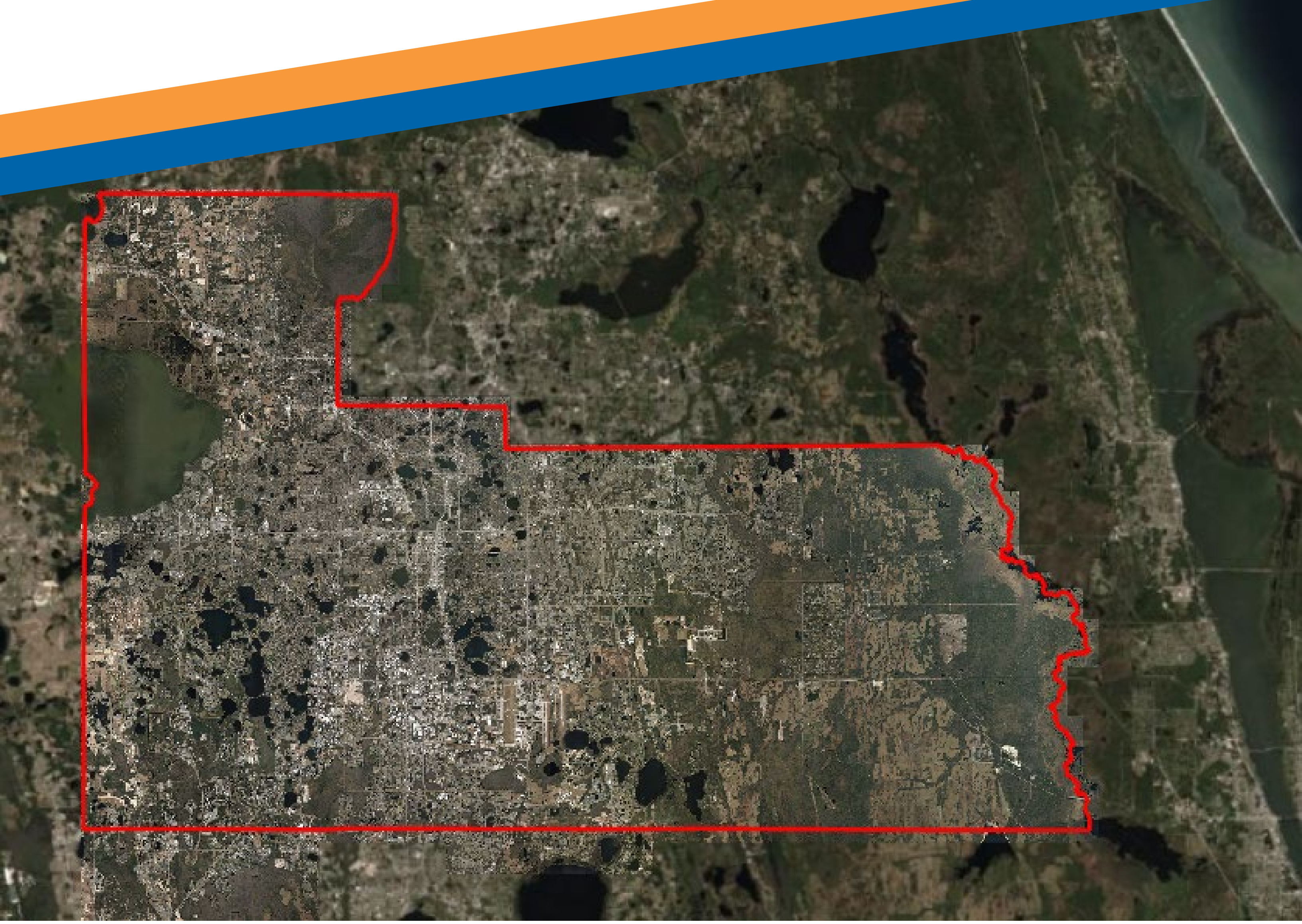
Orange County Stormwater Low Impact Development Manual

Volume 1



Submitted by:
Geosyntec Consultants, Inc.
3504 Lake Lynda Drive, Suite 155
Orlando, Florida 32817

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Geosyntec consultants

engineers | scientists | innovators

STORMWATER LOW IMPACT DEVELOPMENT MANUAL

Volume 1

Prepared for:

Orange County Planning Division
201 S. Rosalind Ave., 2nd Floor
Orlando, FL 32802

Orange County Public Works
4200 S John Young Parkway
Orlando, FL 32839

Orange County Environmental Protection Division
3165 McCrory Place, Suite 200
Orlando, FL 32803

Prepared by:

Geosyntec Consultants, Inc.
3504 Lake Lynda Drive, Suite 155
Orlando, FL 32817

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Orange County

Jennifer Cummings (Project Manager) – Public Works Department

Julie Bortles (Environmental Programs Administrator) – Environmental Protection Division

Roberto Ng (Senior Engineer) – Public Works Department

Olan Hill (Assistant Manager) – Planning Division

Jennifer Thomson (NPDES Program Supervisor)

Geosyntec Team

Mark Ellard (Senior Principal)

Mike Hardin (Principal Engineer)

Jovana Radovanovic (Staff Scientist)

Cathy Foerster (Senior Professional)

Eric Davis (Senior CADD/Drafting Tech)

Kenneth Hamilton (Senior Staff Professional)

Ruth Hamberg (Landscape Architect) – Alliance Design & Construction, Inc.

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ACRONYMS AND ABBREVIATIONS

BAM	Biosorption Activated Media
BMAP	Basin Management Action Plan
BMP	Best Management Practice
CEC	Cation Exchange Capacity
DCIA	Directly Connected Impervious Area
DEM	Digital Elevation Model
EMC	Event Mean Concentration
EPA	Environmental Protection Agency
ERP	Environmental Resource Permit
FAC	Florida Administrative Code
FDEP	Florida Department of Environmental Protection
GSI	Green Stormwater Infrastructure
H&H	Hydrologic and Hydraulic Modeling
ICPR4	Interconnected Channel and Pond Routing Model
LID	Low Impact Development
MS4	Municipal Separate Storm Sewer System
N_2	Nitrogen Gas
NH_3	Ammonia
NO_2	Nitrite
NO_3	Nitrate
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NWL	Normal Water Level
OFS	Outstanding Florida Springs
OFW	Outstanding Florida Waters
PFA	Primary Focus Area
RAP	Reasonable Assurance Plan
SFWMD	South Florida Water Management District
SJRWMD	St. Johns River Water Management District
SWMM	Storm Water Management Model
SWMP	Stormwater Management Program

Tc	Time of Concentration
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TP	Total Phosphorus
UF/IFAS	University of Florida/Institute of Food and Agricultural Sciences
VBS	Vegetated Buffer Strips
WERF	Water Environment Research Foundation
WMD	Water Management District

1 BACKGROUND AND MANUAL ORGANIZATION

The Orange County Stormwater Low Impact Development Manual consists of two volumes. This volume, Volume 1, introduces low impact development (LID), discusses county characteristics, assesses the site and site constraints, and goes over low impact development practices that are considered applicable in Florida. Volume 2 provides more specific information for LID practices applicable to Orange County, including design details, operation and maintenance guidelines, and monitoring guidance.

This section states the purpose of the Design Manual and a breakdown of the sections and general manual organization. It also identifies the intended users for this manual and defines commonly used terms and abbreviations. Finally, a general introduction to stormwater is provided.

1.1 Purpose and Scope

Volume 1 of the Design Manual is intended to provide uniform guidance across Orange County to local jurisdictions, developers, and property owners in Orange County on the basic principles of LID; identifying the problems of urban stormwater runoff including flooding and water quality impairment; and the physical, site, cost, and operation and maintenance constraints typically seen with using LID practices when compared to conventional stormwater management techniques. It also gives an overview of current state, local, and water management district regulations that apply to Orange County, as well as recommendations for future regulations to accommodate new LID practices. The manual takes into consideration different conditions throughout the County that may affect different LID practices and goes over practices that are applicable to Orange County.

1.2 Organization and Intended Users

Volume 1 is organized into six (6) sections and is intended to be used primarily by professionals engaged in planning, designing, constructing, operating, and maintaining development and retrofit projects in Orange County. Additionally, the Florida Friendly Landscaping Plant List and References are included in **Appendix A**. The GSI Maintenance and Planting Manual can also be used as a reference for plant selection (Bean et al., 2023). **Appendix B** includes a practice selection discussion and practice selection matrix which provides a suitability ranking for each practice with respect to Orange County, as well as a summary of cost benefit associated with Total Phosphorus (TP) and the assigned ranking. Attachments that provide more specific information for LID practice applicable to Orange County can be found in Volume 2 of the Design Manual. This information includes design details, operation and maintenance guidelines, and monitoring guidance.

- **Section 1 – Background and Manual Organization** provides an overview of the purpose and scope as well as a brief introduction to stormwater. A list of commonly used terms related to LID is included for clarification and better understanding of the manual. Additionally, the organization of the manual is presented.
- **Section 2 – Low Impact Development Introduction** presents the LID concept, which includes the differences between conventional development and LID, and the goals, benefits, and challenges associated with LID.

- **Section 3 – County Characteristics** provides a description of the County to characterize different regions as it relates to the implementation of LID practices, such as topography, soils, and land use. It also discusses County regulations as well as those from the water management districts (WMDs), and the state of Florida.
- **Section 4 – Site Assessments and Constraints** provides guidance on how to assess the area of interest and looks at the applicability of LID. The section covers what is included in a physical site assessment while also looking at redevelopment potential and permitting requirements.
- **Section 5 – Florida Low Impact Development Practices and County Approved LID Practices and Technical Design Criteria** includes an introduction and guidance to each of the 19 LID practices considered applicable in Florida. It also includes a discussion on the County approved LID practices and the LID practices technical design criteria.
- **Section 6 – References** provides references used within the Manual.

1.3 Definitions

As some terms related to stormwater are used interchangeably in the industry, the following definitions are provided for clarification and better understanding of how these terms are used in this manual. A prime example of this are the terms Low Impact Development (LID), Green Stormwater Infrastructure (GSI), and Best Management Practices (BMP). For the purposed of this manual, LID and GSI are assumed to be a type of BMP. See below for definitions of terms used in this manual.

- **Average Annual Runoff Coefficient**: The average ratio of runoff depth to precipitation depth over an extended period of time, usually 15 years or greater, normalized by the total numbers of years to obtain an average annual value.
- **Bacteria**: Historically, regulations based on bacteria focused primarily on fecal coliforms. In 2016, FDEP, and thus Orange County and this Manual, switched to *E. coli* for freshwater systems.
- **Basin Management Action Plan (BMAP)**: A BMAP is a framework for water quality restoration that contains local and state commitments to reduce pollution loading through current and future projects and strategies. The pollutant reduction goals are ones previously established by a total maximum daily load (TMDL).
- **Best Management Practice (BMP)**: For the purposes of this manual, a BMP is any structural or non-structural practice that results in the capture, treatment, and/or attenuation of stormwater runoff. This includes practices that leverage retention, detention, and infiltration processes for flood reduction, as well as various physical, biological, and chemical processes for water quality improvement.
- **Biosorption Activated Media (BAM)**: A class of filter media that promotes biofilm growth and leverages biological, chemical, and physical processes to remove nitrogen and phosphorus species. The media can range from coarse material, intended for higher flow

capacity, or finer material, intended for slower flow applications, such as for use in the bottom of a retention BMP.

- **Curve Number (CN)**: CN is the hydrologic factor which is used to reflect the runoff potential of a particular land use and soil type. Values for CN range from 30-100, with low values reflecting a low runoff potential and higher values reflecting a high runoff potential.
- **Directly Connected Impervious Area (DCIA)**: DCIA is the impervious area that is directly connected to a drainage feature, i.e., if runoff from the area flows directly into the drainage conveyance system, such as a gutter or storm sewer, and does not drain to a pervious area (Harper and Baker, 2007). Runoff from impervious area must run over a minimum of 20 ft of pervious area to be considered disconnected.
- **Drainage Area**: An area where runoff from precipitation drains to a common point, i.e., creeks, streams, rivers, lakes, and reservoirs. The perimeter of a drainage area can be identified using topographic and drainage infrastructure maps to determine the boundary between where runoff would and would not flow to the collection point or drainage area outlet.
- **Gray Infrastructure**: Refers to engineered infrastructure for water resources, typically consisting of concrete and metal components. Examples include treatment plants, pipes, and reservoirs. In gray infrastructure, runoff is directed away from certain locations and towards others.
- **Green-Ampt Method**: The Green-Ampt method is a rainfall excess estimation method that leverages the physical characteristics of soils to determine the fraction of rainfall that infiltrates into the ground, is stored in the soils, and becomes stormwater runoff. This rainfall excess estimation method can be used for either discrete design storm modeling or continuous simulation modeling but is generally needed for a continuous simulation as opposed to other methods as it allows for the long-term tracking of soil water storage availability.
- **Green Stormwater Infrastructure (GSI)**: GSI consists of structural practices that incorporate the principals of LID to trap and treat stormwater near its source, minimizing the quantity, and improving the quality of stormwater discharging to gray stormwater infrastructure and downstream water resources. GSI can be used in place of, or in conjunction with, traditional gray infrastructure.
- **Horizon West Town Center**: Located in the southwest portion of Orange County, Horizon West Town Center is comprised of more than 23,000 acres encompassing five Villages and a 3,500 acre Town Center. The area was identified as an opportunity to evaluate the use of LID practices in an urban environment where the benefits and costs of the more sustainable water resource management systems can be measured and quantified.
- **Infrequent Maintenance**: Refers to maintenance that occurs a few times during the life of the practice, such as repairs or replacements.

- **Interconnected Channel and Pond Routing (ICPR)**: ICPR is a hydrologic and hydraulic modeling tool with a focus on interconnected and interdependent pond systems. The author of this modeling tool is Streamline Technologies and it is proprietary.
- **Karst**: Karst describes areas underlain by carbonate rocks, primarily limestone and dolomite. Karst formation involves the chemical weathering and erosion of carbonate rocks and is characterized by sinkholes and caves.
- **Low Impact Development (LID)**: LID is an approach to land development (or re-development) that works with nature to manage stormwater as close to its source as possible. LID employs principles such as preserving and recreating natural landscape features, minimizing effective imperviousness to create functional and appealing site drainage that treat stormwater as a resource rather than a waste product.
- **New Development**: Construction on sites that were previously greenfield areas; no previous construction or development were present.
- **Non-Directly Connected Impervious Area (Non-DCIA)**: Non-DCIA includes impervious areas which are not considered to be directly connected to drainage infrastructure. This is defined as having a flow distance of at least 20 feet of pervious area that runoff would have to flow over prior to discharge into a drainage conveyance. Runoff generated from these areas can infiltrate into the soil depending on soil types and land cover characteristics reducing the runoff volume from these areas compared to impervious areas directly connected.
- **Non-Directly Connected Impervious Area Curve Number (Non-DCIA CN)**: The non-DCIA CN includes pervious and impervious areas that are not directly connected to a drainage conveyance. It is calculated by using the open space reference in the TR-55 document for pervious areas and using 98 for non-DCIA impervious areas. Then, the area-weighted average is calculated. A common mistake that occurs when calculating the non-DCIA CN is double counting the impervious areas, which occurs when using one of the TR-55 reference land use values, other than open space, for the non-DCIA CN as this value includes the DCIA.
- **Outstanding Florida Springs (OFS)**: Section 373.802(4), Florida Statutes (F.S.), defines “Outstanding Florida Springs” or “OFS” to include all historic first magnitude springs, as determined by the department using the most recent Florida Geological Survey springs bulletin, and the following additional six springs: DeLeon, Peacock, Poe, Rock, Wekiva, and Gemini. OFS do not include submarine springs or river rises. There are 30 OFS consisting of 24 historic first magnitude springs and the 6 named additional springs.
- **Outstanding Florida Waters (OFW)**: An OFW is a waterbody deemed worthy of special protection because of its natural attributes (e.g., excellent water quality or exceptional ecological, social, educational, or recreational value). Waters are designated OFW to prevent the lowering of existing water quality due to permitted activities and to preserve the exceptional ecological and recreational significance of the waterbody. It is worth noting that these have additional regulatory requirements.

- **Peaking Factors**: Peaking factor is the ratio of the maximum flow to the average daily flow of a system (Zhang et al., 2012). Peaking factors are a hydrologic and hydraulic (H&H) modeling parameter.
- **Pre-developed Land**: The land use condition currently existing prior to any new improvements. This can include an undeveloped condition or an improved condition such as pasture or a previously constructed building or other improvement.
- **Redevelopment**: Construction on sites having existing commercial, industrial, institutional, or residential land uses, excluding silviculture or agriculture, where all or part of the existing impervious surface will be replaced with the same or lesser intense land use as part of the proposed activity and has not been previously permitted under Part IV of Chapter 373 F.S.
- **Regular Maintenance**: Refers to annual/semi-annual/monthly practice upkeep, such as mowing, debris removal, pruning, and weeding.
- **Runoff Coefficient (C)**: The runoff coefficient represents the ratio of runoff depth to the precipitation depth. This value can be calculated on either an event basis or for an annual period.
- **Seasonal High Groundwater Table (SHGWT)**: The SHGWT represents the average high elevation of the groundwater table during the wet season. SHGWT determination should be in line with the State requirements, which states that "estimates are completed using generally accepted engineering and scientific principles which reflect drainage practices, average wet seasonal water table elevation, antecedent moisture, and any underlying soil characteristics that would limit or prevent percolation of stormwater through the entire soil column." For determining seasonal highs in wetlands and surface waters: A qualified scientist shall determine the seasonal high in wetlands and surface waters by utilizing the States requirements. The average surveyed wetland contour line may be used in lieu of the seasonal high for the purposes of setting a tailwater condition for modeling.
- **Soil Survey Geographic Database (SSURGO)**: A database that contains information about soil as collected by the National Cooperative Soil Survey over the course of a century. The information was gathered by walking over the land and observing the soil. Many soil samples were analyzed in laboratories. The SSURGO database reports physical and chemical properties of soils that are necessary for some modeling approaches, such as the Green-Ampt method of runoff estimation. It is worth noting that mapped soils may not reflect actual conditions, particularly in urban and peri-urban areas. Any soils properties used in engineering design should always be confirmed on-site by a licensed geotechnical professional engineer.
- **Special Basins**: Basins that are draining to an OFW, OFS, or other waterbodies that warrant extra levels of treatment. This is done to protect against degradation of already impaired waterbodies or protect healthy/pristine waterbodies from degradation.
- **Storm Water Management Model (SWMM)**: SWMM is an H&H modeling tool used for planning, analysis, and design related to stormwater runoff, combined and sanitary

sewers, and other drainage systems. The author of this modeling tool is the EPA and it is non-proprietary.

- **Stormwater Runoff**: Stormwater runoff is the fraction of rainfall that does not evaporate, get absorbed by vegetation, and/or infiltrates into the ground. Stormwater runoff picks up pollutants such as nutrients, trash, and sediments, as it flows over land surfaces.
- **Time of Concentration (Tc)**: Tc refers to the amount of time it takes for a single drop of water to travel from the hydraulically most distant point in a drainage area to the outlet.
- **Total Maximum Daily Load (TMDL)**: A TMDL is the calculation of the maximum amount of a pollutant allowed to enter a waterbody so that the waterbody will meet and continue to meet water quality standards for a given pollutant. A TMDL determines a pollutant reduction target and allocates load reductions necessary to the source(s) of the pollutant of concern. BMAPs are the plans for implementing TMDLs.
- **Total Nitrogen (TN)**: TN is made up of ammonium (NH_4), nitrite (NO_2), nitrate (NO_3), and particulate and dissolved organic forms of nitrogen. NH_4, NO_2, and NO_3 are dissolved forms of nitrogen. In this manual, nitrogen will be referred to as TN, unless nitrogen species are stated explicitly.
- **Total Phosphorus (TP)**: TP is made up of particulate phosphorus and dissolved phosphorus. In this manual, phosphorus will be referred to TP, unless phosphorus species are stated explicitly.
- **Total Suspended Solids (TSS)**: TSS is a measure of the small particles of solid pollutants in waterbodies. Solids may originate from many sources, including erosion from pervious surfaces, dust, litter, and other particles deposited on impervious surfaces from human activities or the atmosphere (EPA, 1999).
- **Undeveloped Land**: As referred to in this manual, this refers to the natural state of a piece of land prior to human modification. This is to include physical properties such as soils, topography, vegetative communities, and animal communities and chemical properties such as EMCs.

1.4 Stormwater Introduction

This section covers changes made to hydrology by urban development. It also covers common pollutants found in urban stormwater and typical pollutant removal processes. Lastly, this section discusses the goals of stormwater management in the context of this manual.

1.4.1 Stormwater Characteristics from Urban Development

Urban development results in many changes to a site that can impact stormwater runoff quality and quantity. Some examples of site changes are increased soil compaction, increased impervious area, stormwater runoff, and water quality degradation. Some pollutants commonly found in stormwater runoff may include sediments, nutrients, and heavy metals (Orange County, 2014). These pollutants can be removed by physical, chemical, and biological processes. LID practices typically employ these processes for the removal of pollutants associated with stormwater runoff.

1.4.1.1 Changes to Urban Hydrology

The effects of urban development on a watershed are far reaching. They typically include physical changes as well as secondary effects, including chemical changes. Altered topography due to grading, altered hydrologic flow patterns, altered and compacted soils due to vehicle traffic and excavations, and paving/addition of impervious surfaces are examples of physical changes. These changes often lead to increased stormwater runoff due to the reductions in infiltration rate or natural soil water holding capacity as well as the increased impervious surfaces. Development fundamentally changes the way stormwater moves through a watershed by efficiently conveying water to downstream waterbodies via directly connected impervious surfaces and stormwater drainage infrastructure, which historically has been designed to quickly move water downstream. This increases the rate and total volume of stormwater that is discharged into receiving waterbodies instead of infiltrating to the soil and thus recharging the groundwater. The combination of these impacts can lead to an increase in the magnitude and frequency of flooding.

Chemical changes to stormwater can occur due to increased flow lengths and velocities associated with urban development which can increase erosion and pick up pollutants that have accumulated on impervious surfaces. This combined with the potential pollutants associated with anthropogenic activities such as application of chemicals within the watershed (e.g., fertilizers, herbicides, and/or pesticides), wear and tear of mechanical equipment (e.g., heavy metals and oils), wastewater treatment infrastructure (e.g., leaky infrastructure, failing septic systems) and industrial activities (e.g., manufacturing facilities stormwater discharges), can increase some pollutants and the introduction of other pollutants to downstream waterbodies. Additionally, the efficient drainage and reduced infiltration can result in changes to downstream systems, such as streams or wetlands, which may suffer from decreased natural flows. This all can increase nutrient and other pollutant discharges in habitats compared to the undeveloped conditions. This can result in poor downstream water conditions, for example, increased turbidity decreases the amount of light entering the waterbody, which has impacts on dissolved oxygen levels and growth of organisms and vegetation. Additionally, the introduction of nutrients from stormwater may disrupt the naturally occurring nutrient cycles and may lead to events like algal blooms and eutrophication.

1.4.1.2 Typical Stormwater Pollutants and Associated Removal Processes

Understanding what pollutants are commonly found in stormwater makes it easier to determine how the pollutant was introduced, how it can be removed, and what LID practice can provide that removal. As stated previously, the most common pollutants found in stormwater are sediments, nutrients (nitrogen and phosphorus), heavy metals (zinc, nickel, lead, chromium, cadmium, and copper), pathogenic bacteria, pesticides, and organic pollutants (gasoline and oils) (Alachua County, 2018). For the purposes of this manual, only sediments, nutrients, and pathogenic bacteria are discussed further. This is because state water quality regulations are based on these pollutants.

Regulations are based on maintaining the beneficial use of water resources, and hyper-eutrophic conditions are not meeting their beneficial use. Background levels of algae and nutrients occur naturally, but over-nutrifying water shifts the nutrient cycle out of balance. Hyper-eutrophic conditions are a result of excess nutrient pollution and typically exhibit a strong algal response in the waterbody. When algal blooms occur, they can impact the clarity of the water and decrease light penetration, resulting in a die-off of beneficial vegetation. Additionally, when the algae die, decomposing bacteria can deplete oxygen levels in the water, harming other aquatic life and decreasing the rate of decomposition of organic compounds.

There are many sources of nutrients. Nutrients are applied to farms, lawns, and public landscaped spaces as fertilizers which may be washed off by stormwater or enter the groundwater through leaching. Septic takes are also a potential source of nutrients, as they discharge nutrients into the groundwater which can seep into drainage infrastructure or waterbodies. Nitrogen from atmospheric deposition and vehicular exhausts is another source of nutrients which are deposited onto impervious surfaces such as parking lots, rooftops, and roads which can be washed off by stormwater. Typically, nitrogen and phosphorus, which are two macro-nutrients for plant growth, are the two primary nutrient pollutants that are regulated in Florida.

Nitrogen

Nitrogen is found naturally in the environment and exists in several forms. In stormwater, it is typically found in both inorganic and organic forms. The inorganic forms include ammonium (NH4), ammonia (NH_3), nitrite (NO_2), and nitrate (NO_3). The organic forms include particulate and dissolved organic nitrogen. The sum of these nitrogen species make up Total Nitrogen (TN).

Nitrogen moves through the watershed according to the nitrogen cycle, which dictates how nitrogen is converted to different forms. Animal waste and decaying organic material are sources of organic nitrogen which naturally occurring organisms can convert to ammonium or ammonia via a process called mineralization. Under aerobic conditions, nitrifying bacteria readily convert ammonia to nitrite, and then into nitrate via a process called nitrification. Nitrate is very soluble in water and is not removed by sedimentation or sorption mechanisms. Removal of nitrate must be done via biological processes, e.g., plant uptake, denitrification, or through anammox, which LID practices typically leverage to achieve their removals. Denitrification is a process where, under anoxic conditions, denitrifying bacteria converts nitrate to nitrogen gas, resulting in it off gassing to the atmosphere. Anammox is a process where, under anoxic conditions, anammox bacteria convert nitrite and ammonia to nitrogen gas, resulting in it off gassing to the atmosphere.

It is noted that, due to the mobility of nitrate in the water column, excess nitrates can easily enter surface waterbodies or the groundwater. Nitrates are naturally occurring, however the EPA has set a drinking water standard for drinking water which is 10 mg/L of NO_3–N (EPA, 2022a). High levels of nitrates can be found coming from sources like septic systems, wastewater discharges, and fertilizer input, so monitoring is important to protect drinking water supplies. While 10 mg/L is set as the drinking water standard, lower levels of nitrate can pose a significant risk to aquatic ecosystems. As nitrate is a bio-available form of nitrogen for plant growth, excess nitrogen can result in the excess growth of algae. This is especially true for springs, for example, which have very sensitive ecosystems that make them vulnerable to algal blooms due to elevated nitrate concentrations. Since Orange County has several springs, including Wekiva Springs which is designated as an Outstanding Florida Spring by FDEP, and several Outstanding Florida Waters, such as the Econlockhatchee River System, protection of groundwater must be considered in sensitive groundwater areas, such as near waterbodies and in karst geologies. More information regarding karst areas of the County is discussed in **Section 3.1**. Based on this, considerations should be made when incorporating retention practices in sensitive areas. LID practices that use

BAM media and/or vegetation as a means for nutrient removal can be effective to remove nitrates and should be considered in these sensitive areas.

Phosphorus

Phosphorus in stormwater can be either organic or inorganic forms. The most common inorganic form is soluble reactive phosphorus, also called ortho-phosphate. This is the form of phosphorus that can be readily taken up by vegetation for growth. Phosphorus is the other macro nutrient for plant growth and typically occurs in low concentrations in the natural environment, often being the growth limiting nutrient for aquatic vegetation in surface waterbodies. Based in this, relatively small increases in its concentration can result in hyper-eutrophic conditions, i.e., increased growth of algae and nuisance vegetation.

There are four primary mechanisms to remove phosphorus from stormwater (Alachua County, 2018).

- Adsorption: Adsorption is the process by which pollutants stick to the surface of particles. Phosphorus readily adsorbs to particle surfaces, especially clays, iron, and aluminum oxides. As such, phosphorus is frequently attached to the surfaces of sediments in stormwater. Based on this, filtration/adsorption is an effective means to remove both particulate bound as well as dissolved phosphorus. The particulate bound can be removed via filtration processes such as straining, impaction, and depth filtration. Dissolved phosphorus can be removed via adsorption processes. It is noted that filter media's high in clay, iron, or aluminum tend to have high adsorption capacities.

- Sedimentation: Most of the phosphate is bound to particulates and can be mechanically removed by sedimentation and infiltration. The effectiveness depends on the particle sizes and densities.

- Uptake by plants: Of the small fraction of phosphorus that is naturally soluble, most of it is bioavailable, i.e., readily taken up by plants. Additionally, some particulate-bound phosphorus can become bioavailable when broken down by bacteria. Long contact times in wet detention ponds and wetlands facilitate its removal from stormwater.

- Precipitation from solution: Precipitation is a chemical reaction between phosphorus and dissolved calcium, iron, or aluminum to form a precipitate. An example of this is by adding coagulants such as Aluminum Sulfate (Alum) which results in the formation of aluminum phosphate that precipitates out of solution.

LID practices that use soil, media, or vegetation as a means for nutrient removal can remove dissolved phosphorus. The difference in the amount removed depends on the concentration and specific removal mechanism. Often, phosphorus may become stored in sediment, which requires the dredging of sediment to completely remove it from the system. Additionally, plant uptake does remove phosphorus from the water column, but the plant must be removed before it starts to decompose and reintroduce the phosphorus back into the water. These factors need to be considered when implementing BMPs that incorporate these removal mechanisms.

1.4.2 Goals of Stormwater Management

Florida was the first state in the United States of America to adopt a rule that requires all new development to treat stormwater to a specified pollutant level (Martin and West, 2021). Prior to modern stormwater regulation, which became effective February 1982 (F.A.C. Ch. 17-25, 1982)), the primary focus of stormwater systems was preventing flooding and ensuring runoff was efficiently conveyed away from developed areas to downstream waterbodies. The F.A.C. stormwater management rule outlined in Chapter 62-40, titled "Water Resource Implementation Rule" establishes that water management districts shall achieve at least 80% reduction of the average annual load. If the stormwater system discharges to an Outstanding Florida Water, the criteria increases to 95% reduction. The goals of modern stormwater management systems are to protect property and the health of local ecosystems and surface waterbodies to maintain their beneficial uses while minimizing flooding. This is achieved through the implementation of practices to mitigate flooding and protect water quality.

Based on an extensive study performed by Harper and Baker (2007) examining the treatment efficiency of typical stormwater BMPs and comparing to the presumptive criteria, i.e., that wet detention and dry retention systems that were designed according to current standards were achieving 80% removal of TN and TP, it was determined that these practices on their own did not achieve this removal target. Based on this, implementation of a treatment train approach, where multiple treatment practices that incorporate multiple removal mechanisms are implemented in series with each other, to increase the water quality treatment achieved. Therefore, implementation of multiple strategies to meet water quality treatment objectives will be necessary in most circumstances, and it is important to consider the removal mechanisms leveraged by the practice to ensure that the practices are complementary. Stormwater LID practices can generally be placed in two categories:

a) Non-structural LID practices are often referred to as source control practices and are typically leveraged as early as the planning phase of a project. Examples include preserving open space, minimizing soil compaction and imperviousness, planning for cluster development, and the use of Florida Friendly Landscaping. Additionally, performing maintenance on existing drainage infrastructure, such as cleaning pipes and stormwater ponds of deposited sediments and street sweeping are other examples of nonstructural LID practices. It is noted that nonstructural practices are not the focus of this LID manual.

b) Structural LID practices, which this manual is primarily focused on, are physical structures used to mitigate the changes in stormwater caused by urban development. Structural BMPs can further be organized in retention, detention, and filtration based on their primary treatment mechanism, and GSI falls under this category.

The information presented in this LID manual provides a County specific resource to address stormwater pollution. The practices listed and discussed were selected based on their relevance to conditions within the County.

2 LOW IMPACT DEVELOPMENT INTRODUCTION

This section introduces Low Impact Development (LID), the principles and philosophy, and the differences between conventional practices and LID practices. Additionally, this section will cover the goals, benefits, and challenges of LID, as well as go over standards supporting LID in Orange County.

2.1 Introduction

The 1972 Federal Water Pollution Control Act was the first major U.S. law addressing water pollution, and it initially focused on localized, easily identifiable sources (e.g., discharge of raw sewage or industrial waste) known as point sources of water pollution. In the Water Quality Act of 1987, Congress responded to the nonpoint source stormwater problem by requiring industrial stormwater discharges and municipal separate storm sewer systems to obtain National Pollution Discharge Elimination System (NPDES) permits. The permit exempted agricultural discharges; however, Congress created a nonpoint source pollution demonstration grant program at the U.S. Environmental Protection Agency (EPA) to expand the research and development of nonpoint controls and management practices.

The EPA has determined that pollution transported in precipitation and runoff from urban and agricultural lands (nonpoint source pollution) is the primary cause of water quality impairment in the United States (EPA, 2000). Runoff from urban environments includes roads, roofs, parking lots, and pervious areas such as lawns and fields that enter stormwater conveyance systems (i.e., storm drain inlets and piping network) or receiving waters. Land development creates an increase in impervious surfaces, which increases the number of nonpoint sources of pollution. As stormwater runs off impervious surfaces (i.e., rooftops, roads, parking lots, etc.), it:

- Causes increases in runoff volumes and flow rates.
- Increases runoff velocities.
- Transports pollutants into receiving waters.

In June of 1999 the EPA published the first LID Manual, *Low Impact Development Design Strategies: An Integrated Design Approach* (EPA 841-B-00-003) to promote this comprehensive approach to stormwater management and site development. LID practices are typically designed and constructed in conjunction with conventional stormwater management approaches. LID practices utilize distributed micro-scale practices to treat runoff through the processes of storage, infiltration (groundwater recharge), evapotranspiration, vegetative uptake, and filtration. Integration of these practices into new development begins at the site planning level by reducing impervious surfaces, integrating the proposed improvements into the site terrain, preserving and using the natural drainage systems, and planning to replicate predevelopment hydrology. This includes infiltrating and treating stormwater runoff at the source, which reduces the demand on public stormwater infrastructure. It is noted that careful planning leads to more efficient and sustainable site design.

2.2 LID Principals and Philosophy

As defined by the EPA, LID is an approach to land development that works with nature to manage stormwater as close to its source as possible. LID typically includes both non-structural and structural practices, which together work to manage water in a way that reduces the impact of developed areas and promotes the natural movement of water within an ecosystem or watershed. Non-structural practices begin at the site planning level and prevent stormwater generation or reduce pollutant loads, as opposed to structural practices which mitigate stormwater impacts. Non-structural practices should be considered and implemented where applicable prior to taking structural BMPs into consideration. Where specific water quality regulatory requirements are present, such as special basin criteria, LID can be used as an effective tool to meet those regulatory requirements. Prevention can be achieved through non-structural practices such as:

- Preserve natural drainage patterns and pre-development vegetation
  - Maintain natural buffers, natural topography, and drainage ways to slow and store water, promote infiltration, and filter pollutants.
  - Preserve site vegetation, which absorbs and reduces the amount of stormwater runoff.
  - Use native vegetation to reduce irrigation demand, as well as need for fertilizers and pesticides.
  - Minimize compaction of soils and land disturbance and retain native soils.
- Minimize impervious area
  - Reducing impervious area by eliminating curb and gutter, which allows water to flow over pervious grassy areas maximizing infiltration and decreasing driveway length or width.
  - Source control, by retaining more water on the site where it falls.
- Disconnect impervious area
  - Disconnect impervious surfaces by distributing and decentralizing practices, such as diverting downspouts to designated infiltrating areas and allowing infiltration to occur near the source.
- Integrate open space and urban development
  - Design using cluster and concentration of development.

