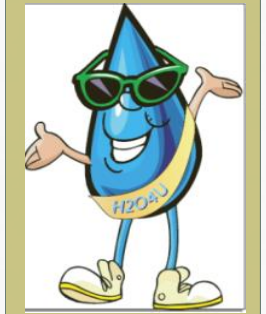
CONTINUATION OF LID BMPs COMMONLY USED

BY: MARTY WANIELISTA



ACKNOWLEDGEMENTS

- The Low Impact Design BMP workshops were presented on August 24 and 25, 2016 at the Escambia County Central Office Complex in Pensacola.
- The Escambia County LID BMP Manual and the LID BMP Workshops were funded in part by a Section 319 Nonpoint Source Management Program Implementation grant from the U.S. Environmental Protection Agency through an agreement/contract with the Nonpoint Source Management Section of the Florida Department of Environmental Protection."

5.7 LID BMP - Swale
Chapter 403.803 (14), Florida Statutes

A manmade trench which:

- Has a top width-to-depth ratio of 6:1 or greater
- Has areas of standing or flowing water only after a rain
- Is planted with vegetation suitable for soil stabilization, stormwater treatment, nutrient uptake
- Designed for soil erodibility, soil percolation, slope, slope length, and the drainage area
- Designed to prevent erosion and reduce pollutants

Use of Swales

Common Names: Linear retention LIDs
Conveyance BMPs

Uses:

- Along streets, rural road sections
- Residential subdivisions
- Pretreatment (BMP Treatment Train)
  - Any land use type, parking lots
  - Before infiltration trenches, wet ponds
- With enhancements
  - Swale blocks
  - Shallow longitudinal slopes (settling)
  - Raised driveway culverts

Swale Design Criteria

OBJECTIVES

- **Conveyance and Water quality**

DESIGN CONSIDERATIONS

- **Depends on type of swale**
- **Soil infiltration - HSG A,B soils**
- **Pavement edge protection**
- **Slope - flat as possible**
- **Cross-section - triangular, trapezoidal**
- **Side slopes - 3:1 or flatter**
- **Bottom width – usually at least 2 feet**
- **Vegetation - lawn grasses, native grasses,**
  - wildflowers, shrubs

Conveyance Swale Design

Equation 5.7.2. Swale length for Trapezoidal Shaped Swales

$$L = \frac{43{,}200\,Q}{\{B + 2\left(\frac{\left(1.068\,n\,Q\,(1+Z^2)^{\frac{1}{3}}\right)\}}{S^{\frac{1}{2}}\,Z^{\frac{2}{3}}\,2\,[(1+Z^2)^{\frac{1}{2}} - Z}\right)^{\frac{3}{8}}(1+S^2)^{\frac{1}{2}}\}i}$$

Where:

L = Length of swale (ft)

B = Bottom width of swale (ft)

Q = Average flow rate (cfs) from **Equation 5.7.1**

n = Manning's Roughness Coefficient

Z = Side slope (horizontal distance for a one foot vertical change)

S = Longitudinal slope

i = Limiting infiltration rate of swale (inches/hour)

Swale Construction

- Verify location and prevent equipment
- Minimize soil compaction
- Construct first, allow vegetation to grow
- Divert flows until DA stabilized
- Stabilization recommendations
  - 0 - 4% Seed with erosion blanket
  - 4 - 8% Staked sod
  - >8% Staked sod, swale blocks
- Do not use muck grown sod

Swale Inspection and Maintenance

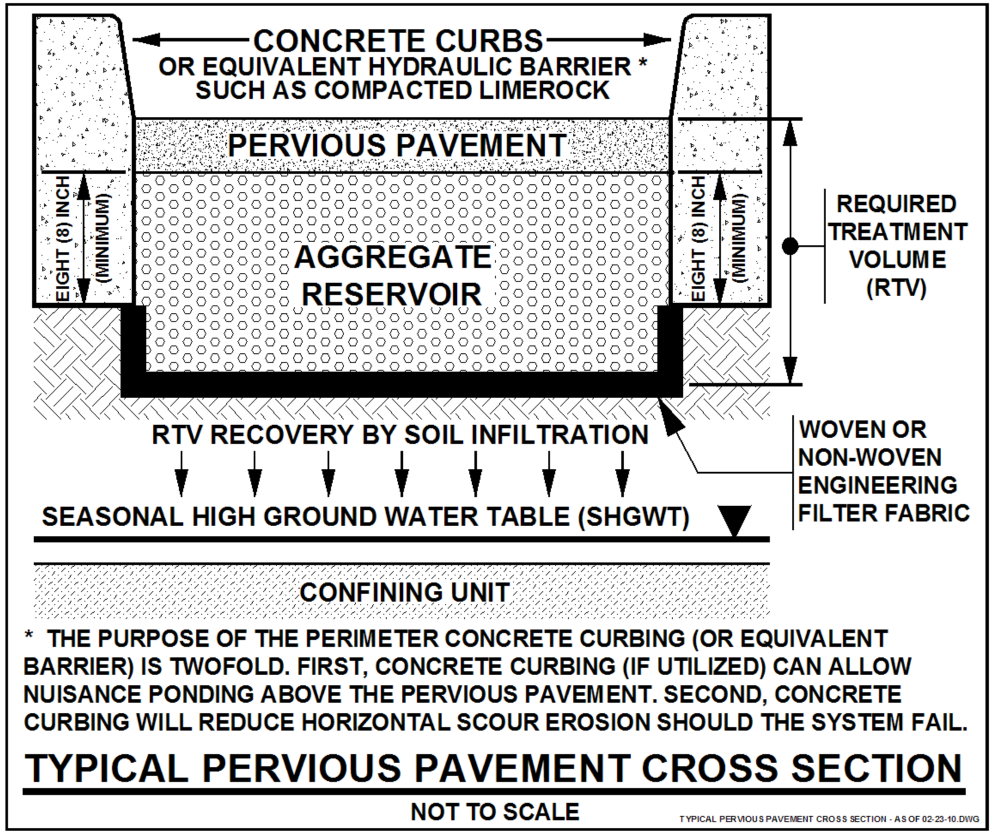
Inspection

- Check treatment volume recovery time and percolation rates; check for standing water
- Monitor erosion and sediment accumulations
- Check vegetation cover and health
- Check flow path for obstructions, damage

Maintenance

- Restore percolation rate if needed
- Remove trash, debris, sediments
- Maintain healthy vegetative cover
- Mowing – as needed, keep grass 3 - 5” long
- Repair any erosion
- Disk, till, or aerate bottom if needed
- Maintain swale blocks, outlets, and pavement

5.9 LID BMP: Pervious Pavements



- Pervious concrete
- Pervious pavers
- Turf block
- Geoweb with sod

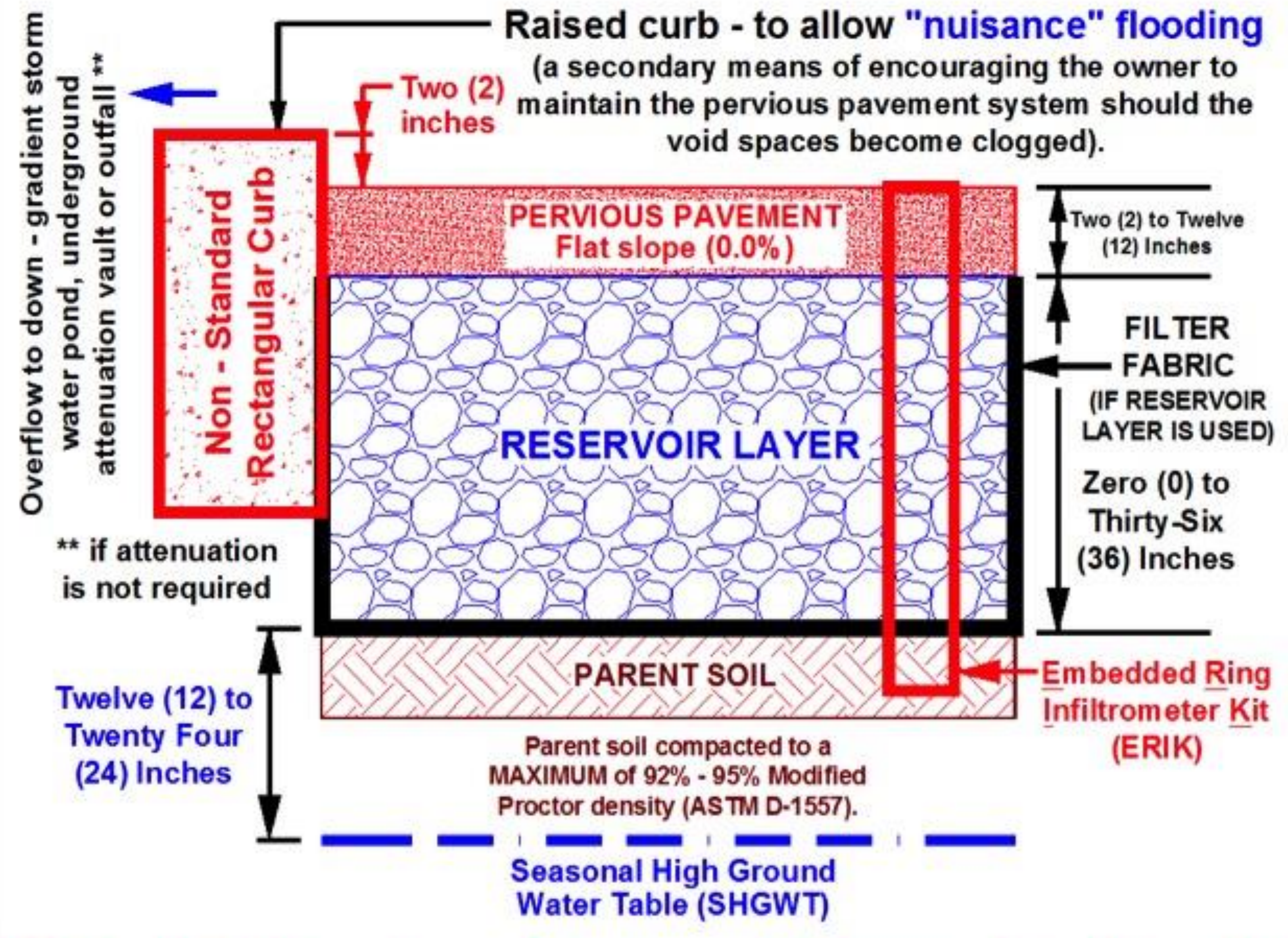
Pervious Pavement Warning

- Very different from regular pavement
- **Good design** is important, but --- You have to locate it properly, build it right, inspect and maintain it.

