Green Infrastructure/LID Operation and Maintenance Considerations

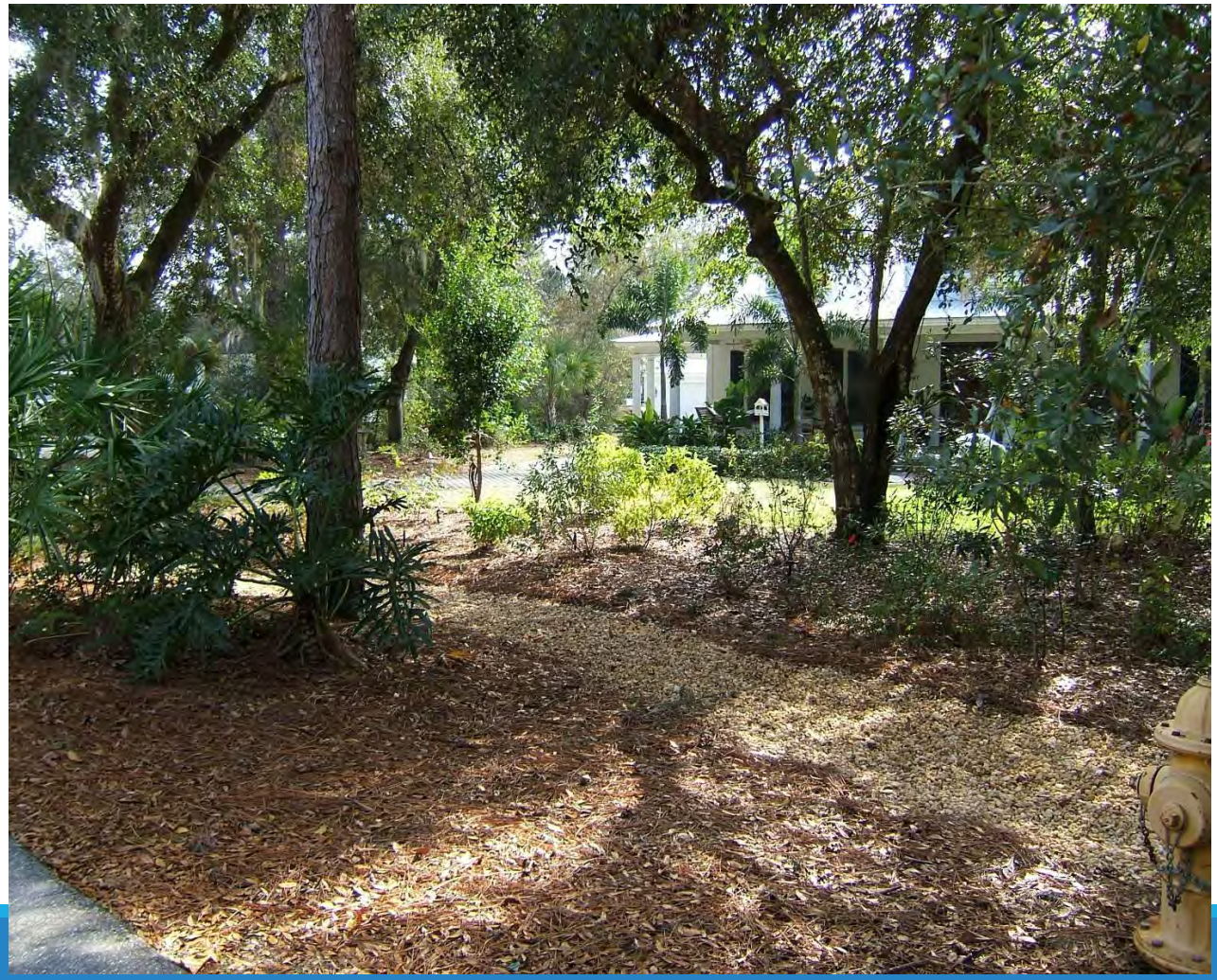
FSA STORMWATER BMP SEMINAR SEPTEMBER 11, 2015

The Importance of Sustainability

Top trends in infrastructure planning and engineering:

- 1990s – Technology
- 2000s – Alternative Project Delivery
- Today – Sustainability

Low-Impact Development



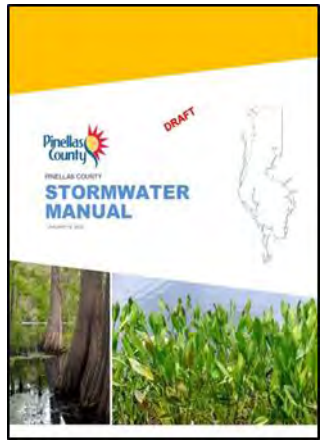
- Treat closer to source
- Smaller, more dispersed
- Often rely on infiltration

Low-Impact Development (LID) Defined

"Low-impact development" (LID) is a stormwater and land use management strategy that strives to mimic pre-disturbance hydrologic processes of infiltration, filtration, storage, evaporation, and transpiration by emphasizing conservation, use of on-site natural features, site planning, and distributed stormwater management practices that are integrated into a project's design, especially it's landscaping.

Unlike conventional stormwater systems, which typically control and treat runoff using a single engineered stormwater BMP located at the "bottom of the hill," LID systems use a suite of stormwater BMPs – source controls, retention, detention, infiltration, treatment and harvesting mechanisms – that are integrated into a project site to function as a **"BMP Treatment Train".**

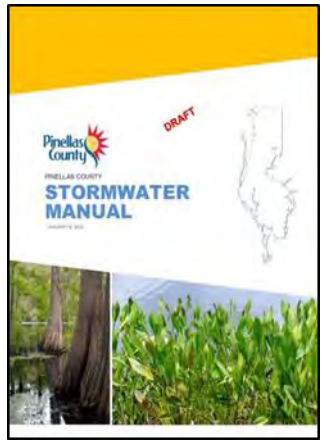
Source – Pinellas County Draft Stormwater Manual



Low-Impact Development (LID) Defined

Typically, LID practices will not completely replace more conventional "bottom-of-the-hill" stormwater management practices, but can be used to complement these practices and to ensure that the entire stormwater management system meets the Pinellas County water resources objectives.