2.2.1 Preserve Natural Drainage Patterns

Conventional land development decreases the time of concentration (Tc), which is the time it takes for a single drop of water to travel from the hydraulically most distant point in a drainage area to the outlet. Decreases in Tc are typically due to increases in connectivity of impervious surfaces, compaction of soils, and/or clearing of land, any of which transports water more quickly from one point to another. As Tc decreases, typically peak flows and runoff velocities increase, which can cause erosion and sediment transport downstream if not managed properly. Unlike conventional development, LID promotes the preservation of natural drainage patterns starting at the site planning and assessment stages of a project.

Existing natural drainage divides and depressions should be maintained and used to direct and store water on-site. By allowing water to flow over vegetated areas velocities decrease, water has the ability to infiltrate, and the water is filtered. The use of pervious flow paths instead of concrete lined conveyances reduces the costs of construction and reduces the need for land disturbance and grading. Natural flow paths may be enhanced by using a vegetated swale in place of curb and gutter systems in street right of ways, which provides storage capacity, reduces velocity, increases infiltration, and filters stormwater. This can also be done by preserving vegetated areas, for example areas with high tree density, to preserve the natural hydrologic processes that occur, such as interception, evaporation, and transpiration.

2.2.2 Minimize Impervious Area

The key element in minimizing impervious area for a development is using alternative layouts. During the site planning phase, finding ways to minimize impervious area through clustering neighborhood layouts, reducing building footprints, parking, and increasing the permeability of existing soils by amending the soils and re-vegetating bare areas, helps maintain pre-development hydrology and ecological function of the site. The largest source of impervious area in urbanized areas are the connections of roadways, sidewalks, parking lots, and driveways, which are all elements used to facilitate transportation. Additionally, new urbanism that has zero lot lines contributes to increased impervious area if not done in conjunction with preservation of open spaces and natural areas. Building with zero lot lines is done by constructing houses along the lot line and decreasing lot sizes, which leads to less pervious areas within the development and more impervious areas like driveways and roofs. Working with zoning and transportation departments to narrow and shorten road sections is an easy way to reduce imperviousness; however, it can be challenging with emergency vehicle access requirements. Therefore, measures, such as eliminating curbs and gutters and allowing water to flow into the rights-of-ways or into a roadside swale, can significantly reduce infrastructure for piping networks.

Parking is a large contributor to impervious surfaces and there are numerous strategies to reduce the amount of impervious surface without losing parking area. For residential driveways, paving strips for tires can be used instead of a full width driveway. They provide a structural surface for tires and pervious area for water to infiltrate and recharge groundwater. Other alternatives include shared driveways, limited width and/or length, and use of pervious/porous pavements. Parking lots that have much greater traffic loads than driveways are slightly more complex. Methods to minimize imperviousness include reducing the number and size of parking spaces, using structured parking decks and using pervious/porous pavements. Pervious/porous pavements can also be used just in parking areas that are designed as overflow parking and may not have the high traffic use compared to the main parking area. Using inverted landscaped parking lot islands and installing curb cuts to allow water to flow over pervious areas allows for integration of stormwater treatment practices and has the potential to reduce the amount of traditional drainage infrastructure necessary. Other LID practices which can be incorporated into parking areas include bioretention areas, tree box filters, and swales. These practices increase runoff treatment, filtration, and detention.

2.2.3 Disconnect Impervious Area

Impervious areas directly connected to the storm sewer, commonly referred to as directly connected impervious area (DCIA), which does not receive water quality treatment prior to discharging into a receiving waterbody such as a lake, pond, or bay, often transports high loads of pollutants. For example, roofs and sidewalks commonly drain onto roads, which convey stormwater through curbs and gutters and ultimately into drop inlets that connect directly to the storm sewer system. In some instances, stormwater may discharge into a stormwater pond, which does provide some level of treatment, but this is not always the case. Design requirements to meet current stormwater permitting criteria generally address this issue, however older developments may require retrofitting.

By disconnecting impervious areas and directing runoff to pervious areas, runoff discharge rates and volumes can be decreased while providing treatment and reducing the potential pollutant loads due to filtering and infiltration. On a smaller level, one of the simplest methods to disconnect impervious surfaces is to disconnect roof downspouts and redirect roof runoff to a pervious area. Additionally, downspouts can be connected to a rain barrel or cistern to be later used for landscape irrigation or other non-potable water uses. In roads or parking lots, using curb cuts or eliminating curbs altogether allows stormwater to drain to areas such as vegetated swales, rain gardens, or vegetated parking lot islands that have curb cuts. At a project-level scale during the planning phase, reducing the need for all stormwater to be conveyed away from the site can be done by introducing LID infiltration practices throughout the project area and treating stormwater incrementally, near the source.

2.2.4 Integrate Open Space and Urban Development

Following the Orange County Sustainable Operations and Resilience Action Plan, January 2021, the County promotes energy efficiency, renewable energy production, green buildings, water conservation, and waste reduction through its Orange to Green program. The County should also explore other incentives to go in tandem with the Orange to Green program. Enhancements to the ways the County conserves and protects its surface water and groundwater resources, such as Low Impact Development practices, can help the County to satisfy future needs in a sustainable manner. Integrating open space into site designs and including more urban developments such as Town Center can help minimize the hydrologic impacts of development. One of the first steps in site planning shall be to understand the existing hydrology and identify sensitive areas deemed essential to the functionality of the site. Sensitive areas include streams, buffer zones, floodplains, wetlands, high permeability soils, and conservation zones. Sensitive areas should be marked, protected, and connected when possible, during development activities, which will minimize hydrologic impacts during development.

Cluster development is a commonly used development technique that not only reduces impervious surfaces but preserves open space and lot yield. It should be noted that preserving open space does not require connectivity, but it should be encouraged. Promoting connectivity, as well as preserving open space, is a type of non-structural LID practice. Cluster development helps maintain the connectivity between forested areas and buffer zones, and it preserves natural areas on a site. Lot size is typically dictated by zoning setbacks which can require longer lengths of driveways and sidewalks to access the building. Buildings can also be built up with additional stories preserving the square footage required instead of increasing the building footprint. With cluster development typically comes greater impervious area per lot. However, cluster development reduces the area being disturbed on a parcel, groups buildings together, and utilizes shared resources. Cluster development decreases the overall construction footprint, reduces the cost of clearing and grading, and provides recreational features and amenities that can increase the value of properties. During the planning stage, any reduction in the reliance on personal cars offers the opportunity to reduce impervious area.

2.3 Conventional versus LID

Conventional stormwater management has historically focused on “end of pipe” solutions that emphasize solving flooding issues and stormwater conveyance (Bean et al., 2019). Conventional practices have focused on directing stormwater runoff into piped systems and moving it efficiently offsite. Due to multiple areas draining into the same belowground stormwater systems, a high volume of water traveling at a high velocity can be created. This poses risks to receiving waterbodies, such as wetlands, creeks, lakes, etc., as it could contribute to erosion. Additionally, sediments picked up aboveground make their way into the receiving waterbodies and have the potential to bury plants and ground-dwelling organisms. Sediments in water also can increase turbidity and reduce sunlight which is vital to aquatic habitats. Conventional practices have proven to convey runoff quickly and efficiently away from the site, with little regard to nutrient, sediments, or other pollutants carried and discharged into receiving waters. Pollutant removal has been viewed as a secondary goal in conventional practices.

Low Impact Development approaches stormwater management through the “slow it, spread it, sink it” mantra. It focuses on addressing flood control and water quality concerns simultaneously. Beginning at the planning level, there is a focus on preserving open areas and limiting soil compaction. Preserving a site’s natural hydrology and stormwater flow paths is key to LID. Since some disturbance is necessary in development, LID focuses on implementing various Best Management Practices (BMPs) to mitigate and offset these disturbances. The “slow it, spread it, sink it” mantra focuses on slowing stormwater runoff down so that infiltration can occur. Retention and detention basins have historically been used to treat stormwater runoff. However, more needs to be done to effectively meet water quality goals. Implementing multiple LID practices throughout the site is most effective at treating stormwater quantity and quality on site, compared to conveying and treating runoff offsite. LID is best applied in greenfield projects since it is easier to design a stormwater plan without space restrictions, but even with redevelopment projects that are space-limited, small scale LID techniques can be implemented to improve stormwater treatment throughout the site. Both conventional stormwater management and LID practices can and should be used in tandem to most effectively meet both water quantity and water quality goals.

2.4 Standards Supporting LID

Although no current Orange County ordinances or regulations exist which specifically discuss LID, many of the current Orange County policies support the use of green infrastructure and LID practices. The documents and policies referenced together with this manual include:

- *Orange County Comprehensive Plan 2010-2030*
- *Orange County Comprehensive Plan 2020-2050 (Vision 2050)*
- *Orange County Sustainability Plan, and*
- *Orange County Code of Ordinances, including:*
    - *Chapter 15 – Environmental Control*
    - *Chapter 19 – Floodplain Management*
    - *Chapter 24 – Landscaping, Buffering, and Open Space*
    - *Chapter 30 – Planning & Development*
    - *Chapter 34 – Subdivision Regulations*

2.5 Goals, Benefits, and Challenges of LID

The goals of LID are to provide stormwater runoff volume solutions, such as decreasing peak discharge rates and total runoff volumes, and to provide stormwater treatment to decrease pollutants and improve water quality. In the planning phase, this is done by preserving natural features, minimizing compaction, and reducing impervious surfaces, and during the treatment phase, the goals are met by managing stormwater close to its source and using a treatment train to slow it, spread it, and sink it.

Benefits of using LID include reduced wetland impacts, downstream erosion, and upland habitat impacts since the principals of LID maximize groundwater recharge, increase baseflow in streams, and protect and restore water quality. The use of LID can also increase soil fertility and soil fauna diversity. LID can also increase development demand for "green" properties that implement LID techniques as well as sustainable heating and cooling technologies. LID implementation can improve aesthetic value and reduce downstream flooding and property damage. Municipal water quality and potable water supplies benefit from LID implementation due to a reduced treatment need, and thus cost, to treat water before distribution.

The challenges of LID include integration with traditional stormwater management practices, and a lack of familiarity of LID practices by contractors and engineers, particularly in terms of how to design LID practices to meet regulatory criteria. There is also a lack of experience with maintenance procedures and uncertainty with the associated costs. Additionally, there are no standard procedures of ensuring the systems are properly maintained when the LID practice is within private property. Regulatory challenges that LID faces include municipal codes and regulations not supporting LID due to current standards requiring conventional stormwater designs and lack of long term performance and cost data. However, as the industry matures, these questions and issues are becoming clearer.

3 COUNTY CHARACTERISTICS

Since Orange County does not have uniform features across the entire County, it is important to provide an overview of the physical characteristics and any differences in features to better understand the County's needs. A description of Orange County is provided in this section, with information such as topography, soils, and land use, as well as regulatory requirements from the Florida Department of Environmental Protection (FDEP), National Pollutant Discharge Elimination System (NPDES) regulations, Federal Emergency Management Agency (FEMA), American Corps of Engineers (ACOE), and the water management district regulations, both South Florida Water Management District (SFWMD) and St. John's River Water Management District (SJRWMD).

3.1 Physical County Characteristics

3.1.1 Topography

A digital elevation model (DEM) was used to evaluate and understand the topographical characteristics within Orange County (**Exhibit 1**). There are multiple lakes throughout the western portion of the County, which are indicated as low spots, while in the eastern portion of the County, there are more rivers and streams. The elevation ranges from 0 – 250 feet (NAVD88), and the western portion of the County has predominantly higher elevations than the eastern portion. Areas with higher elevations, like those present in the western portion of the County, are likely better suited for infiltration practices while lower elevation areas may not have favorable groundwater conditions to support infiltration and must rely on detention and filtration practices. Additionally, areas with steep slopes may experience higher runoff generation and potentially more erosion, so LID practices that promote the spreading of stormwater runoff, and then infiltration, are encouraged.

3.1.2 Soils

Mapping of the hydrological classes of soils across the County indicated two main soil groups, A and A/D (**Exhibit 2**). Hydrological class A is predominantly in the west and northwest, which are freely draining soils with a deeper water table. These soils are more conducive to retention and infiltrating practices where runoff is dissipated readily into the subsurface shallow aquifer. This is particularly evident with soils in their natural state, as development processes can compact soils which may impact infiltration capacity. In the eastern and southern areas of the County, a dual hydrological class of A/D predominates. These are soils that exhibit more freely draining conditions during the dry season but are more representative of poorly draining soils with high water tables during the wet season. To be conservative, stormwater flood design calculations shall assume the D condition. There are some areas of B/D and C/D hydrologic soil classes mixed in with the A/D soils, but they would generally be similarly considered to perform as D soils for flood design purposes. These areas are not conducive to infiltration and retention practices and are areas where detention strategies that hold onto runoff temporarily with a controlled release are commonly applied. Soil types present on a site targeted for development or redevelopment would have a direct bearing on the type of LID practices that would be effective for stormwater quantity and quality control.

Karst areas that are overlain with HSG A soils are often susceptible to pollution due to the lack of organic matter and lack of ability to bind and retain pollutants and nutrients. Sandy soils allow for rapid infiltration of stormwater and have little opportunity for pollutants to filter out. Additionally, since Karst areas have high rates of recharge to springs and groundwater, there is a greater opportunity for pollutants and nutrients to enter the groundwater without being filtered.

3.1.3 Land Use

The characteristics of the land cover are also important in consideration of stormwater runoff. Generally, it is the impact of the impervious area characteristics of a particular land use that drives runoff volumes. For example, highly urbanized areas where there is a high percentage of impervious area, particularly directly connected impervious area (DCIA), generates more runoff than non-compacted open space areas or natural undeveloped parcels with an abundance of pervious areas. Also, dense urban areas may present space constraints when looking to implement stormwater practices that may require significant space, particularly when looking at redevelopment (infill). These areas tend to consist of DCIA directing runoff directly to management features or discharge points. This can result in a significant increase to the volume of runoff to downstream areas, even if peak discharge rate controls are in place. Opportunities to disconnect DCIA and route runoff across pervious areas prior to collection, can help to mitigate these effects, even if the overall impervious area is not significantly reduced. The application of many small footprint LID practices may be more effective in dense urban areas, particularly when worked into existing development features such as parking and landscaping.

Mapping of land use (land cover) across the County clearly indicates the degree of urbanization (**Exhibit 3**). Primary target areas for development exist in the northwest, southwest, south, and eastern areas of the County. New development areas could leverage larger footprint LID strategies that are highly flexible plugging into a development and better integrated into open space and other "green" strategies. In particular, residential developments may leverage neighborhood scale LID practices incorporating a distributed series of interconnected practices with treatment trains. Redevelopment (infill) areas where urbanization has already occurred are best to leverage small footprint LID practices on a more distributed basis to meet stormwater regulatory targets. For example, LID practices that are integrated into landscaping features or parking areas may be best used for infill applications. Land use types where stormwater management practices are to be applied would generally dictate the size and distribution of the LID practice.

3.2 Regulatory Boundaries and Criteria

3.2.1 Orange County Comprehensive Plan

On January 1, 2007, the County adopted a Land Development Code that specifies that stormwater management systems shall be designed to retain or detain, with filtration, 0.5 inches of runoff from the developed site or the runoff generated from the first 1.0 inch of rainfall on the developed site to provide for water quality treatment.

The conservation element of the comprehensive plan states that the County's natural resources are preserved for the benefit of present and future generations. This includes air, surface water, groundwater, vegetative communities, imperiled species, soils, floodplains, recharge areas, wetlands, and energy resources.

Development that occurs in Orange County should incorporate LID principles into the design and develop sites to minimize negative impacts to the environment, especially regarding water quality and quantity. Additionally, the County will develop LID strategies in conjunction with State agencies to reduce impacts to water quality and manage water quantity concerns.

The current Orange County Comprehensive Plan 2010 – 2030, effective July 1, 2022, emphasizes that future development should creatively address stormwater management issues, and it requires use of Best Management Practices (BMPs) which include, but are not limited to:

- Holding runoff in shallow vegetated infiltration areas
- Using clay or geotextile liners for wet detention ponds
- Employing offline stormwater retention areas
- Constructing many small retention areas rather than only a few large retention areas
- Using grassed swales with cross blocks or raised driveway culverts
- Fully vegetated stormwater retention basin side slopes and bottoms
- Using the treatment train concept and LID principals (as discussed in Section 3.0)
- Minimizing the amount of impervious surfaces
- Maximizing the amount of open space left in natural vegetation
- Maximizing the use of pervious pavements (Section 4.0) in parking areas
- Maintaining existing vegetation where feasible
- Buffering sinkholes and other surface-to-ground water conduits, stream channels, and spring shed recharge areas.

A new comprehensive plan is being developed for 2020 through 2050 which could have a significant impact on future land use conditions. It will be implemented through the adoption of a new Land Development Code. The Vision 2050 document is going to cover the following:

- Orange County's new guiding principles and planning framework,
- The following 10 subject areas:
    - Land Use, Mobility, and Neighborhoods,
    - Housing and Community Services,
    - Tourism, Arts, and Culture,
    - Economy, Technology, and Innovation,
    - Natural Resources, Conservation, and Resiliency,
    - Recreation and Open Space,
    - Transportation,
    - Public Schools,

- Community Facilities and Services, and
- Implementation and Property Rights

- Orange County's six geographic planning areas: northwest, southwest, core, south, east, and rural east, and will include goals, objectives, and policies that are specific to those areas.

The plan for Vision 2050 is to protect environmentally sensitive lands while preserving and enhancing established residential neighborhoods through urban infill and redevelopment. This will help with the identification of future development patterns. Smart growth and sustainability are two of Orange County's key planning goals.

3.2.2 Special Regulatory Criteria

Orange County has numerous regulatory requirements that necessitate a focus on pollutant load reduction in stormwater. The State of Florida's total maximum daily load (TMDL) program identifies impaired waterbodies that require specific pollutant load reduction strategies in the contributing areas of those waterbodies. In many of these TMDL impaired areas, basin management action plans (BMAPs) have been or are being developed to provide a framework for stakeholders to implement effective pollutant load reduction strategies to address their respective load allocations. TMDLs and BMAPs are priority water quality drivers, however there are numerous other non-TMDL impaired waters identified throughout the County that likewise should be considered when developing pollutant load reduction strategies. In addition, compliance with the County's NPDES permit necessitates the application of strategies to reduce pollutants in stormwater, particularly at the individual outfall level.

In addition to the above, certain areas of the County are subject to enhanced regulatory requirements for stormwater quality from the water management districts. For example, SJRWMD has special criteria for the Lake Apopka Basin. In this area pre-development and post-development pollutant loads need to be evaluated to ensure no net increase in pollutant loading for a project. For the Lake Apopka Basin there are also specific treatment assumptions related to wet detention and dry retention design criteria. Additional criteria also exist when discharging to outstanding Florida waters (OFWs), outstanding Florida springs (OFSs), or within the Wekiva primary focus area (PFA). See **Exhibits 4** and **5** for a map of OFWs and OFSs, respectively.

These regulatory requirements represent drivers to reduce pollutant loads in stormwater representing specific geographical target areas. Whether associated with a specific waterbody, or a more regional area such as addressed by a BMAP, it follows that engaging in a program of LID practices in the County should be implemented with sensitivity to these geographical-based water quality improvement drivers. It should be noted that the typical focus in addressing stormwater quality is with respect to surface waters. There are areas of the County where groundwater impacts are of concern as well, for example Wekiva and Rock Springs areas. For these groundwater focused areas, providing enhanced load reduction in stormwater management facilities with practices that further treat runoff infiltrated into the groundwater are important as well. This is supported by the County's comprehensive plan.

3.2.3 Florida Department of Environmental Protection

The State of Florida stormwater management goals are outlined in Chapter 62-40 of the FAC, titled "Water Resources Implementation Rule." "The primary goals of the State Stormwater Management Program are to maintain, to the maximum extent practicable, during and after construction and development, the predevelopment stormwater characteristics of the site; to reduce stream channel erosion, pollution, siltation, sedimentation, and flooding; to reduce stormwater pollutant loading discharged to waters to preserve or restore designated uses; to reduce the loss of fresh water resources by encouraging the recycling of stormwater; to enhance groundwater recharge by promoting infiltration of stormwater in areas with appropriate soils and geology; to maintain the appropriate salinity regimes in estuaries needed to support the natural flora and fauna; and to address stormwater management on a watershed basis to provide cost-effective water quality and water quantity solutions to specific watershed problems."

The implementation rule states that stormwater design shall achieve at least 80% reduction of the average annual load of pollutants that cause or contribute to violations of State Water Quality Standards. According to state water quality standards, as set forth in Chapter 62-302 of the Florida Administrative Code (FAC), retention, detention, or both retention and detention shall provide for treatment of stormwater runoff.

FDEP, along with the State's water management districts, had been in the process of developing a statewide stormwater treatment rule. If implemented, this rule would represent a significant step in controlling pollutant loadings from stormwater discharges. A draft rule was published in March of 2010 (FDEP, 2010), and it states that stormwater treatment systems shall be designed to provide an 85% reduction of the post-development average annual loading of nutrients from a project or a reduction such that the post-development average annual loading of nutrients does not exceed the nutrient loading from the project areas natural vegetative community types. While the 2010 rule was not implemented, it was still referenced for permitting purposes. The state recognized the need for an updated stormwater rule and at the time of this manual's publication, a new statewide stormwater rule has been approved by the FDEP but has not been ratified.

The 2010 draft rule suggests the use of three categories of BMPs, which can be used to meet the statewide stormwater treatment goals. These categories include:

- Retention BMPs – recessed area within the landscape that is designed to store and retain a defined quantity of runoff, allowing it to percolate through permeable soils into the shallow groundwater aquifer. Retention BMPs include retention basins or trenches, exfiltration trenches, underground retention systems, underground retention vault or chambers, French drains, swales, vegetated natural buffers, pervious pavements, and green roof/cistern systems.

- Detention BMPs – areas that detain stormwater and discharge it at a specified rate, usually the predevelopment peak discharge rate. Detention BMPs include wet detention and underdrain filtration.

- Source control BMPs – nonstructural BMPs that are used to either minimize the amount of stormwater generated or minimize the amount of pollutants getting into the stormwater.

3.2.3.1 Impaired Waterbodies (303(d) List)

Section 303(d) of the Clean Water Act authorizes the Environmental Protection Agency (EPA) to assist states, territories, and authorized tribes in listing impaired waters and developing TMDLs for these waterbodies (EPA, 2022). The Impaired Waterbodies Program consists of a two-part process. First, the state identifies waters that are impaired or in danger of being impaired, and second, the state calculates pollution reduction levels that will be appropriate to meet water quality standards (EPA, 2022b). To ensure that impaired waters continue to be monitored, the state is required to update and resubmit the list of impaired waters every two years. See **Exhibit 6** for a map of Impaired Waterbodies at the time of the development of this manual.

It should be noted that if a body of water is not on the impaired waterbodies list, it does not mean it is not impaired, as it may be on the list for TMDL, BMAP, 4b, or 4e waterbodies. All lists should be checked to determine if a waterbody is impaired or not.

3.2.3.2 TMDLs

A TMDL establishes the maximum amount of a pollutant allowed in a waterbody and serves as a starting point or planning tool for restoring water quality (EPA, 2022). TMDLs are generated when the state identifies an impaired waterbody and thus needs to determine pollution reduction levels. Generally, load reduction targets are focused on nutrients (Total Nitrogen (TN) and Total Phosphorus (TP)) but may have different load allocation parameter targets. The application of LID practices, particularly in treatment trains, would aid in helping to meet TMDL load reduction requirements in these areas. See **Exhibit 7** for a map of TMDL Waterbodies.

3.2.3.3 BMAPS

Locations that have BMAPS identify areas that have enhanced water quality treatment requirements. Again, the load reduction targets are generally focused on nutrients (TN and TP) but may have different load allocation parameter targets. The application of LID practices, particularly in treatment trains, would aid in helping to meet BMAP load reduction allocations in these areas. See **Exhibit 8** for a map of BMAP waterbodies.

3.2.3.4 4b Plans

A waterbody can be placed in category 4b if it’s impaired but has a Reasonable Assurance Plan (RAP) being implemented to reduce pollutant loadings (FDEP, 2022b). See **Exhibit 9** for a map of 4b plan waterbodies. A RAP covers the following steps (FDEP, 2022b):

- Identify responsible participating entities (stakeholders)
- Delineate the geographic boundary the plan will include
- Identify point and non-point source pollutants
- Determine appropriate water quality targets for the parameters and waterbodies of concern
- Determine necessary nutrient load reductions
- Identify projects to provide the reasonable assurance that the proposed management actions can achieve the designated uses of the waterbody

- Calculate credits or reductions (if applicable) for ongoing and planned projects
- Identify procedures for monitoring, compliance assessment, and reporting
- Establish key indicators that will be assessed to provide assurance of progress
- Establish an implementation timeframe
- Identify possible funding sources

3.2.3.5 4e Plans

A waterbody can be placed in category 4e (Ongoing Restoration Activities) if it's impaired, but recently completed or has ongoing restoration activities underway to restore the designated uses of the waterbody (FDEP, 2022b). The goal of a 4e plan is to implement appropriate restoration activities and, if necessary, additional study so that by the next assessment cycle either a 4b RAP can be approved or the waterbody attains water quality standards for the parameter causing the impairment (FDEP, 2022b). See **Exhibit 10** for a map of 4e plan waterbodies.

3.2.4 Florida NPDES Regulations

Orange County operates under a Municipal Separate Storm Sewer System (MS4) permit issued under the State of Florida NPDES program (FLS000011). Under this permit, Orange County is authorized to discharge stormwater to waters of the State in accordance with an approved Stormwater Management Program (SWMP), monitoring requirements and other provisions, as set forth in the permit. All existing and new stormwater discharges are covered by this permit. The Orange County MS4 permit requires that comprehensive stormwater master planning be implemented to reduce the stormwater discharges of pollutants and that structural controls constructed to manage stormwater are inspected and maintained, by either the County or private entities (i.e., home owners associations).

3.3 Water Management District Regulations

Orange County falls under the jurisdiction of two water management districts: St. Johns River Water Management District (SJRWMD), which covers the northwest and east portions of Orange County, and South Florida Water Management District (SFWMD), which covers the southwest portion of the County (**Exhibit 11**).

3.3.1 South Florida Water Management District Regulations

The SFWMD provides design guidance criteria for a suite of stormwater treatment systems or best management practices. SFWMD provides design criteria related to flood prevention and water quality aspects. SFWMD regulates the rate of discharge of stormwater runoff from developed properties to prevent flooding. The District requires the post-development peak discharge rate to be equal to or less than the pre-development 25-year, 72-hour design storm event.

SFWMD also requires retention of a treatment volume to protect water quality as outlined in **Table 3-1** below. The treatment volume can be achieved by a suite of stormwater treatment systems, which are discussed in detail in the design criteria sections. SFWMD provides a list of structural practices suitable to meet the stormwater requirements, which include the following:

- Dry Retention Basin

- Concrete Grid Pavers
- Exfiltration Trench
- Vegetated Filter Strips
- Grass Swales
- Wet Detention Pond
- Dry Detention Pond
- Constructed Wetlands
- Water Quality Inlets
- Separation Devices
- Chemical Treatment

3.3.2 St. Johns River Water Management District Regulations

The SJRWMD provides design and performance criteria for new development which are similar to the SFWMD criteria. SJRWMD requires that stormwater management systems will not result in discharges to surface and groundwater of the state that can cause or contribute to violations of state water quality standards and will not adversely affect drainage and flood protection on adjacent or nearby properties.

For stormwater management systems, SJRWMD requires post-development peak discharge rates to not exceed predevelopment peak discharge rates, and similar to SFWMD, SJRWMD requires retention or detention of a treatment volume to protect water quality (see **Table 3-1** below). The ERP Applicants Handbook Volume II provides design, evaluation, and performance criteria for the following practices, to meet the stormwater requirements:

- Dry Detention Basin
- Retention Systems
- Exfiltration Trench
- Wet Detention Pond
- Swales
- Wetland Stormwater Management Systems

Table 3-1. Summary of Regulatory Requirements for Detention and Retention Practices

Goal	*Design Parameter*	*St. Johns River Water Management District*	*South Florida Water Management District*	*Orange County*
Water Quality	**Treatment Volume**	▪ Off-line dry detention of the first 1.0-inch of runoff or 2.5-inches of runoff from impervious area, whichever is greater, of the total amount of runoff required to be treated. Dry Retention - one of the following: ▪ Off-line dry retention of the first 0.50-inches of runoff or 1.25-inches of runoff from the impervious area; whichever is greater. ▪ On-line retention of the first 1.0-inch of runoff; or 1.25-inches of runoff from the impervious area plus 0.50-inches of runoff from the entire basin; whichever is greater. ▪ On-line retention that percolates the runoff from the 3-year, 1-hour storm. ▪ For projects with <40% impervious and only HSG A soils, on-line retention from 1-inch of rainfall or 1.25-inches of runoff from impervious area. ▪ Wet detention of first 1-inch of runoff from the developed site or the total runoff from 2.5-inches from the impervious area, whichever is greater.	▪ Wet detention shall be provided for first 1-inch of runoff from the developed site or the total runoff from 2.5-inches from the impervious area, whichever is greater. ▪ Dry detention volume shall be provided equal to 75% of the above amounts for wet detention. ▪ Retention volume equal to 50% of the above amount for wet detention. ▪ Systems with inlets in grassed areas will be credited up to 0.2-inches of the required wet detention amount for contributing areas. Full credit will be based on a ratio of 10:1 impervious area to pervious area with proportionately less credit granted for greater ratios.	▪ Positive bleed down for wet retention ponds: first 0.5-inch of runoff from the developed portion of a site or the runoff generated from the first 1.0-inch of rainfall on developed sites, whichever is greater. ▪ For recharge areas with Type A soils, provide retention of the total runoff generated by a 25-year, 24-hour storm. In areas with no positive outfall, the 100-year, 24-hour storm shall be retained. ▪ For other areas with no positive outfall, retain the 100-year, 24-hour storm.
	Volume Recovery	▪ Dry / wet detention: recover one-half treatment volume between 24 and 30 hours. ▪ Retention: Recover treatment volume within 72 hours.	▪ Gravity control devices sized based on maximum discharge of one-half inch of detention volume in 24 hours.	▪ Detention facilities: recover 50% of total volume (in excess of pollution abatement volume) treatment volume within 24 hours, the rest within an additional 72 hours. ▪ No positive outfall: recover volume within 14 days (drainwells not considered positive outfall).
Flood Attenuation		▪ For highly impervious areas (>50%), peak discharge for the mean annual 24-hour storm must be controlled (Post=Pre). ▪ Less than 50% impervious, control the 25-year, 24-hour design storm event (Post=Pre).	▪ Post-development peak discharge rate is equal to pre-development for 25-year, 72-hour storm event.	▪ Post-development peak discharge rate is equal to pre-development for 25-year, 24-hour storm event.

Sources: SJRWMD (2018). Environmental Resource Permit Applicant's Handbook Volume 2. Retrieved from https://www.sjrwmd.com/static/permitting/PIM-20180601.pdf; SFWMD (2016). Environmental Resource Permit Applicant's Handbook Volume 2. Retrieved from https://www.sfwmd.gov/sites/default/files/documents/swerp_applicants_handbook_vol_ii.pdf; Orange County (2022). Orange County Comprehensive Plan. Retrieved from https://www.ocfl.net/Portals/0/resource%20library/planning%20-%20development/Orange%20County%20Comprehensive%20Plan%20Updated%20July%201,%202022.pdf#search=comprehensive%20plan

4 SITE ASSESSMENT AND CONSTRAINTS

Since LID is not a "one-size-fits-all" solution, it is important to understand that each site will have different water quality needs, as well as constraints and limitations, and thus requires different solutions to meet those goals. This section goes over a site assessment of the area of interest, i.e., the proposed project site, assuming it is located within Orange County. Applicability is discussed, as not every LID practice is appropriate for every site or may require design modifications. Soils, vegetation, existing hydrology, and climate is reviewed in terms of applicability and constraints. Lastly, redevelopment potential and determination of permitting requirements are discussed.

4.1 Area of Interest/Applicability Overview

The area of interest is defined as the project area, or the area that is proposed to be improved. As previously stated, not every LID practice can be applied to every site, and this is especially the case with redevelopment projects. The available space, soils, water table depth, and property ownership and restrictions are all examples of variables that must be considered when evaluating if certain LID practices can be implemented in a site. LID practices vary in size and may also be scaled up or down to fit the available space. Not every practice can be used in all soil conditions, especially in sensitive groundwater areas or seasonal high groundwater tables (SHGWT), but some LID practices provide flexibility with the use of an underdrain. Property ownership as well as deed restricted communities may also cause extra steps to be taken in the site assessment procedure, as extra approvals may be required.

4.2 Water Quality Assessment Methodology Including Treatment Trains

To determine the water quality benefits that a given LID practice will have, a water quality assessment must be performed. This is when both the existing and proposed conditions are evaluated to determine the pollutant loading under both conditions. The difference in these loadings represents the benefit of the practice. Due to the nature of water quality impacts from stormwater, i.e., many different loading events driven by local weather patterns, a long-term continuous simulation hydrologic and hydraulic, and pollutant loading model must be developed to assess these impacts. Results of this effort will provide estimates of the average annual loading and LID practice performance. This needs to be done for both existing and proposed conditions. The results of the proposed conditions must demonstrate that applicable water quality criteria have been met. The long-term continuous simulation model can be done using the Interconnected Channel and Pond Routing Model (ICPR4), Storm Water Management Model (SWMM), or equivalent modeling software, subject to County approval.

It is noted that incorporation of LID practices as recommended in this manual are intended to be part of a treatment train. While LID is not intended to specifically meet flood control criteria, it is expected to alleviate the requirements associated with it. This is achieved through implementing a treatment train approach which disconnects DCIA and/or spreads out storage across the watershed, allowing for smaller ponds for flood control purposes.

It is noted that the model used needs to track long-term soil storage. It is recommended to use a runoff estimation method, such as the Green-Ampt or similar method, that allows for long-term tracking of soil moisture, as this will impact the volume of runoff generated. This can be performed using ICPR4 or other equivalent H&H models. The minimum requirement for historic rainfall data is 10 years, or however much is available for the region in question. It is recommended that the most recent 10 years of complete data is used. A 1-hour increment/time step or shorter is required. Rainfall data must be reviewed for quality assurance. For example, comparing averages and medians, identifying outliers or missing data, and comparing the calculated annual rainfall compared to the average annual rainfall in the region in question. Evapotranspiration should be included in the model, as well as evaporation from lakes, if applicable.