Pervious Pavement Design Criteria

- Is the site appropriate? What are traffic loads?
- Master certified contractor
- SHWT at least 2’ below bottom
- Treatment volume using retention curves
- Design per specs/perc rate – min 2”/hr
- Compaction – max 92-95% to min of 24 inches
- Edge constraint to prevent scour
- Quarterly to annual vacuum sweeping
- ERIK testing and recertification
- Signage to keep muddy vehicles off

Placement, Striking, Pizza Cutter and 7 day Curing



Potential Pervious Pavement Cross Section #1

Scale: None

Refer to the next slide for information on the ERIK device.

Embedded Ring Infiltrometer Kit (ERIK)

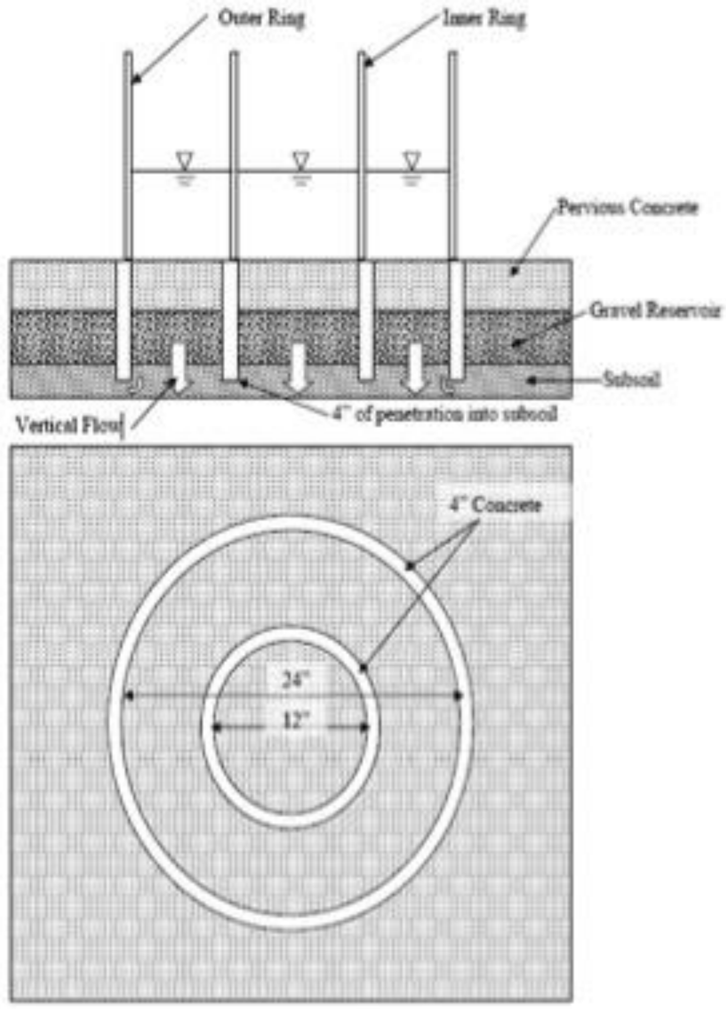


Figure 42: Design profile for Embedded Infiltrometer installation

A single ring ERIK infiltrometer is acceptable provided that is embedded into the subsoil as shown in Figure.

For more information on this in-situ infiltration monitor (ERIK), refer to the UCF research paper entitled "*Construction and Maintenance Assessment of Pervious Concrete Pavements - Final Draft*", dated January, 2007, available at: http://stormwater.ucf.edu/research_ publications.asp

ERIK
(Embedded Ring Infiltrometer Kit)

ERIK in pavement
at
Central Office Complex

Pervious Concrete Information

- Florida Concrete & Products Assn
- http://www.fcpa.org/
- www. ConcreteParkingLots.com
- Manuals
- Training classes –certification of contractors-Master
- Training videos
- Min. 2”/hr perc rate

Pervious Pavement Lesson Learned

Issue: Be aware of and plan for off-site runoff that can run on and overwhelm it

Solution: Divert to take advantage of the entire pervious pavement area

Pervious Pavement
Construction Recommendations

- Installation by certified trained personnel
- Excavate with light, wide tracked equipment
- Inspect bottom and install fabric, 24” overlap
- Install clean, washed stone in < or = 12” lifts, compact subgrade to 92% - 95%
- Check mixtures, pour, and finish
- Cover to allow curing
- Stabilize contributing areas before use
- Post signs to educate users

Pervious Pavement
Inspection and Maintenance Activities

Inspection

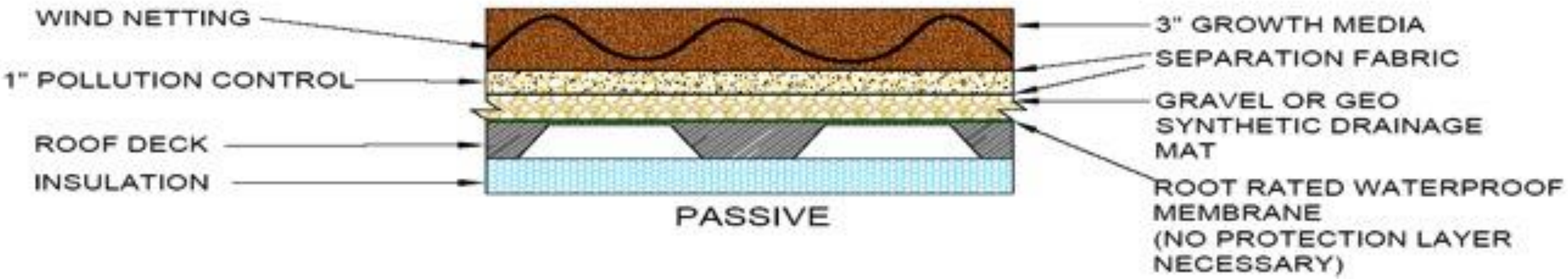
- Check design volume recovery time and occurrence of nuisance flooding
- Test vertical hydraulic conductivity with ERIK
- Check edge constraints and overflow areas for erosion

Maintenance

- Vacuum sweeping as needed
- Good housekeeping by users
- Stabilization of contributing drainage area
- Restoration if needed

5.10 LID BMP - Green Roof with cistern

- **Vegetated roof cover**
- **Active (Intensive): Deep media, intended for public access**
- **Passive (Extensive): Shallow media, intended for maintenance access only, designed for aesthetics**



Benefits Of Green Roofs

- Economic benefit
- Stormwater management
- Improve air quality
- Moderate urban heat island effect
- Building insulation
- Reduce energy consumption
- Sound insulation
- Health and horticultural therapy
- Recreation
- Food supply
- Habitat and wildlife biodiversity
- Aesthetics

Energy Benefits Of Green Roofs In Florida

- Based on UCF green roof monitoring
- Control = New Energy Star roof
- Green roof benefits increase with age while Energy Star roof benefits decline
- Green roofs increase solar panel efficiency

Green Roof Heat Flux Reductions

	2005	2006
Summer	18.8%	43.3%
Winter		49.4%

Florida Pilot Green Roofs

South Florida – 2003 – Bonita Bay Shadow Wood Preserve

August 2003

August 2007

Central Florida – 2005 – UCF Student Union

North Florida – 2011 – Escambia County One Stop Building

Green Roofs In Florida

- **Introduced to Florida in 2003: Now, at least 20 locations in Florida and others underway**
  - **UCF Student Union, physical science and Stormwater Lab (3)**
  - **FSGE (Envirohome) (2) in Indialantic**
  - **Bonita Bay (first one and has been modified for irrigation)**
  - **New American Home in Orlando**
  - **Charlotte County Stadium**
  - **UF Perry Construction Yard Building**
  - **Tecta-America Building in Sanford (tray vs. continuous)**
  - **Romano Eco Center in Lake Worth**
  - **Honda Headquarters in Clermont**
  - **Escambia County Central Office One Stop Permit Building**
  - **Residence on Casey Key**
  - **Orlando Fire Station #1**
  - **Environmental Center, Key West**
  - **Kimley-Horn in Vero Beach**
  - **Gulf Coast College in Panama City**
  - **WAWA stores in select locations (can not meet retention requirements)**
  - **Disney Starbucks**

Brickell City, Miami Redevelopment

- Green roofs and BAM to reduce nutrients part of an
- innovative CLIMATE RIBBON™ architectural feature that will provide active and positive climate control

FSGE Integrated Site Design
green roofs, pervious pave, and landscape swales

- 4500+ gallons

Green Roof/Cistern System Design Considerations

- **Building structural integrity**
- **Treatment volume per retention BMPs or design curve**
- **Waterproof membrane, drainage layer, pollution control media, growth media**
- **Preventing wind uplift – 3' tall parapet**
- **Plants – selection, spacing, density**
- **Roof drain to cistern or other storage**
- **Irrigation – roof plants, excess for landscape**

