard for minimum level of treatment
      - Reduce average annual post-development stormwater pollutant loading of TSS by 80%, or by 95% for stormwater discharges directly into outstanding Florida waters
    - Design criteria to achieve the level of treatment
    - Rebuttable presumption that discharges from a stormwater system will not cause harm to water resources
    - Periodic review and updating for BMPs based on research

Stormwater Rule History – cont.

- Florida Water Resource Implementation Rule - Chapter 62-40 FAC
  - Section 62-40.431 – Stormwater Management Program
    - **3(a)** - FDEP is responsible for coordinating the statewide stormwater management program by establishing goals, objectives and guidance for the development and implementation of stormwater management programs by the Districts and local governments.
    - **3(b)** - The Districts shall be the chief administrators of the state stormwater management program. The Department shall implement the state's stormwater management program in Districts that do not have the economic and technical resources to implement a comprehensive surface water management program.
  - FDEP provides guidance to Districts for treatment systems to meet these objectives, but individual Districts develop specific design criteria for stormwater BMPs
    - Every District has a different set of standards
    - Design criteria vary widely throughout the State
    - Performance efficiencies also vary widely

Stormwater Rule History – cont.

- During the mid 2000s, FDEP began consideration of a Statewide Stormwater Rule to unify design criteria and effectiveness throughout the State

- In 2006, FDEP contracted with ERD as part of FDEP Agreement S0108, titled "Evaluation of Current Stormwater Design Criteria within the State of Florida"

- The Scope of Work included the following:
  - Determine if current stormwater design criteria meet the performance standards outlined in Ch. 62-40.432 FAC.
  - If design criteria fail to meet Ch. 62-40, then recommend changes to meet performance criteria
  - Also evaluated design criteria to achieve no net increase in post development loadings
  - Analysis performed for nitrogen and phosphorus
    - If performance criteria are met for nitrogen and phosphorus, then they will be met for other significant pollutants (BOD, TSS, heavy metals, etc.) as well
  - Develop scientifically defensible and reproducible design methodologies
    - Use proven methodologies familiar to design engineers

Stormwater Rule History – cont.

- Study results provided in June 2007 Report
  - No current stormwater design meets the removal objectives outlined in Chapter 62-40
  - Removal efficiencies between WMDs vary greatly
  - Included a series of tables, figures, methods of calculation, and design examples to achieve
    - 80% removal
    - 95% removal
    - Pre vs. post loadings


Evaluation of Current Stormwater Design Criteria within the State of Florida

Final Report

Prepared for:

FLORIDA DEPARTMENT OF ENVIRONMENTAL PROTECTION

FDEP Contract No. SO108

June 2007

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- Series of TAC meetings were held during 2008-10 to discuss a new stormwater design criteria
  - A new “Applicant’s Handbook” was developed to achieve enhanced removal
  - Effort halted in 2010 by Gov. Scott

- Districts adopted the methods as a <u>standard method</u> of calculating load reductions for use in pre vs. post analyses

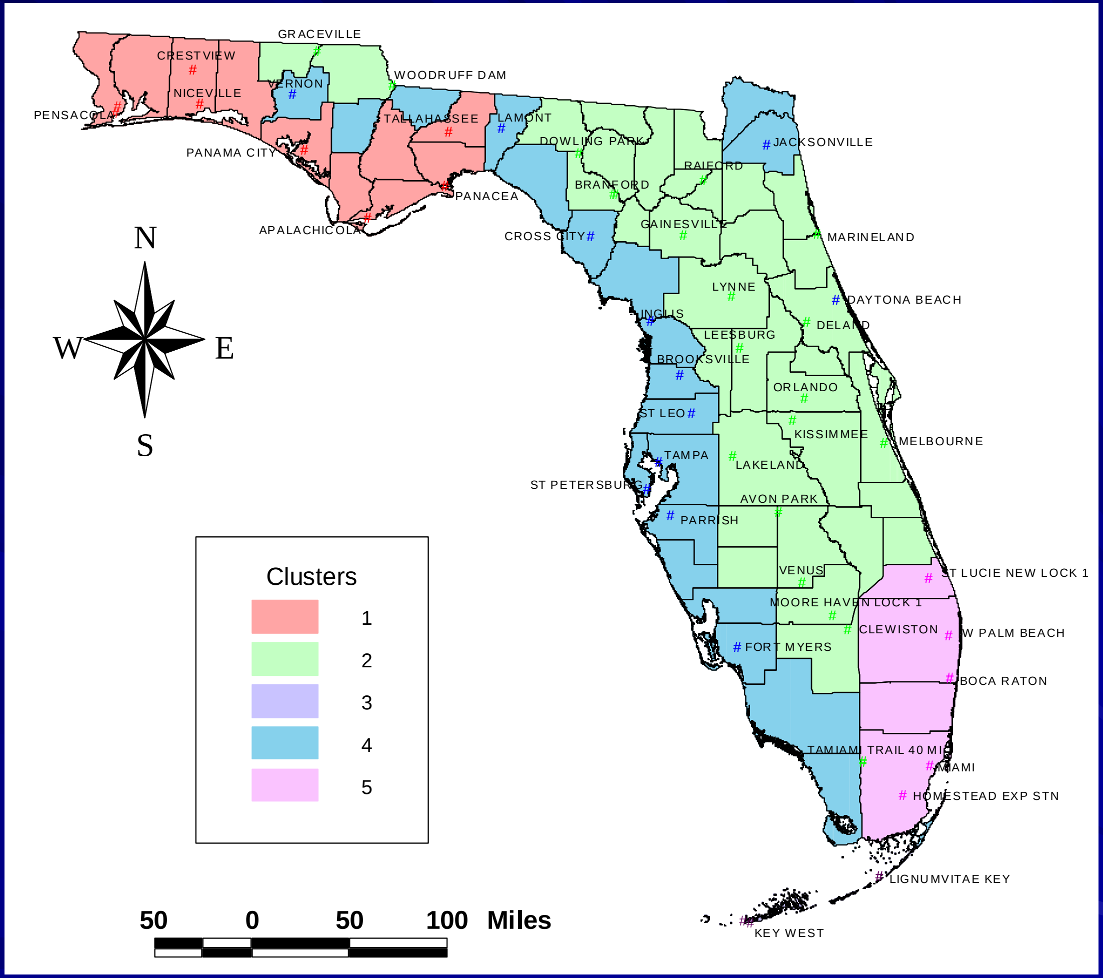
Similar Meteorological Zones

- Cluster analysis used to identify areas with similar annual rainfall/runoff relationships (C values)