Alternatively, the methods presented by Harper and Baker (2007) can be used to evaluate the pollutant loading from a watershed or area of interest. This method is based on continuous simulation modeling that was performed evaluating the runoff from a wide variety of land cover conditions. The result of this effort was to establish average annual runoff coefficients for a wide range of different non-DCIA CN and DCIA percentage conditions. This average annual runoff coefficient is multiplied by the average annual rainfall volume to determine the average annual runoff volume. Total nitrogen (TN) and total phosphorus (TP) event mean concentrations (EMCs) are multiplied by the average annual runoff volume to determine the mass of TN and TP generated for the appropriate land use(s) within the area of interest. Similarly, Harper and Baker (2007) used continuous simulation modeling to evaluate the performance of retention basins for a variety of different retention volumes and watersheds with a variety of different non-DCIA CN values and DCIA percentage conditions. The results of the Harper and Baker (2007) analysis are an atlas of tables that can be used to determine the average annual runoff from an area of interest and the average annual capture efficiency of retention practices. By following the methods presented by Harper and Baker (2007), a pollutant loading analysis can be performed.

There have been recent efforts to develop computer calculation models that leverage the Harper and Baker (2007) method to estimate the average annual runoff, TN, and TP loadings. These include the BMP Trains Model and the SIMPLE Seasonal model, as well as others. These offer a quick and straight forward way to estimate the pollutant loading from areas of interest as well as the water quality benefit of implementing different LID practices.

4.3 Physical Site Assessment

The effectiveness of any given stormwater LID practice is dependent on the physical characteristics of the geographical setting on which they are applied. In this section, soils, vegetation, hydrology, and climate are covered, which are some of the main drivers of LID selection and application. Additionally, if there are target areas throughout the County which need to meet specific water quality goals, this may create an incentive to implement LID practices tailored to meet the needs of the target area.

4.3.1 Soils and Vegetation

One of the primary characteristics that impact stormwater LID selection on a particular site are soils. Soil conditions on a site, including the depth to seasonal water table, directly impact the amount of rainfall the site soils can absorb before runoff is generated. For example, deep sandy soils similar to what is present in the western portions of Orange County have a deep water table and can absorb quite bit of rainfall before runoff occurs. In these areas, practices that promote retention and infiltration can be successful. Conversely, soils that have a high silt or clay content and/or high water table have less capacity to absorb rainfall and therefore generate runoff more readily. In these areas, which are commonly present in the eastern portions of Orange County, strategies that rely on detention-based practices are more applicable. Development compounds the issue of soil absorption of runoff through the actions of clearing and compaction of soils during construction activities. These actions can significantly change the characteristics of a soil from a runoff potential perspective.

Since water quality modeling requires continuous simulation methods such as the Green-Ampt method, it requires extensive soils data. Different methods may have different data requirements and the user should ensure all necessary data is collected and representative to support modeling efforts. The Green-Ampt method uses several soil properties that can be found in the Soil Survey Geographic Database (SSURGO). These parameters are listed below:

- Saturated Vertical Conductivity (SSURGO)
- Saturated Moisture Content
- Moisture Content, Residual
- Moisture Content, Field Capacity (SSURGO)
- Moisture Content, Wilting (SSURGO)
- Moisture Content, Initial = Moisture Content Field Capacity (SSURGO)
- Pore Size Index: calculated using the Brooks-Corey formula with values obtained from SSURGO
- Bubble Pressure calculated using values obtained from SSURGO
- Water Table, Initial (SSURGO)

The following additional parameters are also required for the Green-Ampt runoff excess method:

- Site specific percent (%) impervious values
- Percent (%) directly connected impervious area (DCIA) values

It is noted that percent impervious values and DCIA percent values can be based on direct measurement using GIS tools, using representative areas of a given land use, and using assumed values from literature.

LID practices that can adapt or be applied effectively to work with varying soil conditions can be effective stormwater management strategies. In high infiltration potential areas, LID can simply be used to more effectively direct stormwater to infiltration locations. In high water table or poorer soil areas, LID can act as a resource to distribute runoff to many stormwater practices to leverage the limited soil absorption over a larger area.

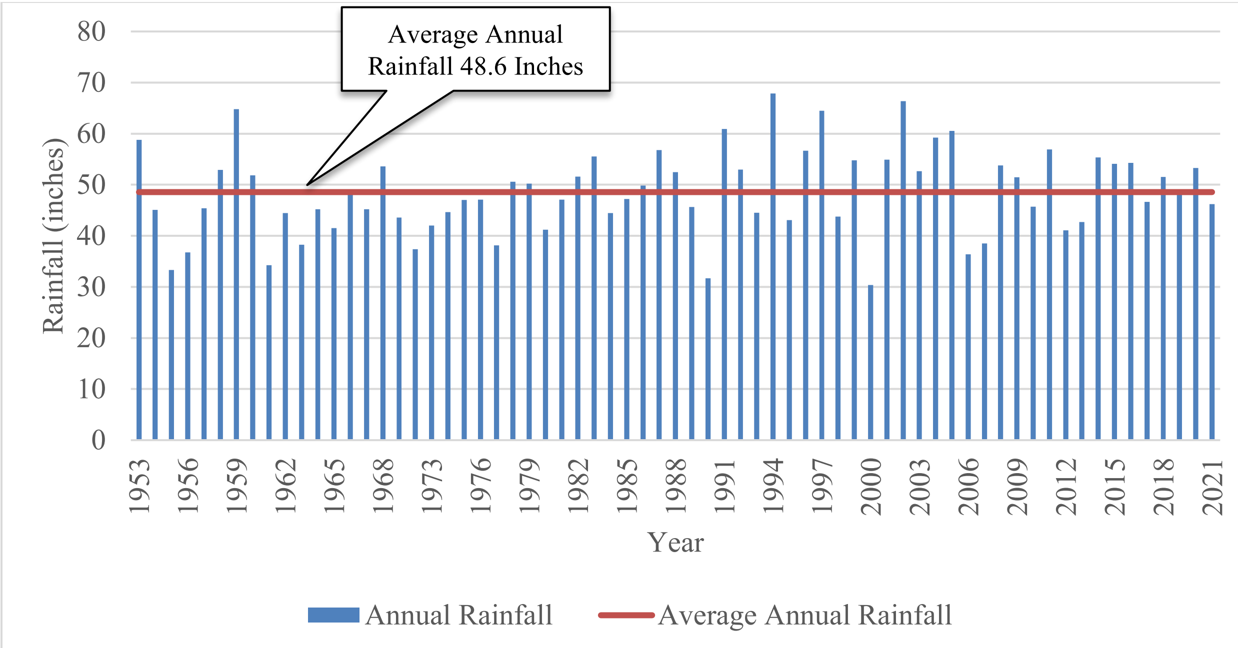
The soils within the County are classified as Hydrologic Soil Group A, which is mostly in the west and northwest portions of the County and drain more freely and have a deeper water table, and dual Hydrologic Soil Group A/D, which is in the eastern and southern areas of the County. Dual Hydrologic Soil Groups are those which drain freely during the dry season but have high water tables and drain poorly during the wet season, e.g. A/D. For stormwater quantity design purposes, a Hydrologic Soil Group of D is assumed for the A/D dual Hydrologic Soil Group as this represents the more conservative condition. These areas are not conducive to infiltration and retention practices and are areas where detention strategies temporarily detain runoff with a controlled release are commonly applied.

4.3.2 Existing Hydrology and Climate

Rainfall in Florida is driven by a few primary weather patterns, frontal storms that accompany winter cold fronts, convective storms that form in the hot summer months as the easterly and westerly sea breezes collide over the center of the state, or tropical cyclones such as hurricanes which can impact the state from the Atlantic Ocean or the Gulf of Mexico. The portion of the state that Orange County resides in is the central region, which can be impacted by all three of these weather phenomena. The frontal storms can generally be characterized as being longer duration lower rainfall intensity storm events. These generate runoff, but due to the low rainfall intensity, provide more time for water to soak into the ground. Convective storms rapidly form and tend to create relatively short duration and high rainfall intensity storm events. This results in the generation of very large runoff volumes and high flow rates in infrastructure due to the high volumes of water deposited faster than the ground can absorb. Additionally, the state of Florida is frequently hit with hurricanes, which can bring between 5 and 20+ inches of rain in the matter of a day or two (Purdum, 2002). These storms tend to result in major flooding and other storm related damages.

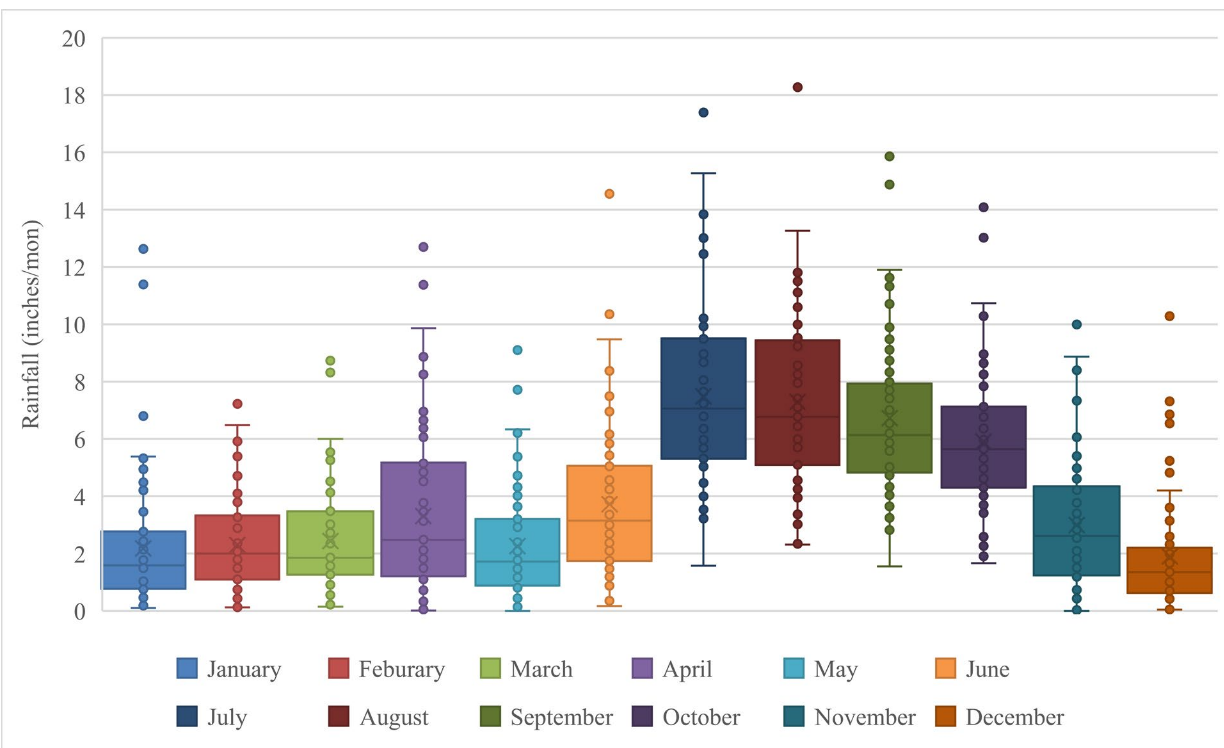
Daily rainfall data from 1953 to 2021 were downloaded from National Oceanic and Atmospheric Administration (NOAA) for the Orlando International Airport (OIA) station (COOP: 086628). These data were evaluated to characterize the average annual rainfall total volumes (**Figure 4-1**) and to evaluate seasonal trends (**Figure 4-2**). The evaluation of the annual rainfall volumes revealed the total volume ranged from approximately 30.4 inches to 67.9 inches, with an average of approximately 48.6 inches. Evaluation of the monthly rainfall total data reveals that the County experiences distinct wet and dry periods throughout the year with the wet periods typically occurring from July through October. This may impact design and/or maintenance considerations for practices that incorporate vegetation, which may require specific plant selection. Plants should be selected to tolerate the range of conditions within the LID practice zones without supplemental irrigation past the establishment period. For example, trees are recommended to have temporary irrigation for the first two growing seasons.

It should be noted that the County has ongoing efforts to study climate change impacts related to stormwater but were not published at the time of this publication.



Note: Data taken from NOAA Precipitation Database, OIA Station (COOP:086628)

Figure 4-1: Orange County Annual Rainfall from 1953 to 2021



Note: Data taken from NOAA Precipitation Database, OIA Station (COOP:086628)

Figure 4-2: Orange County Total Monthly Precipitation Comparison 1953 to 2021

4.4 Redevelopment Potential

While not all of Orange County is built out, a large portion is, and the dominant form of development in the future will likely be redevelopment. Although developing greenfield areas in a way that will enhance water quality in Orange County may be easier to undertake due to less spatial constraints, it is just as important to focus on redevelopment of grayfield areas, especially if they are within the watersheds of sensitive waters.

In redevelopment areas where urbanization has already occurred, leveraging small footprint LID practices on a more distributed basis is a necessary strategy to meet stormwater quality regulatory targets. In these types of areas, LID practices could include conveying runoff from impervious areas to vegetated areas, such as regrading parking lots and inverting parking islands and installing bioretention systems, replacement of impervious parking lots and rooftops with pervious pavements and green roofs, or incorporating infiltration planter boxes or tree box filters to intercept and infiltrate runoff. Redevelopment also provides an opportunity for the implementation of treatment trains for enhanced water quality benefit. This can include multiple LID practices in series with one another, such as a bioretention system intercepting roof runoff and overflowing into a wet detention pond, or enhancement of existing LID practices, such as addition of a filter on wet detention pond discharge. These treatment trains result in increased efficiency and removal of pollutants. In the Wekiva Study Area specifically, new development and substantial redevelopment is encouraged to use LID practices to maintain surface and groundwater flow rates and volumes at predevelopment levels. Water quality treatment is to reduce nutrients and other contaminants in discharges to pre-developed levels, and post-development peak rates are not to exceed predevelopment peak rates of discharge (Orange County, 2022). LID is an important tool to help achieve regulatory objectives.

4.5 Determination of Permitting Requirements

In conjunction with the State of Florida Department of Environmental Protection (FDEP), the State Water Management Districts (WMDs) have developed the Environmental Resource Permit (ERP) Program to streamline the state's regulatory programs (http://www.dep.state.fl.us/water/wetlands/erp/index.htm). The ERP program enables either the FDEP or WMDs to review and issue one permit. It is noted that if wetlands or surface waters may be impacted, additional permitting may be required. The ERP program regulates the construction, alteration, maintenance, removal, modification, and operation of all activities in uplands, wetlands and other surface waters that will alter, divert, impede, or otherwise change the flow of surface waters. This program covers the construction of new buildings, roadways, and parking areas that increase impervious surfaces and stormwater runoff. The program protects water quality from discharge of untreated stormwater runoff and protects off-site flooding due to changes in land use.

Waterbodies must be checked to see if any of the following apply:

- Are on the Impaired Waterbodies (303(d)) List,
- Have a Total Maximum Daily Load (TMDL),
- Are in a Basin Management Action Plan (BMAP) location,

- Have a 4b plan, or
- Have a 4e plan.

It is noted that comparison of the TMDL, BMAP, and impaired waters maps indicated that the majority of the County has some type of enhanced regulatory water quality criteria. These cover essentially the entire west and central areas of the County, with only some areas in the far east County outside of the Econlockhatchee and St. Johns River corridors not having additional water quality requirements.

5 FLORIDA LOW IMPACT DEVELOPMENT PRACTICES, COUNTY APPROVED LID PRACTICES, AND TECHNICAL DESIGN CRITERIA

This section provides a brief discussion of each Low Impact Development (LID) practice examined for this manual. Included are the background, applicability, water quality, and quantity characteristics, as well as operation and maintenance needs. Additionally, this section describes and reviews a selection matrix that was developed to prioritize LID design details and criteria to support this manual.

5.1 LID Practices

A list of LID practices was developed based on a review of Best Management Practice (BMP), Green Stormwater Infrastructure (GSI), and/or LID manuals from municipalities across the state, as well as information gathered from the St. John's River Water Management District (SJRWMD), South Florida Water Management District (SFWMD), Florida Department of Environmental Protection (FDEP), and Environmental Protection Agency (EPA) websites and literature. This effort identified 20 LID practices that were evaluated based on a decision matrix developed specifically for this effort and ranked them. It is noted that the decision matrix is presented later in this Section. Non-structural practices discussed **Section 2.2** in should be considered and implemented where applicable during the planning phase prior to taking structural BMPs into consideration.

It should be noted that the following practices are correspondingly evaluated for applicability, water quality and quantity characteristics, initial costs, cost benefit, and maintenance costs/effort. The cost benefit of each practice is ranked from lowest to highest, assigned a score based on the cost benefit of other LID practices, and used to calculate the overall rank for each practice. It is noted that the capital cost and maintenance costs/effort scores are added together. However, costs are only relevant for the time that this manual was developed as many socio-economic factors, which are highly variable, come into play when determining cost. Thus, this information is used for informational purposes only and it is highly recommended that any cost estimates prepared for new projects use more recent cost data.

For maintenance needs, regular maintenance refers to annual/semiannual/monthly costs for LID practice upkeep. Most maintenance falls under this category. Infrequent maintenance refers to costs that occur a few times during the life of the practice, such as repairs or replacements.

A plant list is included as **Appendix A** and is to be used as a guide when selecting plants for different LID practices within the County. There is a specific focus on soil drainage and soil moisture conditions as well as different sun exposure conditions. Plants are specified in terms of both botanical and common names. Additionally, notes are provided that indicate the size of a mature plant. Detailed design details and example design calculations for various practices are included in Volume 2.

5.1.1 Pervious/Permeable Pavements

In this section, a brief background of pervious/permeable pavements are discussed, identifying the major components of this practice, how it is constructed, how it functions, and the applicability of the practice. Additionally, water quality and quantity characteristics, as well as operation and maintenance needs are addressed.

5.1.1.1 Background on Pervious/Permeable Pavements

Pervious/Permeable Pavements are an LID practice that consists of replacing traditional impervious pavements, such as parking lots, sidewalks, and patios with pervious and/or permeable materials to capture and infiltrate stormwater, see **Figure 5-1**. Pervious/permeable pavements typically consist of multiple layers of high void space materials which provide storage of stormwater while it infiltrates into the ground. The surface layer consists of either pervious loose laid pavement such as pervious concrete or porous asphalt, or permeable paver systems which provides gaps between the pavers allowing water to enter the storage layers. These systems can be designed with or without an underdrain. Systems with an underdrain typically include a filter media layer to provide treatment via filtration/biofiltration prior to collection. Volume reduction may still occur, but to a lesser extent.

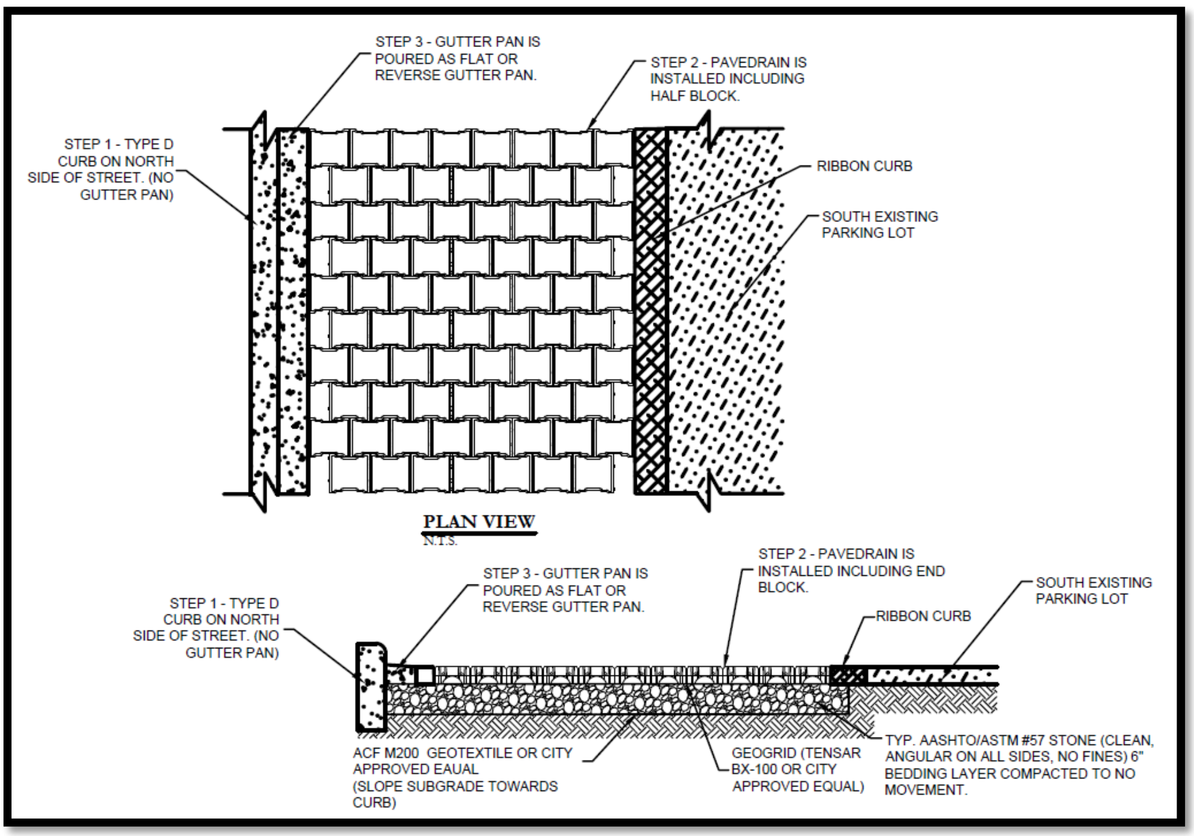


Figure 5-1: Permeable Pavement Details (Geosyntec, 2021)

Pervious/permeable pavement costs can range from $8.00-$15/ft (Geosyntec Consultants, 2013). It is noted that this cost includes pervious and permeable pavements as well as systems with and with-out an underdrain. To normalize the costs of these kinds of LID practices, cost benefit data was referenced to determine the cost per pound of pollutant removed for each practice. For this practice a cost benefit of was determined to be $11,345.00 per pound of TP removed. Compared to other practices examined in this manual, the cost was considered high. Regular annual maintenance costs are around $250 and infrequent maintenance costs are around $600 annually, according to the WERF Whole-Life Cost Tool. Examples of regular maintenance include periodic vacuum sweeping of the pavement surface. Compared to the other practices examined in this memorandum, the maintenance cost is considered to be low. It is noted that since the maintenance cost data was based on projects from across the Country, this includes both systems with and without an underdrain.

5.1.1.2 Practice Applicability

Based on the design flexibility of these systems to incorporate an underdrain or not, pervious/permeable pavements are considered suitable for use in all areas regardless of soils and/or groundwater conditions. They are also suitable for all land use/cover applications in both urban and suburban/rural applications. The lifecycle of pervious/permeable pavement systems that are properly maintained is typically greater than 20 years.

Because the pores are prone to clogging, pervious/permeable pavements should not be used for sediment removal. Areas with high traffic volume or areas with the potential for high wheel sheer should not be considered for this practice due to the high clogging potential. It can be used in both residential and non-residential areas with a low volume and low speed roadways. It is also well suited for both walkways or bike lanes.

5.1.1.3 Water Quantity Characteristics

While pervious/permeable pavement systems will likely not provide sufficient storage to meet flood control requirements, the volume provided in the pavement system will help offset the additional flood control volume that must be provided. Credits can be taken for the storage volume that these systems provide, in accordance with the appropriate water management district ERP guidance.

5.1.1.4 Water Quality Characteristics

Incorporation of pervious/permeable pavements on a site can result in a water quality benefit. Stormwater that is captured and infiltrated results in reduced stormwater volume, and thus mass of pollutants discharged to downstream receiving waterbodies. It is noted that when used in karst geologies, a Biosorption Activated Media (BAM) layer can be incorporated to provide additional nitrate removal via biological processes, i.e., denitrification. It is noted that, due to clogging potential, this practice is not recommended to be used for removal of sediment or other coarse particulate in stormwater (Geosyntec Consultants, 2014). BMPTrains should be used to assess the water quality benefits of this system based on the specifications needed.

5.1.1.5 Operation and Maintenance

To ensure that the pervious/permeable pavement continues operating as intended, it is necessary to perform regular maintenance activities. Sediments and organic material blown or tracked onto these pavements can result in reduced infiltration capacity and water storage capacity. Thus, these systems require vacuum sweeping and management of adjacent areas to limit the sediment buildup in the pores. This should be done annually and on an as-needed basis to ensure that the pavement is functioning as intended. Installation of embedded ring infiltrometer kits (ERIK) devices provides for a means to monitor their long-term performance. These ERIK devices install a 6-inch diameter pipe into the pavement during the time of construction which can be retested over the life of the pavement. These can be used as a maintenance indicator, so maintenance is being performed when required. Additionally, inspection of the pavement system after significant rainfall events can provide insight as to the system performance. If standing water is not quickly infiltrated, maintenance may be required. Also, ASTM standards for pervious concrete (C1701) and permeable pavers (C1781) are methods to measure infiltration at any location on a pavement surface.

5.1.2 Bioretention Swales

In this section, a brief background of bioretention swales is discussed, identifying the major components of this practice, how it is constructed, how it functions, and the applicability of the practice. Additionally, water quality and quantity characteristics, as well as operation and maintenance needs are addressed.

5.1.2.1 Background on Bioretention Swales

Bioretention Swales are an LID practice that consists of swales designed to be wider, baffles to increase the flow path length, incorporate native vegetation to provide nutrient uptake and filtration, and sometimes swale blocks to hold volume for infiltration. Bioretention swales can be incorporated in many settings including within medians or road rights-of-way (**Figure 5-2**), on parking islands or around parking lots, in residential or commercial areas along roadways, or other locations where stormwater drains to pervious areas. Multiple bioretention swales can be used in tandem to treat multiple areas as part of a treatment train, or in tandem with other LID practices.

Typical cost for a bioretention swale is $8-$10 per linear foot (Geosyntec Consultants, 2013). To normalize the costs of these kinds of practices, the cost benefit data was referenced to determine the cost per pound of pollutant removed for each practice. For this practice a cost benefit of $7,709.57/lb TP was determined. Compared to other practices examined in this manual, the cost is considered to be high. It is noted that special training of maintenance staff is necessary to ensure that these systems are properly maintained. These costs are around $527 for regular maintenance activities and $360 for infrequent maintenance, according to WERF Whole-Life Tool. Examples of regular maintenance include weeding/removal of undesirable plants, and other activities associated with typical landscape maintenance. The maintenance cost is considered high relative to the other practices examined in this manual.

Figure 5-2: Bioretention Swale within Casselton Road right-of-way in Casselberry, FL (Geosyntec, 2017)

5.1.2.2 Practice Applicability

Bioretention swales are suitable for use in areas with good infiltrating, well-drained soils, and in both urban and suburban/rural applications. Bioretention swales are versatile and may be used in residential and non-residential areas, as well as parking lots, along street edges, and areas that catch rooftop runoff.

5.1.2.3 Water Quantity Characteristics

Due to the extra volume that bioretention swales provide, they have a high potential to reduce stormwater volume and peak flow rate. Credits can be taken for the storage volume that these systems provide, in accordance with the appropriate water management district ERP guidance.

5.1.2.4 Water Quality Characteristics

Incorporation of bioretention swales on a site can result in a water quality benefit. This improvement is achieved through volume reduction, filtration, biological uptake, and sedimentation from the vegetation and engineered media. BMPTrains should be used to assess the water quality benefits of this system based on the specifications needed.

5.1.2.5 Operation and Maintenance

To ensure that the bioswale continues operating as intended, it is necessary to perform regular maintenance activities. Maintenance associated with this practice consists of weeding/removal of undesirable plants, inspecting for ponding water, sediment accumulation, erosion, invasive plants, and checked inlets and outlets to make sure they are free of debris. It is noted that special training of maintenance staff is necessary to ensure that these systems are properly maintained. Bioretention swales should occasionally be checked to ensure they are meeting storage recovery within the permitted time. The lifecycle of properly maintained bioretention swales is typically greater than 20 years.

5.1.3 Bioretention/Rain Gardens

In this section, a brief background of bioretention/rain gardens is discussed, identifying the major components of this practice, how it is constructed, how it functions, and the applicability of the practice. Additionally, water quality and quantity characteristics, as well as operation and maintenance needs are addressed. It is noted that bioretention/rain gardens will be referred to throughout as bioretention systems.

5.1.3.1 Background on Rain Gardens

Bioretention/Rain gardens are an LID practice that consists of a designed depressional storage area filled with BAM and native vegetation that is intended to capture and treat stormwater, as shown in **Figure 5-3**. These practices are intended to provide volume reduction and filtration/biofiltration to achieve stormwater quality improvement. It is noted that these systems can be designed with an underdrain or without one, depending on the soil and groundwater conditions at the site. Systems with an underdrain will experience minimal volume reduction and most of the water quality benefit will be realized through filtration/biofiltration processes. Additionally, plant selection should be done to consider potential root issues with the underdrain pipes, which could result in added maintenance costs or early system replacement. It is noted that for systems implemented in karst geologic regions, an additional soil amendment can be incorporated to provide nitrate removal of water infiltrating to the surficial aquifer. The water quality performance of systems without an underdrain will be dominated by volume reduction rather than filtration/biofiltration.

The cost associated with bioretention can range from \$5.00-\$35.00/ft^2 (Geosyntec, Stormwater Best Management Practices: Guidance Document, 2013). Cost can also be dependent on complexity of the application (Rutgers, 2022). To normalize the costs of this LID practice, the cost benefit data was referenced to determine the cost per pound of pollutant removed for each practice. For this practice a cost benefit of \$5,024.33/lb TP was determined. Compared to other practices examined in this manual, the cost was considered low. Regular annual maintenance costs are around \$72 and infrequent maintenance costs are around \$156, according to WERF Whole-Life Tool. Maintenance associated with these practices consists of weeding/removal of undesirable plants, and other activities associated with typical landscape maintenance. Special training of maintenance staff is necessary to ensure that these systems are properly maintained. Compared to the other practices examined in this memorandum, the maintenance cost is considered to be high.

Figure 5-3: Bioretention Rain Garden in City of Winter Park, FL (Geosyntec, 2016)

5.1.3.2 Practice Applicability

Based on the design flexibility of these systems to incorporate an underdrain or not, these practices are considered suitable for use in all areas regardless of soil and groundwater conditions in both urban and suburban/rural applications. They are also suitable for all land use/cover applications. Rain gardens can be implemented in parking areas, driveways, sidewalks, walking paths, and rooftops in both residential and commercial/office areas.

5.1.3.3 Water Quantity Characteristics

While bioretention systems will likely not provide sufficient storage to meet flood control requirements, the volume provided from the bioretention systems will help offset the additional flood control volume that must be provided. Credits can be taken for the storage volume that these systems provide, in accordance with the appropriate water management district ERP guidance.

The volume reduction occurs via vegetation interception, infiltration, and soil storage which results in a reduction of discharges to downstream receiving waterbodies. Bioretention systems reduce stormwater volume and peak flow rates.

5.1.3.4 Water Quality Characteristics

Incorporation of bioretention systems on a site can result in a water quality benefit. The filtration/biofiltration occurs as the stormwater moves through the BAM via physical and biological processes, including plant uptake. Bioretention systems are highly effective at removing sediment and heavy metals and are moderately effective at removing nutrients from stormwater runoff (Geosyntec, 2014). BMPTrains should be used to assess the water quality benefits of this system based on the specifications needed.

5.1.3.5 Operation and Maintenance

To ensure that the bioretention system continues operating as intended, it is necessary to perform regular maintenance activities. Maintenance associated with these practices consists of weeding/removal of undesirable plants, limiting washout and erosion, and other activities associated with typical landscape maintenance. Special training of maintenance staff is necessary to ensure that these systems are properly maintained. Typical designs for this practice typically target a lifecycle of 20 years or longer.

5.1.4 Planter Boxes

In this section, a brief background of planter boxes is discussed, identifying the major components of this practice, how it is constructed, how it functions, and the applicability of the practice. Additionally, water quality and quantity characteristics, as well as operation and maintenance needs are addressed.

5.1.4.1 Background on Planter Box

Infiltration Planter Box is an LID practice that consists of a concrete structure filled with BAM and native vegetation. **Figure 5-4** shows an example of a planter box with native vegetation. These practices are intended to provide volume reduction and filtration/biofiltration to achieve stormwater quality improvement. It is noted that these systems can be designed with an underdrain or without one, depending on the soil and groundwater conditions at the site. Systems with an underdrain will experience minimal volume reduction and most of the water quality benefit will be realized through filtration/biofiltration processes. Additionally, plant selection should be done to consider potential root issues with the underdrain pipes, which could result in added maintenance costs or early system replacement.

Typical capital cost associated with infiltration planter boxes is \$24-\$32/ft^2 (Geosyntec, Stormwater Best Management Practices: Guidance Document, 2013) but will depend on variables such as size and plant types used. To normalize the costs of this practice, the cost benefit data was referenced to determine the cost per pound of pollutant removed for each practice. For infiltration planter boxes a cost benefit of \$5,024.33/lb TP was determined. Compared to other practices examined in this manual, the cost was considered low. Regular annual maintenance costs are around \$310 and infrequent maintenance costs are around \$145 annually, according to the WERF Whole-Life Cost Tool. Examples of regular maintenance include weeding/removal of undesirable plants, and other activities associated with typical landscape maintenance. Compared to the other practices examined in this memorandum, the maintenance cost is considered to be high.

Figure 5-4: Urban Designed Infiltration Planter Box (Geosyntec, 2021)

5.1.4.2 Practice Applicability

Based on the design flexibility of these systems to incorporate an underdrain or not, these practices are considered suitable for use in all areas regardless of soils and groundwater conditions in both urban and suburban/rural applications. They are also suitable for all land use/cover applications.

5.1.4.3 Water Quantity Characteristics

While planter boxes will likely not provide sufficient storage to meet flood control requirements, the volume provided in the system will help offset the additional flood control volume that must be provided. Some volume reduction occurs via vegetation interception, infiltration, and soil storage which results in a reduction of discharges to downstream receiving waterbodies. Credits can be taken for the storage volume that these systems provide, in accordance with the appropriate water management district ERP guidance.

5.1.4.4 Water Quality Characteristics

Incorporation of planter boxes on a site can result in a water quality benefit. The filtration/biofiltration occurs as the stormwater moves through the BAM via physical and biological processes, including plant uptake. The water quality performance of systems without an underdrain will be dominated by volume reduction rather than filtration/biofiltration. Planter boxes have moderate removal efficiencies for nutrients and high removal efficiencies for sediment, bacteria, and heavy metals (Geosyntec, 2014). BMPTrains should be used to assess the water quality benefits of this system based on the specifications needed.

5.1.4.5 Operation and Maintenance

To ensure that the planter box continues operating as intended, it is necessary to perform regular maintenance activities. Maintenance associated with these practices consists of weeding/removal of undesirable plants, and other activities associated with typical landscape maintenance. Special training of maintenance staff is necessary to ensure that these systems are properly maintained. The lifecycle of this practice is not expected to reach 20 years.

