8. MANAGEMENT MEASURES

This section outlines needed implementation practices and management measures for Pepperell Watershed, a schedule for implementation of the recommended management measures, an estimate of the associated costs, and potential sources of funding for program implementation.

URBAN NONPOINT SOURCE MANAGEMENT MEASURES – LOW IMPACT DEVELOPMENT AND GREEN INFRASTRUCTURE

As landscapes become more urbanized, there is a corresponding increase in the amount of impervious surfaces that limit the ability of stormwater to infiltrate into the ground. Low impact development minimizes runoff and employs natural processes such as infiltration, evapotranspiration (evaporation and transpiration from plants), and storage of stormwater at multiple fine scale locations to be as near to the source of stormwater as possible. Successful implementation of LID recreates a more natural hydrologic cycle in a developed watershed.

The City of Opelika has expressed interest in addressing non-point source pollution issues through the integration of green infrastructure measures. The following are just a few examples of Low Impact Development and Green Infrastructure practices that could be implemented in the future.

BIORETENTION CELLS (BRC)

Construction Costs: Med/High
Maintenance: Med/High

Figure 71. Bioretention Cell.

Bioretention cells (BRCs) remove pollutants in stormwater runoff through adsorption, filtration, sedimentation, volatilization, ion exchange, and biological decomposition. A BRC is a depression in the landscape that captures and stores runoff for a short time, while providing habitat for native vegetation that is both flood and drought tolerant. BRCs are stormwater control measures (SCMs) that are similar to the homeowner practice, rain gardens, with the exception that BRCs have an underlying specialized soil media and are designed to meet a desired stormwater quantity treatment storage volume. Bioretention works well in dense, urban developments because of the flexibility of its space constraints. Bioretention has demonstrated the following pollutant load reductions in previous scientific research.

Table 14: Bioretention Load Reduction Estimates from Scientific Literature.

Volume	TSS	TP	TN	Cu	Pb	Zn	Oil & Grease	Bacteria	Study
-	97%	35-65%	33-66%	36-93%	24-99%	31-99%	99%	70%	MD Envir. Service 2007
96.5%	60%[1]	31%[1,2]	32%[1]	54%[1]	31%[1]	77%[1]	-	69%(FC)[1] 71%(EC)[1]	Hunt et al. 2008
-	-	-	40%	99%	81%	98%	-	-	Hunt et al. 2006
-	-	58-63%	47-88%	-	-	-	-	-	Passeport et al. 2009
40%	-	35-50%	70-80%	-	-	-	-	97%*	Smith & Hunt
51%	-	16%	43%	-	-	-	-	-	Sharkey 2006
48%	-	-39%	38%	-	-	-	-	-	
-	-	65-87%	49%	43-97%	70-95%	64-95%	-	-	Davis et al. 1997 ; EPA NPDES 2005
-	29%	-11%	44%	68%	-	23%	-	-	N.P.R.D. 2007**
-	75%	50%	50%	75-80%	75-80%	75-80%	-	-	StormWater BMP FHWA; Prince George's County 1993
-	80%	65-87%	49%	-	-	-	-	-	USEPA 2004

*Values based on only 6 collected samples, not a statistically significant finding

**Reductions based on an average of multiple studies

[1]Concentration Reductions (mg/L – TSS, TN, TP) (µg/L – Cu, Pb, Zn) (CFU/100mL – FC) (MPN/100mL – EC)

[2]Negative value represents an increase in pollutant concentration

Potential Projects:

- **Working with local developers** to replace detention ponds with bioretention.
- **Identify areas of need and opportunity** through modeling or by working with the community.

Constructed Stormwater Wetland (CSW)

Construction Costs: Med

Maintenance: Med

Figure 72: Constructed stormwater wetland.

CSWs are areas designed to treat stormwater and function similarly to natural wetlands. These systems use complex biological, chemical, and physical processes to cycle nutrients, and breakdown other pollutants for treatment of stormwater runoff.

Table 15: Wet Ponds Load Reduction Estimates from Scientific Literature.