- Analysis identified 5 significantly different areas

- Differences due to rainfall distribution rather than annual rainfall depth

- Impacts both runoff volume and infiltration system efficiency



Dry Retention

Regional Variability in Treatment Efficiency of Dry Retention

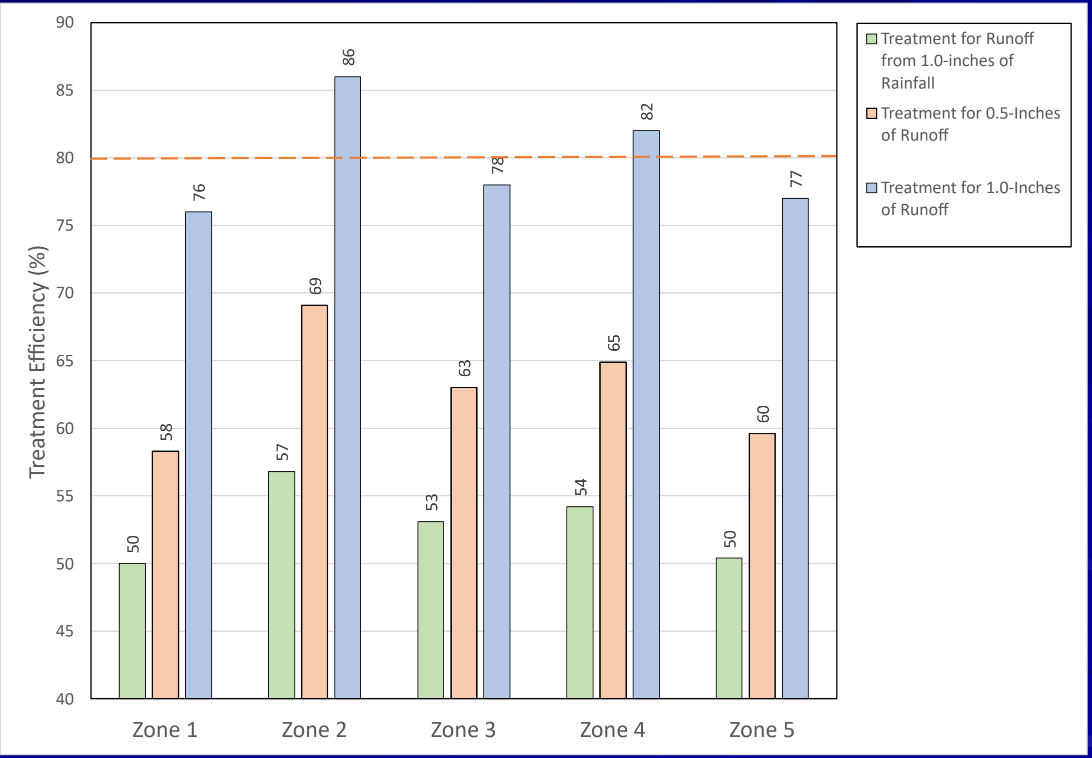
- Performance efficiency of retention systems varies throughout the State

- Design criteria based on runoff depth provide better annual mass removal than treatment of 1 inch of rainfall

- Both retention of 0.5 inch of runoff or runoff from 1-inch of rainfall fail to meet the 80% treatment objective

- Retention of 1-inch of runoff comes close to 80% objective

40% DCIA and non-DCIA CN of 70
(Multi-family, roadway, commercial)



Dry Detention
Available Efficiency Data

Summary of Available Dry Detention Efficiency Data

Reference	Location	Study Site/ Land Use	Mean Removal Efficiencies (%)						
			Total N	Total P	TSS	BOD	Total Cu	Total Pb	Total Zn
Bradfordville Study	Leon County	Comm.	80	92	98	93	--	--	--
Harper & Herr (1995)	Orange County	Comm. & Resid.	-136	-86	77	-49	68	93	25

- Fails to meet the 80% performance criterion
- Dry detention has a highly variable efficiency
- Depends on the volume retained in the system
- Does not appear feasible for use under new rule

Wet Detention
Available Efficiency Data

Reference	Study Site/ Land Use	Type of Efficiencies Reported	Mean Removal Efficiencies (%)							
			Total N	SRP	Total P	TSS	BOD	Total Cu	Total Pb	Total Zn
PBS&J (1982)	Brevard Co./ Commercial	Surface Water	--	--	69	94	--	--	96	--
Cullum (1984)	Boca Raton/ Residential	Surface Water Overall	12 15	93 82	55 60	68 64	-- --	-- --	-- --	-- --
Yousef, et al. (1986)	Maitland/ Highway	Surface Water	35	94	81	--	--	56	88	92
Yousef, et al. (1986)	EPCOT/ Highway	Surface Water	44	92	62	--	--	0	0	88
Harper (1988)	Orlando/ Residential	Surface Water	--	--	91	82	90	90	90	96
Harper & Herr (1993)	DeBary/Comm & Residential	t_d = 7 days t_d = 14 days	20 30	40 60	60 70	85 85	50 60	40 50	60 85	85 95
Rushton & Dye (1993)	Tampa/Light Commercial	Surface Water	--	67	65	55	--	--	--	51
Mean Values			26	73	65	75	67	59	77	85

- Performance efficiency of wet detention is not impacted by regional variability

- Fail to meet 80% goal for either TN or TP

New Stormwater Rule Efforts

- In 2020, the Florida Legislature passed Senate Bill 712 "Clean Waterways Act",
  - Passed with unanimous, bipartisan support
- In December 2020 DEP formed the Clean Waterways Act Stormwater Rulemaking Technical Advisory Committee (TAC)
  - The mission shall be to ".. provide a forum for identifying and constructively outlining recommendations to the department and water management districts for strengthening the stormwater design and operation regulations….."
  - 13 members from a wide range of areas
  - Held 13 workshops from December 5, 2020, to November 2, 2021
  - Developed a series of recommendations concerning:
    - Level of treatment required
    - Maintenance practices
    - Re-development
    - Technical library
- DEP developed a revised Applicant's Handbook – Volume I
  - Few technical changes from TAC recommendations

Summary of Proposed Stormwater Treatment Criteria

Project Type	Total N	Total P
All Sites	Greater of: a. Post ≤ Pre	Greater of: a. Post ≤ Pre
	b. 55% reduction	b. 80% reduction
Discharges to OFWs	Greater of: a. Post ≤ Pre	Greater of: a. Post ≤ Pre
	b. 80% reduction	b. 90% reduction
Impaired Water – Located in HCU-12 watershed upstream of an Impaired Water	Greater of: a. Post ≤ Pre	Greater of: a. Post ≤ Pre
	b. 80% reduction	b. 95% reduction
Impaired Water – Located in HCU-12 watershed and upstream of an Impaired Water with TMDL and BMAP	Must Meet Both: a. Post ≤ Pre	Must Meet Both: a. Post ≤ Pre
	b. BMAP reduction	b. BMAP reduction
Redevelopment	45% reduction	80% reduction
Redevelopment– Located in HCU-12 watershed upstream of an OFW	60% reduction	90% reduction

Pre vs. Post Loading Example

1. Area: 90-acre site, Type D soils

2. Ground Cover/Soil Types

   A. Pre-development – Wet flatwoods
   B. Post development - Residential areas will be covered with lawns in good condition

3. Runoff Calculations

Pre-Development

Project Location	Project Zone	Area (acres)	Impervious Areas		DCIA		Non-DCIA CN Value	Annual Rainfall (in)	Annual C Value	Runoff (ac-ft/yr)
			acres	%	acres	%				
Pensacola	1	95	0	0	0	0	79	65.5	0.154	79.9
Orlando	2	95	0	0	0	0	79	50.0	0.105	41.6
Key West	3	95	0	0	0	0	79	40.0	0.125	39.6

Post Development

Project Location	Project Zone	Area (acres)	Impervious Areas		DCIA		Non-DCIA CN Value	Annual Rainfall (in)	Annual C Value	Runoff (ac-ft/yr)
			%	acres	acres	%				
Pensacola	1	90	25	22.5	16.68	18.75	81.4	65.5	0.304	149.3
Orlando	2	90	25	22.5	16.68	18.75	81.4	50.0	0.253	94.8
Key West	3	90	25	22.5	16.68	18.75	81.4	40.0	0.266	79.8

Example Calculation – cont.