Source – Pinellas County Draft Stormwater Manual



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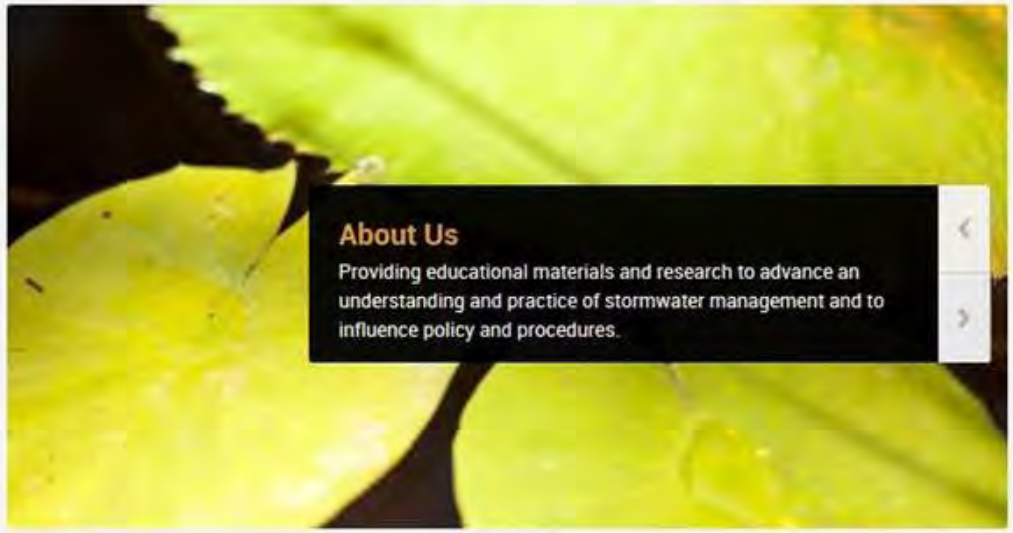
University of Central Florida Stormwater Management ACADEMY

A source for stormwater information supported by the University of Central Florida, Florida Department of Transportation, and Florida Department of Environmental Protection



BMPTRAINS Model (Version 7.5)

DOWNLOAD BMPTRAINS Analysis Model (Version 7.4) - DOWNLOAD user's manual or REGISTER to receive updates and news!

Other Featured Publications

Click here to read the latest publications. Includes pervious pavements, pollution control using BAM, erosion, and sedimentation.

Featured posts

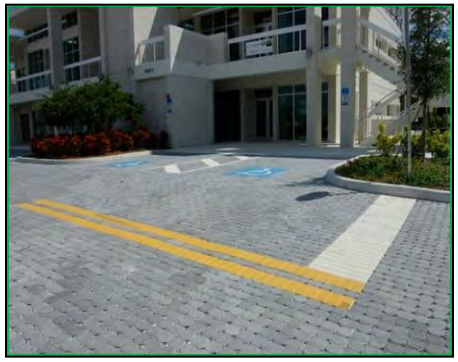
State of Florida Erosion Manual (2013)

This manual will assist designers and reviewers in providing meaningful and practical Erosion and Sediment Control (E&SC) drawings as part of the Stormwater Pollution Prevention Plan (SWPPP) for the contractor to implement.

FULL ARTICLE

Low Impact Development (LID) Alternatives

1. Shallow Bioretention
2. Pervious Pavement System
3. Stormwater Harvesting
4. Greenroof Stormwater Treatment System
5. Rainwater Harvesting
6. Detention with Biofiltration