TSS	TN	TP	Metals	Bacteria	Source	
67%	31%	48%	24.73%	65%	Schueler 1997	EPA BMP Menu
76%	31%	54%	-	68%	N.P.R.D. 2007**	
68%	55%	32%	36-65%	-	USEPA 2004	

**Reductions based on an average of multiple studies

PERMEABLE PAVERS

Construction Costs: High
Maintenance: Med

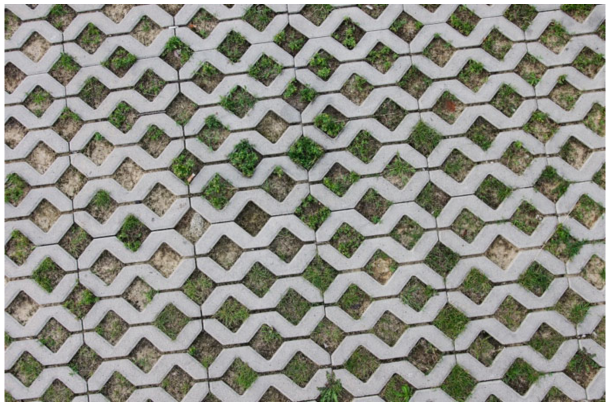

Figure 73: Permeable Concrete Pavers. Source: Adobe Stock Images.

Permeable pavers are a pervious surface used in place of traditional concrete or asphalt to infiltrate stormwater. Permeable pavement refers to any pavement that is designed to temporarily store stormwater in a gravel base layer. Permeable pavement provides a volume reduction of stormwater runoff through temporary storage. It can be used to reduce peak flows and promote stormwater infiltration in urbanizing watersheds. The application of permeable pavement reduces impervious surface area runoff, which has been linked to streambank erosion, flooding, nonpoint source pollution, and other water quality impairments.

Table 16: Porous Pavement Load Reduction Estimates from Scientific Literature.

Volume	TSS	TP	TN	Metals	Bacteria	Source	Source
-	82-95%	60-71%	80-85%	33-99%	-	MWCOG 1983 Hogland et al. 1987 Young et al. 1996	StormWater BMPs FHWA
-	82-95%	65%	80-85%	98-99%	-	USEPA 2004	
31-100%*	-	-	-	-	-	Smith et al. 2006	
66%**	-	-	-	-	-		
75%**	-	-	-	-	-		
81%**	-	-	-	-	-		
53%**	-	-	-	-	-		

*Represents the Range of Reduction for 4 types of Porous Pavement from 17 rainfall events

**Represents an Average Reduction for one of the 4 types of Porous Pavement Tested from 17 rainfall events

GRASSED SWALES (GS), INFILTRATION, SWALES (IS), AND WET SWALES (WS)

Construction Costs: Low

Maintenance: Low

Figure 74: Wet swale along a roadway in Auburn, AL.

A water quality swale is a shallow, open-channel stabilized with grass or other herbaceous vegetation designed to filter pollutants and convey stormwater. Swales are applicable along roadsides, in parking lots, residential subdivisions, commercial developments, and are well suited to single-family residential and campus type developments. Water quality swales are designed to meet velocity targets for the water quality design storm, may be characterized as wet or dry swales, may contain amended soils to infiltrate stormwater runoff, and are generally planted with turfgrass or other herbaceous vegetation.

Table 17: Swales Load Reduction Estimates from Scientific Literature.

TSS	**TN**	**TP**	**Cu**	**Pb**	**Zn**	**Source**	
60-85%	10-90%	15-90%	45-80%	-	68-88%	CRWA 2008	
81%	38% *	9%	51%	67%	71%	U.S. EPA Fact Sheet 1999	
--	51%, 41%	63%, 42%	70%, 49%	56%, 76%	93%, 77%	Yousef et al. 1987**	
30-90%	0-50%	20-85%	0-90%	0-90%	0-90%	City of Austin (1995); Claytor & Schueler (1996); Kahn et al. (1992); Yousef et al. (1985); Yu & Kaighn (1995); Yu et al. (1993 & 1994)	StormWater BMPs FHWA

* Value Reduction of Nitrate Only ** Observations from two sites respectively

Table 18: Infiltration Trench/Basin Load Reduction Estimates from Scientific Literature.