Summary of pre and post loadings and required nutrient load reductions

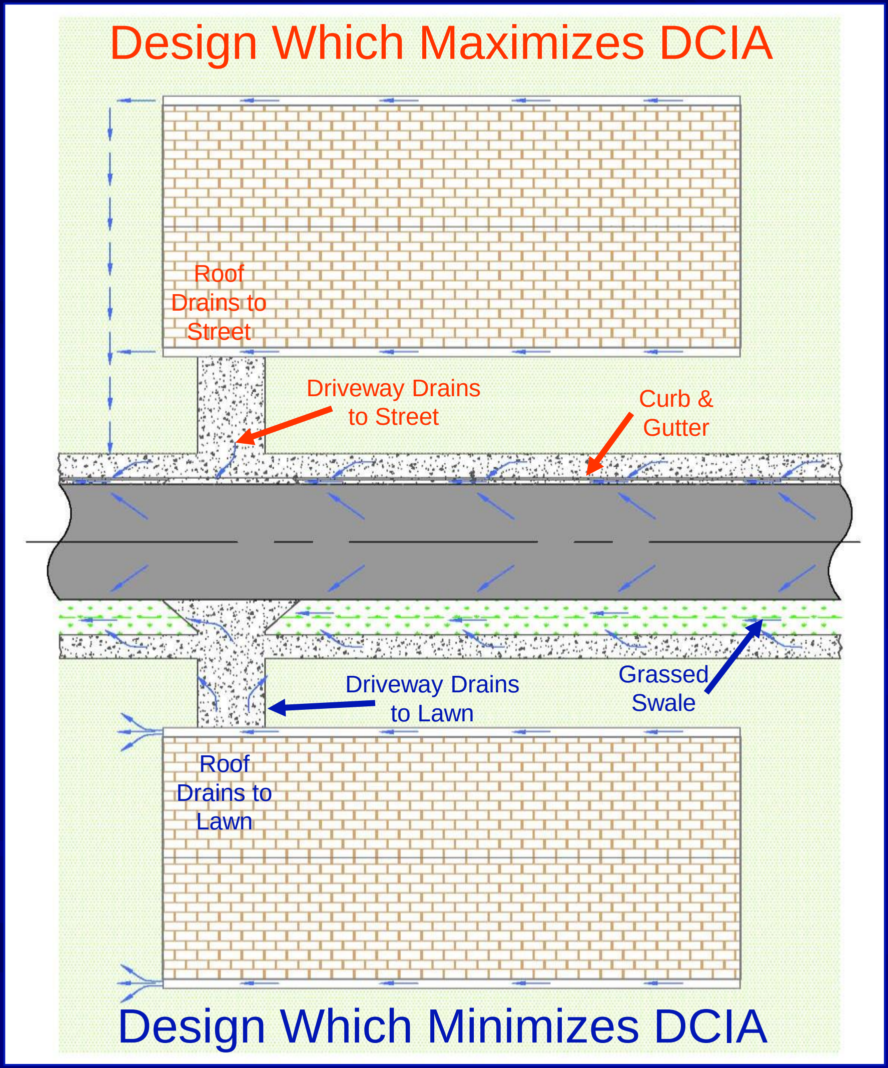
Project Location	Total Nitrogen			Total Phosphorus		
	Pre-Load (kg/yr)	Post-Load (kg/yr)	Required Removal (%)	Pre-Load (kg/yr)	Post-Load (kg/yr)	Required Removal (%)
Pensacola (Zone 1)	105	344	69.3	2.56	55.4	95.4
Orlando (Zone 2)	54.9	219	74.9	1.33	35.2	96.2
Key West (Zone 3)	52.3	184	71.6	1.27	29.6	95.7

How do we achieve the required nutrient load reductions?

1. Reduce Generated Runoff Volume

Simple Design Changes

a. Disconnect/Reduce DCIA



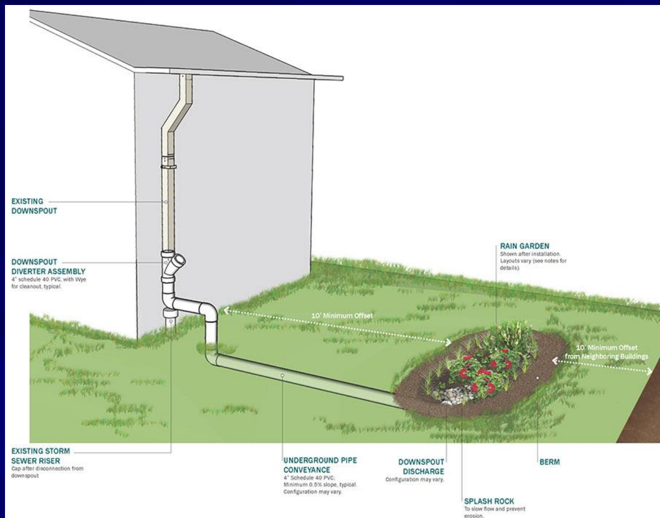
Impacts of Disconnecting DCIA

Parameter	Standard Design	Disconnect DCIA
% Imp.	40	40
DCIA (%)	20	0
Hydrologic Soil Group (HSG)	D	D
Pervious CN	80	80
Non-DCIA CN	84.5	87.2
C Value		
-Zone 1	0.341	0.261 (-23%)
-Zone 2	0.286	0.196 (-31%)
-Zone 3	0.297	0.210 (-29%)
-Zone 4	0.306	0.219 (-28%)
-Zone 5	0.325	0.245 (-25%)

- Reduce volumetric and nutrient loading by 23-31%
- Lower construction cost
  - Less infrastructure
  - Smaller pond
- May be prohibited by code in some areas
  - Require education and code changes

Simple Design Changes

b. On-Site Retention by Lot



- May options are available to retain runoff on individual lots
- On-site retention combined with swales could easily reduce runoff volume by >50%
- Marketed as environmentally conscious community
- Limited only by imagination
- On-site systems can be altered/removed by homeowner
- Permitting issues with private property

2. Heavy Reliance on Infiltration/Retention Systems

Description

- Family of practices where the stormwater is disposed of by infiltration or evaporation rather than by surface discharge

- Removal effectiveness is a function of the runoff volume lost
- Does not consider lateral seepage into waterways

Purpose

- Reduce total runoff volume
- Reduce pollutant loadings

Pollutant Removal

- Percolation, evaporation
- Filtering and adsorption

Common Infiltration Systems

Get the water into the ground!

Retention Areas

Roadside Swales

Exfiltration Systems

Dry Pond

The mass load reduction is a direct function of the fraction of annual runoff volume infiltrated