LID BMPs Covered

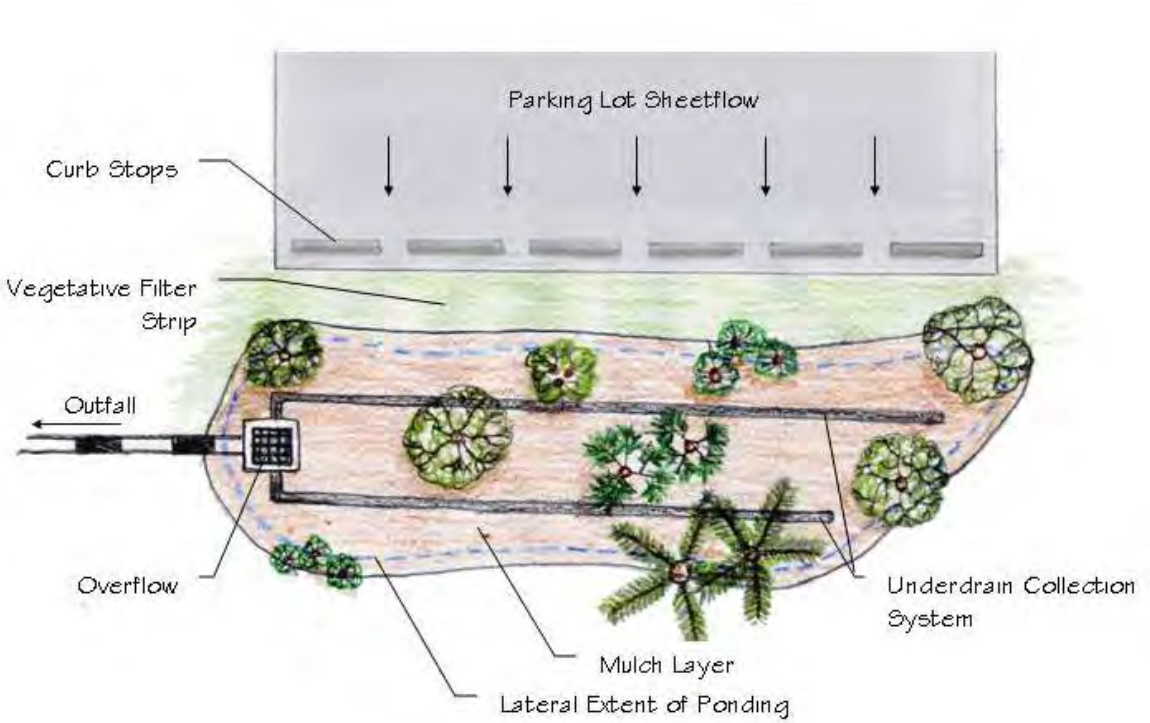
Bioretention
Biofiltration

Pervious Pavement

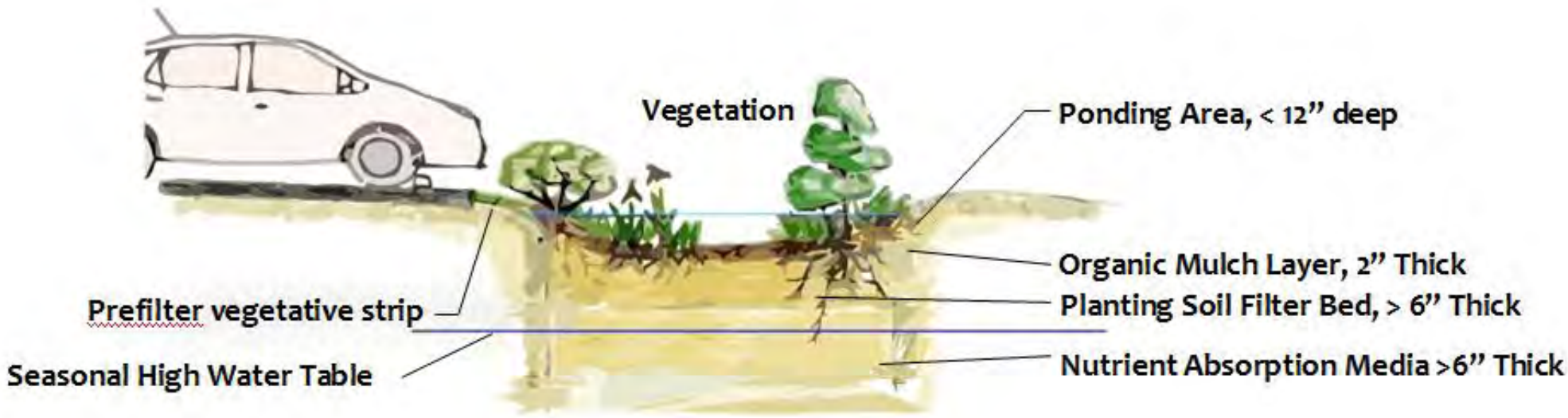
Swales Level Spreaders

Bioretention and Biofiltration

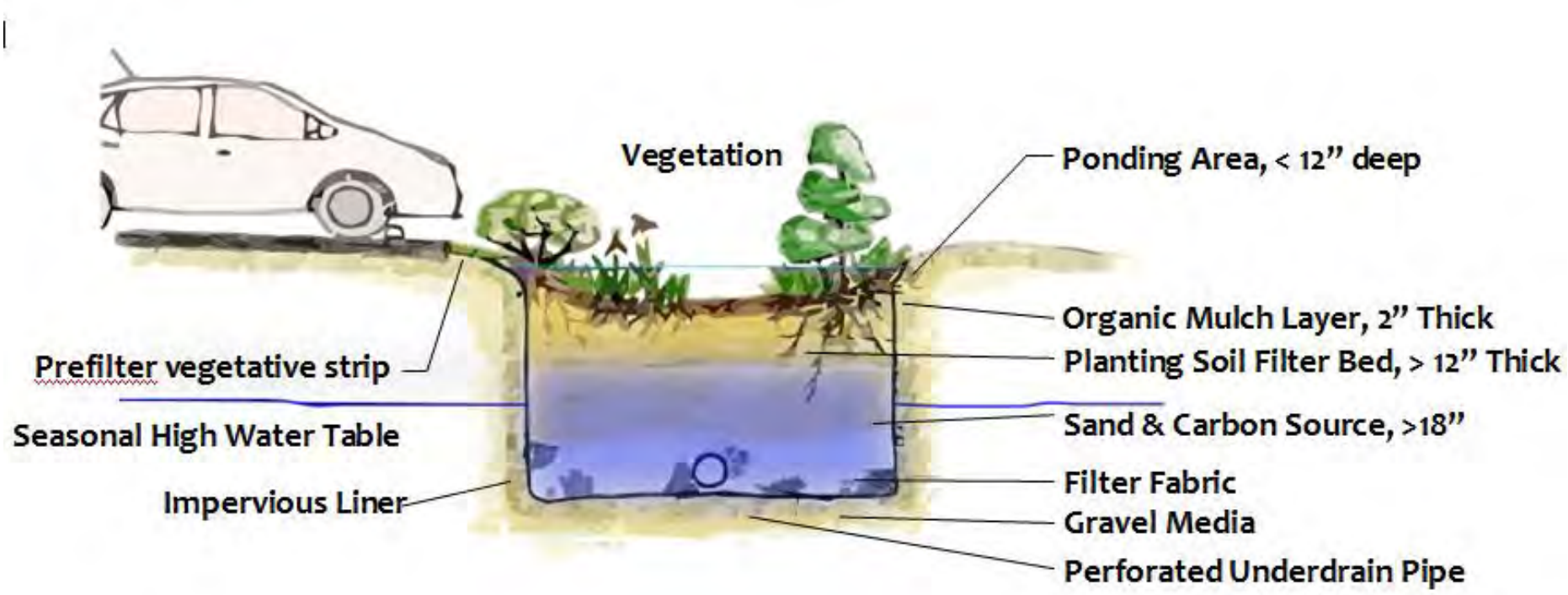
- Shallow landscaped depressions
- Engineered media
- Retention: no underdrain
- Detention/filtration: underdrain