5.1.5 Tree Box Filters

In this section, a brief background of tree box filters is discussed, identifying the major components of this practice, how it is constructed, how it functions, and the applicability of the practice. Additionally, water quality and quantity characteristics, as well as operation and maintenance needs are addressed.

5.1.5.1 Background on Tree Box Filters

Tree Box Filters are an LID practice that consist of a concrete structure that has sufficient space to allow for the mature tree rootball. This structure can be filled with BAM and vegetation, e.g., trees and native vegetation, and is intended to replace gray infrastructure such as inlets. These practices are intended to provide volume reduction and filtration/biofiltration to achieve stormwater quality improvement. **Figure 5-5** shows an example of a tree box filter. There are several types of tree box filters but for the purposes of this manual, when discussing tree box filters, it means a concrete system with media and a tree. With these kind of contained systems root barriers do not typically need to be used. However, using a system such as these that provide limited space for the tree roots may result in needing more frequent tree replacements and tree selection is limited. It is noted that these systems can only be designed with an underdrain since the concrete box will be closed on the sides and bottom. This makes implementation of the tree box filter system independent of the soil and groundwater conditions at the site. Systems such as these, with an underdrain, will experience minimal volume reduction and most of the water quality benefit will be realized through filtration/biofiltration processes. Additionally, plant selection should be done to consider potential root issues with the underdrain pipes, which could result in added maintenance costs or early system replacement.

Tree box filters have a capital cost that can range from $10,000 to $18,000 (Geosyntec Consultants, 2013; Geosyntec Consultants, 2020). To normalize the costs of these kinds of practices, the cost benefit data was referenced to determine the cost per pound of pollutant removed for each practice. For this practice a cost benefit of $3,156.04/lb TP was determined. Compared to other practices examined in this manual, the cost was considered low. Regular annual maintenance costs range from $100-$500 per box unit, according to the WERF Whole-Life Cost Tool. Examples of regular maintenance include weeding/removal of undesirable plants, and other activities associated with typical landscape maintenance. Special training of maintenance staff is necessary to ensure that these systems are properly maintained. Compared to the other practices examined in this memorandum, the maintenance cost is considered to be high.

Figure 5-5. Urban Designed Tree Box Filter

5.1.5.2 Practice Applicability

Based on the design of contained tree box filters, these practices are considered suitable for use in all areas regardless of soils and groundwater conditions. They are also suitable for all land use/cover applications in both urban, suburban/rural applications. The lifecycle of tree box filters is expected to reach 20 years.

Tree box filters can be used in parking areas, street edges, sidewalks, and walking paths in both residential and non-residential/commercial areas. Since these systems have an underdrain, a BAM layer needs to be incorporated so it can provide nutrient removal prior to going into the underdrain and offsite.

5.1.5.3 Water Quantity Characteristics

While tree box filters will likely not provide sufficient storage to meet flood control requirements, the volume provided in the tree box filter system will help offset the additional flood control volume that must be provided. Some volume reduction occurs via tree/vegetation interception, infiltration, and soil storage which results in a reduction of discharges to downstream receiving waterbodies. Credits can be taken for the storage volume that these systems provide in accordance with the appropriate water management district ERP guidance.

5.1.5.4 Water Quality Characteristics

Incorporation of tree box filters on a site can result in a water quality benefit. The filtration/biofiltration occurs as the stormwater moves through the BAM via physical and biological processes, including plant uptake. BMPTrains should be used to assess the water quality benefits of this system based on the specifications needed.

5.1.5.5 Operation and Maintenance

To ensure that the tree box filter continues operating as intended, it is necessary to perform regular maintenance activities. Maintenance associated with these practices consists of weeding/removal of undesirable plants, and other activities associated with typical landscape maintenance. Special training of maintenance staff is necessary to ensure that these systems are properly maintained and operating as intended by making sure stormwater is infiltrating properly into the tree box filter. Removal of debris and undesired vegetation should be done on a regular basis.

5.1.6 Stormwater and Rainwater Harvesting

In this section, a brief background of stormwater and rainwater harvesting is discussed, identifying the major components of this practice, how it is constructed, how it functions, and the applicability of the practice. Additionally, water quality and quantity characteristics, as well as and operation and maintenance needs are addressed.

5.1.6.1 Components of Stormwater Harvesting Systems

Stormwater & Rainwater Harvesting is an LID practice which consists of capturing stormwater and using it for non-potable applications such as irrigation, equipment washing, spray trucks, or toilet flushing. It is noted that if reclaimed water is available in an area, it should be considered prior to stormwater and rainwater harvesting. Stormwater harvesting is typically associated with capture of stormwater from a larger, diverse watershed, usually using either a new or existing wet detention pond. Rainwater harvesting is typically associated with capture of rainwater from a rooftop. **Figure 5-6** shows rooftop rainwater harvesting flowing to an underground storage system, where harvested water is pumped out for reuse. Water captured from rainwater harvesting is typically of a higher quality than stormwater since roof tops are typically cleaner than paved surfaces, this is especially true if there is no overhanging tree branches.

Stormwater harvesting cost can range from $1-$4/gal of storage, for a cistern, and $60 to $100 for individual rain barrels (Geosyntec, Stormwater Best Management Practices: Guidance Document, 2013). Additional cost could be incurred depending on the complexity and if pretreatment of water is necessary for the harvesting application. To normalize the costs of these kinds of practices, cost benefit data was referenced to determine the cost per pound of pollutant removed for each practice. For this practice a cost benefit of $570.04/lb TP was determined. Compared to other practices examined in this manual, the cost was considered low. Maintenance associated with this practice will vary depending on the quality of stormwater/rainwater harvested and the harvesting application. The following factors are likely to require more frequent maintenance activities: lower water quality of harvested water, incorporation of system controls/monitoring equipment, the required quality of harvested water for the intended application, and incorporation of pumping systems. Regular annual maintenance costs are around $1,000 and infrequent maintenance costs are around $300 annually, according to the WERF Whole-Life Cost Tool.

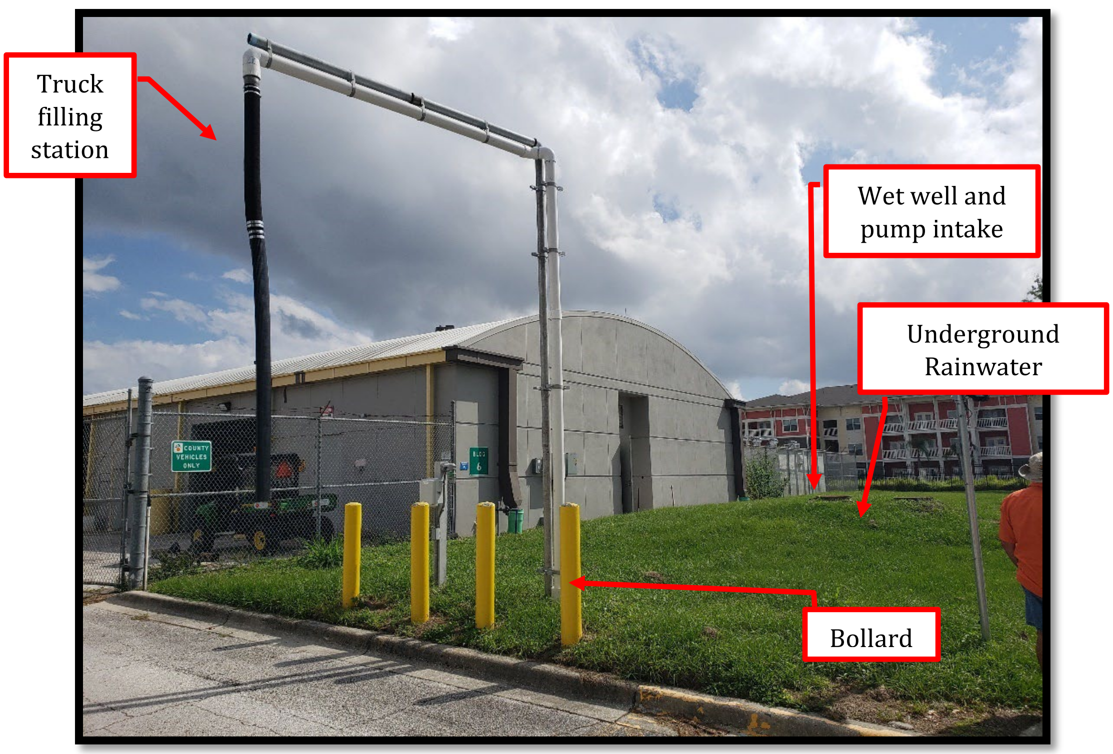


Figure 5-6: Active Rooftop Rainwater Harvesting System in Orange County, FL (Geosyntec, 2019)

5.1.6.2 Practice Applicability

Stormwater and rainwater harvesting is suitable for use in all areas regardless of soils and groundwater conditions. They are also suitable for all land use/cover applications and in both urban and suburban/rural applications. Water storage systems used by these practices are generally designed for a 20-year or longer life expectancy.

It is noted that, since it is not practical for inspection of residential applications to ensure proper use of water and maintenance of systems is being done, that no credits are provided for residential applications. Based on this, stormwater and rainwater harvesting as presented in this manual is for non-residential applications.

5.1.6.3 Water Quantity Characteristics

Stormwater harvesting systems are volume-based and provide peak flow rate and runoff volume reduction depending on re-use of stored stormwater between rain events. When the cistern or rain barrel contains enough storage volume to fully capture runoff from storms, runoff during wet weather events may be eliminated. However, if stored stormwater is not used between events and the cistern or rain barrel is full at the beginning of the storm, the stormwater harvesting system will act as a flow-through device, providing minimal volume or peak flow rate reduction, if any. The performance of a stormwater harvesting system is heavily dependent of the re-use of stored stormwater between rainfall events.

5.1.6.4 Water Quality Characteristics

Stormwater harvesting systems as stand-alone practices do not provide water quality treatment; however, they do provide pollutant load reductions through volume reductions. In order to provide volume reductions, the stored stormwater runoff must be used between rainfall events. The decrease in nutrient load reductions will be proportional to the decrease in stormwater volumes. BMPTrains should be used to assess the water quality benefits of this system based on the specifications needed.

5.1.6.5 Operation and Maintenance

To ensure that the stormwater and rainwater harvesting system continues operating as intended, it is necessary to perform regular maintenance activities. Maintenance associated with these stormwater harvesting systems will vary depending on the quality of the stormwater/rainwater harvested and the harvesting application. The following factors are likely to require more frequent maintenance activities: lower water quality of harvested water, incorporation of system controls/monitoring equipment, the required quality of harvested water for the intended application, and incorporation of pumping systems. Debris removal from inlet screens may be periodically necessary.

5.1.7 Filtration with BAM

In this section, a brief background of filtration with BAM is discussed, identifying the major components of this practice, how it is constructed, how it functions, and the applicability of the practice. Additionally, water quality and quantity characteristics, as well as and operation and maintenance needs are addressed.

5.1.7.1 Background on BAM

BAM Enhancements are an LID practice where BAM filter media is placed in the bottom of traditional retention practices, such as dry retention ponds. It is noted that BAM refers to a class of filter media that promotes biofilm growth and leverages biological processes to remove nitrogen and phosphorus species. This media can range from coarser media, intended for higher flow capacity, to finer media that is intended for use in the bottom of retention/infiltrating LID practices. For the purposes of this manual, BAM is assumed to be the finer media. This BAM is engineered in a way that optimizes the soil texture to maintain soil moisture which facilitates conditions that allow for denitrification to occur. **Figure 5-7** illustrates a BAM design concept. This practice is typically used in areas with karst geologies or near surface waterbodies where migration of nitrate in the surficial aquifer is a concern. However, BAM can also be used to enhance several different kinds of LID practices or be used in conjunction with other practices to create a treatment train.

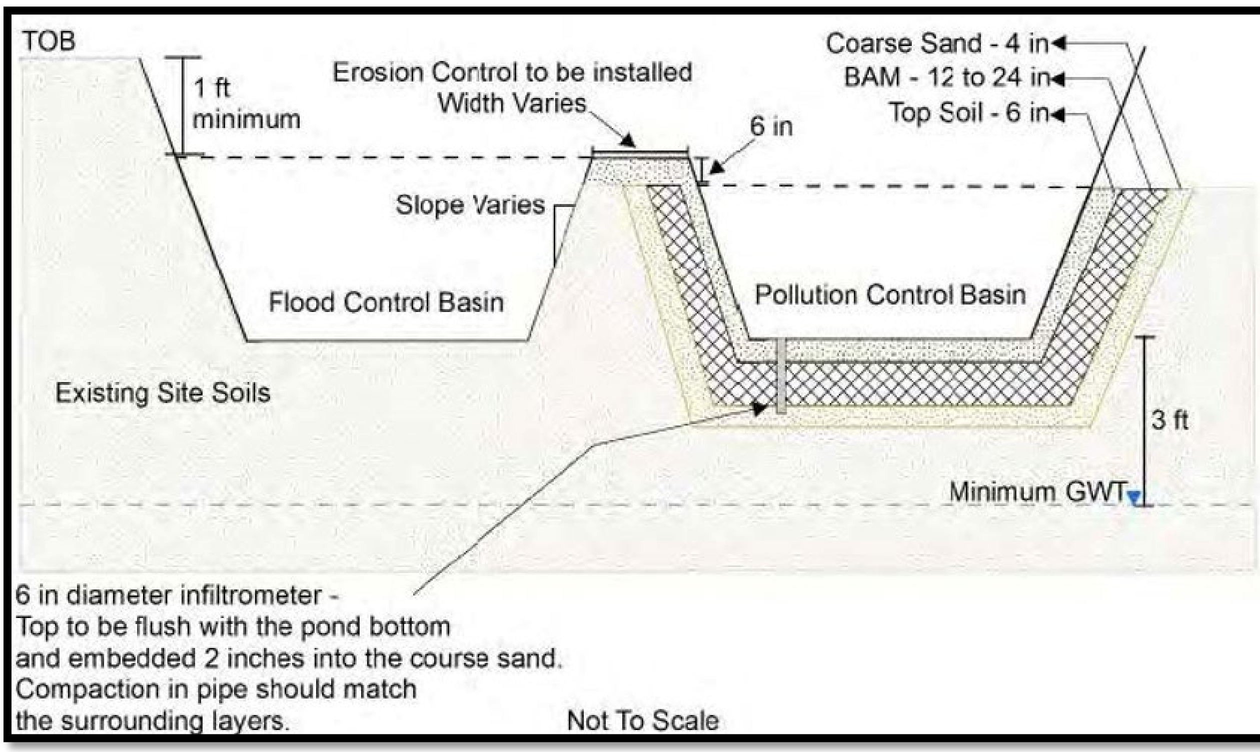


Figure 5-7. Design Details of Biosorption Activated Media System (Geosyntec, 2017)

BAM enhancement cost is dependent on several factors; however, typical cost can range from \$30-\$100/ft^3 of media (FRTR, 2020). To normalize the costs of these kinds of practices the cost benefit data was referenced to determine the cost per pound of pollutant removed for each practice, specifically TP. For this practice a cost benefit of \$6,890.60/lb TP was determined, and compared to other practices examined in this manual, the cost was considered high.

Filtration/biofiltration systems with BAM are LID practices that consist of the use of an engineered filter media to filter stormwater for solids removal and promote the growth of biofilms which provide biological treatment of nutrients leveraging the nitrogen cycle. Additionally, removal occurs through adsorption of phosphate species to the media. **Figure 5-8** illustrates a conceptual design of a biofiltration system with BAM. As stated previously, these systems are diverse in their design and applications and can consist of stand-alone upflow/downflow filters or upflow/downflow filters associated with another LID practice such as a wet detention pond or baffle box.

The capital cost for filtration/biofiltration systems with BAM is dependent on the size, media used, and other variables. Based on feedback from the product vendor, the typical cost ranges from \$550-\$850/ft^2. To normalize the costs of these kinds of practices the cost benefit data was referenced to determine the cost per pound of pollutant removed for each practice. For this practice a cost benefit of \$4,398.22/lb TP was determined. The cost of this practice was determined to be low. The maintenance associated with this practice is consistent with typical maintenance associated with retention ponds with the exception that this practice will also require periodic infiltration testing to ensure appropriate infiltration rates and inspection of the divider berm for erosion.

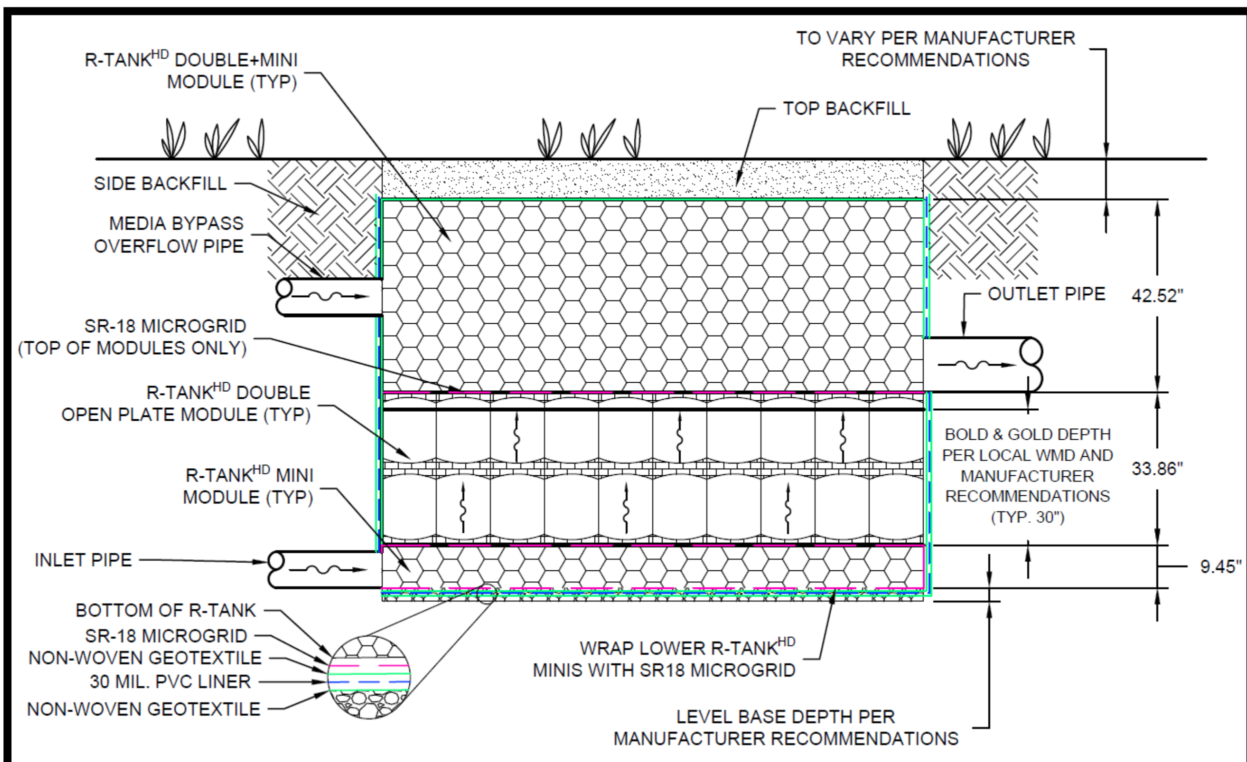


Figure 5-8: Biofiltration System with BAM Detail (Geosyntec, 2019)

5.1.7.2 Practice Applicability

BAM enhancement LID practices are suitable for use in areas with good infiltrating, well drained soils and in both urban and suburban/rural applications. Additionally, BAM can be used in conjunction with other LID practices that have underdrains to provide some treatment before collection in the underdrain and discharge. They are also suitable for all land use/cover applications in both urban and suburban/rural applications.

5.1.7.3 Water Quantity Characteristics

Biofiltration systems with BAM are designed primarily to address stormwater quality, thus, they will likely not provide sufficient storage to meet flood control requirements. No significant volume reduction is expected with this practice.

5.1.7.4 Water Quality Characteristics

Incorporation of biofiltration systems with BAM on a site can result in a water quality benefit. Biofiltration systems with BAM provide a high water quality reduction for both nitrogen and phosphorus through physical and biological processes. BMPTrains should be used to assess the water quality benefits of this system based on the specifications needed.

5.1.7.5 Operation and Maintenance

To minimize maintenance efforts, it is recommended that pretreatment, such as nutrient separating baffle boxes or inlet baskets, be provided to remove larger solids/debris. Maintenance activities associated with BAM enhancements consists of periodic inspection of the filter media for clogging or other issues and replacement when the media gets clogged, or the phosphorus sorption capacity has been exhausted. Vegetation should be inspected and replaced if determined to not be healthy, and invasives and debris should be removed. Therefore, the maintenance cost for this practice is associated with media replacement, which depending on the specific design, could last 20 years or longer. It is noted that site conditions must be taken into consideration and appropriate pre-treatment provided if warranted to minimize particulate and gross solids loading which could shorten the media life.

5.1.8 Green Roof

In this section, a brief background of green roofs is discussed, identifying the major components of this practice, how it is constructed, how it functions, and the applicability of the practice. Additionally, water quality and quantity characteristics, as well as and operation and maintenance needs are addressed.

5.1.8.1 Background on Green Roofs

Green Roofs are an LID practice that incorporate a specialized growth media, plants, and a cistern to capture runoff and irrigate a roof. This practice replaces an impervious surface, a rooftop, with a pervious surface (**Figure 5-9**). Green roofs capture, store, and attenuate rainfall to reduce the volume of stormwater and decrease the peak discharge rate. Incorporation of a cistern to capture runoff from the green roof and reuse it for irrigation of the roof further reduces the volume of stormwater runoff. The primary water quality benefit provided by green roofs is a function of stormwater volume reduction, however the plants and media will also filter out pollutants.

The cost for green roofs can be high. Average cost, per ft^2, can range from $20-$30 (EPA, 2020; Geosyntec, Stormwater Best Management Practices: Guidance Document, 2013), or more, depending on the specific design. It is noted that green roofs can require additional engineering and design considerations that include structural enhancements and safety features. Additionally, there may be a need for building code updates to accommodate design features that green roofs require. To normalize the costs of these kinds of practices, cost benefit data was referenced to determine the cost per pound of pollutant removed for each practice. For this practice a cost benefit of $7,301.71/lb TP was determined. Compared to other practices examined in this manual, the cost was considered high. Regular annual maintenance costs are around $4,120 and infrequent maintenance costs are around $2,500 annually, according to the WERF Whole-Life Cost Tool. Maintenance associated with a green roof is higher than most LID practices as there are several components that require frequent attention, specifically weeding/removal of undesirable plants, inspection of waterproof membrane, testing and inspection of the irrigation system, and periodic cleaning of the cistern. Compared to the other practices examined in this memorandum, the maintenance cost is considered to be high.

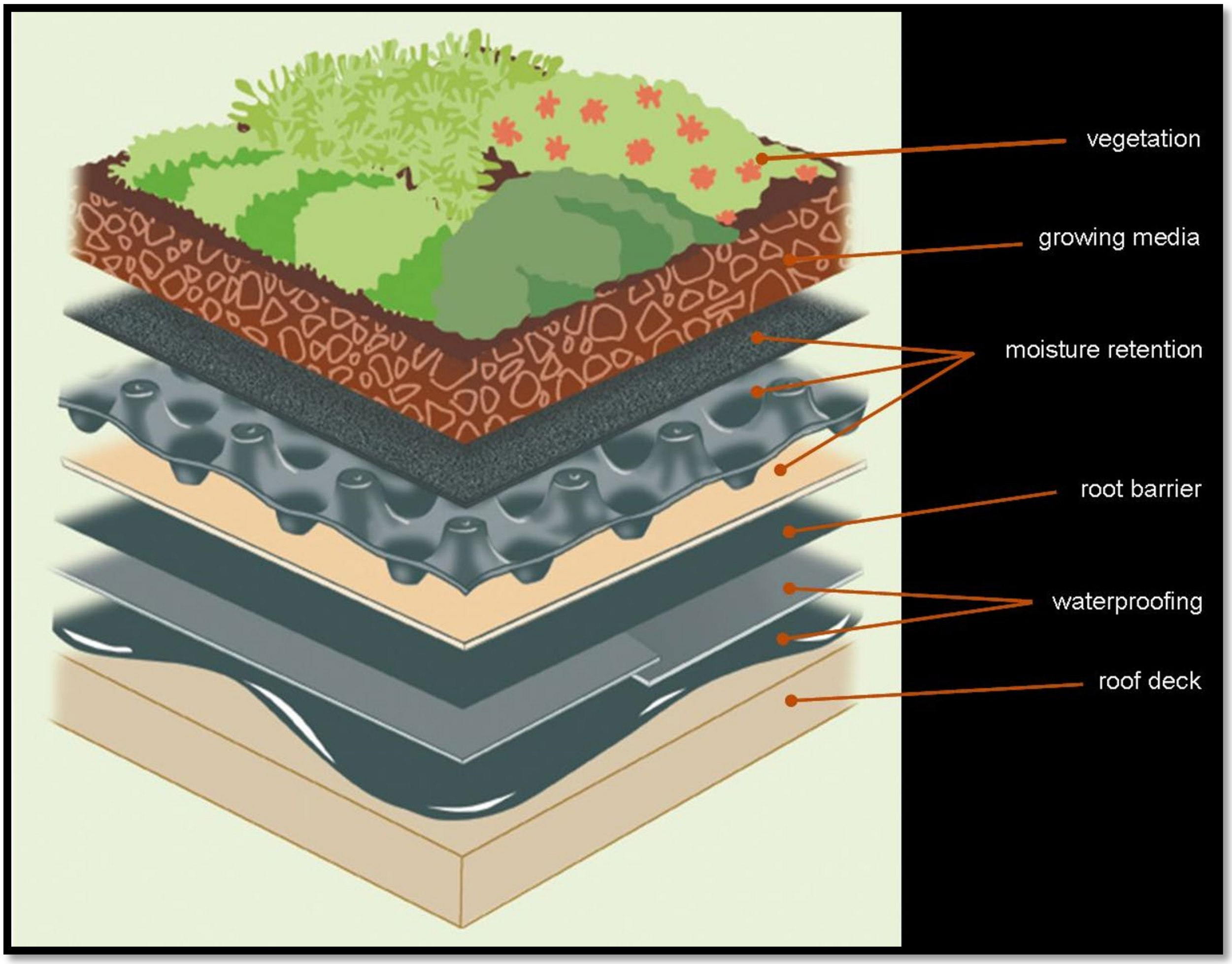


Figure 5-9: Green Roof Schematic (Geosyntec, 2017)

5.1.8.2 Practice Applicability

Green roofs are suitable for use in all areas regardless of soils and groundwater conditions. They are also suitable for all land use/cover applications but are more commonly used in an urban setting.

5.1.8.3 Water Quantity Characteristics

While green roofs will likely not provide sufficient storage to meet flood control requirements, the volume provided from the green roofs will help offset the additional flood control volume that must be provided. Greens roofs may reduce the peak discharge rate of stormwater. Credits can be taken for the storage volume that these systems provide, in accordance with the appropriate water management district ERP guidance.

5.1.8.4 Water Quality Characteristics

Incorporation of bioretention swales on a site can result in a water quality benefit. While the primary water quality benefit provided by green roofs is volume reduction, the plants and media will also filter out pollutants. BMPTrains should be used to assess the water quality benefits of this system based on the specifications needed.

5.1.8.5 Operation and Maintenance

To ensure that the green roof continues operating as intended, it is necessary to perform regular maintenance activities. Maintenance associated with a green roof is higher than most LID practices as there are several components that require frequent attention, specifically weeding/removal of undesirable plants, inspection of waterproof membrane, testing and inspection of the irrigation system, and periodic cleaning of the cistern. With proper maintenance, the lifecycle of a green roof will exceed 20 years.

5.1.9 Underground Storage and Exfiltration

In this section, a brief background of underground storage and exfiltration is discussed, identifying the major components of this practice, how it is constructed, how it functions, and the applicability of the practice. Additionally, water quality and quantity characteristics, as well as and operation and maintenance needs are addressed.

5.1.9.1 Background on Underground Storage and Exfiltration

Underground Storage and Exfiltration is a more traditional LID practice that leverages storage systems to store and infiltrate water into the ground to achieve volume reduction and water quality improvement, (**Figure 5-10**). Stormwater that is infiltrated results in reduced stormwater volume discharged to downstream receiving waterbodies. The benefit of these underground systems is that they can be put in most locations, including under parking lots or other site features, thus requiring less land for other stormwater infrastructure, such as ponds. It is noted that exfiltration systems are not appropriate for areas with high groundwater conditions, as they require a minimum of 2 ft above the seasonal high groundwater table, but underground storage can be used provided the system is appropriately anchored to resist any buoyant forces.

The capital cost for underground storage and exfiltration practices is typically $4.00/ft^3 (Schueler, 1997) to $8.90/ft^3 (Geosyntec, 2017). To normalize the costs of these kinds of practices the cost benefit data was referenced to determine the cost per pound of pollutant removed for each practice. For this practice a cost benefit of $2,966.98/lb TP was determined. Compared to other practices examined in this manual, the cost was considered low. Maintenance associated with these practices typically consists of vacuuming out the isolator row periodically and is considered to be low relative to other practices examined in this manual.

Figure 5-10: Underground Storage Exfiltration in Cape Canaveral, FL (Geosyntec, 2017)

5.1.9.2 Practice Applicability

Underground storage and exfiltration practices are suitable for use in areas with good infiltrating, well drained soils and in both urban and suburban/rural applications.

5.1.9.3 Water Quantity Characteristics

There is a high volume reduction potential when using underground storage. Credits can be taken for the storage volume that these systems provide, in accordance with the appropriate water management district ERP guidance.

5.1.9.4 Water Quality Characteristics

Incorporation of bioretention swales on a site can result in a water quality benefit. There is a high pollutant removal potential for all pollutants. BMPTrains should be used to assess the water quality benefits of this system based on the specifications needed.

5.1.9.5 Operation and Maintenance

To ensure that the underground storage exfiltration system continues operating as intended, it is necessary to perform regular maintenance activities. Maintenance associated with these practices typically consists of vacuuming out the isolator row periodically and is low. After large rain events, trash and debris should be removed from the up-gradient sediment/trash removal devices to promote proper function of the system. System failures are generally the result of inadequate/improper O&M procedures within the up-gradient sediment/trash removal devices, and/or within the underground retention system itself (Pinellas County, 2021). Typical designs for this practice are intended to have a lifecycle of 20 years or longer.

5.1.10 Vegetated Buffer Strip

In this section, a brief background of vegetated buffer strips (VBS) is discussed, identifying the major components of this practice, how it is constructed, how it functions, and the applicability of the practice. Additionally, water quality and quantity characteristics, as well as and operation and maintenance needs are addressed.

5.1.10.1 Background on Vegetated Buffer Strips

Vegetated Buffer Strip (VBS) is an LID practice that consists of providing a strip of vegetation adjacent to an impervious surface, typically a roadway, to infiltrate and filter stormwater generated from the impervious surface. **Figure 5-11** illustrates a vegetated buffer strip adjacent to a roadway. These systems typically incorporate sod and BAM to maximize infiltration and biological uptake.

VBS cost will vary greatly but is estimated at $50 to $100 per linear foot (Geosyntec, Stormwater Best Management Practices: Guidance Document, 2013). To normalize the costs of these kinds of practices, cost benefit data was referenced to determine the cost per pound of pollutant removed for each practice. For this practice a cost benefit of $5,024.33/lb TP was determined. Compared to other practices examined in this manual, the cost was considered high. Maintenance associated with this practice is minimal and requires only periodic infiltration testing to ensure appropriate infiltration rates.

5.1.10.2 Practice Applicability

VBSs are suitable for use in areas with good infiltrating, well drained soils and in both urban and suburban/rural applications.

Figure 5-11: Vegetated Buffer Strip (Geosyntec, 2022)

5.1.10.3 Water Quantity Characteristics

While VBSs will likely not provide sufficient storage to meet flood control requirements, the volume provided from the VBS will help offset the additional flood control volume that must be provided. Credits can be taken for the storage volume that these systems provide, in accordance with the appropriate water management district ERP guidance.

5.1.10.4 Water Quality Characteristics

Incorporation of VBSs on a site can result in a water quality benefit. Water quality improvement is achieved via filtration/biofiltration. BMPTrains should be used to assess the water quality benefits of this system based on the specifications needed.

5.1.10.5 Operation and Maintenance

To ensure that the VBS operating as intended, it is necessary to perform regular maintenance activities. Maintenance associated with this practice is minimal and requires periodic infiltration testing to ensure appropriate infiltration rates. VBSs should be inspected after major storms to ensure there is no debris accumulation or erosion occurring. The health of vegetation should also be inspected periodically and any invasives should be removed immediately. The lifecycle of this practice is expected to surpass 20 years.

5.1.11 Street Sweeping

In this section, a brief background of street sweeping is discussed, identifying the major components of this practice, how it is constructed, how it functions, and the applicability of the practice. Additionally, water quality and quantity characteristics, as well as and operation and maintenance needs are addressed.

5.1.11.1 Background on Street Sweeping

Street Sweeping and storm drain cleanout practices are common LID practices used by local governments. More recently they have been used to comply with National Pollutant Discharge Elimination System stormwater permits. **Figure 5-12** shows a common vacuum street sweeper.

Street sweeping is done in urban and suburban areas where there is a higher potential for street debris containing a high amount of organic matter, such as streets with dense tree canopy cover. Street sweeping is done by sweeping trucks equipped with brooms and vacuum fans to pick up sediment, rocks, leaves, and other debris. The material collected can be combined with sediment from catch basins or treatment ponds for disposal. Small amounts of metals picked up during street sweeping can be disposed of in Class I or II landfills or waste-to-energy facilities, or Class III landfills if there is low concern of contamination (Bean et al. 2019).

The capital cost for street sweeping is considered high, typically from $140,000 and $250,000 per vehicle (MDOT, 2008). It should be noted that street sweeping is an LID practice that many municipalities are familiar with and have the necessary equipment and staff to complete. Street sweeper vehicles can be purchased or leased, which would bring down capital and maintenance costs, or a vendor can be hired to perform the street sweeping activity. For the purposes of this manual, it is assumed that the sweepers would either be bought or leased. To normalize the costs of these kinds of practices the cost benefit data was referenced to determine the cost per pound of pollutant removed for each practice. For this practice a cost benefit of $257/lb TP was determined based on the statewide street sweeping assessment performed by FSA (Berretta, 2011). This was compared to the other practices examined in this memorandum to determine whether the cost benefit is high or low relative to the other practices examined. Based on this, the cost benefit was considered low relative to the other practices examined in this memorandum. Maintenance activities associated with these practices are considered high relative to other LID practices. Cleaning and maintaining a street sweeping vehicle can cost $80-$90 an hour, according to several municipal sweeping programs.

Figure 5-12: Street Sweeping Vehicle Dumping Debris in Lakeland, FL (Geosyntec, 2015)

5.1.11.2 Practice Applicability

Street sweeping is suitable for urban and suburban communities. Focus should be placed on urban environments where street debris contains a higher amount of organic material, such as areas with denser tree canopy cover.

5.1.11.3 Water Quantity Characteristics

Street sweeping is not expected to provide any water quantity benefits.