Dry Retention Options

Permeable Pavers

Permeable Asphalt

Permeable Planters

Grassed Parking Areas

Rain Gardens

- Further reduce delivered runoff volume

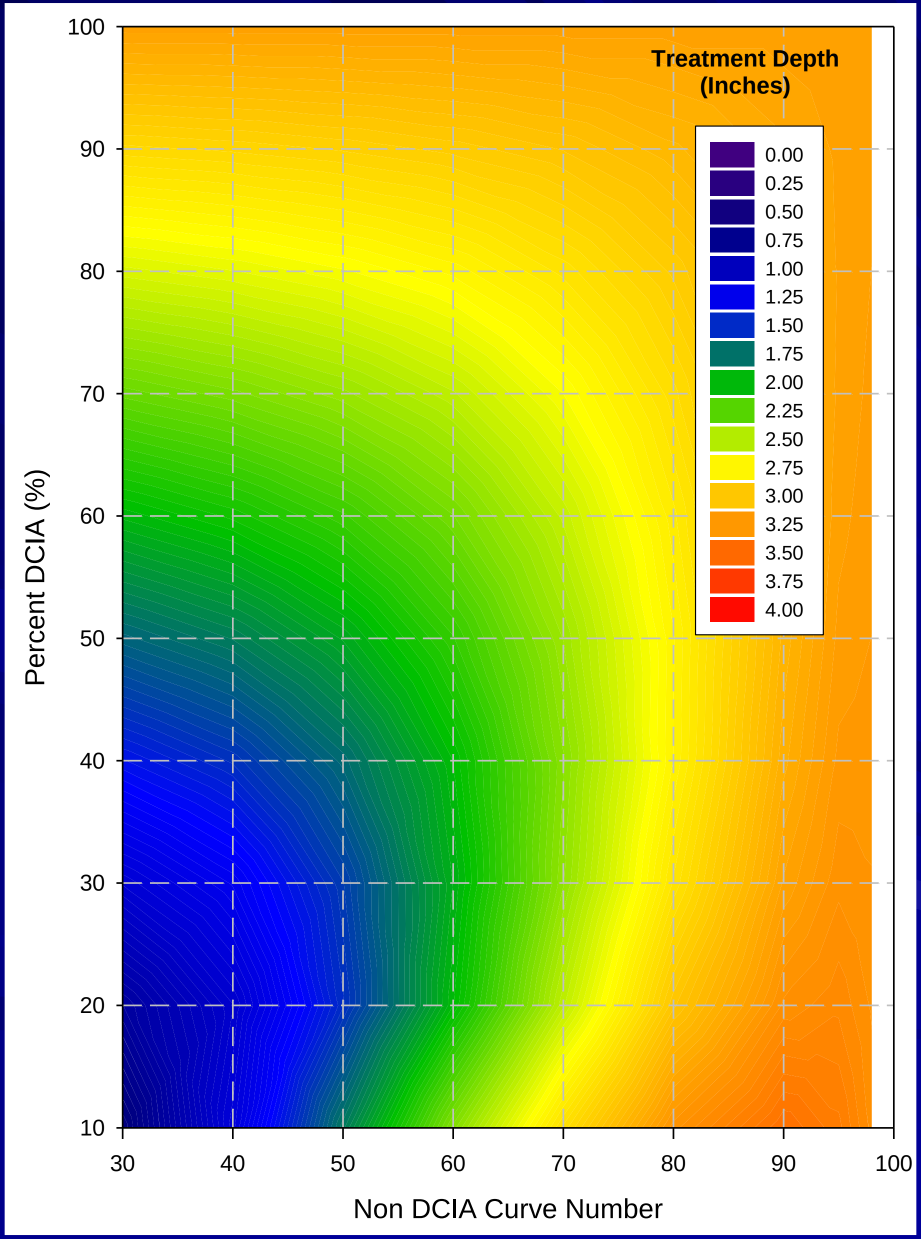
Required Retention Requirements for Previous Example

Project Location	DCIA (%)	Non-DCIA CN Value	TN Removal (%)	TP Removal (%)	Required Retention Depth (in)
Pensacola (Zone 1)	18.75	79	69.3	95.4	3.8
Orlando (Zone 2)	18.75	79	74.9	96.2	2.7
Key West (Zone 3)	18.75	79	71.6	95.7	4.5

- Retention requirements dictated by TP since the required removal is greater
- Without volume reduction, retention requirements increase substantially
  - Factor of 3-10 times
- FDEP assumes that runoff infiltrated into the ground has no loading on surface waters

Retention Depth Required to Achieve 95% Mass Removal

State-Wide
Average



Infiltration Processes

- May be used as only treatment method
- May be used as part of an overall system
- Some type of infiltration or volumetric removal will likely be required for all treatment systems
- Treatment train systems will be required in many cases

Treatment Train Concept
Section 9.5.1 AH Vol. 1.

- Removal for BMPs in series:
  - Infiltration (Volume reduction) Systems
    - Equation assumes each BMP acts independently of upstream BMPs, and that upstream BMPs do not impact performance of downstream BMPs
      - Efficiencies are cumulative

3. Wet Detention Ponds

Wet detention ponds are essentially man-made lakes

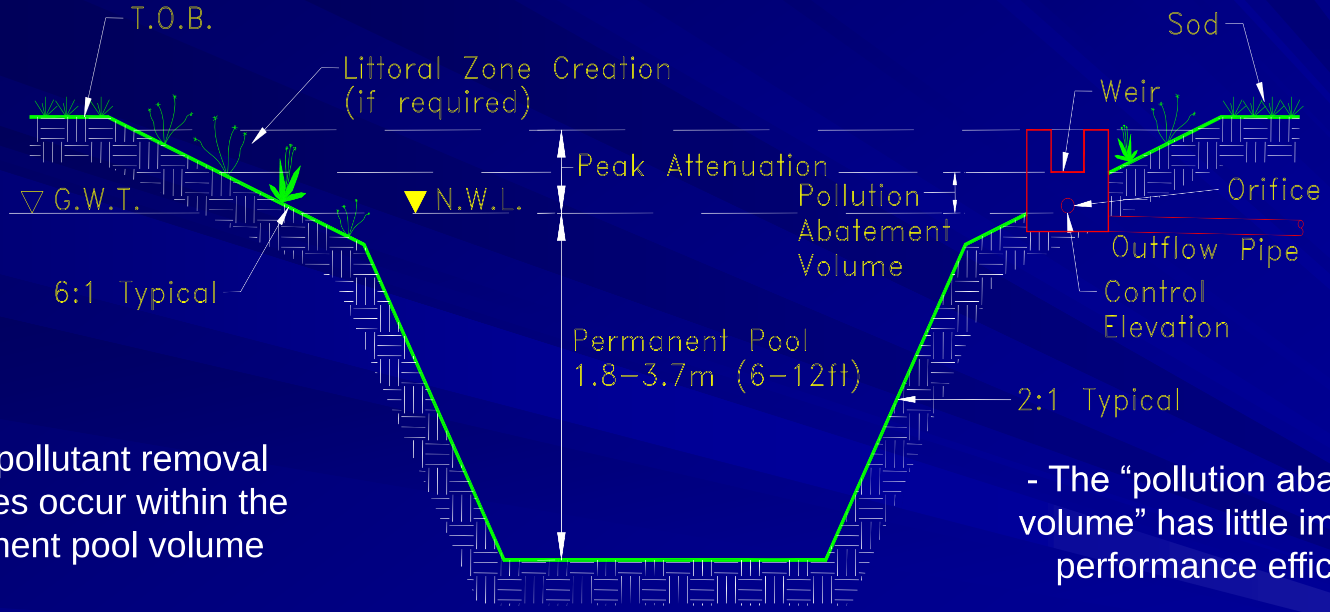
Wet Detention Ponds Can Be Constructed as Amenities

Wet Detention Lakes Can Be Integral to the Overall Development Plan

- Physical Processes
  - Gravity settling – primary physical process
    - Efficiency dependent on pond geometry, volume, residence time, particle size
  - Adsorption onto solid surfaces
- Biological processes
  - Uptake by algae and aquatic plants
  - Metabolized by microorganisms

Wet Detention Pond

- New Stormwater Rule eliminates the "pollution abatement" or "water quality" volume
- Mass removals are directly related to the residence time
- Detention times are no longer restricted
  - Only allows detention time credit for volume about anoxic zone



- Most pollutant removal processes occur within the permanent pool volume

- The "pollution abatement volume" has little impact on performance efficiency

$$\text{Detention Time, } t_d \text{ (days)} = \frac{PPV}{RO} \times \frac{365 \text{ days}}{\text{year}}$$

Treatment Train Concept
Section 9.5.1 AH Vol. 1.