Bioretention Cross Section View



Biofiltration Cross Section View



Bioretention/Biofiltration Design Considerations

- Pretreatment (Filter strip, settling area, or both)
- Ponding depth
- Infiltration rate
- Drought-resistant plants
- Irrigation
- Adequate mulch
- Underdrain cleanout
- Area served
- Maintenance access

Detention with Biofiltration

Advantage/Benefits

- Applicable to small drainage areas.
- Applicable to high water table conditions.
- Good retrofit capability.
- Can be planned as an aesthetic feature.
- Used where contamination is a threat.

Disadvantages/Limitations

- Requires landscaping.
- Requires underdrain system.

Maintenance Requirements

- Inspect and repair/replace treatment area components
- Remove trash, litter and sediment.

Bioretention/Biofiltration Typical Problems and Inspection

- Inadequate infiltration - Ponding
  - 24 hours after ½” rain
  - 48 hours after 1” rain
  - 72 hours after 1 ½” rain
- Sediment build up

- Overgrown/choked
- Erosion and bare soil
- Blocked inlet
- Trash accumulation
- Sightline issues

Bioretention/Biofiltration
City of Palmetto

Bioretention/Biofiltration Routine Maintenance

Description	Typical Frequency	Typical Timing
Weeding and pruning	Twice per year	Spring and summer
Trash removal	Twice per year	
Add mulch	2-3 years	Spring
Pretreatment sediment removal	Once per year	*Look upstream if more frequent
Underdrain cleanout	Once per year	

Bioretention/Biofiltration Non-Routine Maintenance

Description	Typical Frequency
Sediment removal	> 5 years
Media replacement	> 10 years
Vegetation replacement	2-3 years
Erosion control/stabilization	

Pervious Pavement

Pervious Pavements

Advantage/Benefits

- Has potential to reduce the size of or eliminate stormwater structures from impervious areas
- Increases usable/developable space or decreased developed footprint
- May increase aesthetic value

Disadvantages/Limitations

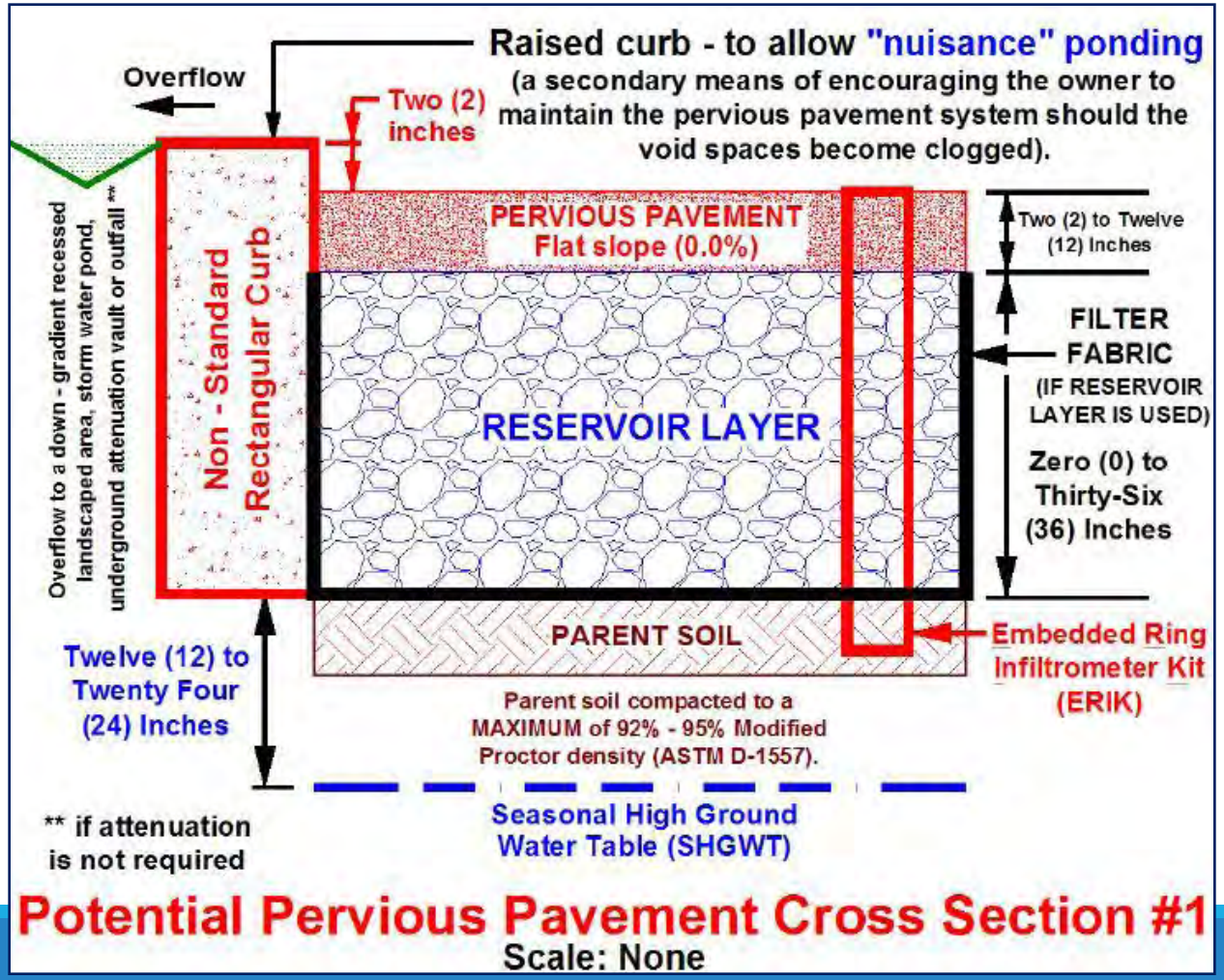
- Typically has higher construction cost than conventional impervious pavements
- Not suitable for all site soil conditions
- If the surface fails, it must be reconstructed, not resurfaced