Roof Support For A Green Roof

Up to 70 lbs/SF

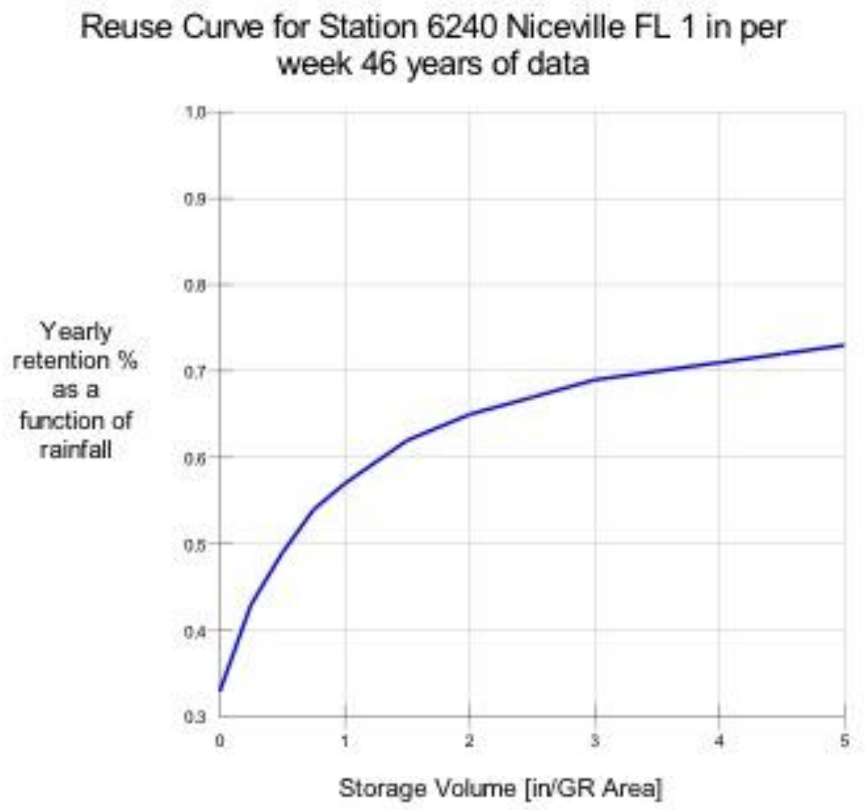
Up to 35 lbs/SF

Up to 50 lbs/SF

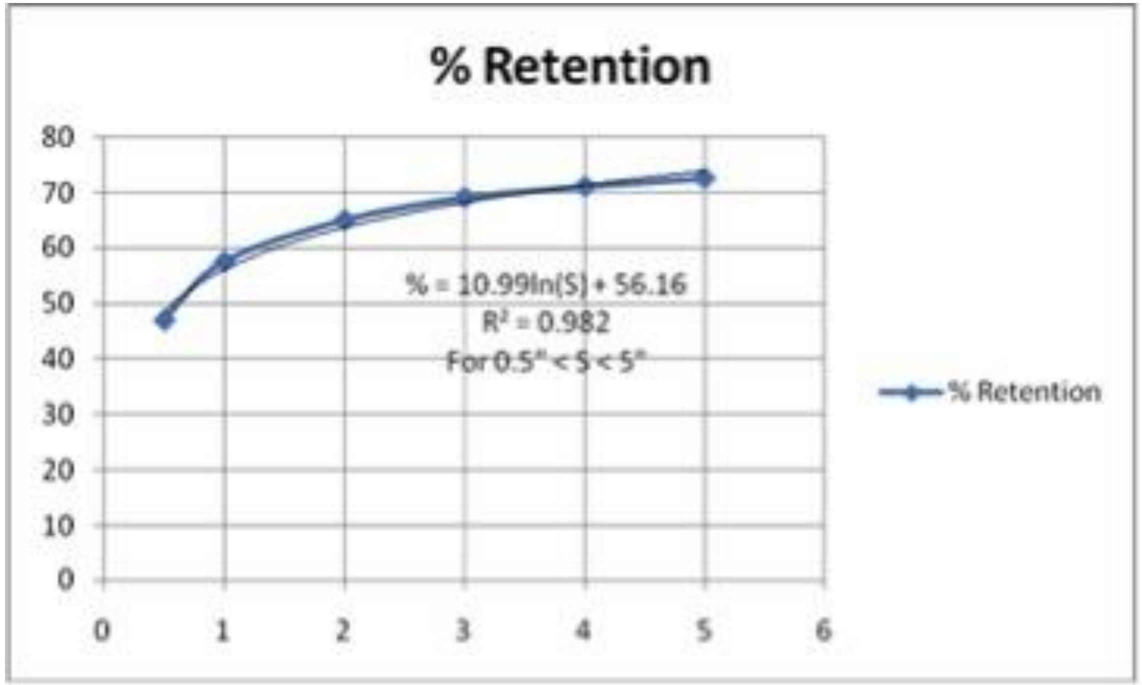
Up to 25 lbs/SF

CSTORM Model for Green Roof Cistern Design

- Cistern Design
  - Use CSTORM Model
  - Choose desired yearly stormwater retention volume
  - Use respective cistern volume
  - Storage volume will vary with location



Green Roof Retention Effectiveness



In Pensacola, a green roof will provide 33% annual retention of stormwater.
With a cistern, the annual retention percentage increases to about 70%.

Maintenance Of Green Roofs

- Initial irrigation schedule follows ground level schedule.
- If used for pollution control credit, must maintain a log of irrigation times.
- If using a dedicated cistern, inspect for functioning at least once per month, this is primarily for cistern leaks and pump operation.
- For the first two years, pull unwanted vegetation at least once per month. Usually only once per year thereafter.
- Every year, replace plants to “fill in” where others have not survived.
- Safety tips:
  - Wear shoes
  - Keep hydrated
  - Do not lean over sides
  - Watch for lighting
  - Use insect control.

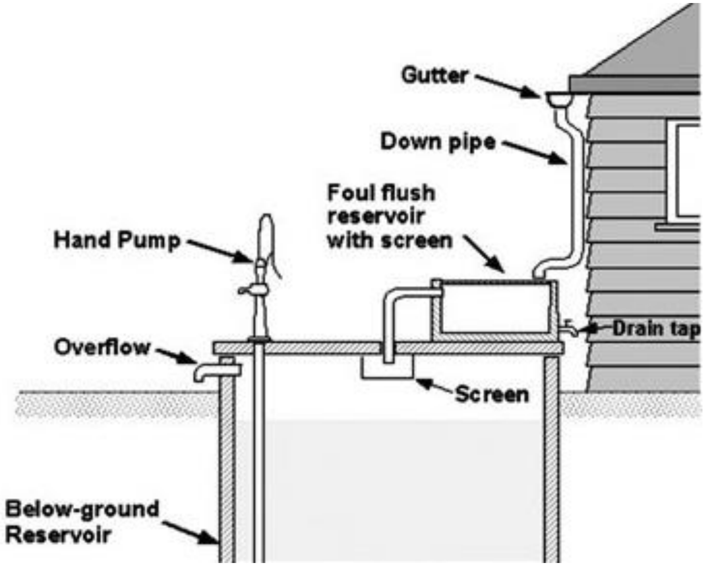
Green Roof Stormwater Price Comparison

50,000 square foot roof				
	Down Town Orlando [Magnolia]	Lee Road and I-4	University Blvd.	International Drive
Pond Price (Including Land Cost)	$5,800,000.00	$1,550,000.00	$1,200,000.00	$2,100,000.00
Green Roof Price	$1,400,000.00	$1,400,000.00	$1,400,000.00	$1,400,000.00
Realized savings	$4,400,000.00	$150,000.00	-$200,000.00	$700,000.00

Green Roof price includes fifty years of maintenance while the Pond price does not include any maintenance or fencing, green roof cost = $28/sq ft.

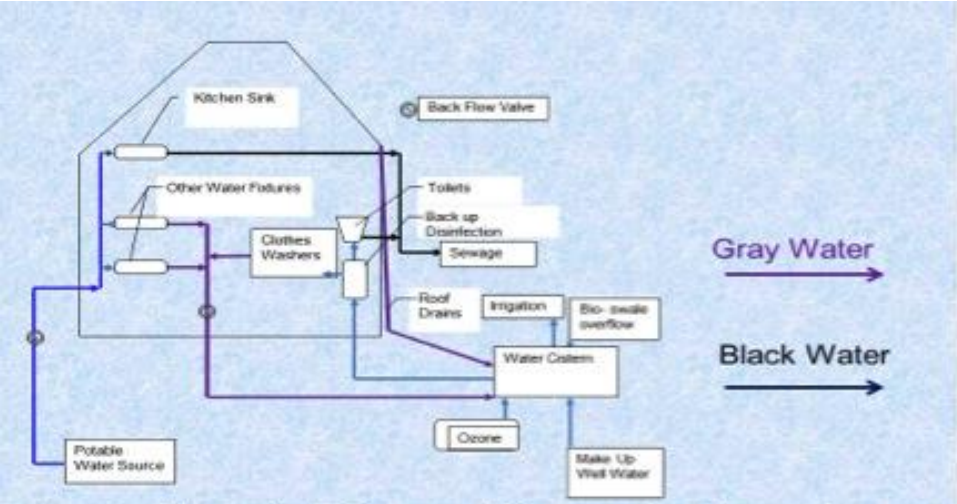
5.11 LID BMP – Rainwater Harvesting

- The collection and storage of roof runoff to reuse
- Reduces DCIA, runoff volume, loading, use of potable water
- Variety of uses from irrigation to potable uses