- Removal for BMPs in series:
  - Systems based on removing pollutants or reducing concentrations
    - Efficiency of the treatment train must account for the reduced loading or concentrations that are available for removal by the subsequent downstream treatment device

Roadside Swale

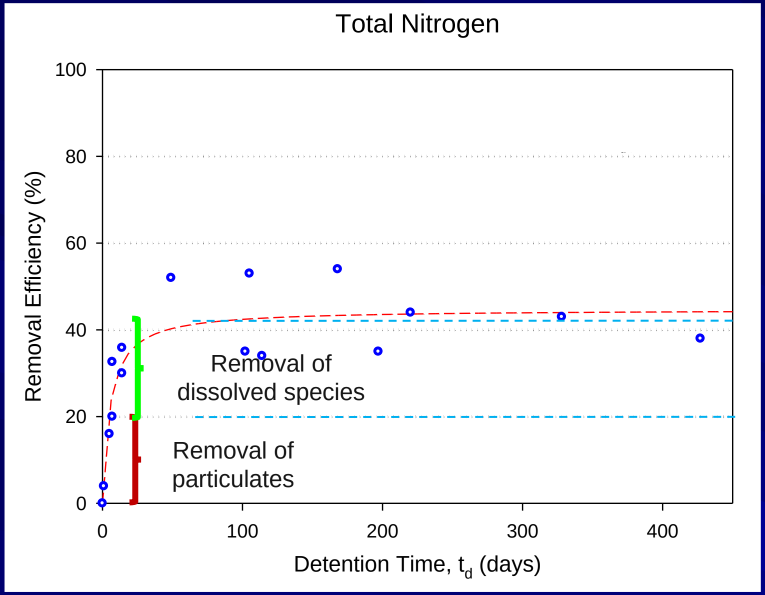
→

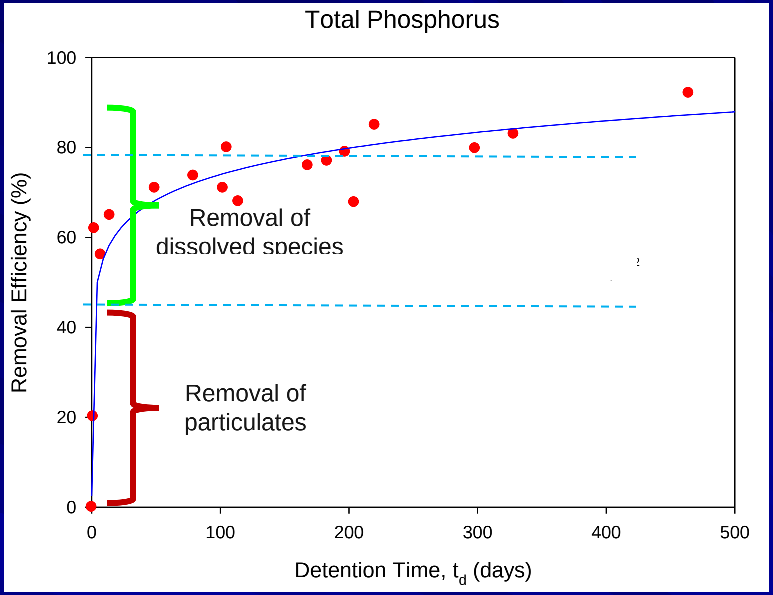
Wet Detention

- Roadside swale will remove particulates and runoff volume, reduce runoff concentrations
- Solids would be removed in the wet detention
- Concentration reduction in swale will reduce efficiency of wet detention

Nutrient Removal Relationships for Wet Ponds

Nutrient Removal is Primarily a Function of Detention Time





- These relationships were developed for untreated runoff only
- The relationships do not apply when the runoff gets pre-treatment
- Removal of dissolved pollutants is a function of concentration
  - Removal rates decrease as the water column concentration decreases
  - Removal stops when Irreducible concentration is reached
    - TN = 350 µg/L
    - TP = 10 µg/L

Wet Detention Enhancement

a. Floating Islands

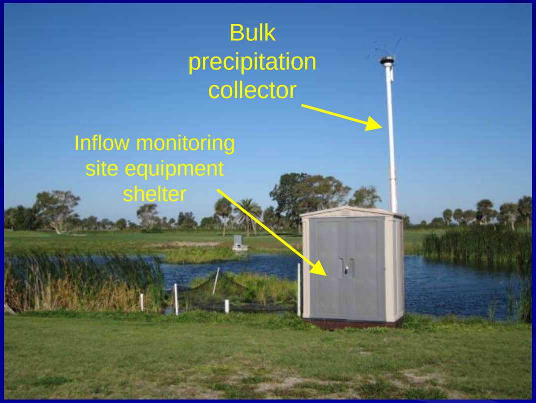
Adding plants to mats

Dragging mats to selected location

Grown plants in mat

Root mass at end of study

Root mass under mat at end of study



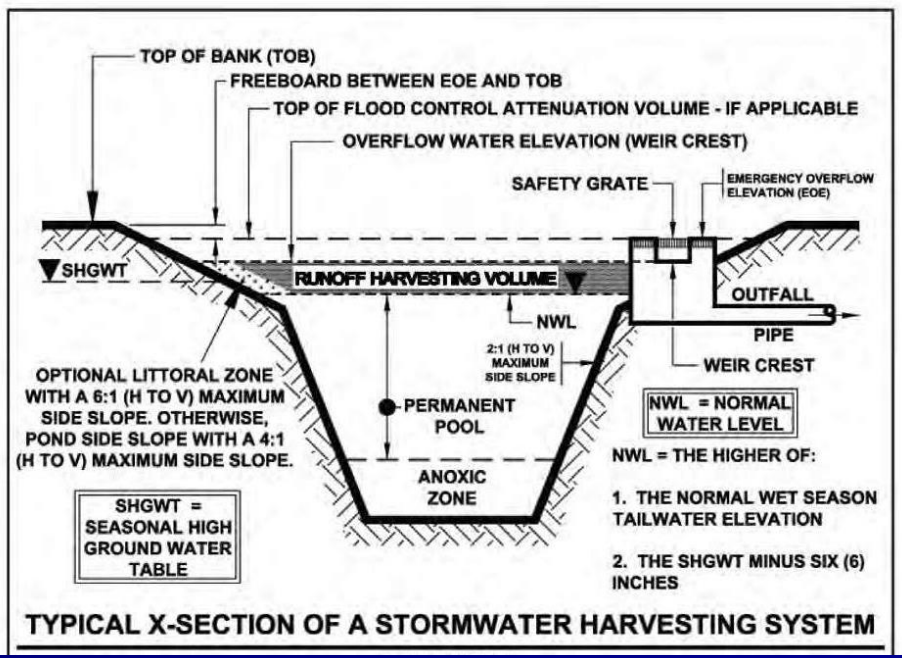
Inflow monitoring site

- Efficiency highly impacted by nutrient concentrations in water
- Achieved ~ 10% concentration reduction for TP and 12% increase for TN
- BMPTrains assigns 10% removal for each

Wet Detention Enhancement

b. Reuse Irrigation

- Beneficial reuse of stored runoff for irrigation
- All runoff reused for irrigation is a direct reduction in offsite loadings
- Combining reuse with wet detention can easily achieve the required annual load reductions
- Efficiency calculations are available



Wet Detention Enhancement

c. Alum Addition System

- Retrofit pond (1.5 ac.) constructed for a 173-acre watershed with little stormwater treatment