Maintenance Requirements

- Vacuum as needed when infiltration measurements are lower than 1.5 inches per hour
- Check bi-monthly to assess the amount of infiltration, ideally during a rain event

Pervious Pavement Design Considerations

- Certified installer
- Edge restraint
- In-situ infiltration measurements
- Reservoir layer and native soils
- Turning motion and heavy traffic
- Contributing area



Pervious Pavement
Typical Problems and Inspection

- Structural integrity
- Clogging

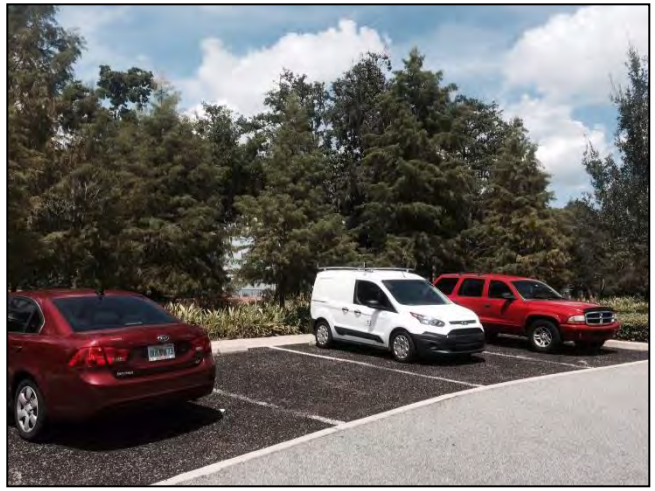
Pervious Pavement Routine Maintenance

- Vacuuming
  (at least 2 times per year)
- **High-pressure washing**
- Aggregate replacement
- **Minimize/stabilize upstream pervious areas**

Pervious Pavement
Lake Concord Park, City of Casselberry

Pervious Concrete

Turf Block



Flexi-Pave

Grassed Swale

Grassed Swale Design Considerations

- Shallow depth of flow
- Gradual side slopes
- Gradual longitudinal slope
- Adequate depth to water table

Grassed Swale
Typical Problems and Inspection

- Bare soils
- Dead vegetation
- Erosion
- Sedimentation
- Standing water

Grassed Swale Maintenance

Description	Typical Frequency	Notes
Routine		
Mowing	Variable	Remove clippings if possible
Sediment removal (minor)	1-3 years	Look upstream if more frequent
Non-routine		
Regrading and restabilizing	> 5 years	Look upstream if more frequent
Upstream stabilization	Variable	

Shallow Bioretention

Advantage/Benefits

- Applicable to small drainage areas
- Applicable to high water table conditions
- Good retrofit capability
- Can be planned as an aesthetic feature

Disadvantages/Limitations

- Requires landscaping

Maintenance Requirements

- Prune and weed to keep any structures clear
- Maintain/mow the prefilter or swale at least twice during the growing season and remove clippings from the flow path
- Replace mulch over the entire area every 2 to 3 years
- Remove trash and debris, sediment from inflow and outflow system and any dead or severely damaged vegetation as needed