5.1.11.4 Water Quality Characteristics

Incorporation of street sweeping in an area can result in a water quality benefit. These practices are intended to protect water quality through removal of pollutants from the watershed before it can be washed into surface waterbodies. It is noted that street debris consists of eroded sediment from yards and other landscaped areas, large organic materials such as leaves, acorns, and twigs, as well as contamination from vehicle wear and tear. BMPTrains should be used to assess the water quality benefits of this system based on the specifications needed.

5.1.11.5 Operation and Maintenance

Maintenance activities associated with these practices are considered high relative to other LID practices. The lifecycle of this practice is not expected to reach 20 years per vehicle.

5.1.12 Nutrient Separating Baffle Box

In this section, a brief background of nutrient separating baffle boxes is discussed, identifying the major components of this practice, how it is constructed, how it functions, and the applicability of the practice. Additionally, water quality and quantity characteristics, as well as and operation and maintenance needs are addressed.

5.1.12.1 Background on Baffle Boxes

Nutrient Separating Baffle Box is an LID practice that provides solids separation for stormwater. This practice consists of prefabricated concrete vaults with multiple chambers using flow deflectors to facilitate settling of particulates and a metal mesh basket to remove large organic and inorganic debris. These practices are typically installed in line with traditional drainage systems as far downstream as possible to provide treatment to as much of the watershed as possible. **Figure 5-13** shows an example of the inside of a nutrient separating baffle box. It is noted that these systems can have an upflow filter using BAM as a final treatment step prior to discharge. Should an upflow filter be included in the design, some dissolved nutrient removal is anticipated assuming the filter is appropriately sized for the watershed size and runoff characteristics.

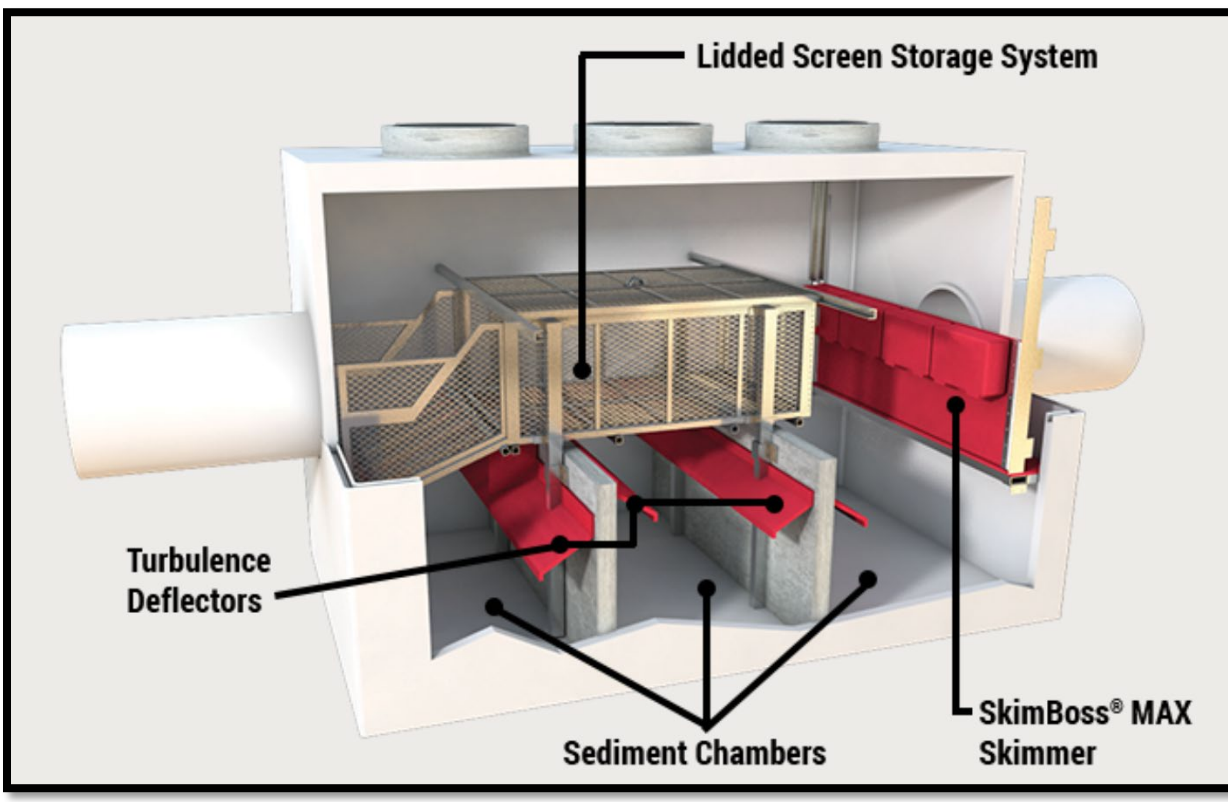


Figure 5-13: Nutrient separating Baffle Box Installation
(https://oldcastleinfrastructure.com/brands/nutrient-separating-baffle-box-nsbb/)

Based on feedback from a product vendor, capital costs for nutrient separating baffle box practices are typically $20,000-$30,000 each (Geosyntec, Stormwater Best Management Practices: Guidance Document, 2013) but can surpass $100,000 per structure. To normalize the costs of these kinds of practices the cost benefit data was referenced to determine the cost per pound of pollutant removed for each practice. For this practice a cost benefit of $10,747.38/lb TP was determined. Compared to other practices examined in this manual, the cost was considered high. Annual maintenance is dependent on the size of the box but can typically be between $2,000-$25,000, according to the WERF Whole-Life Cost Tool. Maintenance of these systems is considered high when compared to other practices, as the chambers and mesh metal baskets need to be cleaned out regularly (can be as frequent as monthly).

5.1.12.2 Practice Applicability

Nutrient separating baffle boxes are suitable for use in all areas regardless of soils and groundwater conditions. They are also suitable for all land use/cover applications in both urban and suburban/rural applications.

5.1.12.3 Water Quantity Characteristics

Nutrient separating baffle boxes are not expected to provide any water quantity benefits.

5.1.12.4 Water Quality Characteristics

Incorporation of nutrient separating baffle boxes on a site can result in a water quality benefit. This practice is typically used as a pre-treatment practice to provide solids removal of stormwater prior to another practice. The water quality benefit of these systems is realized through reduction of solids and organic materials. Effectiveness is highly dependent on regular maintenance of the system and quality characteristics of storm inflows. BMPTrains should be used to assess the water quality benefits of this system based on the specifications needed.

5.1.12.5 Operation and Maintenance

To ensure that the nutrient separating baffle boxes operate as intended, it is necessary to perform regular maintenance activities. Boxes can be maintained and cleaned out using a vacuum truck to remove accumulated sediment and debris. Maintenance of these systems is considered high when compared to other practices, as the chambers and mesh metal baskets need to be cleaned out regularly (can be as frequent as monthly). This practice is expected to have a 20 year or longer lifecycle.

5.1.13 Dry Retention Ponds

In this section, a brief background of dry retention ponds is discussed, identifying the major components of this practice, how it is constructed, how it functions, and the applicability of the practice. Additionally, water quality and quantity characteristics, as well as and operation and maintenance needs are addressed.

5.1.13.1 Background on Dry Retention Ponds

Dry Retention Ponds are LID practices that provides storage and infiltration to reduce flooding and treat stormwater. This practice consists of a designed depressional storage area and sod, that is intended to capture and treat stormwater, see **Figure 5-14**. It is noted that for systems implemented in karst geologic regions, an additional soil amendment can be incorporated to provide nitrate removal of water infiltrating to the surficial aquifer.

Typical capital cost for dry retention ponds ranges from $0.50-$1.00/ft^3 of storage (Communities, 2019). To normalize the costs of these kinds of practices, the cost benefit data was referenced to determine the cost per pound of pollutant removed for each practice. For this practice, a cost benefit of $3,650.86 per pound of phosphorus removed was determined. Compared to other practices examined in this manual, the cost was considered low. Regular annual maintenance costs are around $593 and infrequent maintenance costs are around $3,101 annually, according to the WERF Whole-Life Cost Tool. Maintenance associated with this practice is consistent with typical sod maintenance which requires frequent mowing but may also require periodic sediment removal. Compared to the other practices examined in this memorandum, the maintenance cost is considered to be high.

Figure 5-14: Dry Retention Pond in Orange County, FL (Geosyntec, 2020)

5.1.13.2 Practice Applicability

Dry retention ponds are suitable for use in areas with good infiltrating, well drained soils and in both urban and suburban/rural applications. The lifecycle for these types of LID practices is expected to surpass 20 years.

5.1.13.3 Water Quantity Characteristics

These practices are intended to provide volume reduction to achieve stormwater quality improvement. The volume reduction occurs via infiltration and soil storage which results in a reduction of discharges to downstream receiving waterbodies. Credits can be taken for the storage volume that these systems provide, in accordance with the appropriate water management district ERP guidance.

5.1.13.4 Water Quality Characteristics

Incorporation of bioretention swales on a site can result in a water quality benefit. Since the water quality benefit of these practices is based on the volume of stormwater infiltrated, the anticipated water quality benefit of these practices is considered high. BMPTrains should be used to assess the water quality benefits of this system based on the specifications needed.

5.1.13.5 Operation and Maintenance

Retention basins should be checked regularly to ensure that soils do not experience clogging, which would lead to a reduction in function. Inspection frequency for these systems is also mandated in some NPDES MS4 permits. Over time if soils are clogged, water may pond and create issues with a higher groundwater table or groundwater mounding. Ensuring that there is no erosion on slopes and no sedimentation after major storms is critical in maintaining retention basins. It should be ensured that the retention basin is recovering its storage volume within allowed time frames.

Other inspection items include ensuring inlets/outlets are clear and are not obstructed, and if any pipes, structures, or trash racks are broken, they should be replaced as soon as possible. Vegetation should be inspected to make sure it is healthy and providing proper nutrient removal and replacing it if it is not. Any invasive vegetation should immediately be removed. Mosquito breeding should be controlled, especially following a rain event that results in standing water. The lifecycle for these types of practices is expected to surpass 20 years.

5.1.14 Wet Detention Ponds

In this section, a brief background of wet detention ponds is discussed, identifying the major components of this practice, how it is constructed, how it functions, and the applicability of the practice. Additionally, water quality and quantity characteristics, as well as and operation and maintenance needs are addressed.

5.1.14.1 Background on Wet Detention Ponds

Wet Detention Ponds provide particle settling and biological processes to treat stormwater. This practice consists of a designed pond with outfall to provide storage and treatment of stormwater as illustrated in **Figure 5-15**. It is noted that these systems can be designed with a littoral zone, a shallow planted area that is intended to provide substrate for beneficial microbes to provide some additional treatment of captured stormwater, but not all detention ponds have this component. Typically, if a littoral zone is not included the pond volume is required to be larger but this varies depending on the water management district. Since the effectiveness of these processes are time dependent, the performance of these systems is relative to the provided volume relative to the size of the watershed.

Figure 5-15: Residential Wet Detention Pond in Orange County, FL (Geosyntec, 2021)

The capital construction cost for wet detention ponds is typically \$0.50-\$1.00/ft^3 depending on the specific design (Communities, 2019). Cost can vary based on several factors including if a littoral zone is used. To normalize the costs of these kinds of LID practices the cost benefit data was referenced to determine the cost per pound of pollutant removed for each practice. For this practice, a cost benefit of \$3,650.86 per pound of phosphorus removed was determined. Compared to other practices examined in this manual, the cost was considered low. Regular annual maintenance costs are around $593 and infrequent maintenance costs are around $1,420 annually, according to the WERF Whole-Life Cost Tool. Maintenance associated with these practices is consistent with typical maintenance associated with sod but may require some degree of aquatic weed control and periodic sediment removal.

5.1.14.2 Practice Applicability

Wet detention practices are suitable for use in areas with poor infiltrating, poorly drained soils, and in both urban and suburban/rural applications. Use of wet detention in urban applications is usually impacted by the cost and availability of land as these they require a large footprint.

5.1.14.3 Water Quantity Characteristics

It is noted that these practices are typically used to provide flood storage for a watershed as well as the water quality benefits noted. Credits can be taken for the storage volume that these systems provide, in accordance with the appropriate water management district ERP guidance.

5.1.14.4 Water Quality Characteristics

These practices are intended to provide water quality improvement via particle settling and biological processes, which result in a concentration reduction of nutrients and solids. BMPTrains should be used to assess the water quality benefits of this system based on the specifications needed.

5.1.14.5 Operation and Maintenance

Maintenance associated with this practice is considered high relative to other LID practices since there is more upkeep associated with vegetation and debris and may occasionally require some degree of aquatic weed control or sediment removal. Inspection frequency for these systems is also mandated in some NPDES MS4 permits. Accumulation of sediment needs to be monitored, as well as erosion, and inflow/outflow structures should be checked after major storms to prevent clogging that may affect the operation of the pond. Healthy vegetation must be maintained for proper operation, and removal or replacement of vegetation may be necessary. The pond should also be inspected regularly to ensure that mosquitos are not breeding. With proper upkeep, the lifecycle of this LID practice is expected to surpass 20 years.

5.1.15 Living Shorelines

In this section, a brief background of living shorelines is discussed, identifying the major components of this practice, how it is constructed, how it functions, and the applicability of the practice. Additionally, water quality and quantity characteristics, as well as and operation and maintenance needs are addressed.

5.1.15.1 Background on Living Shorelines

Living Shorelines consist of maintaining or planting native vegetation along the shorelines of waterbodies, including bays, lakes, rivers, and streams. As illustrated in **Figure 5-16**, this practice is intended to provide a shallow planted area to provide substrate for beneficial microbes to provide treatment of stormwater or surface water, reduce erosion, and provide habitat. Living shorelines reduce the amount of erosion that usually occurs; therefore, the anticipated water quality benefit of these systems is considered moderate to low compared to other LID practices.

Installation cost for living shorelines varies from $1,000-$5,000/LF (NOAA, 2022). To normalize the costs of these kinds of practices the cost benefit data was referenced to determine the cost per pound of pollutant removed for each practice. For this practice a cost benefit of $57.00/lb TP was determined. Compared to other practices examined in this manual, the cost was considered low. Regular annual maintenance costs are around $100/LF, according to the NOAA Fisheries. Examples of regular maintenance include weeding/removal of undesirable plants, vegetation harvesting and replacement, as well as other activities associated with typical landscape maintenance. Compared to the other practices examined in this memorandum, the maintenance cost is considered to be high.

Figure 5-16: Living Shoreline (Geosyntec, 2022)

5.1.15.2 Practice Applicability

It is noted that living shorelines considered suitable for use in areas with poor infiltrating, poorly drained soils, and in both urban and suburban/rural applications. They are also suitable for all land use/cover applications.

5.1.15.3 Water Quantity Characteristics

No significant volume reduction is expected from this practice, rather concentration reductions are expected to be the primary nutrient removal mechanism.

5.1.15.4 Water Quality Characteristics

The water quality treatment for these systems occurs via reduced erosion of soils along the waterbody edge, filtration of stormwater that flows through these areas, and biological processes due to the microbial community. BMPTrains should be used to assess the water quality benefits of this system based on the specifications needed.

5.1.15.5 Operation and Maintenance

Maintenance associated with these practices is considered high relative to other practices and consists of weeding/removal of undesirable plants, vegetation harvesting and replacement, as well as other activities associated with typical landscape maintenance. Special training of maintenance staff is necessary to ensure that these systems are properly maintained. The lifecycle of Living Shorelines is not expected to exceed 20 years as this practice requires frequent harvesting and replacement of plants.

5.1.16 Managed Aquatic Plant Systems

In this section, a brief background of managed aquatic plant systems is discussed, identifying the major components of this practice, how it is constructed, how it functions, and the applicability of the practice. Additionally, water quality and quantity characteristics, as well as and operation and maintenance needs are addressed.

5.1.16.1 Background on MAPS

Managed Aquatic Plant Systems (MAPS) is an LID practice that consists of planting native vegetation in floating mats installed in wet detention ponds, lakes, or other surface waterbodies. The roots of the plants hang in the water column taking up nutrients which support plant growth. Additionally, the hanging roots provide structure and substrate for beneficial microbes to provide treatment of stormwater or surface water. **Figure 5-17** shows an example of MAPS. The anticipated water quality benefit of these systems is considered moderate to low compared to other practices.

The capital cost for managed aquatic plant systems is approximately \$35.00/ft^2 (Zisette, 2019) and typically includes floating ecosystem mats, aquatic plants, the anchoring system, and the media columns. To normalize the costs of these kinds of practices, the cost benefit data was referenced to determine the cost per pound of pollutant removed for each practice. For this practice a cost benefit of \$27,613.63/lb TP was determined. Compared to other practices examined in this manual, the cost was considered high. Maintenance associated with this practice consists of periodic harvesting and replacement of vegetation. Special training of maintenance staff is necessary to ensure that these systems are properly maintained. The annual maintenance cost is typically 3% of the full instillation cost (Zisette, 2019). Compared to the other LID practices examined in this memorandum, the maintenance cost is considered to be high.

Figure 5-17: Managed Aquatic Plant System (MAPS) in Brevard County, FL (Geosyntec, 2017)

5.1.16.2 Practice Applicability

MAPS are considered suitable for use in areas with poor infiltrating, poorly drained soils, and in both urban and suburban/rural applications. They are also suitable for all land use/cover applications.

5.1.16.3 Water Quantity Characteristics

No significant volume reduction is expected from this practice, rather concentration reductions are expected to be the primary nutrient removal mechanism.

5.1.16.4 Water Quality Characteristics

The water quality treatment for these systems occurs via biological processes due to plant uptake and the microbial community. It is noted that these systems require periodic harvesting and replacement of vegetation; this is how the nutrient mass is removed from the system. BMPTrains should be used to assess the water quality benefits of this system based on the specifications needed.

5.1.16.5 Operation and Maintenance

Maintenance associated with these practices is considered high relative to other LID practices and consists of periodic harvesting and replacement of vegetation. Special training of maintenance staff is necessary to ensure that these systems are properly maintained. The annual maintenance cost is typically 3% of the full instillation cost (Zisette, 2019). The lifecycle of this practice is based on the longevity of the materials used. As the materials are subject to photo degradation, this practice is not expected to last 20 years.

5.1.17 Constructed Wetlands

In this section, a brief background of constructed wetlands is discussed, identifying the major components of this practice, how it is constructed, how it functions, and the applicability of the practice. Additionally, water quality and quantity characteristics, as well as and operation and maintenance needs are addressed.

5.1.17.1 Background on Constructed Wetlands

Constructed Wetlands consist of planting native wetland vegetation in shallow constructed areas to provide treatment of stormwater prior to discharge to downstream surface waterbodies. An example of a constructed wetland is shown in **Figure 5-18**. The vegetation component of these systems provides structure and substrate for beneficial microbes to colonize and provide treatment of stormwater.

The cost associated with constructed wetlands is typically $50,000-250,000 (Geosyntec Consultants, 2013). Wetlands tend to be more expensive than retention basins due to the selection of soils, vegetation, and forebay requirements. To normalize the costs of these kinds of practices the cost benefit data was referenced to determine the cost per pound of pollutant removed for each practice. For this practice a cost benefit of $6,040.30/lb TP was determined. Compared to other practices examined in this manual, the cost was considered high. Regular annual maintenance costs are around $593 and infrequent maintenance costs are around $1,420 annually, according to the WERF Whole-Life Cost Tool. Maintenance associated with this practice consists of periodic harvesting and replacement of vegetation. Compared to the other LID practices examined in this memorandum, the maintenance cost is considered to be high.

5.1.17.2 Practice Applicability

Constructed wetlands are suitable for use in areas with poor infiltrating, poorly drained soils, and in both urban and suburban/rural applications. They are also suitable for all land use/cover applications.

5.1.17.3 Water Quantity Characteristics

No significant volume reduction is expected from this practice, rather concentration reductions are expected to be the primary nutrient removal mechanism.

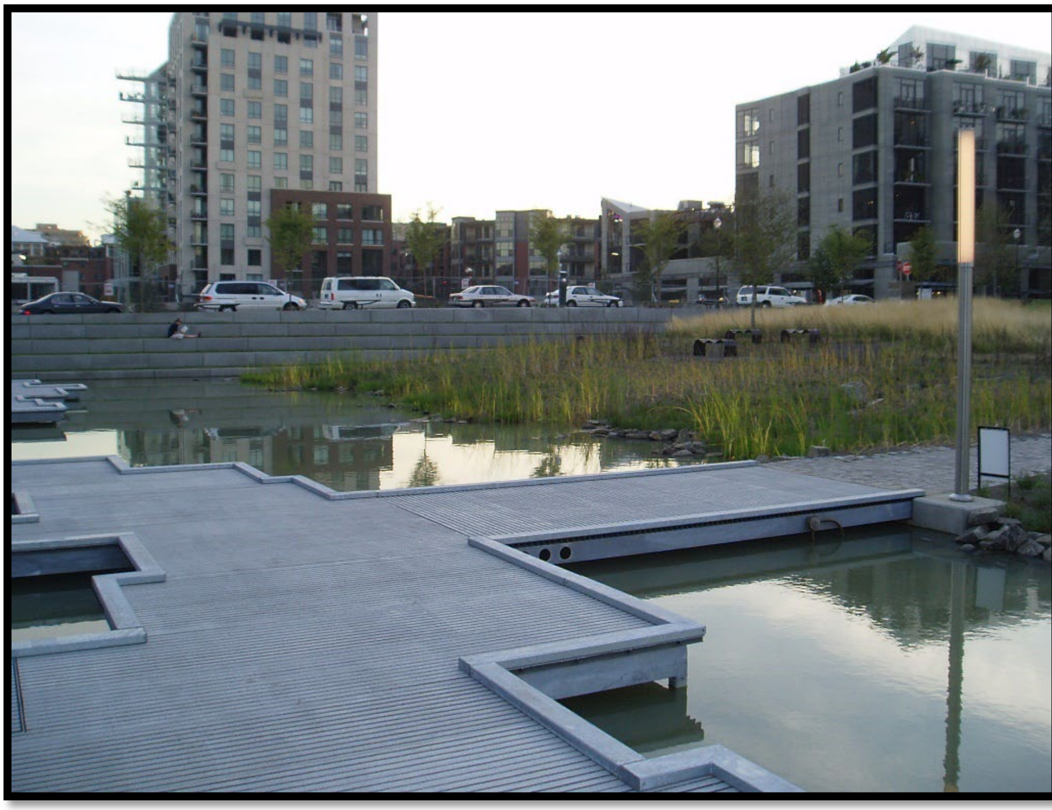


Figure 5-18: Constructed Wetland (Geosyntec, 2021)

5.1.17.4 Water Quality Characteristics

The water quality treatment for these systems occurs via biological processes due to the said microbial community. It is noted that these systems require periodic harvesting and replacement of vegetation; this is how the nutrient mass is removed from the system. BMPTrains should be used to assess the water quality benefits of this system based on the specifications needed.

5.1.17.5 Operation and Maintenance

Maintenance associated with these practices is considered high relative to other LID practices and consists of periodic harvesting and replacement of vegetation. Special training of maintenance staff is necessary to ensure that these systems are properly maintained. Since constructed wetlands are designed to mimic natural systems, if they are properly maintained they are assumed to have an indefinite lifecycle. Therefore, this lifecycle is expected to exceed 20 years.

5.1.18 Florida-Friendly Landscaping

In this section, a brief background of Florida-Friendly Landscaping is discussed, identifying the major components of this practice, how it is constructed, how it functions, and the applicability of the practice. Additionally, water quality and quantity characteristics, as well as and operation and maintenance needs are addressed.

5.1.18.1 Background on Florida-Friendly Landscaping

Florida-Friendly Landscaping consists of planting native vegetation in place of sod. **Figure 5-19** demonstrations the use of this practice on a small-scale residential area. This practice focuses on placement of the 'right plant in the right place' to ensure proper ecosystem function and success of the plant. Reducing the need for fertilizers and herbicides in landscapes results in less opportunity for fertilizer and chemical wash off. The result of this is reduced stormwater nutrient event mean concentrations (EMCs). The water quality benefit for these systems occurs via this reduced potential for fertilizer wash off. Based on this, no significant volume reduction is expected from this practice, rather concentration reductions are expected to be the primary nutrient removal mechanism.

Exact landscaping costs were not able to be accurately determined. However, to normalize the costs of these kinds of LID practices cost benefit data was referenced to determine the cost per pound of pollutant removed for each practice. For this practice a cost benefit of $5,024.33/lb TP was determined. It is noted that cost benefit numbers were unable to be found for Florida-friendly landscaping so engineering judgement was used to assess the cost of this practice. Based on this, the cost is considered to be high. Special training of maintenance staff is necessary to ensure that these systems are properly maintained. Examples of regular maintenance include periodic weeding and replacement of vegetation. The maintenance cost is considered high relative to the other practices examined in this manual.

5.1.18.2 Practice Applicability

Florida-Friendly landscaping is suitable for use in all areas regardless of soils and groundwater conditions. Specific plant requirements may limit the kinds of plants that can be planted in some regions, but the University of Florida/Institute of Food and Agricultural Sciences (UF/IFAS) has extensive guidance on plant selection on their website. This practice is also suitable for all land use/cover applications in both urban and suburban/rural applications. An added benefit of Florida-Friendly Landscaping is the creation and/or protection of natural habitat for pollinators and other native species.

5.1.18.3 Water Quantity Characteristics

Incorporating native plants or those well adapted to the climate and soil conditions where they will be planted can save large amounts of irrigation water as well as time and expense for upkeep. The more Florida-Friendly Landscaping that is incorporated, the greater the water quantity benefits.

5.1.18.4 Water Quality Characteristics

The use of Florida-Friendly Landscaping can create a low-maintenance and resource-efficient landscape that will have the capacity to thrive without supplemental inputs of fertilizers, pesticides, herbicides, etc. The more Florida-Friendly Landscaping that is incorporated, the greater the water quality benefits will be. BMPTrains should be used to assess the water quality benefits of this system based on the specifications needed.

Figure 5-19: Florida Friendly Landscape (UF IFAS, 2022)

5.1.18.5 Operation and Maintenance

Maintenance associated with these practices is considered high relative to other LID practices and consists of periodic weeding and replacement of vegetation. Special training of maintenance staff is necessary to ensure that these systems are properly maintained. Since Florida-Friendly landscapes are designed to mimic natural systems, if they are properly maintained they are assumed to have an indefinite lifecycle. Therefore, this lifecycle is expected to exceed 20 years.

5.1.19 Interceptor Trees

In this section, a brief background of interceptor trees is discussed, identifying the major components of this practice, how it is constructed, how it functions, and the applicability of the practice. Additionally, water quality and quantity characteristics, as well as and operation and maintenance needs are addressed.

5.1.19.1 Background on Interceptor Trees

Interceptor Trees are an LID practice that consist of protection of existing or planting of new trees to intercept and store rainfall, thus reducing stormwater runoff generated from a site. **Figure 20** shows an example interceptor trees. These practices are intended to provide volume reduction to achieve stormwater quality improvement. The volume reduction occurs via tree interception, infiltration, and soil storage which results in a reduction of discharges to downstream receiving waterbodies.

Capital costs for interceptor trees involve the cost per tree used. Typically, this is between $106-$2,423 per tree depending on the type of tree used (Nursery, 2022). To normalize the costs of these kinds of LID practices, cost benefit data was referenced to determine the cost per pound of pollutant removed for each practice. For this practice a cost benefit of $3,126.95/lb TP was determined. Compared to other practices examined in this manual, the cost is considered to be low. It is noted that special training of maintenance staff is necessary to ensure that these systems are properly maintained. According to Orlando Tree Services, these costs are typically $77-$140 per tree. This can be significantly higher if tree is planted near a sidewalk or street. Examples of regular maintenance include weeding/removal of undesirable plants, sidewalk/street repair, and other activities associated with typical tree maintenance. The maintenance cost is considered high relative to the other practices examined in this manual.

Figure 5-20: Rainfall Interceptor Trees in Winter Park, FL (Geosyntec, 2018)

5.1.19.2 Practice Applicability

Interceptor trees are considered suitable for use in all areas regardless of soils and groundwater conditions. They are also suitable for all land use/cover applications in both urban and suburban/rural applications. The full growth size of the tree should be kept in mind when considering the location for the interceptor trees. Trees should avoid obstructions, such as overhead power lines, utilities, and sidewalks.

5.1.19.3 Water Quantity Characteristics

No significant volume reduction is expected from interceptor trees

5.1.19.4 Water Quality Characteristics

The pollutant removal potential is low to moderate and is directly related to the reduction in stormwater volume. BMPTrains should be used to assess the water quality benefits of this system based on the specifications needed.

5.1.19.5 Operation and Maintenance

Maintenance associated with these practices is considered high relative to other LID practices and consists of watering during the establishment period, weeding/removal of undesirable plants, sidewalk/street repair, and other activities associated with typical tree maintenance. Special training of maintenance staff is necessary to ensure that these systems are properly maintained. This can be significantly higher if the tree is planted near a sidewalk or street. Since trees have longer life spans, the lifecycle for this practice is assumed to be 20 years or more.

5.2 County Approved LID Practices

The County has selected four practices which appear to be most applicable for use throughout Orange County. Additional information including design criteria, site suitability, pollutant removal efficiencies, regulatory and permitting considerations, construction considerations, design specifications, maintenance considerations, and design calculations for well-draining and poor-draining soils can be found in Volume 2. The breakdown of how the four practices were chosen can be found in **Appendix B**. The intent is for additional practices to be added in the future based on scoring. BMPs not currently included in Volume 2 can still be applied within the County, but must have approval from the County Engineer.

5.3 LID Practice/Technical Design Criteria

LID practices should not create or increase upstream flooding and should provide water quality improvement to meet or help meet regulatory criteria. Depending on which water management district the site is under, the appropriate criteria should be followed to demonstrate compliance with flood reduction. Without proper guidance to determine what criteria is appropriate, a complex regulatory environment is created where requirements can be confusing and difficult to police. However, the County has several impaired waterbodies to restore as well as waterbodies currently not impaired that it would like to proactively protect. To this end, several regulatory approaches were examined, namely application of a geographically appropriate special basin criteria, "post </= pre" approach, or a standard increased treatment requirement criteria. These three approaches are each discussed further below.

- Application of a geographically appropriate special basin criteria could take several forms. It could specifically follow individual Total Maximum Daily Load (TMDL), Basin Management Action Plan (BMAP), and/or impaired waters boundaries/contributing areas, or a general requirement (blanket approach) that could be applied across all target areas. The former would be a more specific approach that would match the pollutant load reduction requirements to the individual TMDL/BMAP/impairment requirements. However, this would be challenging to administer since many varying criteria would need to be tracked. The latter option would provide a simpler approach using a blanketed single criterion that covers all the subject special water quality areas. However, the water quality metric that would be applied throughout would have to be strict enough to ensure that even the most special water quality areas requirements are being met.
- Use of a "post </= pre" approach is commonly applied in stormwater management. To simplify, it means that post-development impacts to water quality need to be mitigated to provide a water quality equivalent to that of pre-development conditions. Applying this approach may be simplest in a blanketed way, i.e. determining a "pre" and "post" condition over an entire area instead of multiple "pre" and "post" conditions. However, uncertainty arises when trying to establish what the pre-development conditions are,

e.g., original native conditions or the abandoned commercial site, or the pasture that existed a few years before that. Since this makes “post < pre” determination difficult, it also makes enforcement difficult.

- The adoption of the standard “increased treatment” requirement may be an appropriate option to consider, i.e., a 50% increase across the board in treatment volume requirement. This criteria is required by St. Johns River Water Management District in the Big Econ Basin, Wekiva Basin, or a direct discharge into an OFW and South Florida Water Management District in all basins in Orange County. The SJRWMD has specific nutrient criteria for the Lake Apopka Basin that exceeds the 50% increase in treatment volume. This approach is a straightforward way to apply an easy-to-understand criteria over a blanketed area and for consistency purposes the County could require this criterion in all Basins in the County.

LID practices are one way to ensure that 50% additional treatment volume is being provided across the County. If the new statewide stormwater rule goes into effect, then the above criteria would not be recommended as the new rule would be more stringent.

Example calculations for special basins are included as part of the practice specific design guidance documents, which are presented in Volume 2 of this LID Manual. Although the manual and calculations are focused on water quality, the LID practices listed in the manual can provide attenuation for flood control and should be factored into site design.

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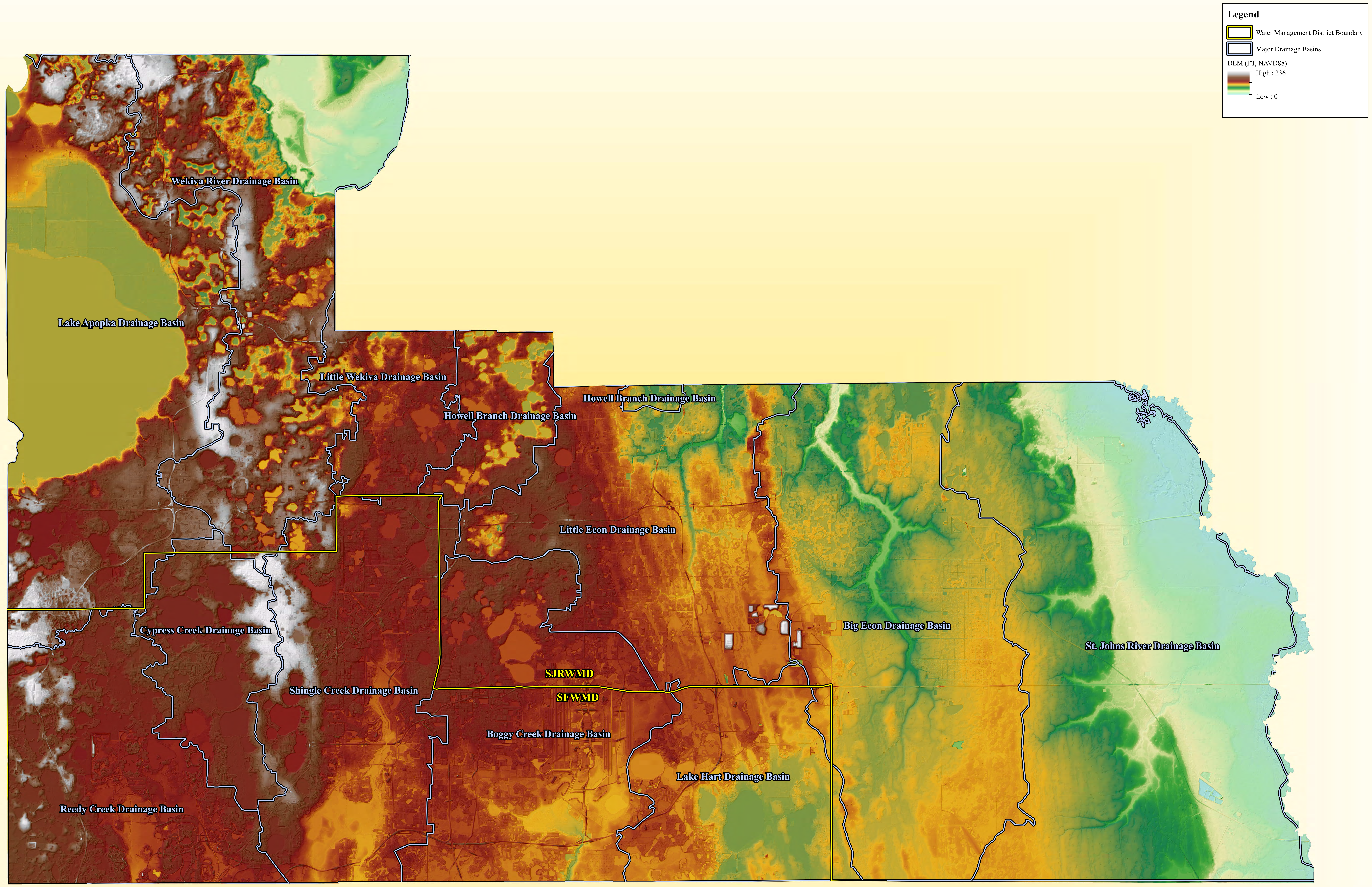
EXHIBITS



Sources:
Digital Elevation Model (DEM): National Elevation Dataset (NED),1/3 Arc Second Raster, USGS, 2022
Water Management District Boundary: Orange County, 2001
County Boundary: Orange County, 2020
Major Drainage Basins: Orange County, 2020

N

0 0.75 1.5 Miles

Topography Map

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ORANGE COUNTY GOVERNMENT FLORIDA

Exhibit 1

Soil Hydrologic Group	Coverage [acres]	Coverage [%]
A	174769	27.21%
A/D	290814	45.28%
B/D	55151	8.59%
C/D	45208	7.04%
D	310	0.05%
Pits	834	0.13%
Urban land	10872	1.69%
Water	64313	10.01%

According to the NRCS, soil hydrologic groups are defined as follows:

- A type soils are those with a high infiltration rate (low runoff potential) when thoroughly wet. These soils consist mainly of deep, well drained to excessively drained sands or gravelly sands.
- B type soils are those with a moderate infiltration rate low/moderate runoff potential) when thoroughly wet. These soils consist mainly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture.
- C type soils are those with a slow infiltration rate moderate/high runoff potential) when thoroughly wet. These soils consist mainly of soils that have a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture.
- D type soils are those with a very slow infiltration rate (high runoff potential) when thoroughly wet. These soils consist mainly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a clay layer at or near the surface, and soils that are shallow over nearly impervious material.
- Dual class soils groups are assigned two classifications with the first letter indicating the drained condition and the second letter indicating the undrained condition.