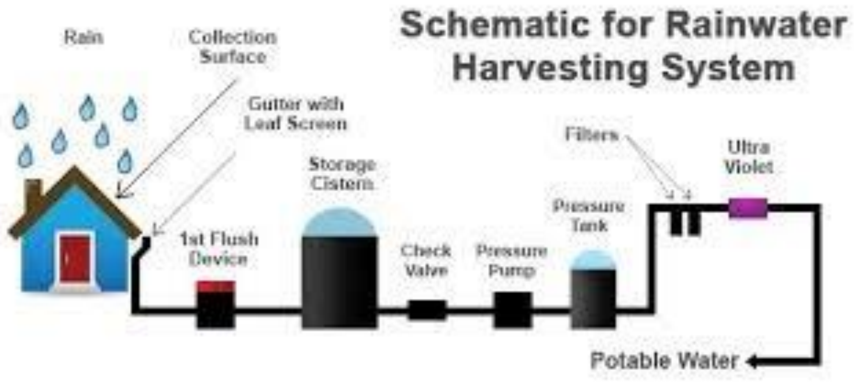


Types of Rainwater Harvesting Systems

1. Non-potable residential with rain barrel
2. Non-potable outdoor use with cistern
3. Non-potable indoor/outdoor use with cistern – Health Dept approval

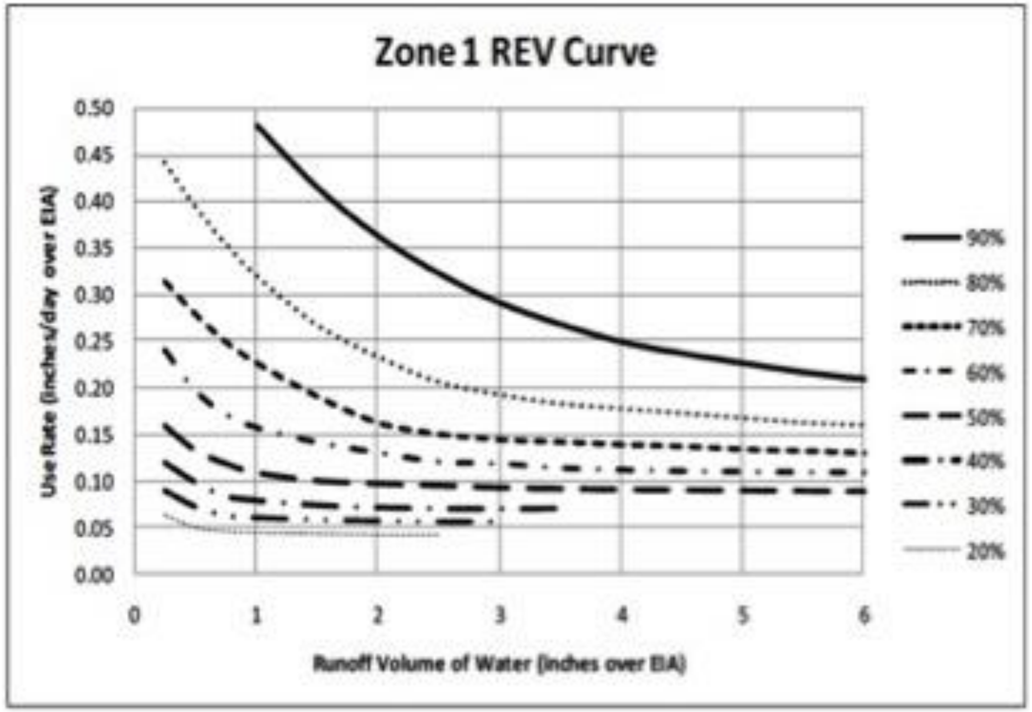


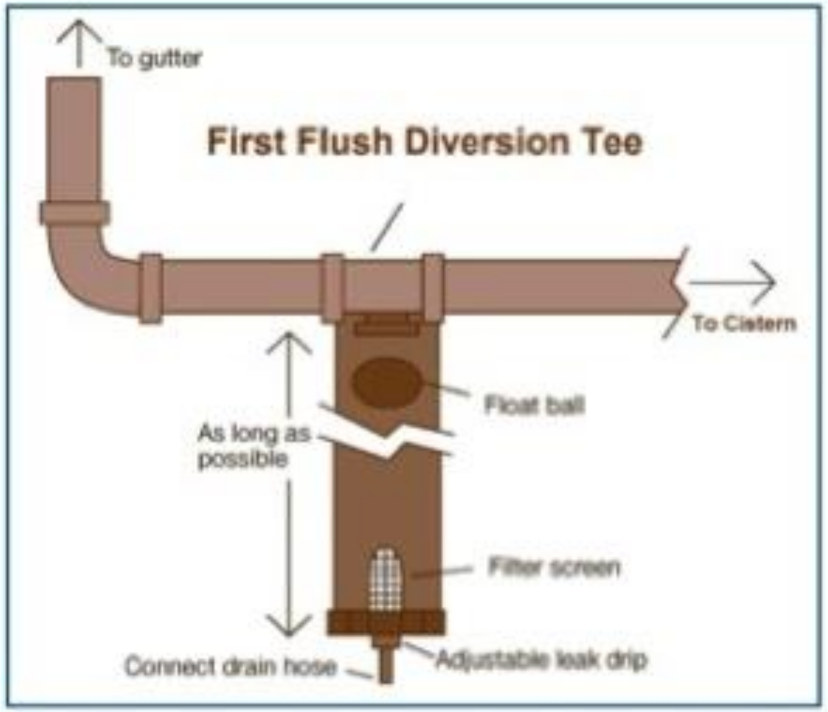
Integrated Gray and Stormwater Harvesting
Reducing Potable Water Use



Rainwater Harvesting Design Criteria

- Effectiveness related to cistern volume and daily demand for harvested water
- 1” rain/SF = 0.6 gallons of water
- Divert first flush with diversion tee





Rainwater Harvesting Design Criteria

- **Cistern can be above or below ground with overflow drain and auxiliary supply**
- **Water supply line must have meter**
- **Filter system depends on use of water. If no asphalt shingle roofs, use fine filters (5-20 microns)**

Rainwater Harvesting Design Criteria

Safety Considerations

- Control access to cistern and pumps
- Label pipes “non-potable water”
- Separate from potable supply with backwater prevention, air gap

Permitting Considerations

- May require NWFWMD water use permit
- May require Escambia County Health Department permit and building permit

Rainwater Harvesting Construction, Operation, Maintenance, Record Keeping

Construction

- Install catchment system and rain garden for overflow, irrigation system or other reuse system components
- Test to assure no leaks, proper operation

Inspection/Maintenance

- Inspect all components regularly and repair as needed

Record Keeping

- Maintenance log that includes flow meter data of volume harvested and used, inspection dates, maintenance performed, etc.

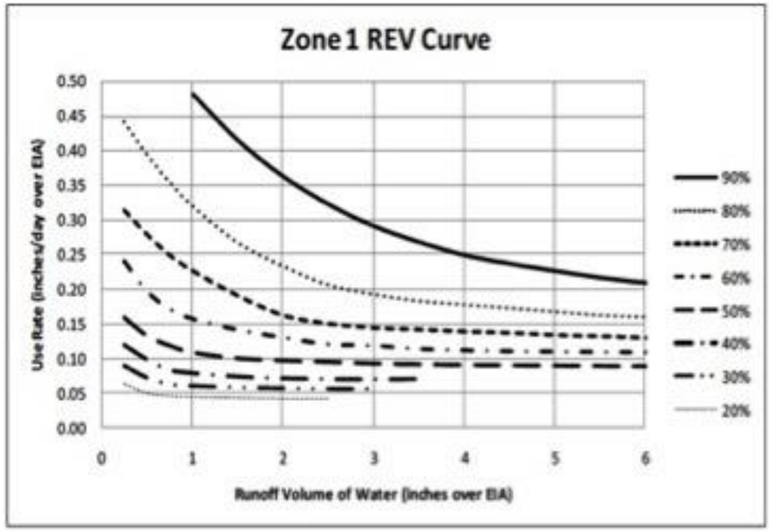
5.12 LID BMP - Stormwater Harvesting

Watershed Based: Using retained or detained stormwater for non-potable uses, such as irrigation, car washing, toilet flushing, wetland enhancement, etc.

1. **Lower use of potable water and cost.**
2. **Increase BMP effectiveness (wet detention) and reduce stormwater pollution into surface waters.**
3. **Save and maintain groundwater.**
4. **Save and enhance vegetation**
5. **Reduce salt water intrusion.**

Stormwater Harvesting Design Considerations

- Design with REV curves
- REV Curve assumptions
  - Use rate is constant – rate/day over EIA
  - Irrigate twice/week
  - No irrigation after rain > use rate
  - If irrigate DA to the wet detention storage, decreases load reduction



Project SMART - Florida

Regional wet detention pond serving roadway and commercial property

COLLECTS RUNOFF WATER

Wet detention pond cleaned, reshaped, revised to allow stormwater harvesting

Test case to verify design REV criteria

CONTROLS POLLUTION

Water harvesting for irrigation of lawns
Community saved potable water
as well as money.