LID STRATEGIES

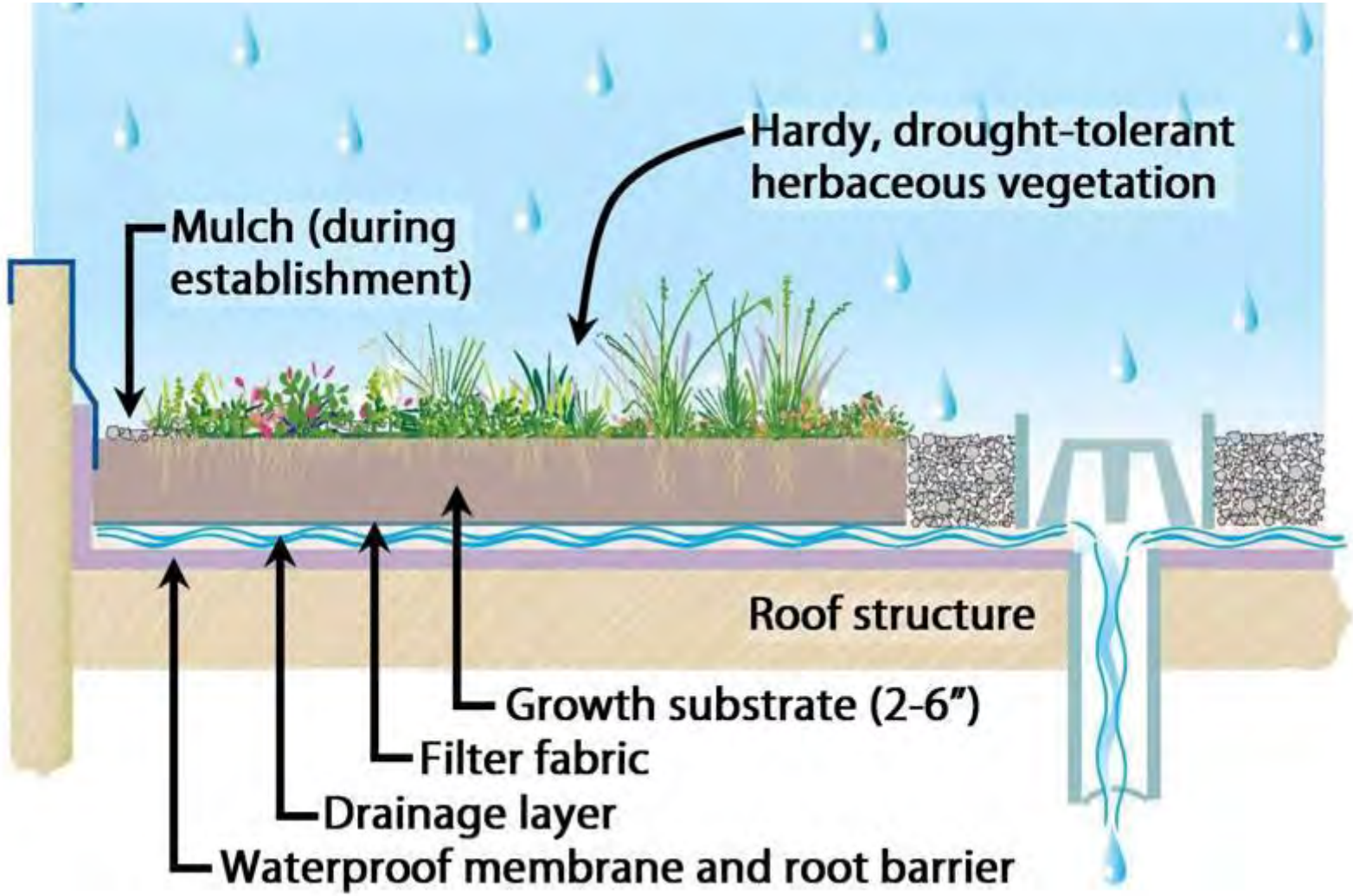
Green Roof Systems

Runoff Reduction, Reduce Heating/Cooling Costs

- Rainwater stored in a lightweight engineered soil medium
- Hardy, drought-resistant vegetation
- Reduce runoff by 50%
- Not for use in stressed basins

LID STRATEGIES

Green Roof Systems



LID STRATEGIES

Green Roof Systems

Greenroof Stormwater Treatment Systems

Maintenance Requirements

- The maintenance record or log of activities should include data on the following:
  - Irrigation volume measured using a flow meter, cistern overflow volume, observations of the irrigation system and replacement of parts, removal of nuisance species or invasive exotics, removal and replacement of dead or damaged plants and maintenance of roof mechanical equipment
- Inspections every two years