Three non-standard soil hydrologic group classifications are also included in the soils data for the County, specifically Pits, Urban Land, and Water. These are discussed further below:

- Pits classifications are used to describe excavations from which soil and other geologic material have been removed for use as fill material. These areas are typically assigned a hydrologic soil group of D to represent a high runoff potential.
- Urban Land classifications are used to describe impervious ground cover such as high-density residential developments, commercial buildings, streets, etc. that are covered to the extent that a determination of the natural soil communities cannot be determined. These areas are typically assigned a hydrologic soil group of D to represent high runoff potential.
- Water classification are used to describe water surfaces such as lakes, ponds, streams, creeks, and other similar features that are wet year round. These areas are assumed to have a very high runoff potential.

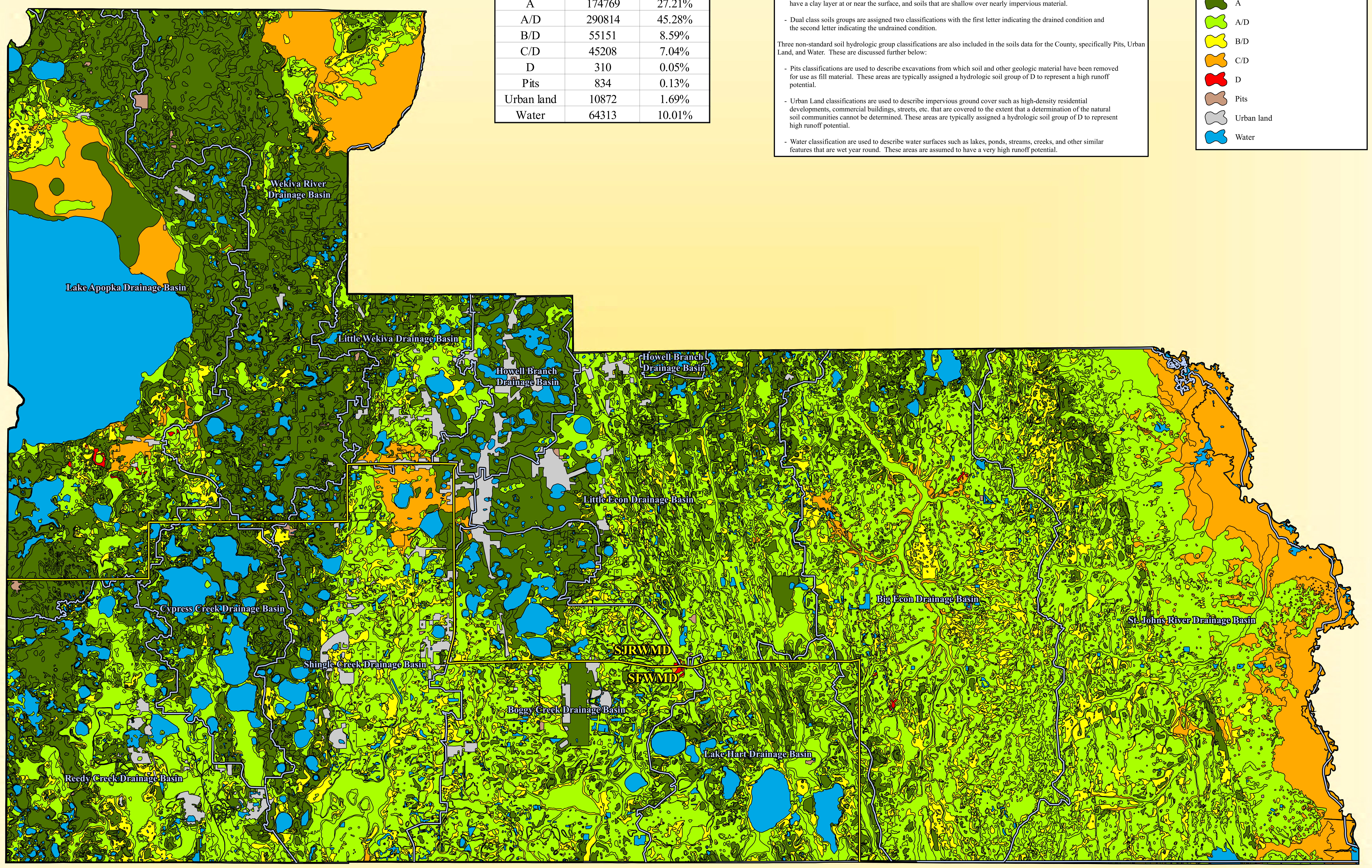
Legend

Water Management District Boundary

Major Drainage Basins

Soil Hydrologic Groups

- A
- A/D
- B/D
- C/D
- D
- Pits
- Urban land
- Water



Sources:
Water Management District Boundary: Orange County, 2001
County Boundary: Orange County, 2020
Soils: NRCS, 2013
Major Drainage Basins: Orange County, 2020

N

0 0.75 1.5 Miles

Soils Map

Stormwater Low Impact Development Manual

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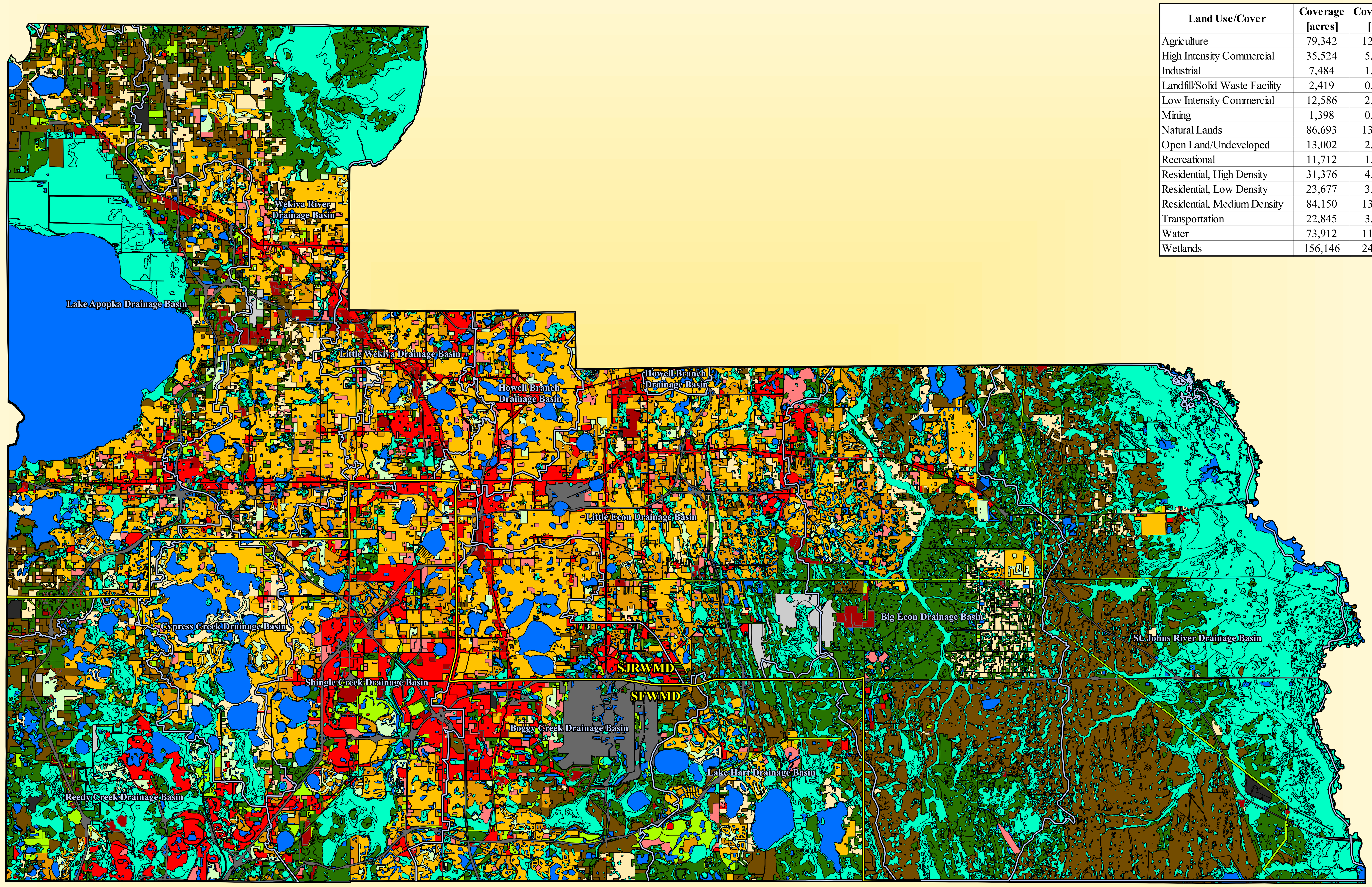
ORANGE COUNTY GOVERNMENT FLORIDA

Exhibit **2**



Land Use/Cover	Coverage [acres]	Coverage [%]
Agriculture	79,342	12.4%
High Intensity Commercial	35,524	5.5%
Industrial	7,484	1.2%
Landfill/Solid Waste Facility	2,419	0.4%
Low Intensity Commercial	12,586	2.0%
Mining	1,398	0.2%
Natural Lands	86,693	13.5%
Open Land/Undeveloped	13,002	2.0%
Recreational	11,712	1.8%
Residential, High Density	31,376	4.9%
Residential, Low Density	23,677	3.7%
Residential, Medium Density	84,150	13.1%
Transportation	22,845	3.6%
Water	73,912	11.5%
Wetlands	156,146	24.3%

Legend

- Orange County Major Drainage Basins
- Water Management District Boundary

Land Use / Cover

- Agriculture
- High Intensity Commercial
- Industrial
- Landfill/Solid Waste Facility
- Low Intensity Commercial
- Mining
- Natural Lands
- Open Land/Undeveloped
- Recreational
- Residential, High Density
- Residential, Low Density
- Residential, Medium Density
- Transportation
- Water
- Wetlands

Sources:
Water Management District Boundary: Orange County, 2001
County Boundary: Orange County, 2020
Land Use: SJRWMD, 2014 & SFWMD, 2014
Major Drainage Bases: Orange County, 2020

N
0 0.75 1.5 Miles

Land Use Map

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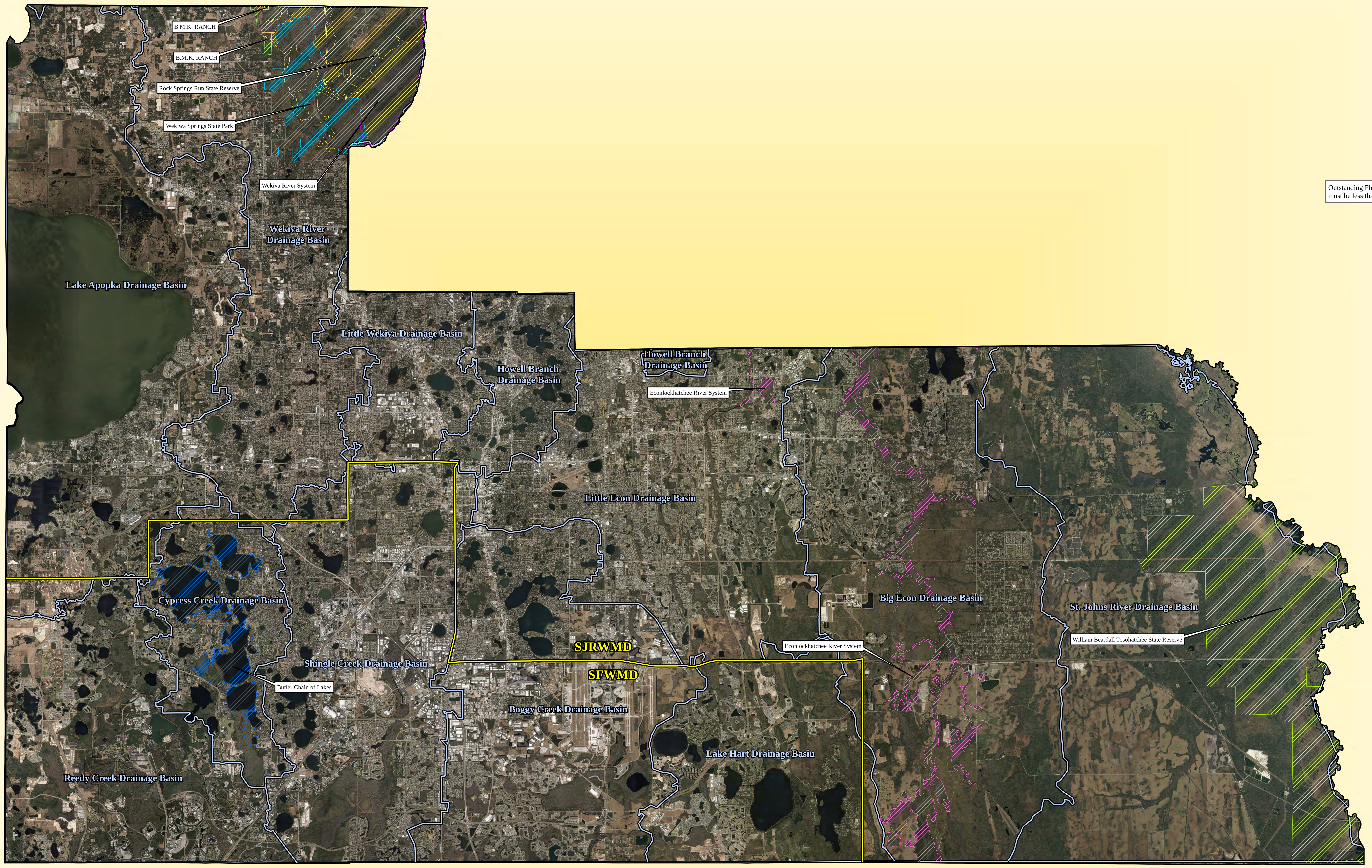
Exhibit **3**



Legend

- Orange County Major Drainage Basins
- Water Management District Boundary

Outstanding Florida Waters

- B.M.K. Ranch
- Butler Chain of Lakes
- Econlockhatchee River System
- Rock Springs Run State Reserve
- Wekiva River Aquatic Preserve
- Wekiva River Buffers
- Wekiva River System
- Wekiwa Springs State Park
- William Beardall Tosohatchee State Reserve

Outstanding Florida Waters are waterbodies that have special water quality criteria, namely post-development nutrient loading must be less than or equal to pre-development conditions. This must be demonstrated through pollutant loading modeling.

Sources:
Aerial: Orange County, 2021
Water Management District Boundary: Orange County, 2001
County Boundary: Orange County, 2020
Outstanding Florida Waters: FDEP, 2021
Major Drainage Basins: Orange County, 2020

N

0 0.75 1.5 Miles

Outstanding Florida Waters Map

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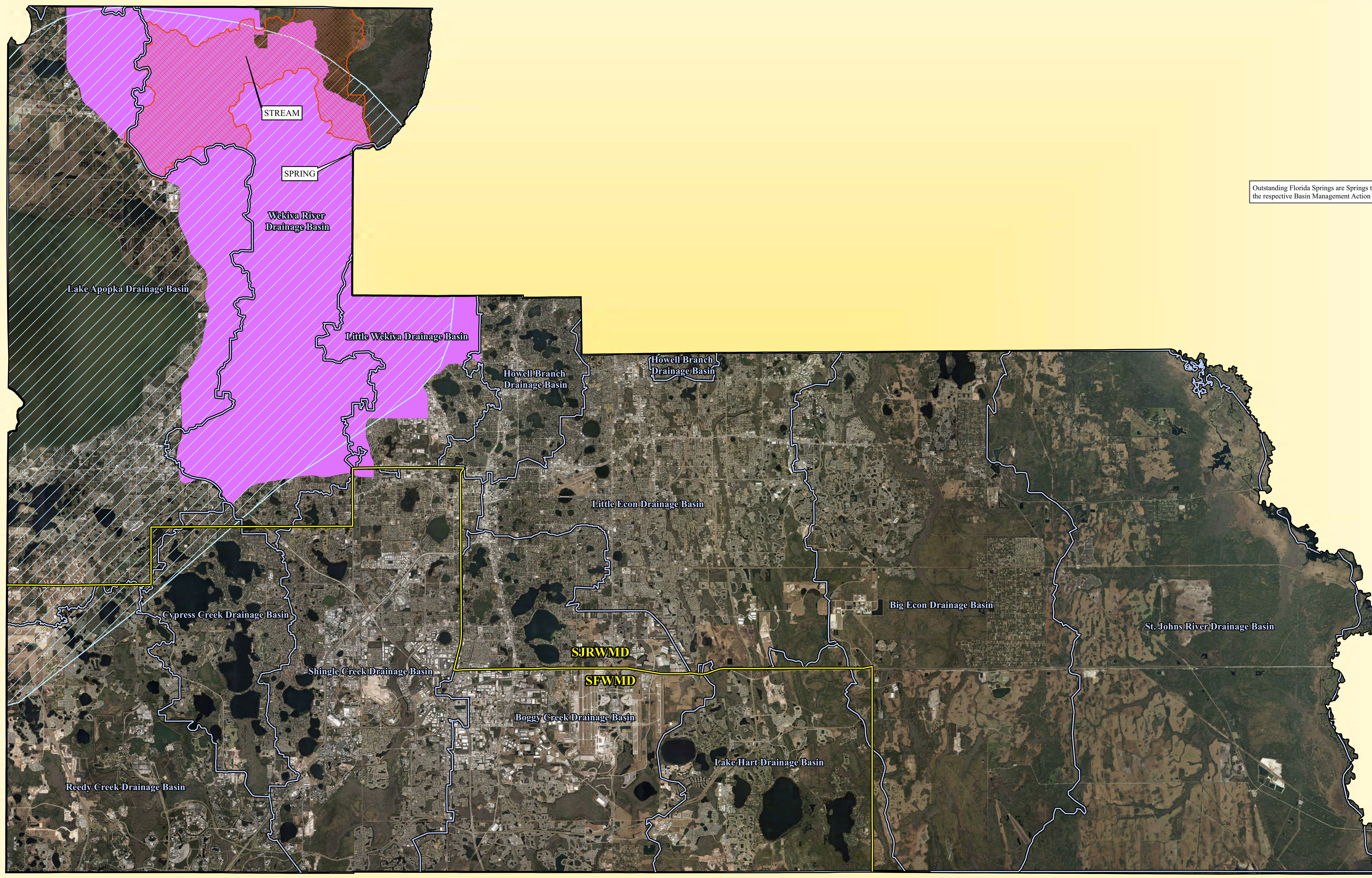
Exhibit 4



Legend

- Water Management District Boundary
- Orange County Major Drainage Basins

Outstanding Florida Springs

- Spring
- Stream
- Rock and Wekiva Springs Springshed
- Wekiwa-Rock Springs Priority Focus Area

Outstanding Florida Springs are Springs that have special water quality criteria focused on nitrogen control, which is defined in the respective Basin Management Action Plans (BMAPs)

Sources:
Aerial: Orange County, 2021
Water Management District Boundary: Orange County, 2001
County Boundary: Orange County, 2020
Outstanding Florida Springs and Springsheds: FDEP, 2021
Priority Focus Area: FDEP, 2021
Major Drainage Basins: Orange County, 2020

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0 0.75 1.5 Miles

Outstanding Florida Springs Map

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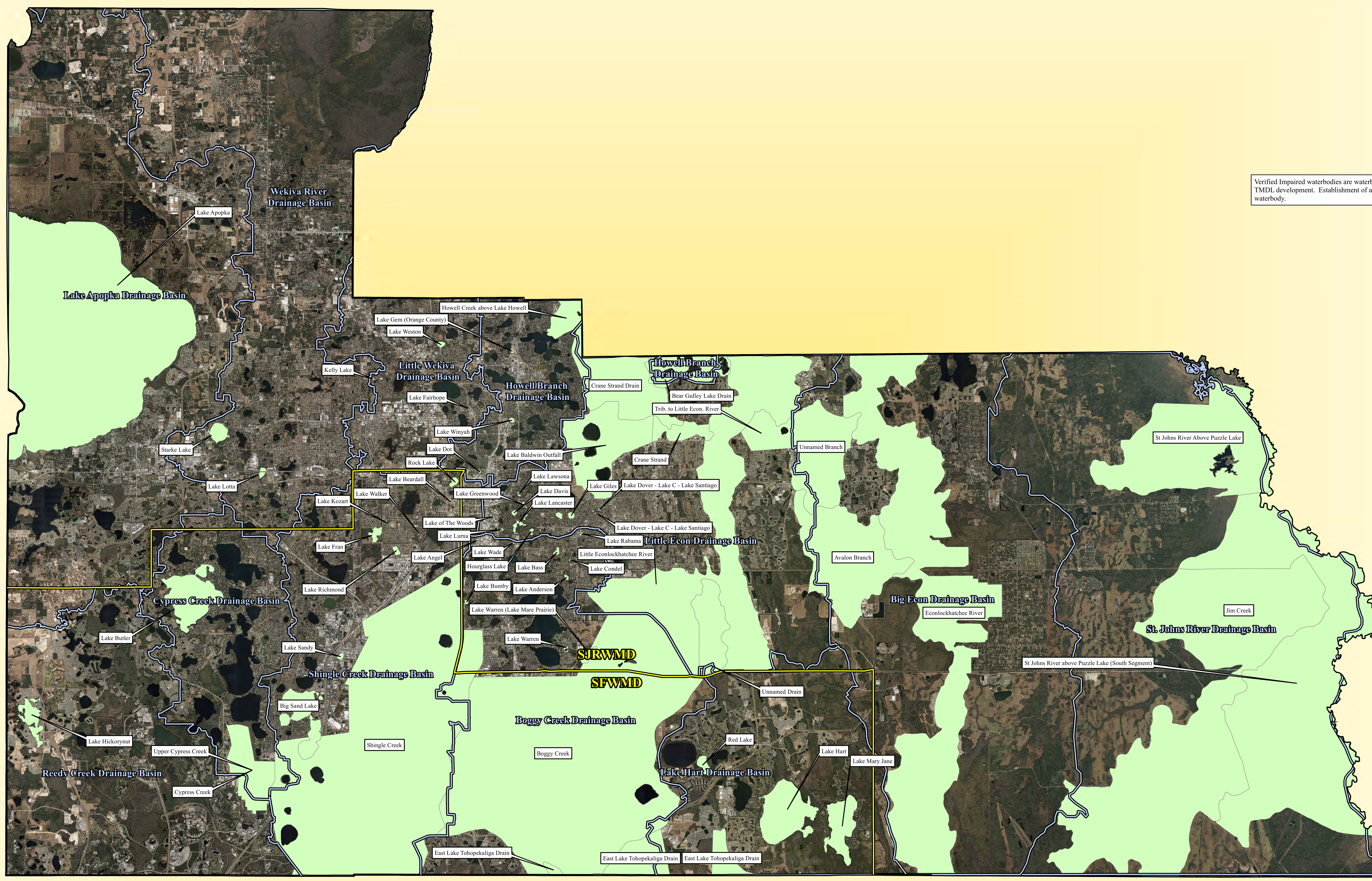
Exhibit 5



Legend

- Water Management District Boundary
- Orange County Major Drainage Basins
- Verified Impaired List

Verified Impaired waterbodies are waterbodies that are currently not meeting their applicable water quality criteria and are slated for TMDL development. Establishment of a TMDL will result in more stringent water quality standards for water discharging into the waterbody.

Sources:
Aerial: Orange County, 2021
Water Management District Boundary: Orange County, 2001
County Boundary: Orange County, 2020
Verified Impaired List: FDEP, 2021
Major Drainage Basins: Orange County, 2020

N

0 0.75 1.5 Miles

Verified Impaired Waterbodies Map

Stormwater Low Impact Development Manual

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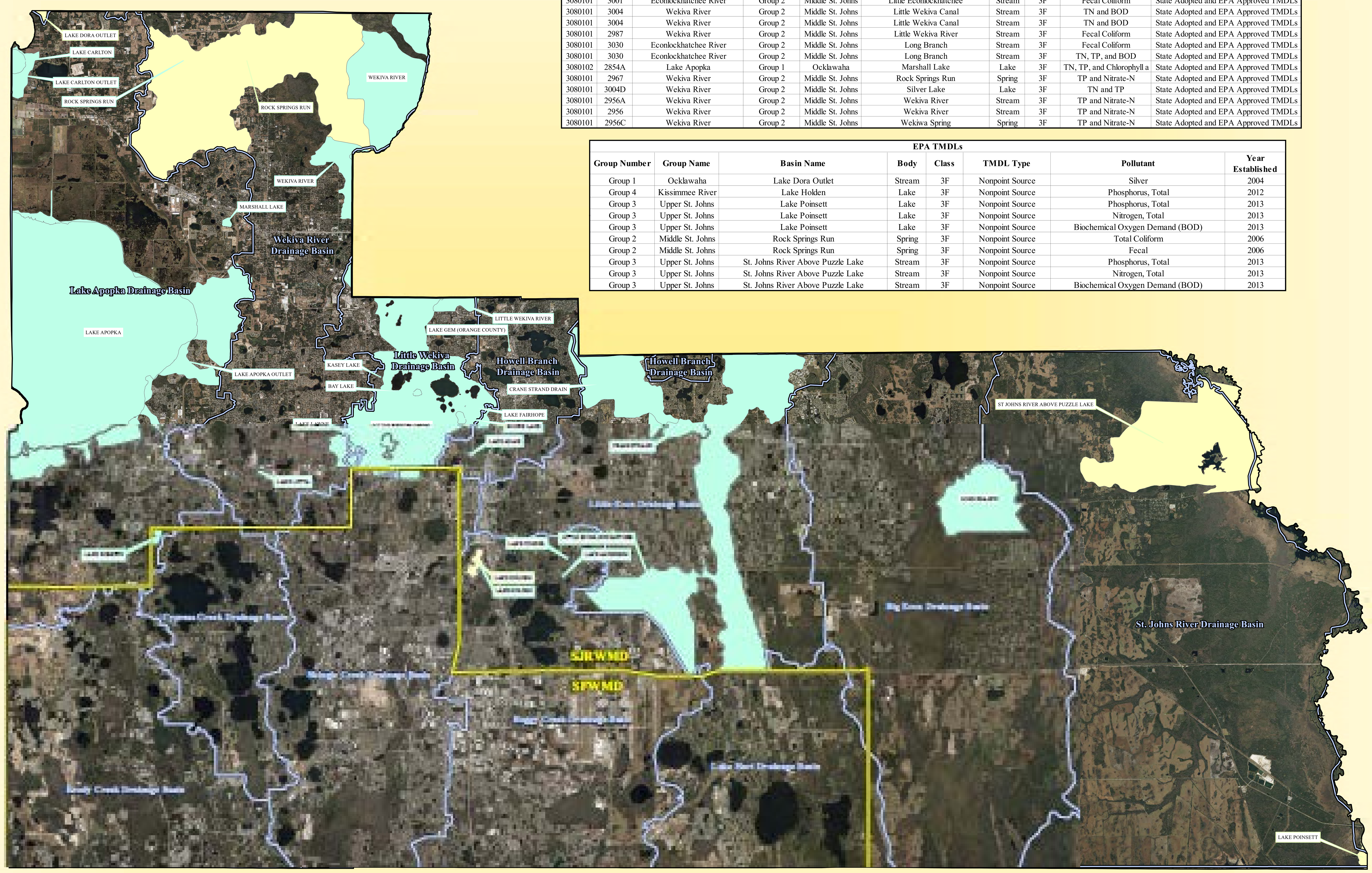
ORANGE COUNTY GOVERNMENT FLORIDA

Exhibit 6

FDEP TMDLs									
HUC	WBID	Planning Unit	Group Number	Group Name	Waterbody Name	Body	Class	Pollutants	TMDL Status
3080101	3004G	Wekiva River	Group 2	Middle St. Johns	Bay Lake	Lake	3F	TN and TP	State Adopted and EPA Approved TMDLs
3080101	3023	Econlockhatchee River	Group 2	Middle St. Johns	Crane Strand	Stream	3F	Fecal Coliform	State Adopted and EPA Approved TMDLs
3080101	3014	Econlockhatchee River	Group 2	Middle St. Johns	Crane Strand Drain	Stream	3F	TN and BOD	State Adopted and EPA Approved TMDLs
3080101	3014	Econlockhatchee River	Group 2	Middle St. Johns	Crane Strand Drain	Stream	3F	Fecal Coliform	State Adopted and EPA Approved TMDLs
3080101	3002Q	Wekiva River	Group 2	Middle St. Johns	Kasey Lake	Lake	3F	TN, TP, and Chlorophyll a	Draft
3080101	2997R	Lake Jesup	Group 2	Middle St. Johns	Lake Adair	Lake	3F	TN and TP	State Adopted and EPA Approved TMDLs
3090101	3168E	Upper Kissimmee Planning Unit	Group 4	Kissimmee River	Lake Anderson	Lake	3F	Chlorophyll a	Draft
3080102	2835D	Lake Apopka	Group 1	Ocklawaha	Lake Apopka	Lake	3F	TP	State Adopted and EPA Approved TMDLs
3080102	2835B	Lake Apopka	Group 1	Ocklawaha	Lake Apopke Outlet	Stream	3F	TP	State Adopted and EPA Approved TMDLs
3080102	2834C	Lake Harris Unit	Group 1	Ocklawaha	Lake Beauclair	Lake	3F	TP	State Adopted and EPA Approved TMDLs
3080102	2837B	Lake Harris Unit	Group 1	Ocklawaha	Lake Carlton	Lake	3F	TP	State Adopted and EPA Approved TMDLs
3080102	2837	Lake Harris Unit	Group 1	Ocklawaha	Lake Carlton Outlet	Stream	3F	TP	State Adopted and EPA Approved TMDLs
3090101	3168X5	Upper Kissimmee Planning Unit	Group 4	Kissimmee River	Lake Condel	Lake	3F	TN, TP, and Chlorophyll a	Draft
3080101	3004R	Wekiva River	Group 2	Middle St. Johns	Lake Fairhope	Lake	3F	TN, TP, and Chlorophyll a	Draft
3080101	2997V	Wekiva River	Group 2	Middle St. Johns	Lake Gem (Orange County)	Lake	3F	TN and TP	State Adopted and EPA Approved TMDLs
3090101	3168H	Upper Kissimmee Planning Unit	Group 4	Kissimmee River	Lake Holden	Lake	3F	TN and TP	State Adopted and EPA Approved TMDLs
3080101	3004C	Wekiva River	Group 2	Middle St. Johns	Lake Lawne	Lake	3F	TN and TP	State Adopted and EPA Approved TMDLs
3080101	3002G	Wekiva River	Group 2	Middle St. Johns	Lake Lotta	Lake	3F	Chlorophyll a	Draft
3080102	2872A	Lake Apopka	Group 1	Ocklawaha	Lake Roberts	Lake	3F	TN, TP, and Chlorophyll a	State Adopted and EPA Approved TMDLs
3080101	3001	Econlockhatchee River	Group 2	Middle St. Johns	Little Econlockhatchee	Stream	3F	Fecal Coliform	State Adopted and EPA Approved TMDLs
3080101	3004	Wekiva River	Group 2	Middle St. Johns	Little Wekiva Canal	Stream	3F	TN and BOD	State Adopted and EPA Approved TMDLs
3080101	3004	Wekiva River	Group 2	Middle St. Johns	Little Wekiva Canal	Stream	3F	TN and BOD	State Adopted and EPA Approved TMDLs
3080101	2987	Wekiva River	Group 2	Middle St. Johns	Little Wekiva River	Stream	3F	Fecal Coliform	State Adopted and EPA Approved TMDLs
3080101	3030	Econlockhatchee River	Group 2	Middle St. Johns	Long Branch	Stream	3F	Fecal Coliform	State Adopted and EPA Approved TMDLs
3080101	3030	Econlockhatchee River	Group 2	Middle St. Johns	Long Branch	Stream	3F	TN, TP, and BOD	State Adopted and EPA Approved TMDLs
3080102	2854A	Lake Apopka	Group 1	Ocklawaha	Marshall Lake	Lake	3F	TN, TP, and Chlorophyll a	State Adopted and EPA Approved TMDLs
3080101	2967	Wekiva River	Group 2	Middle St. Johns	Rock Springs Run	Spring	3F	TP and Nitrate-N	State Adopted and EPA Approved TMDLs
3080101	3004D	Wekiva River	Group 2	Middle St. Johns	Silver Lake	Lake	3F	TN and TP	State Adopted and EPA Approved TMDLs
3080101	2956A	Wekiva River	Group 2	Middle St. Johns	Wekiva River	Stream	3F	TP and Nitrate-N	State Adopted and EPA Approved TMDLs
3080101	2956	Wekiva River	Group 2	Middle St. Johns	Wekiva River	Stream	3F	TP and Nitrate-N	State Adopted and EPA Approved TMDLs
3080101	2956C	Wekiva River	Group 2	Middle St. Johns	Wekiwa Spring	Spring	3F	TP and Nitrate-N	State Adopted and EPA Approved TMDLs

EPA TMDLs							
Group Number	Group Name	Basin Name	Body	Class	TMDL Type	Pollutant	Year Established
Group 1	Ocklawaha	Lake Dora Outlet	Stream	3F	Nonpoint Source	Silver	2004
Group 4	Kissimmee River	Lake Holden	Lake	3F	Nonpoint Source	Phosphorus, Total	2012
Group 3	Upper St. Johns	Lake Poinsett	Lake	3F	Nonpoint Source	Phosphorus, Total	2013
Group 3	Upper St. Johns	Lake Poinsett	Lake	3F	Nonpoint Source	Nitrogen, Total	2013
Group 3	Upper St. Johns	Lake Poinsett	Lake	3F	Nonpoint Source	Biochemical Oxygen Demand (BOD)	2013
Group 2	Middle St. Johns	Rock Springs Run	Spring	3F	Nonpoint Source	Total Coliform	2006
Group 2	Middle St. Johns	Rock Springs Run	Spring	3F	Nonpoint Source	Fecal	2006
Group 3	Upper St. Johns	St. Johns River Above Puzzle Lake	Stream	3F	Nonpoint Source	Phosphorus, Total	2013
Group 3	Upper St. Johns	St. Johns River Above Puzzle Lake	Stream	3F	Nonpoint Source	Nitrogen, Total	2013
Group 3	Upper St. Johns	St. Johns River Above Puzzle Lake	Stream	3F	Nonpoint Source	Biochemical Oxygen Demand (BOD)	2013



Legend

- Water Management District Boundary
- Orange County Major Drainage Basins
- EPA TMDLs
- FDEP TMDLs

TMDL waterbodies are waterbodies that have waterbody specific water quality targets.