TSS	TN	TP	Metals	Bacteria	Sources	
50%	-	51%	52-93%	96%	Birch et al. 2005	
99%	60-70%	65-75%	95-99%	98%	Schueler, 1987	Wisconsin Manual 2000
90%	60%	60%	90%	90%	Schueler, 1992	EPA Fact Sheet
85%	-	85%	-	-	PA Stormwater Manual 2006	
75-99%	45-70%	50-75%	75-99%	75-98%	Young et al. 1996	StormWater BMPs FHWA
75%	55-60%	60-70%	85-90%	90%	USEPA 2004	

Rainwater Harvesting (Rainbarrels, Cisterns)

Construction Costs: Med

Maintenance: Med

Figure 75: Rain barrels in a residence, connected to garden.

Rainwater harvesting is the collection of rainwater for reuse, typically from a rooftop, and can be used as a form of rooftop runoff management to reduce runoff from impervious surfaces. Rooftop systems typically collect stormwater through a connection to a rain gutter system that connect to a cistern. Sometimes vegetation or planters can also be used to filter the rooftop runoff. Rainwater harvesting systems may be above or below ground systems and can be large or small depending on the site, application, and intended use. When designed and used properly, these systems are an excellent way of saving water, energy, and money while also reducing the amount of stormwater that may otherwise enter rivers during a storm event.

Below is a sample cost estimate for a single rain barrel, minus the downspout, in a residential area for use in small-scale irrigation and gardening purposes only. The estimate assumes that the homeowner, garden group, or volunteers provide the labor, including assembly of rain barrel if necessary. The disturbed area is considered to be minimal and small enough to avoid any permits and fees. The following are average costs for a typical, newly manufactured rain barrel plus optional accessories.

ITEM	***COST***
Rain Barrel with sealed top	$120
Overflow Kit/Runoff pipe	$35
Rain Diverter	$18
Soaker Hose	$21
Linking Kit	$12
Spigot, if not supplied	$5
Additional Guttering	$5

Total Estimate: $216[21]

RAINGARDENS

Construction Costs: Low

Maintenance: Low

Figure 76: A newly planted rain garden begins to serve its function.

A rain garden is a shallow depression in a landscape that captures water and holds it for a short period of time to allow for infiltration, filtration of pollutants, habitat for native plants, and effective stormwater treatment for small-scale residential or commercial drainage areas. Rain gardens use native plants, mulch, and soil to clean up runoff. As urbanization increases and pervious surfaces decrease, rain gardens are an excellent practice to promote infiltration of up to 30% more stormwater than traditional lawns. Residential stormwater management can often help homeowners save money on lawn irrigation when lawns are converted to rain gardens. These areas are designed to capture 3 to 6" of runoff after a storm, which allows water to infiltrate and return to groundwater, rather than being discharged to a stormwater conveyance system. Funding will be sought to facilitate the installation of raingardens throughout the watershed.

Figure 77: Rain Water Garden. Source: Alabama LID Handbook

Potential Projects:

- **Installation of GI retrofits downtown** (First Avenue Construction, either with the City or with local land owners).
- **Installation of a raingarden or bioswale** at Opelika City Hall during construction for ADA compliance.
- **Installation of a raingarden** at West Forest Intermediate, Northside, or Morris Avenue Intermediate.

Curb Cuts

Construction Costs: Med
Maintenance: Low

Figure 78: Curb cuts allow water to flow into a vegetated area.

Curb cuts convey stormwater into vegetated areas such as roadside swales, parking lot islands, rain gardens, or bioretention areas. Curb cuts are an easy retrofit that can be used in residential or commercial land use areas and are effective in moving stormwater to landscaped areas. Curb cuts do not perform any pretreatment, but can minimize erosion by creating diffuse flow into other stormwater control measures (SCMs). Curb cuts can also be installed to redirect stormwater into a grassy field. While this is not directly considered a LID practice, it does reduce stormwater quantity in the receiving water body. Roadside curb cuts usually intercept perpendicular stormwater flow and in many cases multiple curb cuts are needed to adequately collect and move stormwater.