Low Impact Development (LID) Annual Cost Projection

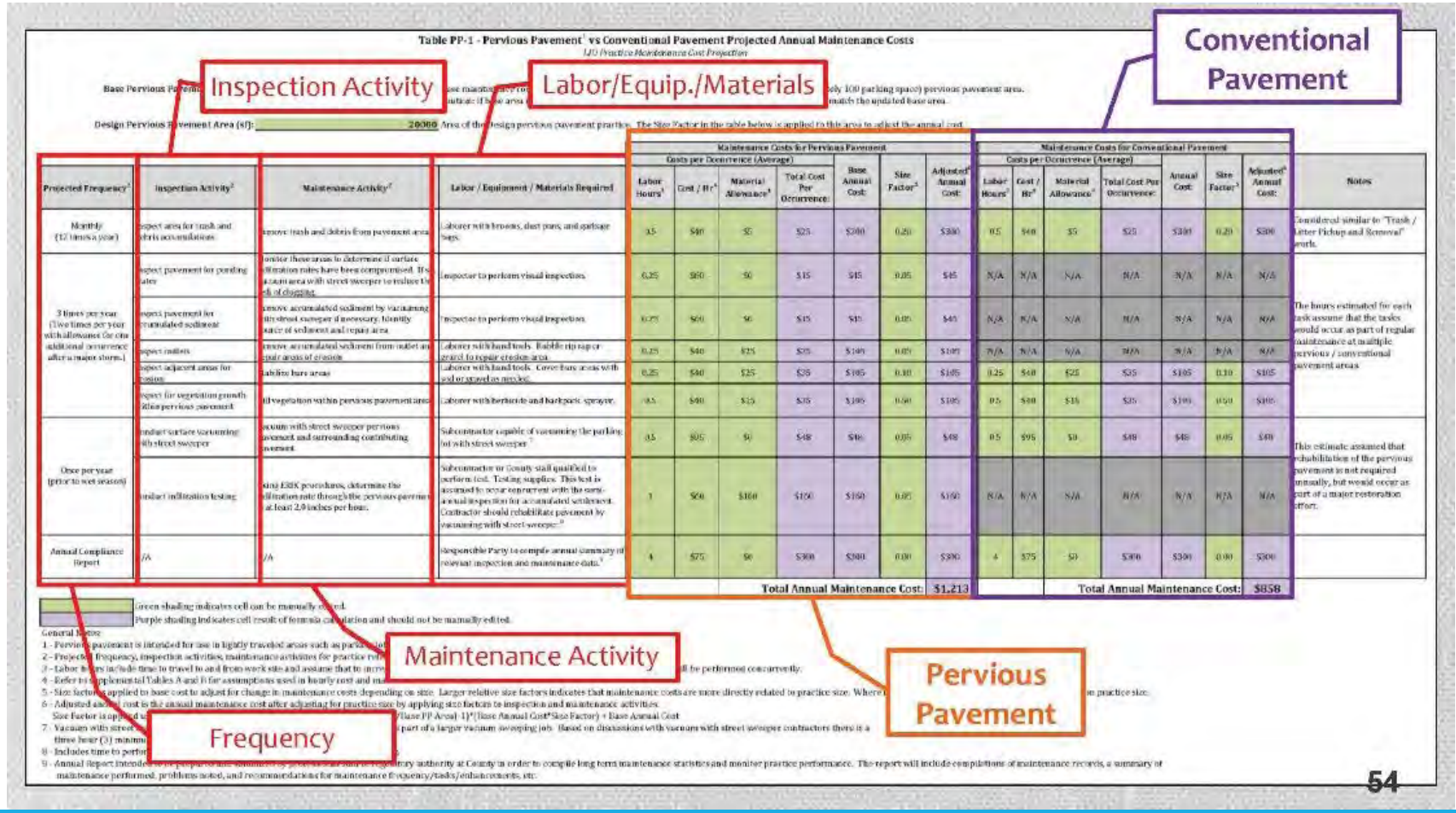


Table PP-1 - Pervious Pavement[1] vs Conventional Pavement Projected Annual Maintenance Costs

LID Practice Maintenance Cost Projection

Base Pervious Pavement Area (sf): 20000 Area of the design pervious pavement practice. The Size Factor in the table below is applied to this area to adjust the annual cost.

				Maintenance Costs for Pervious Pavement							Maintenance Costs for Conventional Pavement							
				Costs per Occurrence (Average)							Costs per Occurrence (Average)							
Projected Frequency[3]	Inspection Activity[2]	Maintenance Activity[2]	Labor / Equipment / Materials Required	Labor Hours[4]	Cost / Hr[4]	Material Allowance[5]	Total Cost Per Occurrence:	Base Annual Cost:	Size Factor[6]	Adjusted[6] Annual Cost:	Labor Hours[4]	Cost / Hr[4]	Material Allowance[5]	Total Cost Per Occurrence:	Annual Cost:	Size Factor[6]	Adjusted[6] Annual Cost:	Notes
Monthly (12 times a year)	Inspect area for trash and debris accumulations	Remove trash and debris from pavement area	Laborer with brooms, dust pans, and garbage bags.	3.5	$40	$5	$25	$300	0.20	$300	0.5	$40	$5	$25	$300	0.20	$300	Considered similar to "Trash / Litter Pickup and Removal" work.
3 times per year (Two times per year with allowance for one additional occurrence after a major storm.)	Inspect pavement for ponding water	Monitor these areas to determine if surface infiltration rates have been compromised. If so, vacuum area with street sweeper to reduce likelihood of clogging	Inspector to perform visual inspection.	0.25	$60	$0	$15	$45	0.05	$45	N/A	N/A	N/A	N/A	N/A	N/A	N/A	The hours estimated for each task assume that the tasks would occur as part of regular maintenance at multiple pervious / conventional pavement areas.
	Inspect pavement for accumulated sediment	Remove accumulated sediment by vacuuming with street sweeper if necessary. Identify source of sediment and repair area	Inspector to perform visual inspection.	0.25	$60	$0	$15	$45	0.05	$45	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
	Inspect outlets	Remove accumulated sediment from outlet and repair areas of erosion	Laborer with hand tools. Rubble rip rap or gravel to repair erosion area.	0.25	$40	$25	$35	$140	0.05	$105	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
	Inspect adjacent areas for erosion	Stabilize bare areas	Laborer with hand tools. Cover bare areas with sod or gravel as needed.	0.25	$40	$25	$35	$105	0.10	$105	0.25	$40	$25	$35	$105	0.10	$105	
	Inspect for vegetation growth within pervious pavement	Kill vegetation within pervious pavement area	Laborer with herbicide and backpack sprayer.	0.5	$40	$15	$35	$105	0.50	$105	0.5	$40	$15	$35	$105	0.50	$105	
Once per year (prior to wet season)	Conduct surface vacuuming with street sweeper	Vacuum with street sweeper pervious pavement and surrounding contributing pavement	Subcontractor capable of vacuuming the parking lot with street sweeper.[7]	0.5	$95	$0	$48	$48	0.05	$48	0.5	$95	$0	$48	$48	0.05	$48	This estimate assumed that rehabilitation of the pervious pavement is not required annually, but would occur as part of a major restoration effort.
	Conduct infiltration testing	Using ASTM procedures, determine the infiltration rate through the pervious pavement. If less than at least 2.0 inches per hour,	Subcontractor or County staff qualified to perform test. Testing supplies. This test is assumed to occur concurrent with the semi-annual inspection for accumulated sediment. Contractor should rehabilitate pavement by vacuuming with street sweeper.[8]	1	$60	$100	$160	$160	0.05	$160	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
Annual Compliance Report	N/A	N/A	Responsible Party to compile annual summary of all inspection and maintenance data.[9]	4	$75	$0	$300	$300	0.00	$300	4	$75	$0	$300	$300	0.00	$300	
						Total Annual Maintenance Cost:		$1,213					Total Annual Maintenance Cost:		$858			

Green shading indicates cell can be manually edited.

Purple shading indicates cell result of formula calculation and should not be manually edited.

General Notes:

1 - Pervious pavement is intended for use in lightly traveled areas such as parking lots.

2 - Projected frequency, inspection activities, maintenance activities for practice ref... all be performed concurrently.

3 - Labor hours include time to travel to and from work site and assume that to incr...

4 - Refer to Supplemental Tables A and B for assumptions used in hourly cost and ma...

5 - Size factor is applied to base cost to adjust for change in maintenance costs depending on size. Larger relative size factors indicates that maintenance costs are more directly related to practice size. Where i... to practice size.

6 - Adjusted annual cost is the annual maintenance cost after adjusting for practice size by applying size factors to inspection and maintenance activities.
Size Factor is applied s... /(Base PP Area)-1)*(Base Annual Cost*Size Factor) + Base Annual Cost

7 - Vacuum with street ... part of a larger vacuum sweeping job. Based on discussions with vacuum with street sweeper contractors there is a three hour (3) minimu...