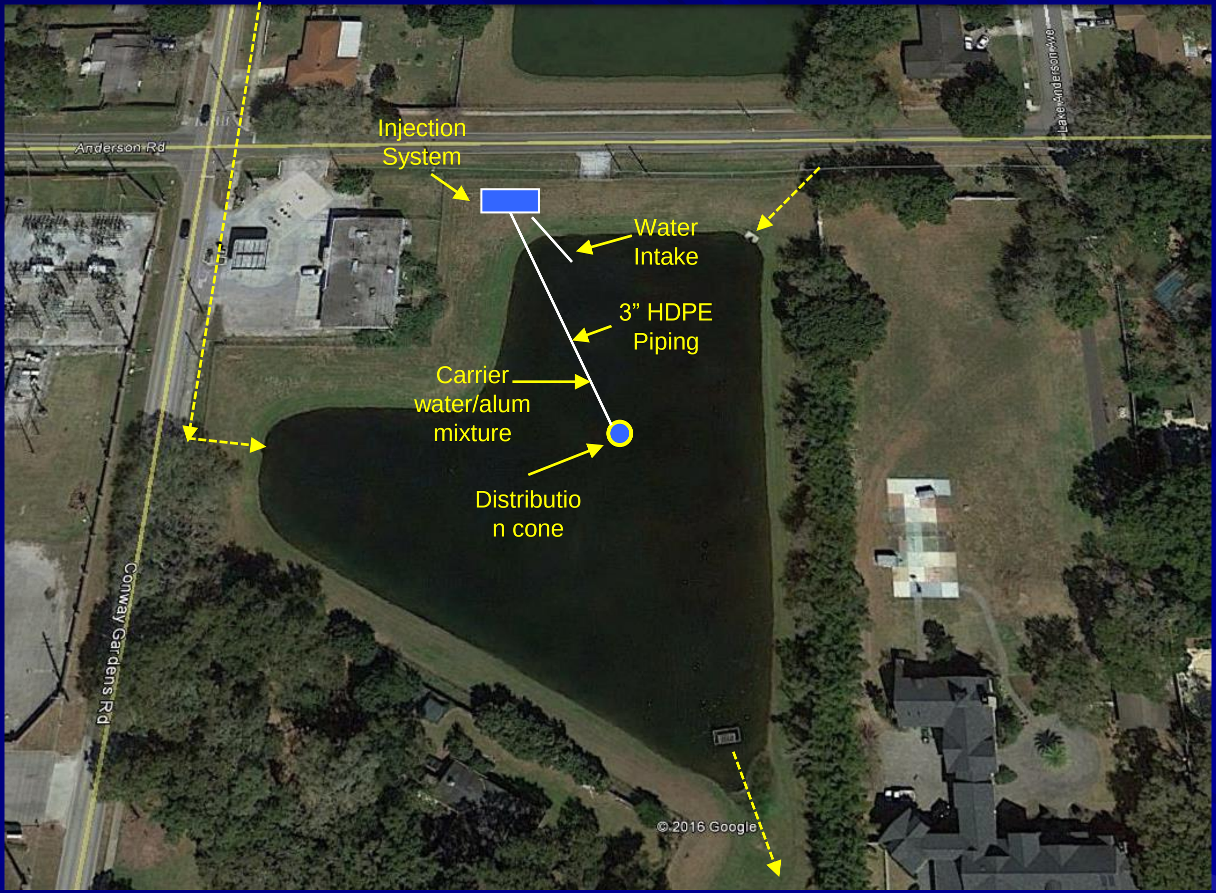
- Pond discharge concentrations were elevated

Alum addition system recommended to enhance pond performance and reduce nutrient loadings

Lake Anderson Pond Overview

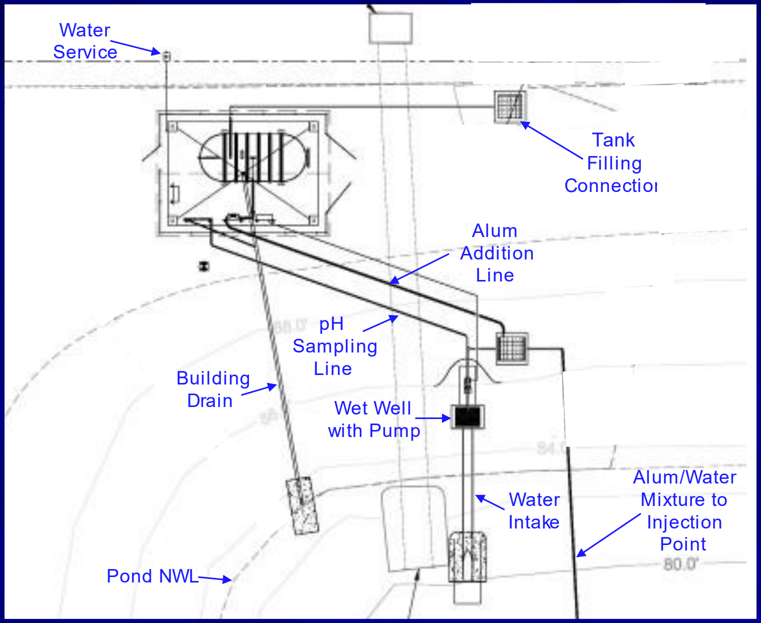
Lake Anderson Pond Enhancement System Overview

- Lake Anderson system is designed to treat the pond water rather than the runoff inflow
- Alum addition is based on the water column pH
  - Increases in nutrients result in increases in algal growth which results in a proportional increase in pH
  -
  - pH is used as a surrogate for nutrient concentrations
  - Alum is added to achieve a pre-set pH value of 7 or less
  - System is designed to distribute floc throughout the water column and maximize the contact time between the floc and water
  - Floc containing nutrients settles on the pond bottom
- System provides a low-cost enhancement in pond performance

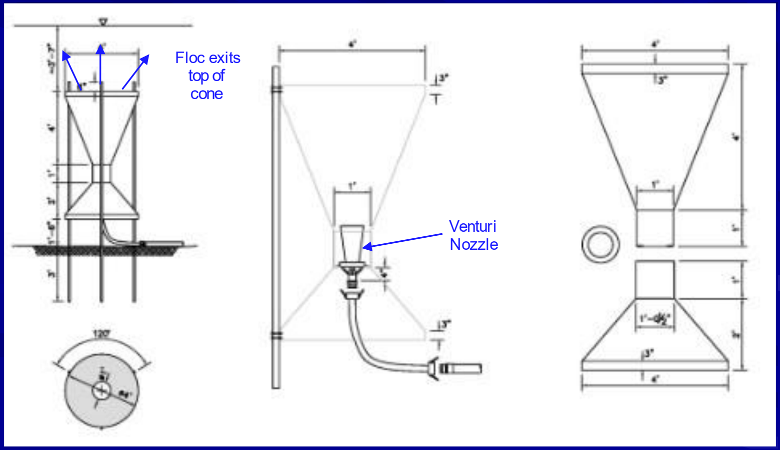


Alum Addition System Overview

- Required modification to the stormwater permit for the pond
- Construction cost ~ $220,000
- Alum use estimated to be ~ 5,200 gal/year