AND REUSES THE WATER

Examples: Over 300 in Florida

Sources: Horizontal Subsurface Systems and G. Hartman

www.stormwater.ucf.edu

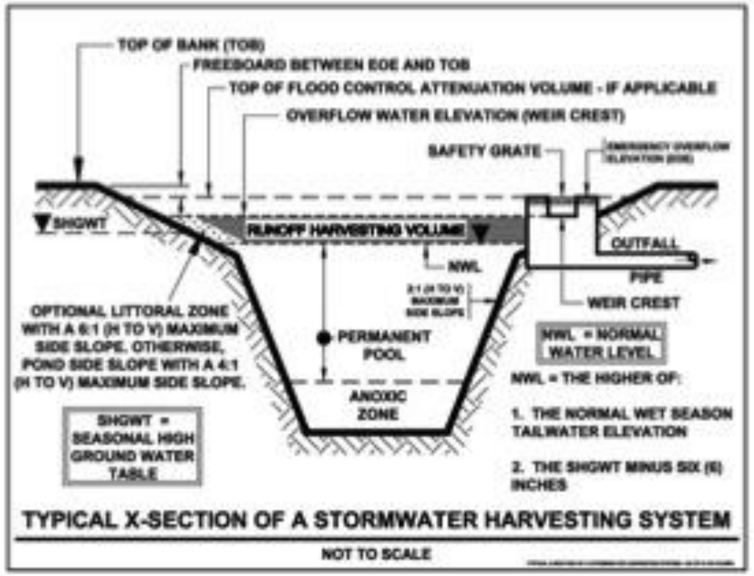
1. South Bay Utilities

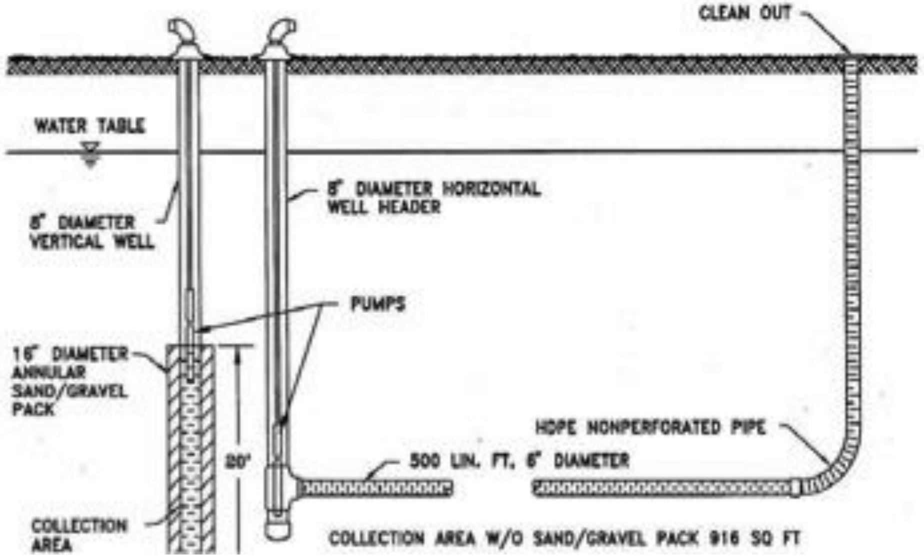
   - Upscale residential irrigation demand
   - No CUP
   - No FPSC
   - No FDEP

- 50¢/1,000 gallons
- Shallow wells
- Customer agreements 900 homes - HOA
- Coastal / fragile resource

Stormwater Harvesting Design Considerations

- Construct wet detention per NWFWMD
- Determine EIA = C*A to get storage volume
- Must be pretreated = horizontal well or equiv
- Over 700 horizontal wells in Florida
- Determine irrigation schedule





Stormwater Harvesting Construction, Maintenance, Record Keeping

Construction

- Wet detention system
- Filter system
- Irrigation or reuse system

Inspection and Maintenance

- Inspect components regularly to ensure proper operation
- Repair components as needed

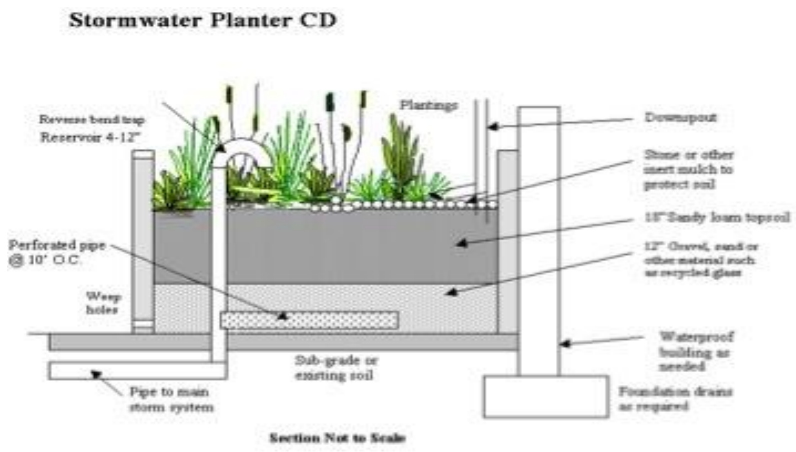
Record Keeping

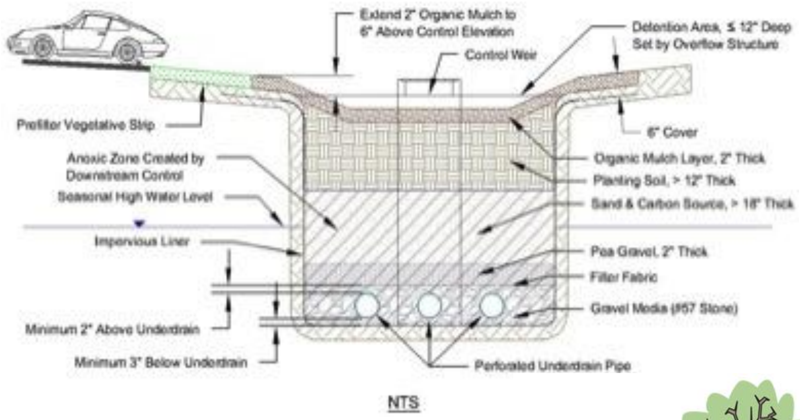
- Maintenance log that includes flow meter data of volume harvested and used, inspection dates, maintenance performed, etc.

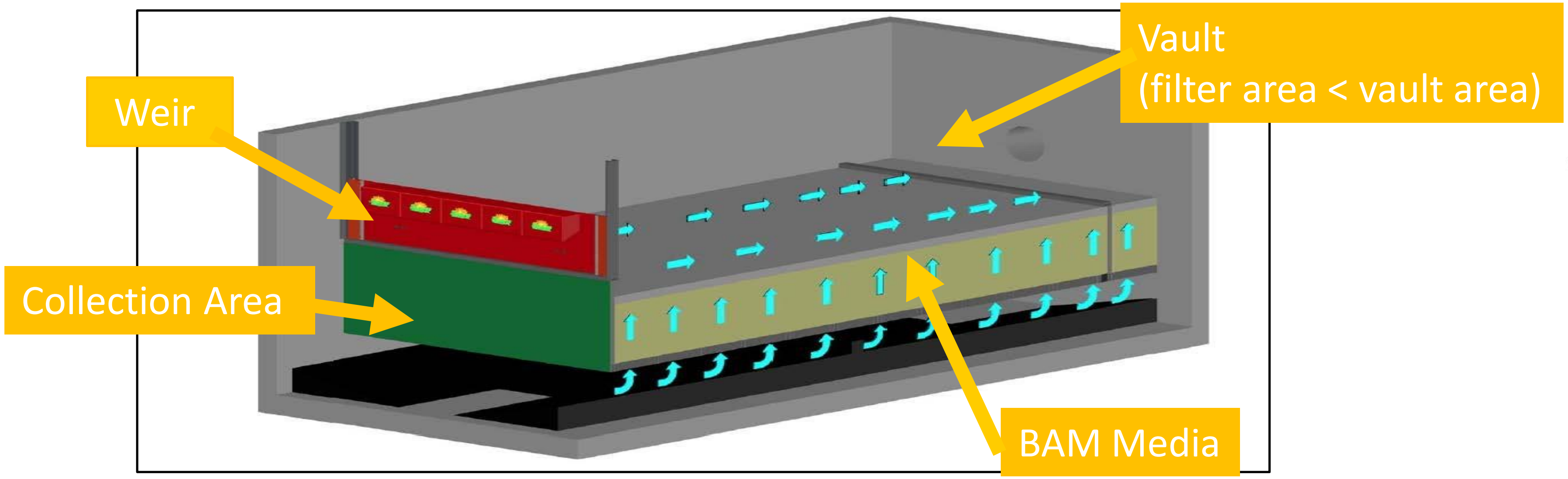
5.15 LID BMP – Biofiltration using Biosorption Activated Media (BAM)

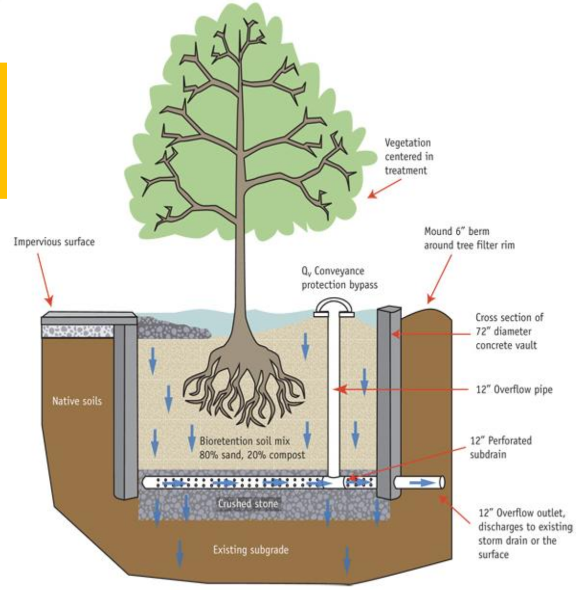
- Suite of offline BMPs with engineered media (BAM) to enhance pollutant removal of native soils
- Retention or detention BMPs
- Include rain gardens, landscape planter boxes, tree box filters, upflow filters
- In areas with high SHGWT, use liner to separate from ground water to create anoxic zone in bottom to promote nitrate removal

LID BMP – Biofiltration using Biosorption Activated Media (BAM)









Design Chart Assistance

Inside Dim ftxft	Filter Area (SF)	Max CFS	Release (CF) 1st Day*	Release (CF) next 2 days	Total volume 3 days (CF)
4 x 4	14	0.0312	1347	1347	2695
4 x 8	30	0.0668	2887	2887	5775
5 x 10.5	42.5	0.0947	4091	4091	8181
6 x 12	54	0.1203	5197	5197	10395
6 x 15	72	0.1604	6930	6930	13860
8 x 17	107.5	0.2395	10347	10347	20694
10 x 20	164	0.3654	15785	15785	31570
10 x 25	200	0.4456	19250	19250	38500
12 x 25	240	0.5347	23100	23100	46200
	note: rate of maximum filtration is 0.002228 CFS/SF				
	* half the maximum				

Note:
filter area < vault area

Example Calculations for a 14 SF filter.