Sources:
Aerial: Orange County, 2021
Water Management District Boundary: Orange County, 2001
County Boundary: Orange County, 2020
FDEP TMDLs: FDEP, 2021
EPA TMDLs: FDEP, 2021
Major Drainage Basins: Orange County, 2020

N

0 0.75 1.5 Miles

TMDL Waterbodies Map

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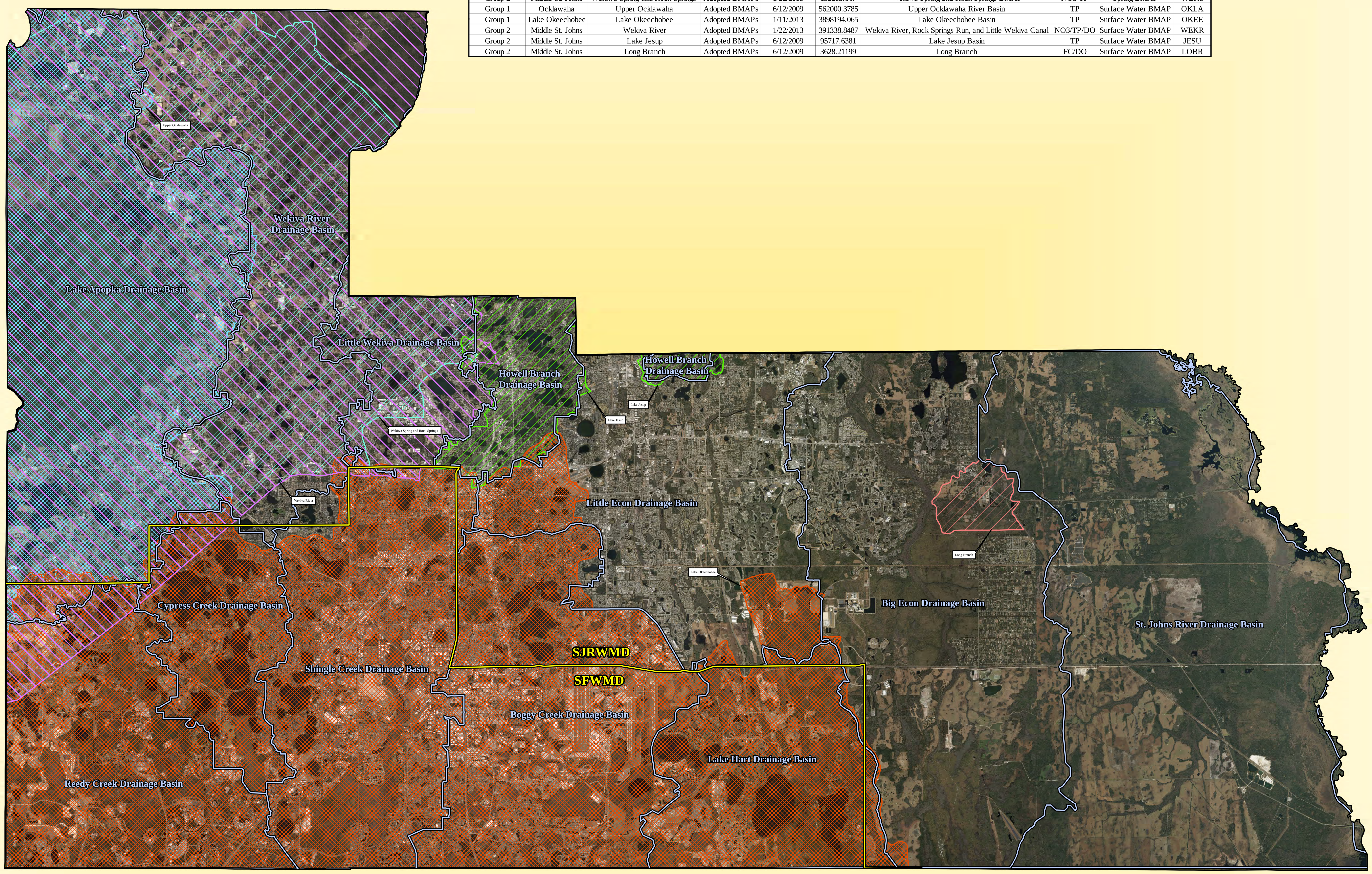
Orange County Government Florida

Exhibit **7**

Group Number	Group Name	Project	Status	Submittal Date	Acres	Document Name	Parameters	Type	BMAPID
Group 2	Middle St. Johns	Wekiwa Spring and Rock Springs	Adopted BMAPs	1/22/2013	192283.867	Wekiwa Spring and Rock Springs BMAP	NO3/TP	Spring BMAP	WEKS
Group 1	Ocklawaha	Upper Ocklawaha	Adopted BMAPs	6/12/2009	562000.3785	Upper Ocklawaha River Basin	TP	Surface Water BMAP	OKLA
Group 1	Lake Okeechobee	Lake Okeechobee	Adopted BMAPs	1/11/2013	3898194.065	Lake Okeechobee Basin	TP	Surface Water BMAP	OKEE
Group 2	Middle St. Johns	Wekiva River	Adopted BMAPs	1/22/2013	391338.8487	Wekiva River, Rock Springs Run, and Little Wekiva Canal	NO3/TP/DO	Surface Water BMAP	WEKR
Group 2	Middle St. Johns	Lake Jesup	Adopted BMAPs	6/12/2009	95717.6381	Lake Jesup Basin	TP	Surface Water BMAP	JESU
Group 2	Middle St. Johns	Long Branch	Adopted BMAPs	6/12/2009	3628.21199	Long Branch	FC/DO	Surface Water BMAP	LOBR



Legend

- Water Management District Boundary
- Orange County Major Drainage Basins

BMAPs

- Upper Ocklawaha
- Wekiwa Spring and Rock Springs
- Wekiva River
- Lake Okeechobee
- Lake Jesup
- Long Branch

Sources:
Aerial: Orange County, 2021
Water Management District Boundary: Orange County, 2001
County Boundary: Orange County, 2020
BMAPs: FDEP, 2021
Major Drainage Basins: Orange County, 2020

N

0 0.75 1.5 Miles

BMAP Map

Stormwater Low Impact Development Manual

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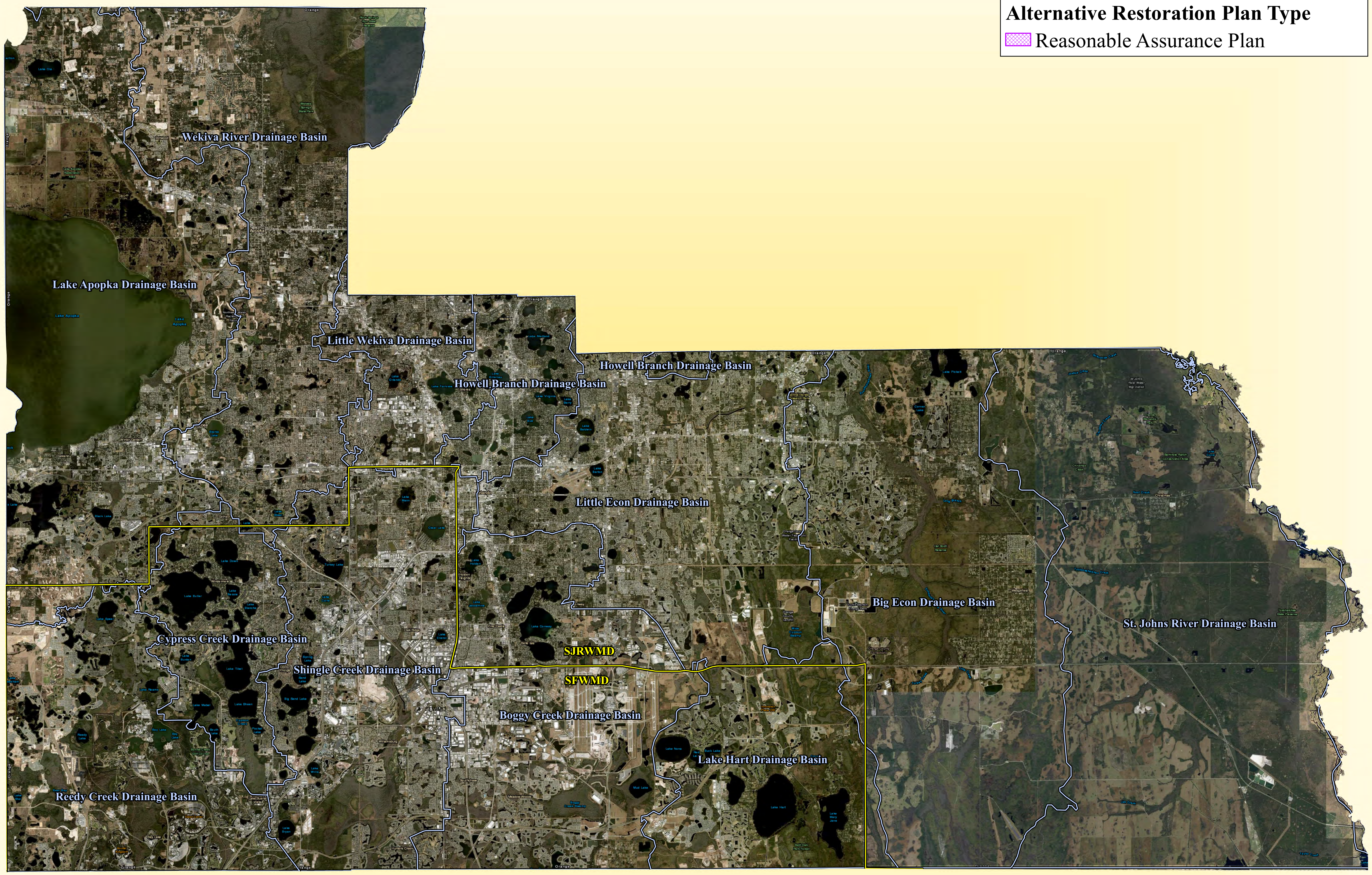
Exhibit **8**



Note: There are currently no Reasonable Assurance Plans in Orange County

Legend

- Water Management District Boundary
- Orange County Major Drainage Basins

Alternative Restoration Plan Type

- Reasonable Assurance Plan

Sources:
County Boundary: Orange County, 2020
Water Management District Boundary: Orange County, 2001
Restoration Plans: FDEP, 2022
Aerial: Orange County, 2021

N

0 0.75 1.5 Miles

Reasonable Assurance Plan (4b) Map

Stormwater Low Impact Development Manual

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Orange County Government Florida

Exhibit **9**

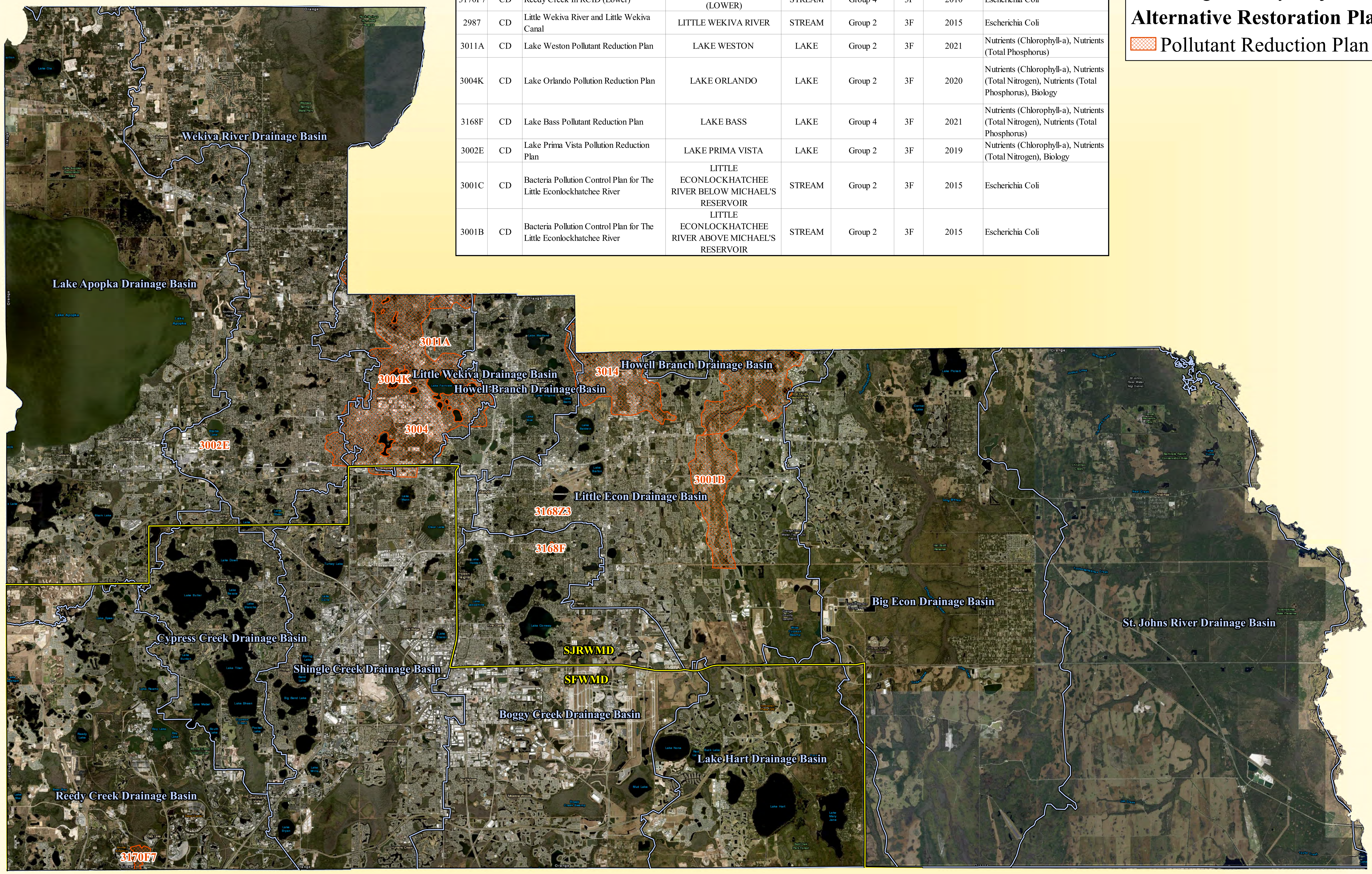
WBID	District	Plan Name	Water Body	Water Type	Group Number	Class	Year Adopted	Parameter
3004	CD	Little Wekiva River and Little Wekiva Canal	LITTLE WEKIVA CANAL	STREAM	Group 2	3F	2015	Escherichia Coli
3168Z3	CD	Lake Arnold Pollutant Reduction Plan	LAKE ARNOLD	LAKE	Group 4	3F	2020	Nutrients (Chlorophyll-a), Nutrients (Total Nitrogen), Nutrients (Total Phosphorus)
3014	CD	Crane Strand Drain Bacteria Pollution Control Plan	CRANE STRAND DRAIN	STREAM	Group 2	3F	2021	Escherichia Coli
3170F7	CD	Reedy Creek In RCID (Lower)	REEDY CREEK IN WCID (LOWER)	STREAM	Group 4	3F	2010	Escherichia Coli
2987	CD	Little Wekiva River and Little Wekiva Canal	LITTLE WEKIVA RIVER	STREAM	Group 2	3F	2015	Escherichia Coli
3011A	CD	Lake Weston Pollutant Reduction Plan	LAKE WESTON	LAKE	Group 2	3F	2021	Nutrients (Chlorophyll-a), Nutrients (Total Phosphorus)
3004K	CD	Lake Orlando Pollution Reduction Plan	LAKE ORLANDO	LAKE	Group 2	3F	2020	Nutrients (Chlorophyll-a), Nutrients (Total Nitrogen), Nutrients (Total Phosphorus), Biology
3168F	CD	Lake Bass Pollutant Reduction Plan	LAKE BASS	LAKE	Group 4	3F	2021	Nutrients (Chlorophyll-a), Nutrients (Total Nitrogen), Nutrients (Total Phosphorus)
3002E	CD	Lake Prima Vista Pollution Reduction Plan	LAKE PRIMA VISTA	LAKE	Group 2	3F	2019	Nutrients (Chlorophyll-a), Nutrients (Total Nitrogen), Biology
3001C	CD	Bacteria Pollution Control Plan for The Little Econlockhatchee River	LITTLE ECONLOCKHATCHEE RIVER BELOW MICHAEL'S RESERVOIR	STREAM	Group 2	3F	2015	Escherichia Coli
3001B	CD	Bacteria Pollution Control Plan for The Little Econlockhatchee River	LITTLE ECONLOCKHATCHEE RIVER ABOVE MICHAEL'S RESERVOIR	STREAM	Group 2	3F	2015	Escherichia Coli

Legend

- Water Management District Boundary
- Orange County Major Drainage Basins

Alternative Restoration Plan Type

- Pollutant Reduction Plan



Sources:
County Boundary: Orange County, 2020
Restoration Plans: FDEP, 2022
Aerial: Orange County, 2021

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0 0.75 1.5 Miles

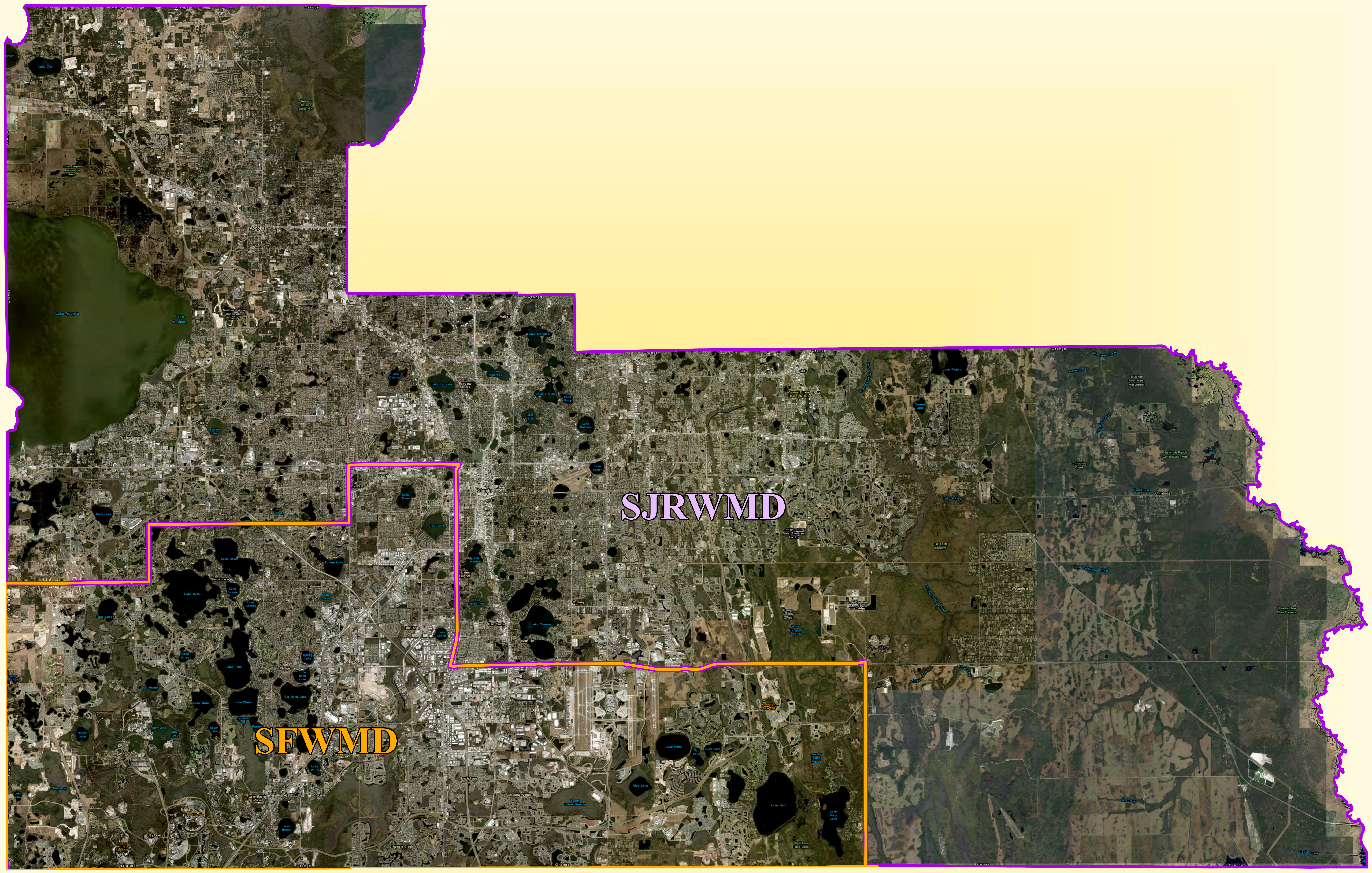
Pollutant Reduction Plan (4e) Map

Stormwater Low Impact Development Manual

Geosyntec consultants

Orange County Government Florida

Exhibit **10**



Legend

- SFWMD Boundary
- SJRWMD Boundary
- Orange County Boundary

Sources:
Water Management District Boundary:
Orange County, 2001
Aerial: Orange County, 2021

N

0 0.75 1.5 Miles

Regulatory Boundaries Map

Stormwater Low Impact Development Manual

Geosyntec consultants

ORANGE COUNTY GOVERNMENT FLORIDA

Exhibit **11**

APPENDIX A

Florida Friendly Landscaping Plant List and References

Tree Type Determination Based on Available Soil Volume

While the tables below guide readers on choosing the appropriate vegetation for each of the LID practices in Volume 2, it should be noted that the amount of soil volume available in the LID practice should dictate the choice of tree to be planted (Gilman and Partin, 2017). Not only should the soil volume available be sufficient to sustain a tree for a reasonable period of time, the soil volume should also take into account trunk flare growth (Gilman and Partin, 2017). This is important since occasionally trees are planted in areas that are big enough for the root ball during planting but do not allow much future growth. Consequences of placing too big of a tree in too small of an area include, but are not limited to, roots not spreading widely enough and leading to instability during times of high winds, such as the hurricane season, as well as concrete or other sidewalk/road materials cracking or being displaced from roots growing past the intended area. Guidance on tree sizing based on available soil volume can be found in **Table A.1**. It should be noted that these measurements apply when rootable soil depth is 3 ft or greater. For soil less than 3 ft deep, smaller maturing trees are required.

Table A.1: Soil requirements for trees based on their size at maturity (Gilman and Partin, 2017)

Tree Size at Maturity	Total Soil area	Distance from Paved Road
Height or spread: lesser than 30 ft	10 ft x 10 ft	2 ft
Height or spread: lesser than 50 ft	20 ft x 20 ft	6 ft
Height or spread: greater than 50 ft	30 ft x 30 ft	10 ft

Florida Friendly vegetation should be utilized in these practices. If trees are proposed, they must be wind tolerant if planted within the right-of-way. There are numerous resources that are updated after Hurricanes/storms that classify trees wind tolerance. Trees within the right-of-way will require submittal of a study performed by an accredited College or association stating the tree has a wind tolerance of medium to high. Florida native vegetation is required when planted adjacent to natural areas and conservation easements; otherwise, it's strongly encouraged.

Zone 9b Hydric Shade

Select plants based on their mature size and consider the amount of space needed for each. It should be noted that depending on its surroundings, vegetation may or may not reach the full potential size. Use plant material appropriately sized and scaled for the size of the bioretention system. Most bioretention systems are typically not very large. Smaller plants such as low growing shrubs, perennials and grasses are usually selected for smaller facilities. Medium sized facilities may include small trees. The list below includes some large trees and shrubs to be used in bigger stormwater bioretention projects.

The following plant list is for partial to full shade, Hydric/Moist, sandy/loam/muck soil conditions where water infiltrates the soil slowly. Plants on this list thrive in well drained moist soil most of the time. During rain events water ponds before soaking in slowly. Plants listed below can withstand both moist and moderately dry conditions. Recommend using trees, when appropriate, on slopes or top of bank rather at the bottom.

NATIVE FLORIDA PLANTS: Mesic/Hydric Hammock, Hardwood Swamp Forests, Cypress Swamp Forests, Freshwater Marshes and Flatwoods are the Florida Native plant associations utilized to formulate this plant list.

PLANT LIST FOR PARTIAL TO FULL SHADE AND MOIST SOILS			
Botanical Name	**Common Name**	**Notes**	**Size**
TREES			
Acer rubrum	Red Maple	Large deciduous tree	70’
Acer saccharum s. floridanum	Florida Maple	Med. deciduous tree	25’
Ardisia escallonioides	Marlberry	Small tree or large Shrub	15’
Aesculus pavia	Red Buckeye	Med. deciduous tree	35’
Aronia arbutifolia	Chokecherry	Small tree or large shrub	10’
Asimina parviflora	Smallflower Pawpaw	Small Tree	15’
Asimina triloba	Common PawPaw	Small tree	20’
Betula nigra ‘DuraHeat’	‘Dura Heat’ River Birch	Large Deciduous tree	50’
Carpinus caroliniana	American Hornbeam	Med. deciduous tree	30’
Cartrema americanum	Wild Olive	Small tree or large shrub	15’
Carya aquatica	Water Hickory	Large deciduous tree	80’
Cercis canadensis	Redbud	Small deciduous tree	30’
Chamaecyparis thyoides	Atlantic White Cedar	Med. Evergreen tree	40’
Chioanthus virginicus	Fringe Tree	Small deciduous tree	20’
Cornus feomina	Swamp Dogwood	Small deciduous tree	30’
Crateagus aestivalis	May Haw	Small deciduous tree	30’
Crateagus marshalli	Parsely Haw	Small deciduous tree, thorns	25’
Cornus foemina	Swamp Dogwood	Small deciduous tree	25’
Cyrilla racemiflora	Titi	Small deciduous tree	25’

PLANT LIST FOR PARTIAL TO FULL SHADE AND MOIST SOILS			
Botanical Name	**Common Name**	**Notes**	**Size**
Diospyros virginiana	Persimmon	Med deciduous Tree	40-60’
Frangula caroliniana	Carolina Buckthorn	Small deciduous tree	15’
Fraxinus pennsylvanica	Green Ash	Large deciduous tree	80’
Gordonia lasianthus	Loblolly Bay	Large evergreen tree	65’
Ilex x attenuata	East Palatka Holly	Small evergreen tree	25’
Ilex cassine	Dahoon Holly	Small evergreen Tree	25’ ht.
Ilex cassine v. myrtlefolia	Myrtle Leaf Holly	Small evergreen tree	25’
Ilex opaca	American Holly	Large evergreen Tree	50’ ht.
Ilex vomitoria	Yaupon Holly	Small evergreen tree	25’ ht.
Magnolia grandiflora	Southern Magnolia	Large evergreen tree	65’
Magnolia virginiana	Sweetbay	Med. evergreen tree	30’
Morus rubra	Red Mulberry	Med. deciduous tree	40’
Myracianthes fragrans	Simpson’s Stopper	Shrub or small tree	20’
Ostrya virginiana	Hophornbeam	Small deciduous tree	30-40’
Pinus elliottii	Slash Pine	Large evergreen tree	100’
Pinus palustris	Longleaf Pine	Large evergreen tree	120’
Pinus taeda	Loblolly Pine	Large evergreen tree	100’
Prunus umbellata	Flatwoods Plum	Small deciduous tree	20’ ht.
Quercus falcata	Red Oak	Large deciduous tree	80’
Quercus shumardii	Shumard Oak	Large deciduous tree	80’
Quercus virginiana	Southern Live Oak	Large evergreen tree	80’
Sassafras albidum	Sassafrass	Small deciduous tree	20-50’
Sabal palmetto	Sabal Palm	Tall palm	100’
Salix nigra	Black Willow	Large deciduous tree	60’
Sapindus saponaria	Wingleaf Soapberry	Small deciduous tree	25’
Sassafras albidum	Sassafras	Med. deciduous tree	40’
Styrax americanus	American Snowbell	Small deciduous tree	12’
Taxodium ascendens	Pond Cypress	Large deciduous tree	80’
Taxodium distichum	Bald Cypress	Large deciduous tree	75’
Vaccinium arboretum	Sparkleberry	Small deciduous tree	25’
Viburnum rufidulum	Rusty Blackhaw	Small deciduous tree	18’
Zanthoxylum clava-herculis	Hercules Club	Small deciduous tree. Thorns	25’
Zanthoxylum fagara	Wild Lime	Small evergreen tree. Thorns	20’
SHRUBS			
Bejaria racemosa	Tarflower	Large evergreen shrub	8’
Agarista popufolia	Pipestem	Large evergreen shrub	15’
Amorpha fruiticosa	False Indigo Bush	Large Deciduous Shrub	12’
Aronia arbutifolia	Chokecherry	Large Deciduous Shrub	6-10’
Arythrina herbacea	Coralbean	Deciduous Shrub	20’

PLANT LIST FOR PARTIAL TO FULL SHADE AND MOIST SOILS			
Botanical Name	**Common Name**	**Notes**	**Size**
Asimina parviflora	Smallflower PawPaw	Deciduous Shrub	4’
Asimina reticulata	Dog Bananna	Deciduous Shrub	2-4’
Callicarpa americana	Beautyberry	Deciduous shrub	8’
Calicanthus floridus	Carolina Allspice	Large deciduous shrub	9’
Cephalanthus occidentalis	Buttonbush	Large deciduous shrub	20’
Chionanthus pygmaeus	Pygmy Fringe Tree	deciduous shrub or small tree	10-12’
Clethra alnifolia	Sweetshrub	Large deciduous shrub	10’
Crinium Americanum	String Lily	Small deciduous shrub	2’
Erythrina herbacea	Coralbean	Large deciduous shrub	20’
Euonymus americanus	American Strawberry Bush	Med. deciduous shrub	6’
Foresteria segregata	Florida Privet	Large evergreen shrub	15’
Hamelia patens	Firebush	Semi-deciduous Shrub	10’
Hamamelis virginiana	Witch Hazel	Large deciduous Shrub	15’ ht.
Hydrangea quercifolia	Oakleaf Hydrangea	Large deciduous shrub	8’
Hypericum cistifolium	Roundpod St. Johns-wort	Small evergreen shrub	3’
Hypericum hypericoides	St. Andrew’s Cross	Small evergreen shrub	4’
Ilex glabra	Gallberry	Large evergreen shrub	12’
Ilex verticillata	Winterberry	Large deciduous shrub	10’
Ilex vomitoria ‘Mrs. Schillings Delight’	‘Mrs. Schiller’s Delight’ Dwarf Yaupon Holly	Small evergreen shrub	3’
Illicium floridanum	Florida Anise	Large evergreen shrub	15’
Illicium parviflorum	Yellow Anise	Large evergreen shrub	15’
Leucothoe axillaris	Dog-Hobble	Small evergreen shrub	4’
Lindera benzoin	Spicebush	Large deciduous shrub	‘10’
Lyonia fruticosa	Staggerbush	Large deciduous shrub	
Lyonia lucida	Fetterbush	Med. evergreen shrub	6’
Morella cerfera	Wax Myrtle	Large evergreen shrub	15’
Morella cerfera ‘Pumila’	Dwarf Wax Myrtle	Small evergreen shrub	4’
Myracianthes fragrans	Simpson’s Stopper	Shrub or small tree	20’
Plumbago zeylanica	Wild Plumbago	Shrub	1’
Ptelea trifoliata	Wafer-Ash	Small deciduous tree or shrub	15’
Psychotria nervosa	Wild Coffee	Large evergreen shrub	15’
Psychotria nervosa ‘Little Psycho’	‘Little Psycho’ Wild Coffe	Small evergreen shrub	3’
Ravina humilis	Rouge Plant	Small evergreen shrub	3-5’
Rhapidophyllum hystrix	Needle Palm	Med. evergreen palm	6’
Rhododendron canescens	Pinxster Azalea	Large deciduous shrub	15’

PLANT LIST FOR PARTIAL TO FULL SHADE AND MOIST SOILS			
Botanical Name	**Common Name**	**Notes**	**Size**
Rhododendron viscosum	Swamp Azalea	Large deciduous shrub	‘15’
Rosa Carolina	Carolina Rose	Small deciduous shrub	4’
Rosa palustris	Swamp Rose	Large deciduous shrub	8’
Sabal minor	Blue Stem Palmetto	Med. evergreen shrub	6’
Sambucus nigra canadensis	Elderberry	Large deciduous shrub	15’
Senna mexicana var. chapmanii	Bahama Senna	Small evergreen shrub	4’
Serenoa repens	Saw Palmetto	Large evergreen palm, usually reclining.	20’
Vaccinium darrowii	Darrow’s Blueberry	Evergreen Low shrub	2’
Viburnum dentatum	Arrowwood	Large deciduous shrub	8’
Vaccinium myrcinites	Shiny Blueberry	Small evergreen shrub	2’
Vaccinium stamineum	Deerberry	Med. Shrub part shade	6-12’
Viburnum nudum	Possum Haw	Large deciduous shrub	12’
Vaccinium obovatum	Walter’s Viburnum	Evergreen tall shrub	10’
Viburnum obovatum ‘Mrs. Schiller’s Delight’	Dwarf ‘Mrs. Schiller’s Delight’ Walter’s Vib	Evergreen low shrub	4’
Zanthoxylum fagara	Wild Lime	Small tree. Thorny.	12-25’
Zamia integrefolia	Coontie	Small evergreen shrub	3’
PERENNIALS/ GRASSES			
Acrostichum danaeifolium	Giant Leather Fern	Large evergreen fern	12’
Andropogon virginicus	Broomsedge Bluestem	Grass	5’
Angadenia berteroi	Pineland Allamanda	Small evergreen shrub	2’
Aralia spinosa	Devil’s Walkingstick	Large deciduous shrub	12’
Aristida stricta	Wiregrass	Grass	4’
Asclepias incarnata	Swamp Milkweed	Perennial	3.5’
Asclepias perennis	Aquatic Milkweed	Perennial	3’
Asclepias verticillata	Whorled Milkweed	Perennial	3’
Dyschcoriste humistrata	Swamp Twinflower	Groundcover	6”
Dyschcoriste oblonifolia	Oblongleaf Twinflower	Groundcover	1’
Euploca polyphylla	Pineland Heliotrope	Groundcover	1’
Coreopsis lanceolata	Lance Leaved Tickseed	Perennial	2.5’
Coreopsis tripterus	Tall Tickseed	Perennial	2-9’
Erythrina herbacea		Perennial	5-10’
Helianthes carnosis	Lakeside Sunflower	Perennial	3’
Heliotropium angiospermum	Scorpion Tail	Perennial	2’
Hibiscus coccineus	Scarlet Hibiscus	Perennial	8’

PLANT LIST FOR PARTIAL TO FULL SHADE AND MOIST SOILS			
Botanical Name	**Common Name**	**Notes**	**Size**
Hibiscus moscheutos 'Carafe Granache'	Rose Mallow	Perennial	6’
Hymenocallis latifolia	Perfumed Spiderlily	Perennial	4’
Iris savannarum	Savanna Iris	Perennial	4’
Iris virginica	Southern Blue Flag	Perennial	4’
Justica pringlei	Cooley’s Justica	Perennial	8”
Lilium catsbaei	Pine Lily	Perennial	2’
Lobelia cardenalis	Cardinal Flower	Perennial	5’
Mimosa strigillosa	Sunshine Mimosa	Groundcover	6”
Nephrolepsis biserrata	Sword Fern	Fern	3.5’
Osmunda regalis v. spectabilis	Royal Fern	Fern	4’
Osmundastrum cinnamomeum	Cinnamon Fern	Fern	4’
Panicum hemitomon	Maidencane	Grass	4’
Phlebodium aureum	Polypody Fern	Fern	2’
Rhexia spp.	Meadow Beauty	Perennial	2’
Rhynchospora colorata	Whitetop Sedge	Perennial	2’
Rudbeckia laciniata	Cutleaf Cornflower	Perennial	6’
Ruella caroliniensis	Wild petunia	Perennial	1-2’
Salvia lyrata	Lyre-leaf Sage	Perennial	1.5’
Spiranthes odorata	Fragrant Ladies Tresses	Perennial	2’
Solidago stricta	Slender Goldenrod	Perennial	5’
Siphium asteriscus	Starry Rosinweed	Perennial	5’
Panicum virgatum	Switchgrass	Grass	4’
Penstemmon lavigatus	Eastern Smooth Beardtounge	Perennial	3’
Phlox divaicata	Wild Blue Phlox	Perennial	2’
Phylla nodiflora	Frogfruit	Groundcover	6”
Pluchia odorata	Sweetscent	Perennial	3’
Symphyotrichum dumosum	Bush Aster	Perennial	4’
Telmatoblechnum serrulatum	Swamp Fern	Fern	3’
Thelypteris kuntii	Southern Shield Fern	Fern	3’
Thelypteris spp.	Maiden Fern	Fern	2’
Tripcasum dactyloides	Eastern Gammagrass	Grass	6’
Tripcasum floridanum	Dwarf Fakahatchee Grass	Grass	3’
Woodwardia areolata	Netted Chain Fern	Fern	1.5
Woodwardia virginica	Chain Fern	Fern	3’

PLANT LIST FOR PARTIAL TO FULL SHADE AND MOIST SOILS			
Botanical Name	**Common Name**	**Notes**	**Size**
Zephyranthes atamasca	Rain Lily	Perennial	1’
AQUATIC WETLAND			
Bacopa monneri	Water Hyssop	Aquatic	6”
Canna flaccida	Golden Canna	Perennial	6’
Equisetum hyemale var. affine	Horsetail	Aquatic	2-4’
Juncus effusus	Soft Rush	Grass	3’
Nuphar advena	Spadderdock	Aquatic	4”
Nymphaea Mexicana	Yellow Water Lily	Aquatic	6”
Nymphaea odorata	White Water Lily	Aquatic	6”
Nymphoides aquatica	Floating Hearts	Aquatic	4”
Orontium aquaticum	Golden Club	Aquatic	1.5’
Panicum hermitomon	Maidencane	Aquatic Grass	4’
Pontederia cordata	Pickerelweed	Aquatic	4’
Sagittaria latifolia	Arrowhead	Aquatic	4’
Sagittaria lancefolia	Duck Potato	Aquatic	5’
Saururus cernuus	Lizard’s Tail	Aquatic	3’
Scirpus cyperinus	Woolgrass	Aquatic	6’
Thalia geniculata	Alligator Flag	Aquatic	9’

Sources: Florida Native Plant Society, Florida Association of Native Nurseries, Florida Natural Areas Inventory, University of Florida Institute of Food and Agricultural Services.