8 - Includes time to perfor...

9 - Annual Report intended ... regulatory authority at County in order to compile long term maintenance statistics and monitor practice performance. The report will include compilations of maintenance records, a summary of maintenance performed, problems noted, and recommendations for maintenance frequency/tasks/enhancements, etc.

Low Impact Development (LID)
Example 10-Year Maintenance Cost Projection

Table PP-2 - Pervious Pavement Projected 10-Year Maintenance Costs*

LID Practice Maintenance Cost Projection

Orange County, Florida

Inflation Rate: 3% *User input inflation rate. The base rate of inflation is 3%.*

Maintenance Activity	Year										Totals
	1	2	3	4	5	6	7	8	9	10	
Monthly Trash and Debris Removal	$300	$309	$318	$328	$338	$348	$358	$369	$380	$391	$3,439
Triannual Minor Inspection, Cleaning, and Restoration	$405	$417	$430	$443	$456	$470	$484	$498	$513	$528	$4,643
Annual Inspection and Maintenance	$208	$214	$220	$227	$234	$241	$248	$255	$263	$271	$2,379
Annual Compliance Report	$300	$309	$318	$328	$338	$348	$358	$369	$380	$391	$3,439
									Total 10 Year Maintenance Cost:		**$13,900**

Green shading indicates cell can be manually edited.

Purple shading indicates cell result of formula calculation and should not be manually edited.

Notes:

*Costs are projected to the specific year from 2013 (year 1) dollars using a base inflation rate of 3%.

**Refer to Table PP-1 for annual maintenance cost assumptions.

Low Impact Development (LID)
Traditional vs. LID Maintenance Cost Comparison (Preliminary)

Maintenance Scenario	Design Practice Size	Estimated Annual Maintenance (2013 Dollars)	Estimated 10-Year Maintenance (3% inflation)
Pervious Pavement	36792 sf	$1,333	$15,278
Bioretention	73846 sf	$11,367	$130,311
Rain Garden	26498 sf	$5,877	$67,377
Planter Box	2448 sf	$1,804	$20,684
Tree Box Filter	10 boxes	$1,586	$18,722
Curb Cuts / Inverted Medians	N/A	N/A	N/A
Stormwater Harvesting (w/ Cisterns)	134528 gal	$9,120	$104,548
Dry Retention Pond	92522 sf	$11,303	$133,462
	Totals:	**$42,390**	**$490,382**

Maintenance Scenario	Design Practice Size	Estimated Annual Maintenance (2013 Dollars)	Estimated 10-Year Maintenance (3% inflation)
Dry Retention Pond	132,675 sf	$15,880	$187,512
Landscaped Area	30,546 sf	$5,889	$69,542
Swale	73,843 sf	$8,779	$103,663
Wet Detention Pond	63,319 sf	$4,451	$49,095
	Totals:	**$34,999**	**$409,812**

The Good…

Highlands Avenue Parking Lot-Pervious Pavement
City of Melbourne, FL

The Good…

EAST SIDE PUMPING STATION GREEN ROOF – WASHINGTON, DC

George Hawkins, CEO and General Manager of DC Water has been pushing for green infrastructure since he took the job more than 5 years ago, but concedes that the predicted impact of green infrastructure will only be accurate over the long term if it is **properly maintained which could be tricky**. Because these projects are small and spread across the city, maintenance can be difficult to deliver or verify. "Bioswales can fill up with silt and muck, and if you don't dig them out, it blocks infiltration of water."

- WaterWorld Magazine- August 2015

The Bad…

Sunset Lane Drainage Improvements – Hillsborough County, FL

APWA Project of the Year 2014!

The Bad…

Sunset Lane Drainage Improvements – Tampa, FL
(August 2015 photo)

The Ugly…

Pervious Pavement
Gulf Boulevard (SR 699)
from Park Boulevard to
Whitehurst Avenue
Town of Indian Shores, FL

The Ugly…

Pervious Pavement
Gulf Boulevard (SR 699) from Park Boulevard to Whitehurst Avenue
Town of Indian Shores, FL

Photo A – Area #1

STATE ROAD NO. 699 (GULF BLVD.)
CITY OF INDIAN SHORES FLOODING ASSESSMENT

Lessons Learned

1. • Consider Maintenance in BMP Selection
2. • Use Treatment Train
3. • Keep It Simple

Sources

Brett Cunningham – SESWA Webinar, May 2012

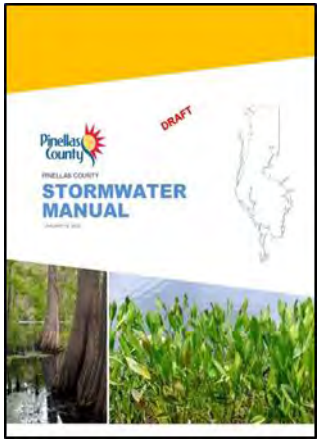
Draft Pinellas County Stormwater Manual
http://www.pinellascounty.org/build/green-resources.htm

Sarasota County LID Manual
https://www.scgov.net/WaterServices/Pages/LowimpactDevelopment.aspx

UCF Stormwater Academy
http://stormwater.ucf.edu/

UCF Operation, Maintenance & Management of Stormwater Management Manual
http://stormwater.ucf.edu/wp-content/uploads/2014/09/stormwaterOMM.pdf

United States Environmental Protection Agency
http://water.epa.gov/polwaste/green/



Green on the Horizon – Challenges of Integrating LID into New Development
Janna Souvorova, PH.D., AICP – Orange County Planning Division and
Mark W. Ellard, PE, CFM, D.WRE – Geosyntec Consultants, Inc.


Q&A
questions & answers