Distribution cone



Lake Anderson Alum Addition System

Control System

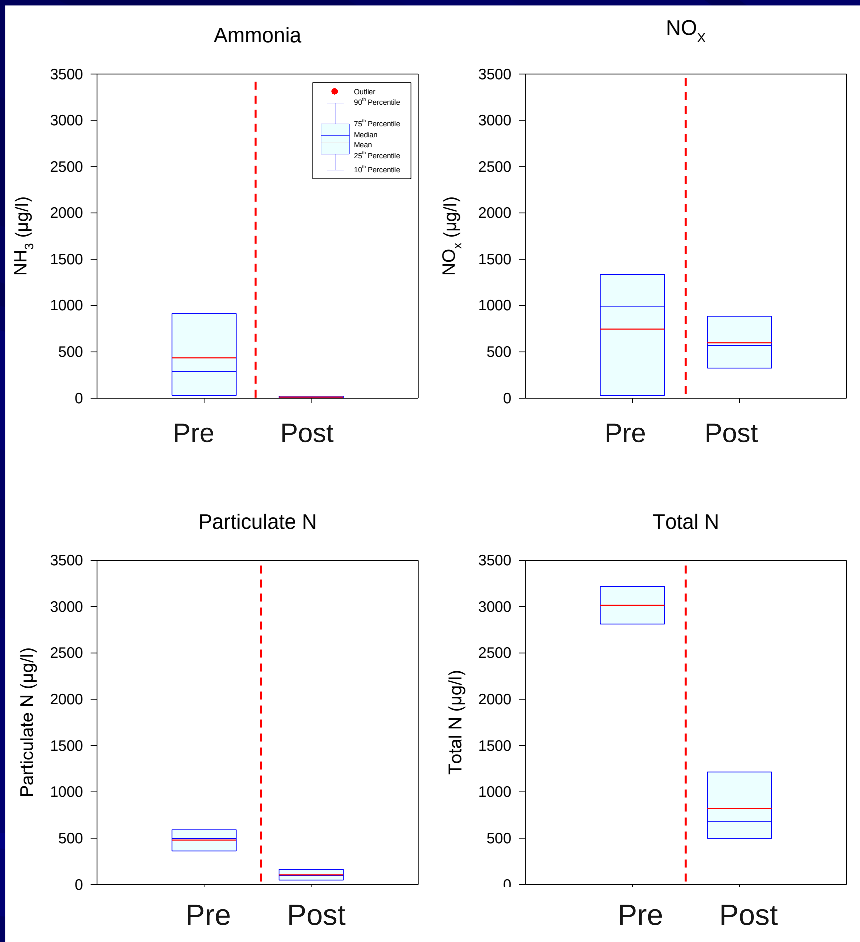
Venturi for Air Addition

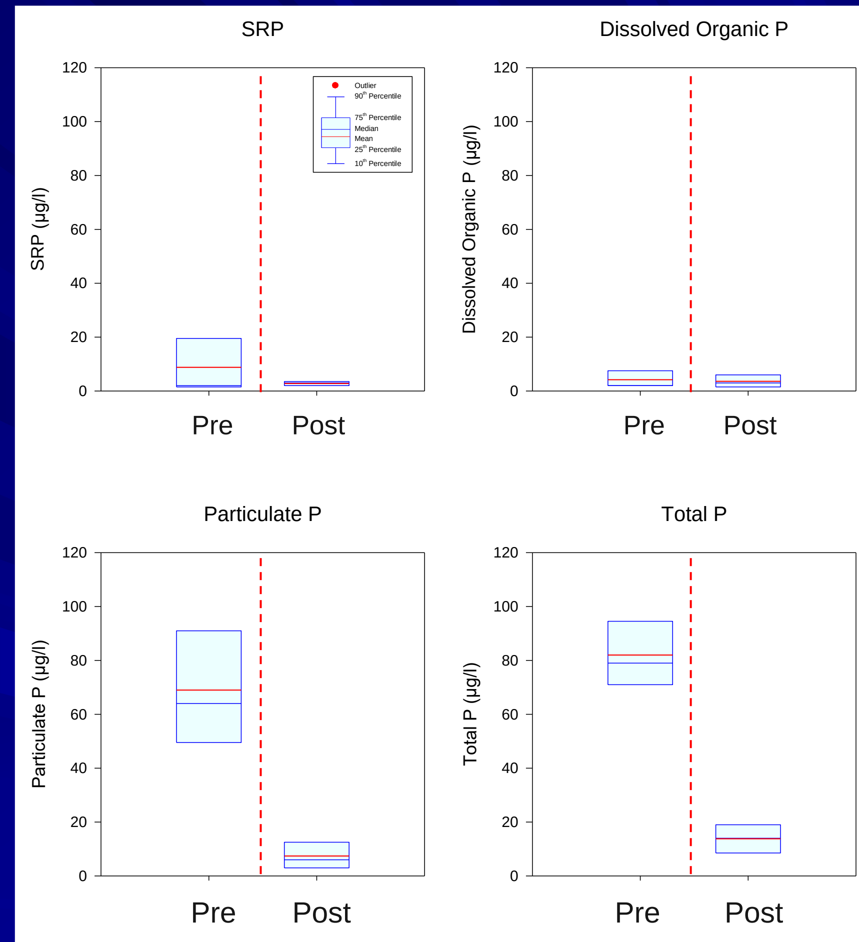
Pond following startup

Fish bedding along pond bank

Aluminator!

Lake Anderson Pond System Performance

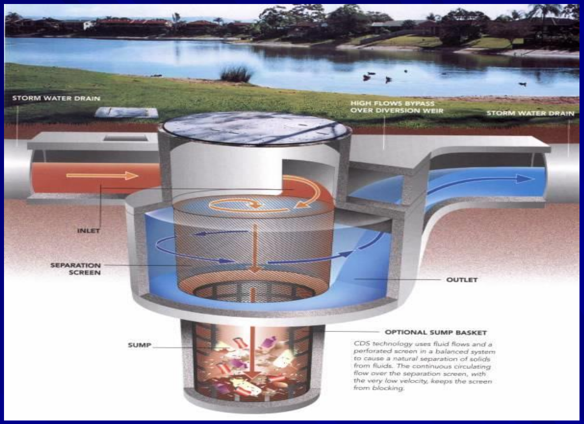


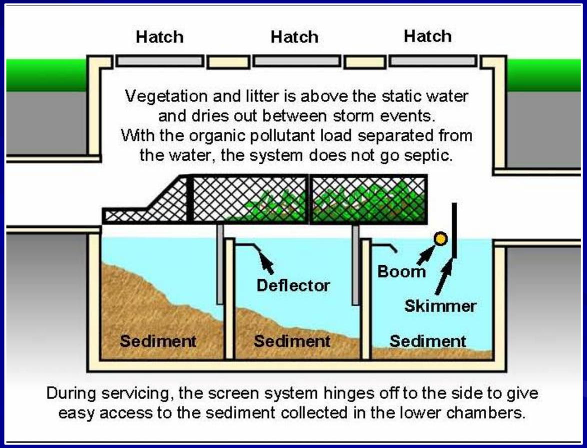


- System increased overall pond efficiency to 80% for TN and 85% for TP
- Combined with reuse irrigation, efficiency can be increased to > 95%

4. Gross Pollutant Separators

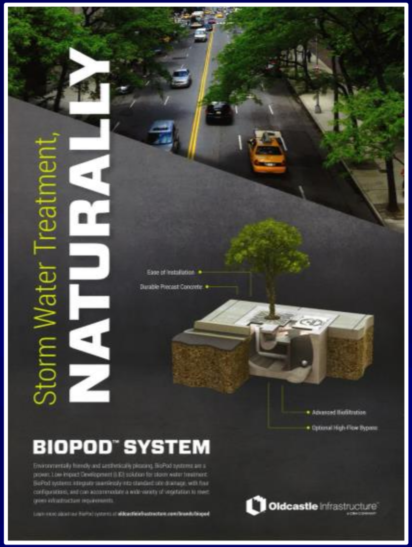
- Primary use as pretreatment device
- Provide no volumetric reduction
- Remove solids, litter, and debris
- Remove pollutants that would be removed in downstream ponds
  - Reduce effectiveness of downstream BMPs
- Gross pollutant separators will not have a large part in new rule