Column 3: Max CFS = 1 GPM/SF x 0.002228 CFS/GPM x 14 SF = 0.0312 CFS

Column 4: Release in 1st day = 0.0312 CFS x 86,400 sec/day / 2 = 1347 CF

Column 5: Remaining half is released, thus 1347, extended value is 1347.49

Column 6: Sum of water released in 3 days (round off values)

LID BMP – Biofiltration using Biosorption Activated Media (BAM)

Biofiltration BMP Components

- **Pretreatment BMPs**
- **Ponding area – 3 to 12 inches deep**
- **Mulch layer – optional, 2” to 4” deep**
- **BAM Media – type varies, 24” thick**
- **Planting media – depends on plants, >6” deep with >2”/hr permeability**
- **Woody and herbaceous plants**
- **Inlets and outlets – assure non-erosive flow**

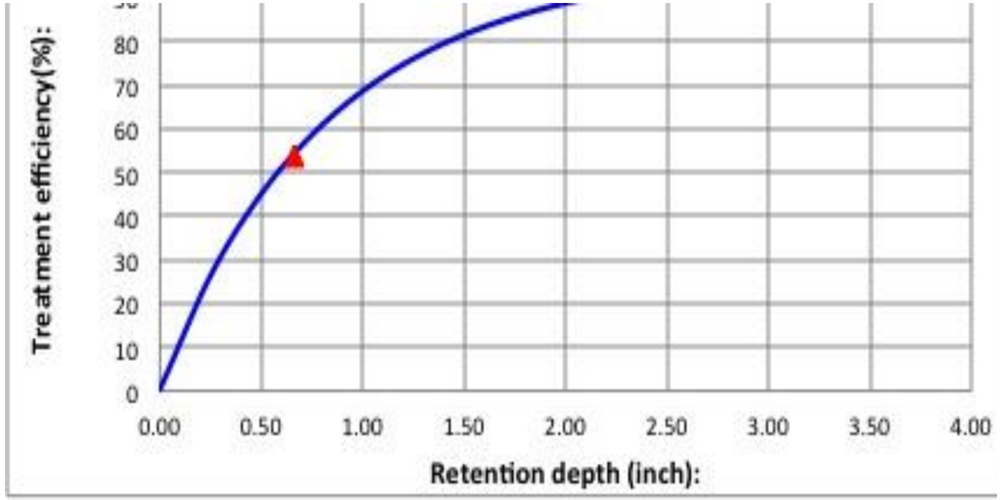
LID BMP –Biosorption Activated Media (BAM)

- **Engineered media tailored for specific WQ enhancements**
- **Includes a wide range of materials with sorption properties and carbon source ranging from soils to expanded clay to tire crumb to activated carbon**
- **UCF publication for SWFWMD “Alternative Stormwater Sorption Media for the Control of Nutrients”**
- **https://stormwater.ucf.edu/wp-content/uploads/2014/09/AlternativeMedia2008.pdf**

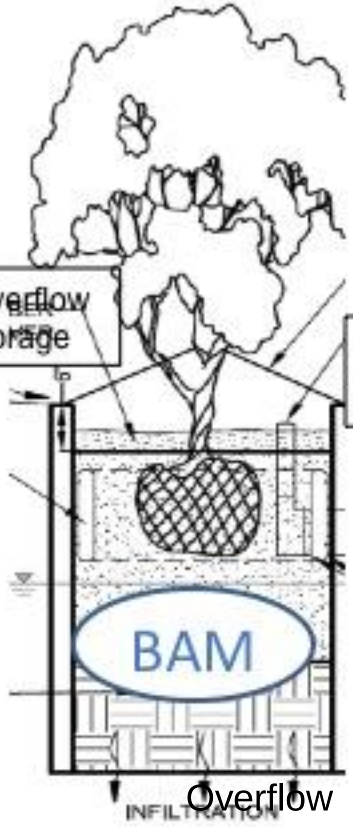
DESCRIPTION OF MEDIA	V 7.8	PROJECTED TREATMENT PERFORMANCE *			TYPICAL LIMITING FILTRATION RATE (in/hr)
Media and Typical Location in BMP Treatment Train	MATERIAL	TSS REMOVAL EFFICIENCY	TN REMOVAL EFFICIENCY	TP REMOVAL** EFFICIENCY	
B&G ECT A first BMP, ex. Up-Flow Filter in Baffle box and a constructed wetland* (USER DEFINED BMP)	Expanded Clay Tire Chips	70%	55%	65%	96 in/hr
B&G OTE Up-flow Filter at Wet Pond & Dry Basin Outflow (FILTRATION)	Organics Tire Chips Expanded Clay	60%	45%	60%	96 in/hr
B&G ECT3 Inter-event flow using Up-flow Filter at Wet Pond Outflow & Down-Flow Filter at Dry Basin (FILTRATION)	Expanded Clay Tire Chip	60%	45%	60%	96 in/hr
SAT A first BMP, as a Down-flow Filter (FILTRATION)	Sand	85%	30%	60%	1.75 in/hr
B&G CTS Down-Flow Filters 12" depth*** at wet pond or dry basin pervious pave, tree well, rain garden, swale, and strips	Clay Tire Crumb Sand & Topsoil	90%	60%	90%	0.25 in/hr

Biofiltration Treatment Effectiveness

- Part of a BMP Treatment Train
- Use graph to determine capture volume CV
- Use BAM effectiveness – depends on blend and its thickness
- Efficiency = CV % * BAM % removal
  Efficiency = 53% * 75%TN = 40% removal