Street Planters and Curb Extensions

Figure 79: An example of a curb extension with urban trees.

Street planters are designed as part of the planting strips found in a developed or urban area. They may feature a cut in the curb to allow inflow and outflow of stormwater running along the curb. Street planters act as rain gardens where stormwater can infiltrate into the ground. Curb extensions literally extend the curb into the existing street to create more planting area and thus handle more stormwater runoff. Curb extensions also provide some protection for parked cars and can reduce the crossing distance for pedestrians.

Tree Boxes

Figure 80: Newly installed Filterra Tree Box. Source Contech Engineered Solutions.

Tree boxes are a green infrastructure stormwater control measure that are designed to collect the first flush of stormwater and treat it prior to discharge into the storm sewer system or to the subsoil. The structure is a pre-manufactured concrete box, which is installed in-ground, filled with soil media and typically planted with native, non-invasive tree or shrub. The tree box functions as a compact bioretention system, which is a green infrastructure or low impact development stormwater control best management practice (BMP). In urban or built-out areas where space is limited, tree boxes can fit within a small existing footprint and as retrofit projects.

Table 19: Filterra Tree Boxes Load Reduction Estimates from Scientific Literature.

	N	P	TSS	Petroleum Hydrocarbon s	Dissolved Zinc	Total Copper
Filterra Tree Planter	**34**	**70%**	**86%**	**87%%**	**54%**	**55%**
	NC State 2015	Herrera 2014, NC State 2015	UVA 2006, Herrera 2009, Herrera 2014, NC State 2015	Herrera 2009	Herrera 2009	UVA 2006, Herrera 2009

Structural Soil

Structural soil is used as a growing medium in tree wells and street planters as well as a base for paving materials. Structural soil not only provides load-bearing capacity, but also allows tree roots to grow without disrupting or heaving the paving material. Structural soil also increases water-holding capacity and is designed to break down pollutants in the stormwater. Structural soil may contain polymers or other materials that absorb and retain water for slow release that irrigates trees and plants during dry spells.

Disconnected Downspouts

Construction Costs: Low
Maintenance: Low

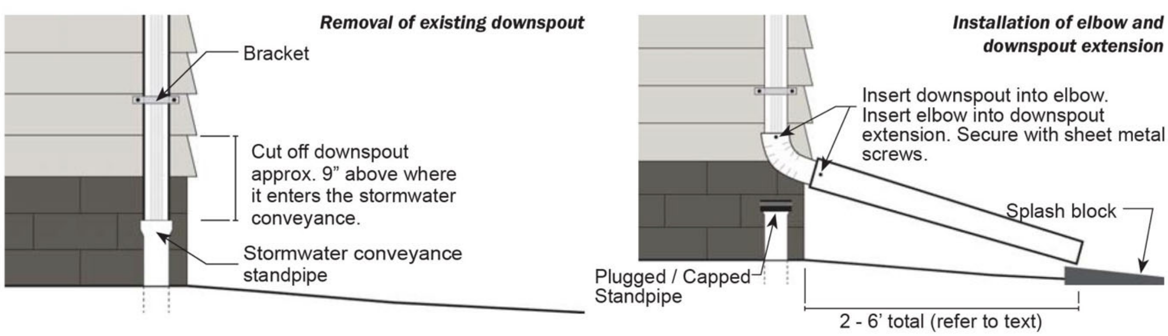

Figure 81: How to Disconnect a Downspout. Photo Source Alabama LID Handbook.

Rooftop runoff can be directed to vegetated areas through the disconnection of rooftop downspouts. By redirecting rooftop runoff, stormwater entering the stormwater conveyance network is reduced and groundwater recharge and runoff infiltration is increased. Disconnected downspouts are often used in conjunction with other stormwater infiltration practices by directing runoff to practices such as rainbarrels, rain gardens, bioretention areas, and grassed swales. In doing so, the need for curbs, gutters, and conventional collection or conveyance of stormwater can be reduced. Disconnecting downspouts can help reduce the volume of untreated stormwater directed to waterways and decrease pollution in local streams and waterways.