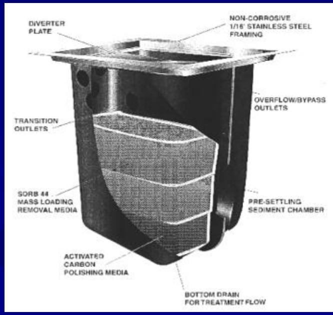




5. LID Systems

a. Limitations of LID Systems

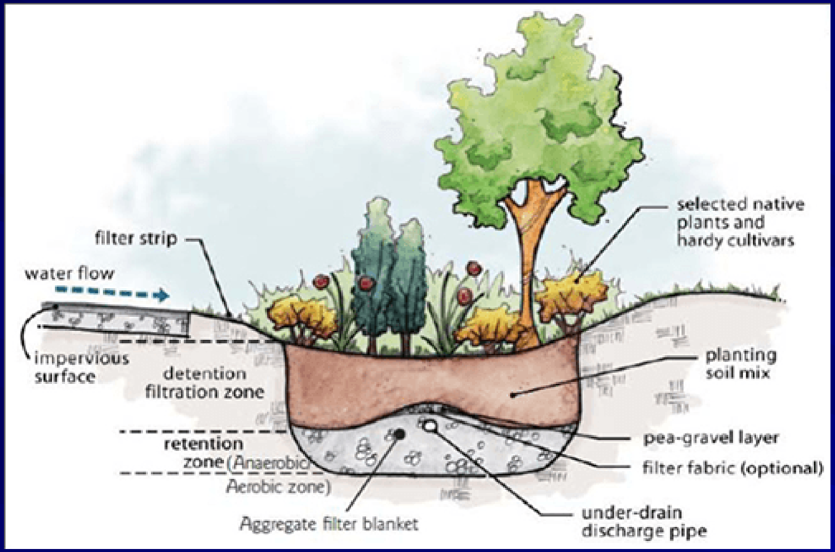




- LID systems are usually designed for small catchments with small loadings
- Most LID devices are not designed with Florida conditions in mind
- Florida rainfall depths and intensities often exceed the capacity of devices designed for northern climates
- Concentration based removal systems require a minimum concentration to perform effectively
- Florida conditions may reduce effectiveness of the system
- Manufacturer’s efficiencies will over-estimate achieved efficiencies

5. LID Systems – cont.

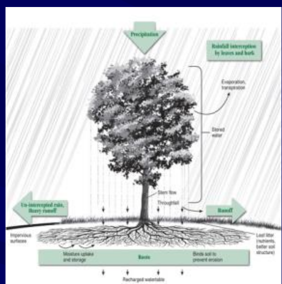
b. Rain Gardens



- Common LID BMP
- Suitable for small areas
- Most likely used as part of a larger system to reduce runoff volume
- Living system that must be maintained
- Located on private property
  - Question of ownership and maintenance responsibility if part of permitted system

5. LID Systems – cont.

c. Rainfall Interception by Urban Trees

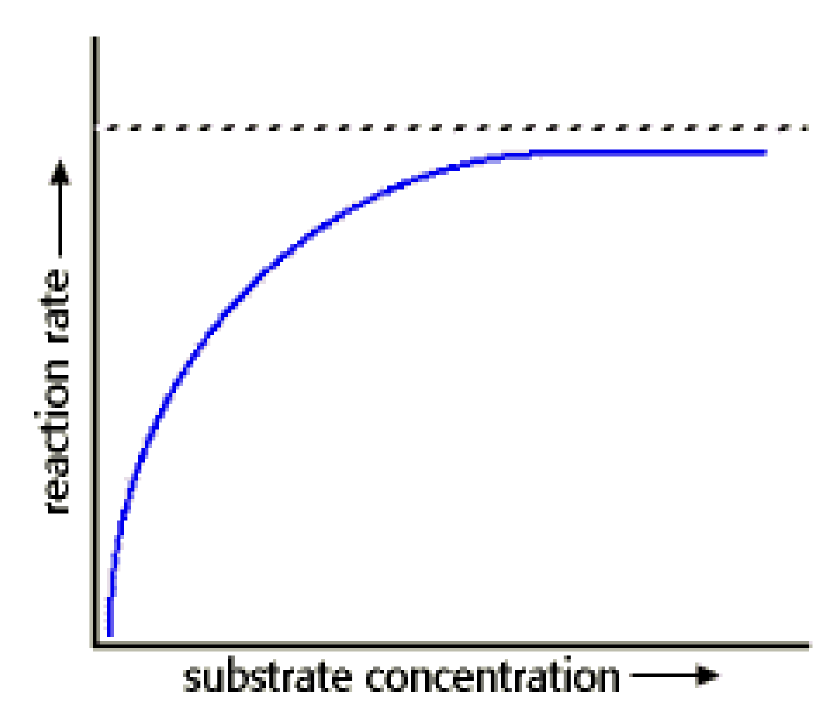


- Benefits of urban trees
  - Intercept 20-80% of direct rainfall
    - Water removed by ET and root uptake
  - Reduce urban heat island
- Suitable for small areas

- Must have a plan to mitigate the impacts of leaf fall
  - Leaves contribute as much as 80% of nutrient loading to runoff during leaf fall conditions

6. Denitrification

- Denitrification reaction is a first-order concentration limited reaction
  - Rate of denitrification decreases logarithmically as nitrate concentrations decrease
  - Slow process
    - ~ 90% complete in 3-4 days
- Reduced anoxic environment
  - Minimum redox potential (Eh) of -100 to -200
- Significant nitrate source
  - Urban runoff may not contain sufficient nitrate, especially if there are upstream concentration reduction BMPs
  - Most ponds have little nitrate
- Degradable carbon source
  - Carbon source must be easily degradable - BOD
  - WWTPs use simple organics such as methanol and acetic acid
  - Urban runoff generally contains low BOD



7. Reuse Irrigation

- The chemical characteristics of reuse water are highly variable, depending on location and level of treatment

- Characteristics of secondary effluent – minimum level of treatment
  - Nitrogen ~ 4-20 mg/l, mostly as NO_3^- and organic N (2-15 times higher than urban runoff)
  - Phosphorus ~ 2-15 mg/l (8-60 times higher than runoff)
  - On average, secondary reuse water is similar in characteristics to septic tank leachate
  - Approximately 2/3 of WWT plants in Florida provide secondary treatment
  - Reuse irrigation is frequently required in local areas and for certain types of developments

7. Reuse Irrigation – cont.

- Secondary reuse increases runoff nutrient concentrations by approx. 50%
  - Secondary reuse contains elevated nutrient concentrations much greater than runoff
- This additional loading must be included in the post development loading calculations
  - Using wastewater reuse for irrigation will require a larger treatment system
  - Transferring the wastewater disposal cost to the developer and homeowners
- On-line stormwater ponds can no longer be used for reuse storage
- This issue will require changes to codes and regulations
- The use of wastewater reuse reduces potential for using stormwater for irrigation
- Utilities will have to find other options for wastewater disposal

7. Reuse Irrigation – cont.
Impacts of Reuse Overspray

- Reuse overspray often enters receiving waterbodies through the stormsewer system or by direct spray onto ponds
  - Secondary reuse contains elevated nutrient concentrations much greater than runoff
- An overspray or leakage of just 5% of the reuse irrigation will increase
  - Annual TN loading by 84%
  - Annual TP loading by 347%

Summary

- Stormwater treatment under the proposed rule will require innovative thinking and a new design paradigm
  - Reduce generated runoff
  - Maximize on-site retention
  - Emphasize swale drainage systems
  - Engineers will have to use their brains
- Only dry retention and wet detention (in some cases) are capable of meeting the load reduction requirements as a single system
- In most cases a treatment train concept will be required
  - Infiltration processes will be a key component of most systems
  - Must consider upstream impacts when calculating efficiencies
- Reuse irrigation from stormwater ponds may be a significant component of the treatment train
- Limitations of LID must be recognized
- Irrigation with secondary reuse is not compatible with the new rule
  - Developer will have to increase treatment system to accommodate reuse
  - Requires developers to subsidize the cost of wastewater disposal

Questions?