Tree Well Filter Retention Design



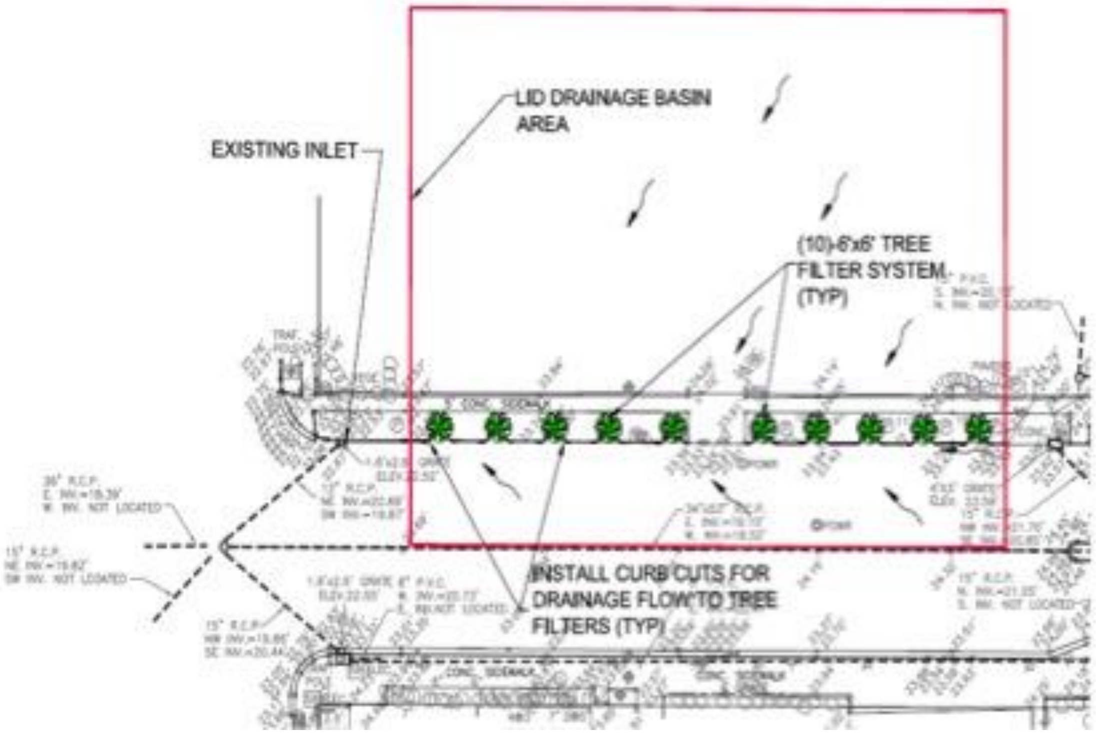
Overflow storage

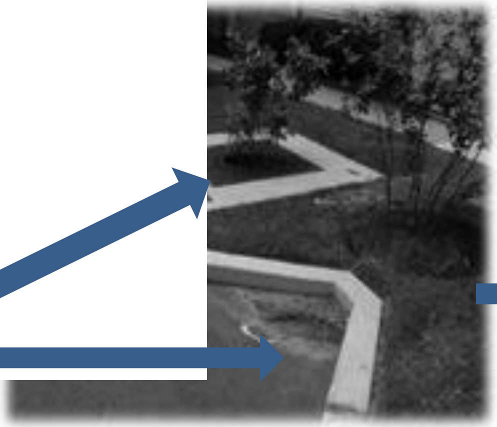
tree anchors

Overflow if not diverted

Overflow

Flow to Tree Wells

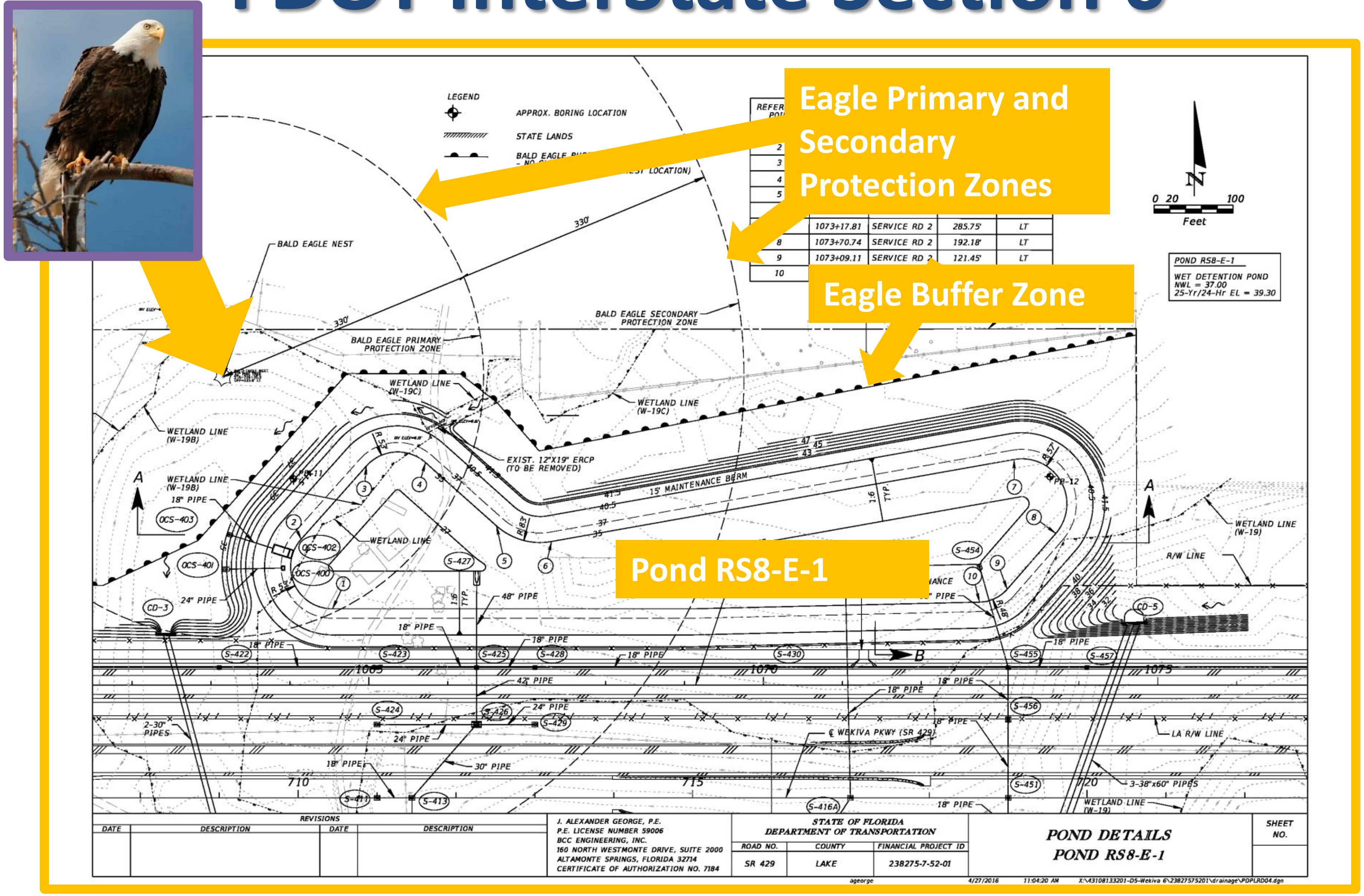




Flow to Tree Well

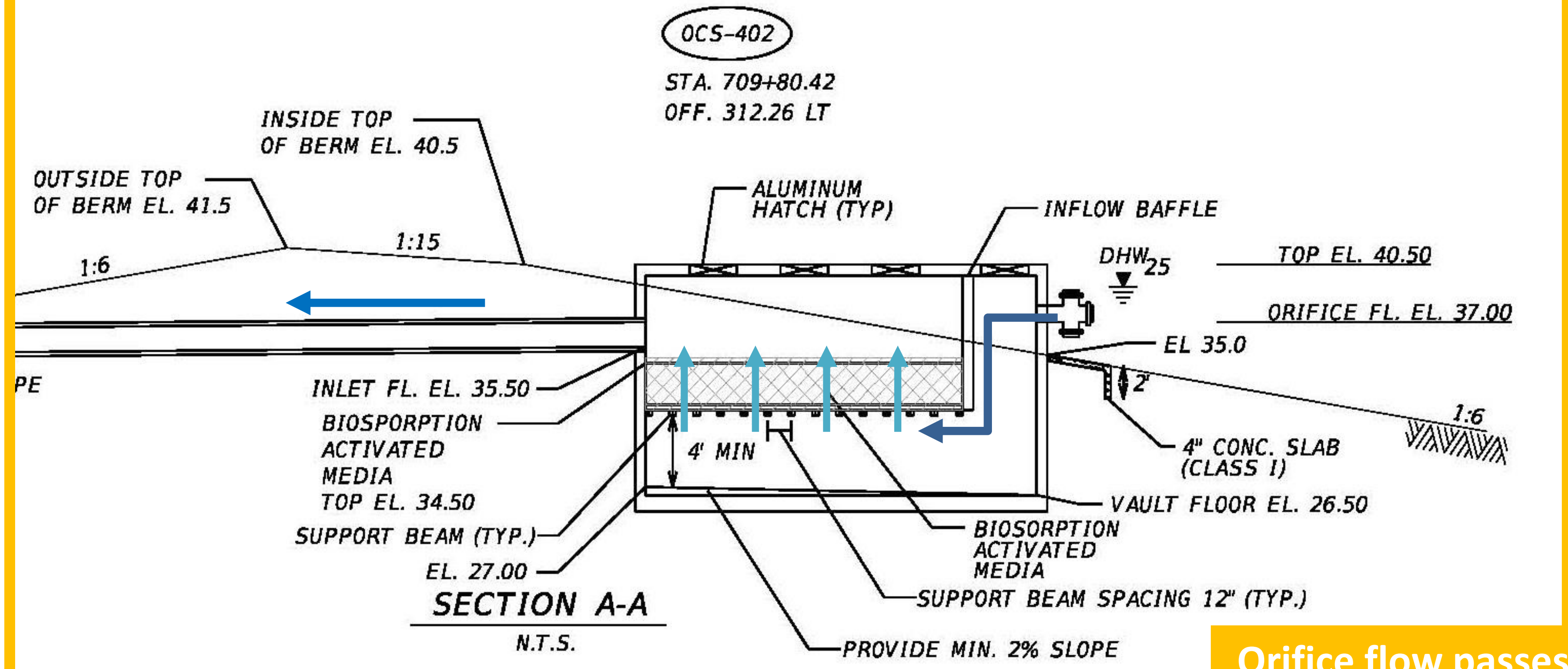
Overflow

FDOT InterState Section 6



FDOT InterState Section 6

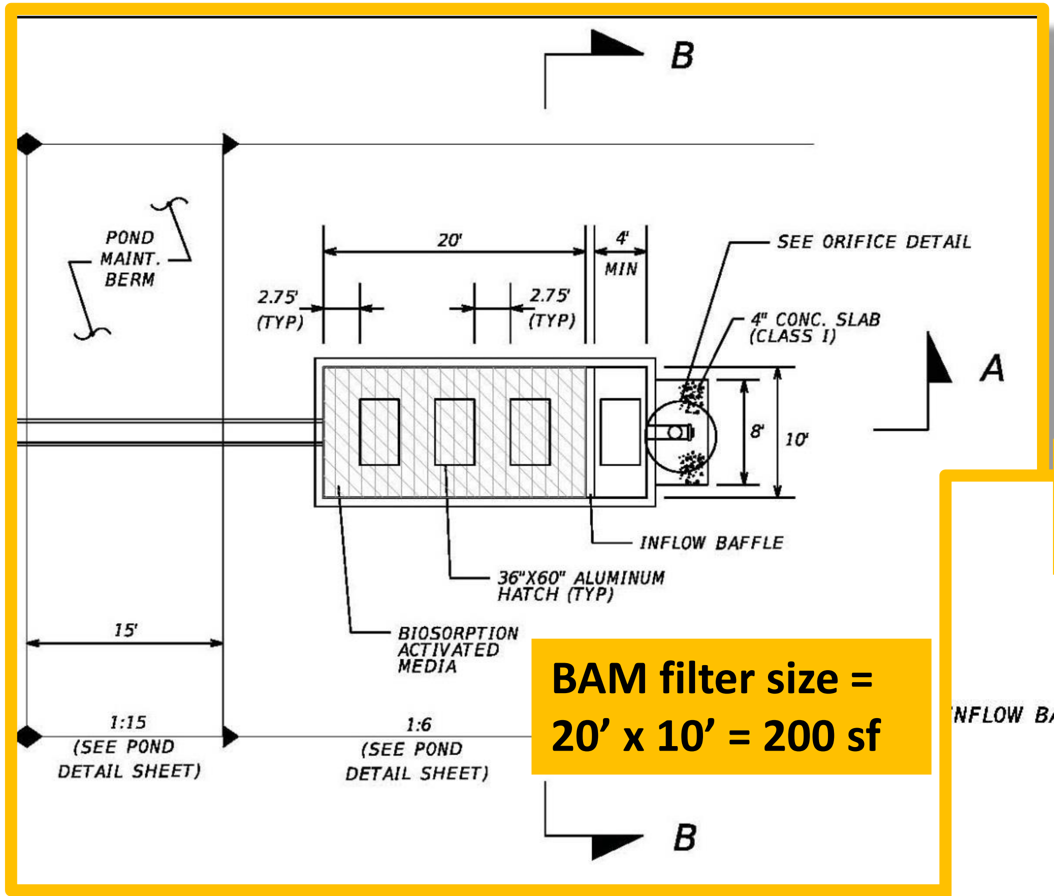
- NRFS Control Structure (OCS-402)

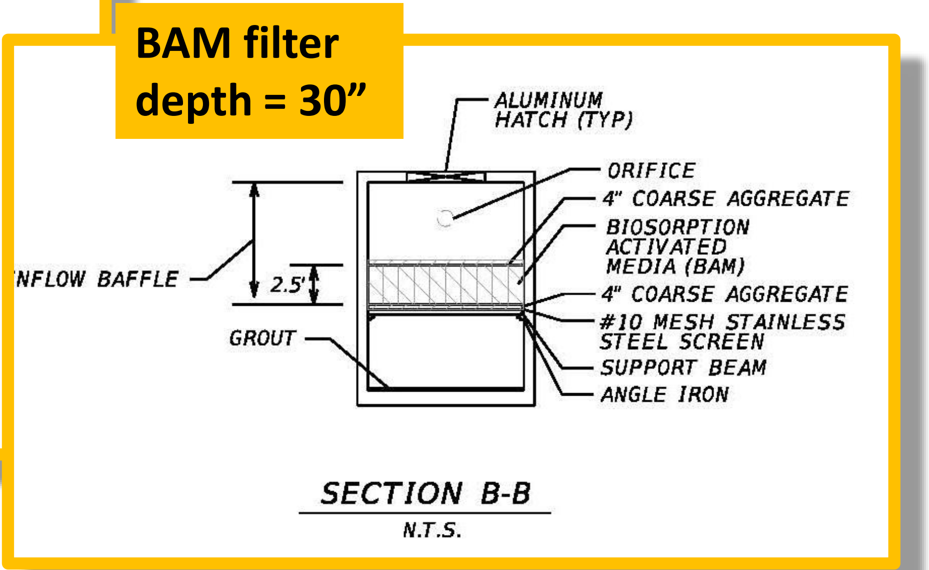


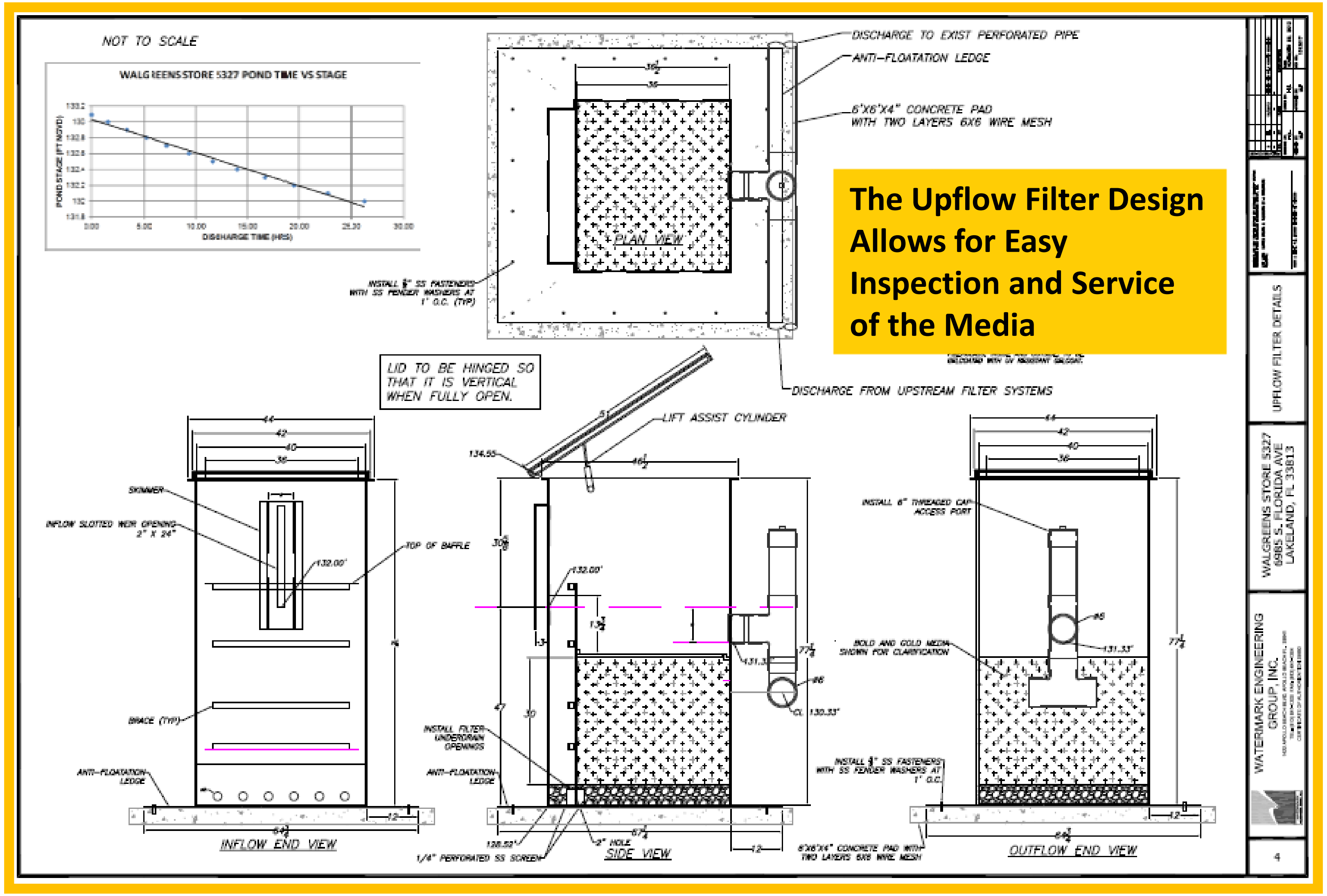
Orifice flow passes through BAM

FDOT Nutrient Removal Filtration System (NRFS)

- **NRFS Control Structure (OCS-402)**







The Upflow Filter Design Allows for Easy Inspection and Service of the Media

WATERMARK
ENGINEERING GROUP, INC.

Upflow Filter Installation by Suntree Technologies

Improved Treatment Using Up-flow Filters with Wet Pond

Filters Work to remove more

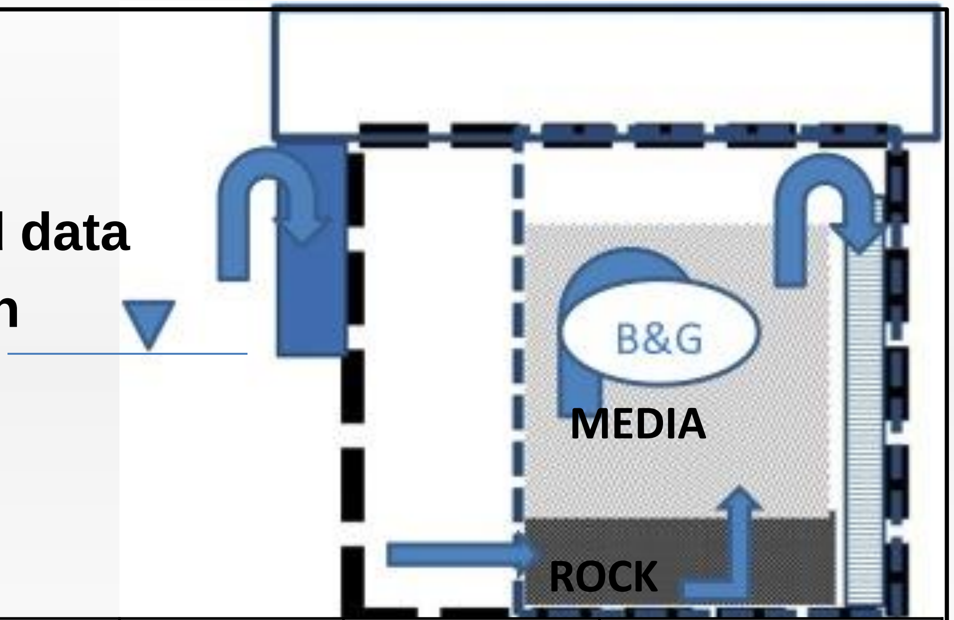
- **Filters can be designed to remove nitrogen without media replacement**
- **For phosphorus, media replacement time is specified**
- **Can be used in BMP & LID Treatment Train Applications with other treatment**

Suntree Technologies Inc.

Up-Flow Input from Wet Detention to Filter

- **Performance**
  - Concentration
  - Averages based on field data
  - Average yearly based on

1.0 inch design for filter



Parameter	TN	TP	TSS
Average Influent Concentration (mg/L)	1.83	0.73	42.7
Expected Average Pond Removal (%)	38	63	79
Average Pond + Filter Removal (%)	70	72	91
Average Annual System Performance	67	70	89

Suntree Technologies Inc.

QUESTIONS, REMARKS AND DISCUSSION

BY: MARTY WANIELISTA AND ERIC LIVINGSTON

August, 2016
Escambia County