Zone 9b Hydric Sun

Select plants based on their mature size and consider the amount of space needed for each. It should be noted that depending on its surroundings, vegetation may or may not reach the full potential size. Use plant material appropriately sized and scaled for the size of the bioretention system. Most bioretention systems are typically not very large. Smaller plants such as low growing shrubs, perennials and grasses are usually selected for smaller facilities. Medium sized facilities may include small trees. The list below includes some large trees and shrubs to be used in bigger stormwater bio-retention projects.

The following plant list is for full sun, Hydric/Moist, sandy/loam/muck soil conditions where water infiltrates the soil slowly. During rain events, water ponds before soaking in slowly. Plants listed below grow in moist conditions but can survive occasional dryer periods. Trees in moist areas, when appropriate for the size of the LID facility, are best used on slopes or top of bank rather at the bottom of a pond.

NATIVE FLORIDA PLANTS: Mesic/Hydric Hammock, Hardwood Swamp Forests, Cypress Swamp Forests, Freshwater Marshes and Flatwoods are the Florida Native plant associations utilized to formulate this plant list.

PLANT LIST FOR FULL SUN AND MOIST SOILS			
Botanical Name	**Common Name**	**Notes**	**Size**
TREES			
Acer rubrum	Red Maple	Large deciduous tree	70’
Ardisia escallonioides	Marlberry	Small tree or large Shrub	15’
Aronia arbutifolia	Chokecherry	Small tree or large shrub	10’
Betula nigra ‘DuraHeat’	‘Dura Heat’ River Birch	Large Deciduous tree	50’
Carpinus caroliniana	American Hornbeam	Med. deciduous tree	30’
Carya aquatica	Water Hickory	Large Deciduous tree	80’
Cercis canadensis	Redbud	Small deciduous tree	30’
Celtis laevigata	Hackberry	Large deciduous tree	80’
Chamaecyparis thyoides	Atlantic White Cedar	Large evergreen tree	50’
Chioanthus virginicus	Fringe Tree	Small deciduous tree	20’
Cornus feomina	Swamp Dogwood	Small deciduous tree	30’
Crategus aestivalis	May Haw	Small deciduous tree	25’
Cyrilla racemiflora	Titi	Small semi evergreen tree	30’
Diospyros virginiana	Persimmon	Med. Deciduous Tree	40-60’
Fraxinus pennsylvanica	Green Ash	Large Deciduous tree	80’
Gordonia lasianthus	Loblolly Bay	Large evergreen tree	65’
Ilex x attenuata ‘East Palatka’	East Palatka Holly	Small evergreen tree	25’
Ilex cassine	Dahoon Holly	Med. Evergreen tree	30’
Ilex decidua	Possum Haw	Small evergreen tree	20’
Ilex opaca	American Holly	Large evergreen tree	50’

PLANT LIST FOR FULL SUN AND MOIST SOILS			
Botanical Name	**Common Name**	**Notes**	**Size**
Ilex vomitoria	Yaupon Holly	Small evergreen tree	25' ht.
Magnolia grandiflora	Southern Magnolia	Large Evergreen tree	
Magnolia virginiana	Sweetbay Magnolia	Large Evergreen tree	50'
Morris rubra	Red Mulberry	Med. deciduous tree	40'
Ostrya virginiana	Hophornbeam	Med. deciduous tree	30-40'
Pinus elliottii	Slash Pine	Large evergreen tree	100'
Pinus palustris	Longleaf Pine	Large evergreen tree	120'
Pinus taeda	Loblolly Pine	Large evergreen tree	100'
Prunus umbellata	Flatwoods Plum	Small deciduous tree	20' ht.
Quercus falcata	Red Oak	Large deciduous tree	80'
Quercus shumardii	Shumard Oak	Large deciduous tree	80'
Quercus virginiana	Southern Live Oak	Large evergreen tree	80'
Sabal palmetto	Sabal Palm	Large palm	60'
Salix caroliniana	Coastal Plain Willow	Small deciduous tree	25-30'
Sassafras albidum	Sassafrass	Med. deciduous tree	20-50'
Taxodium ascendens	Pond Cypress	Large deciduous tree	80'
Taxodium distichum	Bald Cypress	Large deciduous tree	75'
SHRUBS			
Aronia arbutifolia	Chokecherry	Deciduous large shrub	6-10'
Asimina reticulata	Dog-bananna	Deciduous small shrub	4'
Calycanthus floridus	Carolina Allspice	Large deciduous shrub	9'
Callicarpa americana	Beautyberry	Deciduous large shrub	8'
Cephalanthus occidentalis	Buttonbush	Deciduous large shrub	20'
Clethra alnifolia	Sweetpepperbush	Med. Deciduous shrub	5-8'
Foresteria segregata	Florida Privet	Large Evergreen Shrub	15'
Hamelia patens	Firebush	Semi-deciduous Shrub	10'
Hibiscus coccineus	Scarlet Hibiscus	Med. deciduous shrub	6'
Hibiscus grandiflorus	Swamp Rosemallow	Large deciduous shrub	10'
Hypericum cistifolium	Roundpod St. Johnswort	Small evergreen shrub	2.5'
Hyperium hypercoides	St. Andrew's Cross	Small evergreen shrub	4'
Ilex glabra	Gallberry	Large evergreen shrub	10'
Ilex verticillata	Winterberry	Large deciduous shrub	10'
Itea virginica	Virginia willow	Large deciduous shrub	8'
Kosteletzkya pentacarpos	Saltmarsh Mallow	Med. Part decid. shrub	5'
Lantanna			
Lyonia fruticosa	Staggerbush	Large evergreen shrub	6'
Lyonia lucida	Fetterbush	Large evergreen shrub	6'
Morella cerifera	Wax Myrtle	Large evergreen shrub	20'
Morella cerifera 'Pumila'	Dwarf Wax Myrtle	Med evergreen shrub	4'
Myracianthes fragrans	Simpson's Stopper	Shrub or small tree	20'

PLANT LIST FOR FULL SUN AND MOIST SOILS			
Botanical Name	**Common Name**	**Notes**	**Size**
Ptelea trifoliata	Wafer-Ash	Small deciduous tree or shrub	15’
Psychotria nervosa	Wild Coffee	Large evergreen shrub	15’
Psychotria nervosa ‘Little Psycho’	‘Little Psycho’ Wild Coffe	Small evergreen shrub	3’
Rosa carolina	Carolina Rose	Small deciduous shrub	4’
Rosa palustris	Swamp Rose	Large deciduous shrub	8’
Sambucus nigra canadensis	Elderberry	Large deciduous shrub	15’
Serenoa repens	Saw Palmetto	Large evergreen palm, usually reclining.	20’
Siderylon tenax	Tough Buckthorn	Large evergreen shrub. May be thorny.	20’
Tripcasum dactyloides	Eastern Gammagrass	Grass	6’
Tripcasum floridanum	Dwarf Fakahatchee Grass	Grass	3’
Vaccinium darrowii	Darrow’s Blueberry	Evergreen Low shrub	2’
Vaccinium obovatum	Walter’s Viburnum	Evergreen tall shrub	10’
Viburnum obovatum ‘Mrs. Schiller’s Delight’	Dwarf ‘Mrs. Schiller’s Delight’ Walter’s Vib	Evergreen low shrub	4’
Viburnum dentatum	Arrowwood	Large deciduous shrub	8’
Vaccinium darrowii	Darrow’s Blueberry	Small evergreen shrub	2’
Vaccinium myrcinites	Shiny Blueberry	Small evergreen shrub	2’
Vaccinium stamineum	Deerberry	Med. Shrub part shade	6-12’
Xemenia americana	Tallowwood	Large deciduous shrub	20’
Zanthoxylum fagara	Wild Lime	Small tree. Thorny.	12-25’
PERENNIALS/ GRASSES			
Aristida stricta	Wiregrass	Grass	4’
Asclepias incarnata	Rose Milkweed	Perennial	3.5
Asclepias perennis	Swamp Milkweed	Perennial	3’
Asclepias tuberosa	Butterfly weed	Perennial	2’
Bacopa monnieri	Water Hyssop	Groundcover	6”
Canna flaccida	Golden Canna	Wetland	6’
Conoclinium coelestinum	Mistflower	Perennial	2’
Coreopsis floridana	Florida Tickseed	Perennial	4’
Coreopsis gladiana	Southeastern Tickseed	Perennial	2.5’
Coreopsis lanceolata	Lanceleaved Tickseed	Perennial	2.5
Coreopsis nudata	Swamp Tickseed	Perennial	2-3’
Crinium americanum	String Lily	Perennial	2’
Dyschoriste oblongifolia	Oblongleaf Twinflower	Groundcover	6”
Echinaea purpurea	Purple Coneflower	Perennial	2-3’
Eleocharis celluosa	Gulf Coast Spikerush	Wetland, aggressive	3’

PLANT LIST FOR FULL SUN AND MOIST SOILS			
Botanical Name	**Common Name**	**Notes**	**Size**
Equisetum hyemale var. affine	Horsetail	Wetland	3’
Eragrostis elliottii	Elliot’s Lovegrass	Grass	3’
Euploca polyphylla	Pineland Heliotrope	Groundcover	1’
Helianthus agrestis	Southeastern Sunflower	Perennial	3-5’
Helianthus angustifolius	Swamp Sunflower	Perennial	8’
Heliotropium angeospermum	Scorpion Tail	Perennial	2’
Hymenocallis latifolia	Spider Lily	Perennial	3’
Hibiscus aculeatus	Pineland Hibiscus	Perennial	3’ +
Hibiscus coccineus	Scarlet Hibiscus	Perennial	8’
Hibiscus grandiflorus	Swamp Rosemallow	Perennial	10’
Hibiscus moscheutos	Swamp Mallow	Perennial	6’
Hydrocotyle umbellata	Marsh Pennywort	Groundcover	6”
Hydrolia corymbose	Skyflower	Perennial	2’
Hymenocallis latifolia	Mangrove Spiderlily	Perennial	4’
Hymenocallis occidentalis	Northern Spider Lily	Perennial	2’
Iris savannarum	Savanna Iris	Perennial	4’
Iris virginica	Virginia Iris	Perennial	4’
Liatris elegans	Blazing Star Liatris	Perennial	2-4’
Liatris spicata	Spiked Blazing Star	Perennial	2-4’
Lobelia cardinalis	Cardinal Flower	Perennial	4’
Mimosa strigillosa	Sunshine Mimosa	Groundcover	6”
Monarda punctata	Spotted Horsemint	Perennial	2’
Mulenbergia capillaris	Muhly Grass	Grass	1-5’
Osmunda regalis	Royal Fern	Fern	5’
Panicum hemitomon	Maidencane	Grass	4’
Panicum virgatum	Switchgrass	Grass	4’
Phyla nodiflora	Frogfruit	Groundcover	6”
Pityopsis graminifolia	Silkgrass	Perennial	1’
Rhynchospora colorata	Whitetop Sedge	Perennial	2’
Rudbeckia hirta	Black Eyed Susan	Perennial	1-3’
Ruella caroliniensis	Wild petunia	Perennial	1-2’
Salvia coccinea	Tropical Sage	Perennial	2-5’
Salidago spp.	Goldenrods	Perennial	2-6’
Sorghastrum secundum	Lopsided Indiangrass	Herbaceous grass	3-6’
Spartina bakeri	Sand Cordgrass	Grass	5’
Stokesia laevis	Stokes Aster	Groundcover	1.5’
Sisyrinchium angustifolium	Blue Eyed Grass	Groundcover	1’

PLANT LIST FOR FULL SUN AND MOIST SOILS			
Botanical Name	**Common Name**	**Notes**	**Size**
Tripsacum floridanun	Florida Gamma Grass	Grass	4’
Zephyranthes atamasca	Rain Lily	Lily	1’
AQUATIC			
Bacopa caroliniana	Blue Water Hyssop	Winter dormant	6”
Bacopa monnieri	Water Hyssop	Winter dormant	6”
Canna flacida	Golden Canna	Semi-winter dormant	6’
Eleocharis celluosa	Gulf Coast Spikerush	Evergreen sedge	3’
Iris hexigona	Prairie Blue Flag	Winter dormant	2’
Iris virginica	Southern Blue Flag	Winter dormant	4’
Juncus effusus	Soft Rush	Evergreen perennial	3’
Nelumbo lutea	Yellow Lotus	Winter dormant	1’
Nuphar advena	Spatterdock (Lily Pad)	Winter dormant	6”
Nymphaea elegans	Blue Water Lily	Winter dormant	6”
Nymphaea Mexicana	Yellow Water Lily	Winter dormant	9”
Nymphaea odorata	White Water Lily	Winter dormant	6”
Nymphoides aquatica	Floating hearts	Winter dormant	6”
Pontederia cordata	Pickerelweed	Winter dormant	3’
Orontium aquaticum	Golden-Club	Winter dormant	1.5’
Sabatia decandra	Bartram’s Marsh Pink	Perennial	2.5
Sagittaria latifolia	Common Arrowhead	Winter dormant	4’
Saururus cernuus	Lizard’s Tail	Evergreen perennial	3’
Schoenoplectus pungens	Three-square Bullrush	Evergreen grass	5’
Scirpus cyperinus	Woolgrass	Winter dormant	6’
Thalia geniculata	Alligator Flag	Winter dormant	9’
Zizaniopsis miliancea	Giant Cutgrass	Grass	10’

Sources: Florida Native Plant Society, Florida Association of Native Nurseries, Florida Natural Areas Inventory, University of Florida Institute of Food and Agricultural Services.

Zone 9b Xeric Shade

Select plants based on their mature size and consider the amount of space needed for each. It should be noted that depending on its surroundings, vegetation may or may not reach the full potential size. Use plant material appropriately sized and scaled for the size of the bioretention system. Most bioretention systems are typically not very large. Smaller plants such as low growing shrubs, perennials and grasses are usually selected for smaller facilities. Medium sized facilities may include small trees. The list below includes some large trees and shrubs to be used in bigger stormwater bio-retention projects.

The following plant list is for Xeric/Dry partly shady, well drained sandy soil conditions where water infiltrates the soil quickly. Plants on this list thrive in dryer soil most of the time except during rain events where water soaks in rapidly. Plants listed below can withstand periodic moist soil but otherwise prefer dry conditions. Recommend using trees, when appropriate, on slopes or top of bank rather at the bottom.

NATIVE FLORIDA PLANTS: Longleaf Pine Forest, Sandhill Forest, Upland Dry Mesici/Xeric Hammock, Scrub are the Florida native plant associations utilized to formulate this plant list.

PLANT LIST FOR PARTLY SHADY AND WELL DRAINED SOILS			
Botanical Name	**Common Name**	**Notes**	**Size**
TREES			
Cartrema americanum	Wild Olive	Small evergreen tree	15’ ht.
Cartrema floridanum	Scrub Wild Olive	Small evergreen tree	15’
Castanea pumila	Ashe’s Chinquapin	Med. deciduous tree	30’ ht.
Carya floridanum	Scrub Hickory	Med. deciduous tree	30’ ht.
Celtis occidentalis	Hackberry	Small deciduous tree	20’ ht.
Cercis canadensis	Redbud	Med. Deciduous tree	30’ ht.
Chionanthes virginicus	White Fringe Tree	Small Deciduous tree	20’ ht.
Diospyros virginiana	Persimmon	Large Deciduous Tree	40-60’
Frangula caroliniana	Carolina Buckthorn	Small deciduous tree	15’ ht.
Ilex ambigua	Carolina Holly	Small deciduous tree	15’ ht.
Ilex opaca	American Holly	Large Evergreen Tree	50’ ht.
Ilex opaca v. arenicola	Scrub Holly	Small Evergreen tree	20’
Ilex vomitoria	Yaupon Holly	Small evergreen tree	25’ ht.
Myracianthes fragrans	Simpson’s Stopper	Large Shrub or small tree	20’
Ostrya virginiana	Hophornbeam	Med. deciduous tree	30-40’
Quercus falcata	Southern Red Oak	Large deciduous tree	80’ ht.
Quercus geminata	Sand Live Oak	Med. Evergreen tree	30’
Quercus laevis	Turkey Oak	Large Deciduous tree	40’
Pinus elliottii	Slash Pine	Large evergreen tree	100’
Pinus taeda	Loblolly Pine	Large evergreen tree	90’ ht.
Prunus americana	Wild Plum	Med. Deciduous tree	30’ ht.
Prunus umbellata	Flatwoods Plum	Small deciduous tree	20’ ht.

PLANT LIST FOR PARTLY SHADY AND WELL DRAINED SOILS			
Botanical Name	**Common Name**	**Notes**	**Size**
Sapindus saponaria	Wingleaf Soapberry	Med. Deciduous tree	30’
Sassafras albidum	Sassafrass	Small deciduous tree	20-50’
Vaccinium arboretum	Sparkleberry	Small deciduous tree	25’
Ximinia americana	Tallowwood	Small deciduous tree. Thorny.	20’
Zanthoxylum clava-herculis	Hercules Club	Small deciduous tree. Thorny.	25’
Zanthoxylum fagara	Wild Lime	Small evergreen tree. Thorny.	20’
SHRUBS			
Amorpha fruiticosa	False Indigo Bush	Large Deciduous Shrub	12’
Ardisia escallonioides	Marlberry	Large Evergreen Shrub	15’
Aronia arbutifolia	Chokecherry	Large Deciduous Shrub	6-10’
Asimina obovata	Dog Bananna	Small Deciduous Shrub	2-4’
Bejaria racemosa	Tarflower	Large Evergreen Shrub	8’
Callicarpa americana	Beautyberry	Large Deciduous shrub	8’
Cephalanthus occidentalis	Bottonbush	Large Deciduous shrub	20’
Erythrina herbacea	Coralbean	Large deciduous shrub	20’
Eugenia axillaris	White Stopper	Large evergreen shrub	15’
Euonymus americanus	American Strawberry Bush	Med. Deciduous shrub	7’
Hamelia patens	Firebush	Large Semideciduous shrub	20’
Hamamelis virginiana	Witch Hazel	Large Deciduous Shrub	15’ ht.
Hypericum hypericoides	St. Andrews’s Cross	Small evergreen shrub	3-4’
Ilex glabra	Inkberry	Large evergreen shrub	12’
Lantana involucrata	Wild Lantana	Small evergreen shrub	5’
Lyonia fruticosa	Staggerbush	Large evergreen shrub	10’
Morella cerifera	Wax Myrtle	Large evergreen shrub or small tree	15’
Plumbago zeylandia	Wild Plumbago	Small evergreen shrub	1’
Psychotria nervosa	Wild Coffee	Med. Evergreen shrub	6’
Psychotria nervosa ‘Little Psycho’	‘Little Psycho’ Dwarf Wild Coffee	Small Evergreen shrub	2.5’
Ptelea trifoliata	Wafer-Ash	Small deciduous tree or large shrub	5’
Rivina humilis	Rouge Plant	Med. Evergreen Shrub	5’
Sabal minor	Bluestem Palmetto	Large Evergreen shrub	8’
Serenoa repens	Saw Palmetto	Large evergreen palm, usually reclining	20’
Siderylon tenax	Tough Buckthorn	Large evergreen shrub. May be thorny	20’

PLANT LIST FOR PARTLY SHADY AND WELL DRAINED SOILS			
Botanical Name	**Common Name**	**Notes**	**Size**
Vaccinium darrowii	Darrow's Blueberry	Small evergreen shrub	2'
Vaccinium myrsinites	Shiny Blueberry	Small evergreen shrub	2'
Viburnum rufidulum	Rusty Blackhaw	Large Deciduous shrub or small tree	15'
Viburnum obovatum	Walter's Viburnum	Large evergreen shrub	15'
Viburnum obovatum 'Mrs. Schiller's Delight'	Dwarf 'Mrs. Schiller's Delight' Viburnum	Small evergreen shrub	4'
Zamia integrefolia	Coontie	Small evergreen shrub	3'
PERENNIALS/GRASSES			
Aristida s. var beyrichiana	Wiregrass	Grass	4'
Baptisia alba	White Wild Indigo	Perennial	5'
Chrysopsis mariana	Maryland Goldenaster	Perennial	2'
Coryopsis lanceolata	Lance Leaved Tickseed	Perennial	2.5'
Dyschoriste oblongifolia	Oblong Twinflower	Groundcover	1'
Eragrostis sspectabilis	Purple Love Grass	Grass	3'
Erythrina herbacea	Coralbean	Perennial	5-10'
Euploca polyphylla	Pineland Heliotrope	Groundcover	1'
Geobalanus oblongifolius	Gopher Apple	Groundcover	1'
Lobelia cardinalis	Cardinal Flower	Perennial	5'
Panicum virgatum	Switchgrass	Grass	5'
Penstemon australis	Slender Beardtounge	Perennial	3'
Penstemmon multiflorus	Manyflower Beardtounge	Perennial	3'
Phlox divaricata	Wild Blue Phlox	Perennial	2'
Rudbeckia fulgida	Orange Cornflower	Perennial	3'
Ruella caroliniensis	Wild petunia	Perennial	1-2'
Salvia coccinea	Tropical Sage	Perennial	2-5'
Salvia lyrata	Lyre-leaf Sage	Perennial	1.5'
Salvia misella	Creeping Sage	Groundcover	6 inches
Silphium asteriscus	Starry Rosinweed	Perennial	2.5'
Solidago odora	Sweet Goldenrod	Perennial	5'
Solidago odora var. chapmanii	Chapman's Goldenrod	Perennial	5'
Solidago sempervirens	Seaside Goldenrod	Perennial	5'
Solidago stricta	Wand Goldenrod	Perennial	5'
Sorghastrum nutans	Yellow Indiangrass	Herbaceous grass	3 – 5'
Sporobolus junceus	Pineywoods Dropseed	Grass	2'
Symphiotrichum concolor	Eastern Silver Aster	Perennial	3'
Tradescantia spp,	Spiderwort	Perennial	3'
Tripsacum dactyloides	Fakahatchee Grass	Grass	6'
Tripcasum floridanum	Dwarf Fakacatchee Grass	Grass	3'

PLANT LIST FOR PARTLY SHADY AND WELL DRAINED SOILS			
Botanical Name	**Common Name**	**Notes**	**Size**
Vernonia angustifolia	Narrowleaf Ironweed	Perennial	3’

Sources: Florida Native Plant Society, Florida Association of Native Nurseries, Florida Natural Areas Inventory, University of Florida Institute of Food and Agricultural Services.

Zone 9b Dry Sun

Be aware of the scale and size of a space. It should be noted that depending on its surroundings, vegetation may or may not reach the full potential size. Use plant material that has a mature size appropriate for the size of the bioretention system. Most bioretention systems are typically not very large. Smaller plants such as low shrubs, perennials and grasses are usually selected for smaller facilities. Large stormwater ponds, urban wetland parks or campus locations are suitable for large trees. The list below includes large trees and shrubs to be used in large-scale stormwater projects.

The following list is for Xeric/Dry, well drained sandy soil conditions where water infiltrates the soil quickly. Plants on this list thrive in dry soil most of the time except during rain events. Rain water soaks into sandy soils rapidly. Plants listed below can withstand periodic moist conditions but otherwise prefer dry conditions.

NATIVE FLORIDA PLANTS: Longleaf Pine Forest, Sandhill Forest, Upland Mesic Hardwood Forest and Florida Scrub are the Florida Native plant associations utilized to formulate this plant list.

PLANT LIST FOR FULL SUN AND DRY SOILS			
Botanical Name	**Common Name**	**Notes**	**Size**
TREES			
Carya glabra	Pignut Hickory	Large Deciduous Tree	100’ ht.
Castanea pumila	Chinquapin	Med. Deciduous tree	40’ ht.
Diospyros virginiana	Persimmon	Med. Deciduous Tree	40-60’
Ilex opaca ‘arenicola’	Scrub Holly	Small evergreen tree	12-20’
Ilex vomitoria	Yaupon Holly	Small evergreen tree	25’
Ilex vomitoria ‘Pendula’	Weeping Yaupon Holly	Small weeping evergreen tree	20’
Juniperus virginiana	Red Cedar	Large evergreen tree	60’ ht.
Liquidambar styracflua	Sweetgum	Large deciduous tree	80’
Lyonia ferruginea	Rusty Lyonia	Small evergreen tree or large shrub	20’
Ostya virginiana	Hophornbeam	Med. Deciduous tree	30-40’
Pinus elliottii	Slash Pine	Large evergreen tree	100‘ ht.
Pinus palustris	Longleaf Pine	Large evergreen tree	100’ ht.
Prunus umbellata	Flatwoods Plum	Small deciduous tree	20’ ht
Ptelea trifoliata	Wafer-Ash	Small deciduous tree	15’
Quercus chapmanii	Chapman’s Oak	Small deciduous tree or shrub	15’
Quercus geminata	Sand Live Oak	Med. Evergreen tree	30’
Quercus falcata	Southern Red Oak	Large Deciduous Tree	80’
Quercus laevis	Turkey Oak	Med. Deciduous tree	40’ ht.
Quercus stellata	Post Oak	Large deciduous tree	50’ ht.
Quercus virginiana	Live Oak	Large Evergreen tree	80’ ht.
Rhamnus caroliniana	Carolina Buckthorn	Small Deciduous tree	15’
Sassafras albidum	Sassafras	Med. Deciduous tree	20-50’

PLANT LIST FOR FULL SUN AND DRY SOILS			
Botanical Name	**Common Name**	**Notes**	**Size**
SHRUBS			
Agave decipiens	False Sisal	Small Evergreen shrub, sharp pointe leaves	5'
Aronia arbutifolia	Chokecherry	Large Deciduous Shrub	6-10'
Asimina obovata	Scrub Flag Pawpaw	Large deciduous shrub	10'
Asimina pygmea	Pygmy Pawpaw	Small Deciduous Shrub	2'
Asimina reticulata	Dog-banana	Med. Deciduous shrub	4'
Bejaria racemosa	Tarflower	Large Evergreen Shrub	8'
Callicarpa americana	Beautyberry	Large Deciduous shrub	8'
Chionanthus pygmaeus	Pygmy Fringe Tree	Large Deciduous Shrub	10-12'
Chrysobalanus icaco 'horizontal'	Horizontal Cocoplum	Small evergreen shrub or groundcover. (not freeze hardy)	2'
Conrandina brevifolia	Shortleaved Rosemary	Small evergreen shrub	3'
Conrandina canescens	False Rosemary	Small evergreen shrub	2-3'
Conrandina etonia	Scrub Mints	Small evergreen shrub	3'
Conrandina grandiflora	Pineland Mint	Small evergreen shrub	3'
Erythrina herbacea	Coralbean	Deciduous shrub, thorns, variable size.	3-20'
Hamelia patens	Firebush	Large Semi-deciduous Shrub	10'
Hypericum reductum	Scrub St. Johns Wort	Small Evergreen Shrub	3'
Hypericum tenufolium	Atlantic St. Johns Wort	Small Evergreen Shrub	
Ilex vomitoria 'nana' or 'schillings dwarf'	Dwarf Yaupon Holly	Small Evergreen Shrub	3-5'
Lantana depressa var. depressa	Gold Lantana	Small Evergreen Shrub	2'
Lantana involucrata	Wild Sage	Small Evergreen shrub	4'
Lyonia ferruginea	Rusty Lyonia	Large Evergreen Shrub or small tree	10-15'
Myracianthes fragrans	Simpson's Stopper	Large Shrub or small tree	20'
Nolina brittonia	Britton's Beargrass	Small Shrub / Grass	5'
Rivina humilis	Rouge Plant	Med. Evergreen shrub	5'
Rhus copallinum	Winged Sumac	Large deciduous shrub	10'
Sabal etonia	Scrub Palmetto	Small – Med. Evergreen shrub	5'
Serenoa repens	Saw Palmetto	Large evergreen palm, usually reclining, thorns	20'
Siderylon tenax	Tough Buckthorn	Medium to Large evergreen shrub. thorny.	20'
Severina buxifolia	Boxthorn	Large evergreen shrub	12'
Vaccinium darrowii	Darrow's Blueberry	Small Evergreen shrub	2'

PLANT LIST FOR FULL SUN AND DRY SOILS			
Botanical Name	**Common Name**	**Notes**	**Size**
Viburnum dentatum	Arrowwood	Large deciduous shrub	6-8’
Viburnum obovatum	Walter’s Viburnum	Large evergreen shrub or small tree	15’
Viburnum obovatum ‘Mrs. Schiller’s Delight’	Dwarf Mrs. Schiller’s Delight Walter’s Viburn.	Small evergreen shrub	3-4’
Yucca filamentosa	Adam’s Needle	Small Evergreen plant (except flower spike).	3-12’
Xemenia americana	Tallowwood	Large deciduous shrub. Thorny.	20’
Zanthoxylum fagara	Wild Lime	Large shrub or small tree. Thorny.	12-25’
Zamia integrifolia	Coontie	Small evergreen shrub	3’
PERENNIALS/ GRASSES			
Aristida s. var beyrichiana	Wiregrass	Grass	4’
Asclepias humistrata	Pineland Milkweed	Perennial	3’
Asclepias tuberosa	Butterfly weed	Perennial	2’
Baptista alba	White Wild Indigo	Perennial	5’
Calamintha georgiana	Georgia Calaminth	Perennial	3’
Carphephorus corymbosus	Florida Paintbrush	Perennial	3’
Chrysopsis mariana	Maryland Goldenaster	Perennial	2’
Conrandina etonia	Scrub Mints	Perennial	2-3’
Conrandina grandiflora	Pineland Mint	Perennial	3’
Coreopsis leavenworthii	Leavenworth’s Tickseed	Perennial	2-3’
Coreopsis tripterus	Tall Tickseed	Perennial	2-9’
Crossopetalum ilicifolium	Christmasberry	Low Shrub/ groundcover	3’
Echinaea purpurea	Purple Coneflower	Perennial	2-3’
Eragrostis spectabilis	Purple Love grass	Grass	4’
Euploca polyphyla	Pineland Heliotrope	Groundcover	1’
Flaveria linearis	Yellowtop	Perennial	3’
Garberia heterophylla	Garberia	Perennial	1-6’
Geobalanus oblongifolius	Gopher Apple	Groundcover	1’
Glandularia maritima or tampensis	Beach Verbena, Tampa Vervain	Groundcover	1’
Helianthus debilis	Beach Sunflower	Groundcover	1.5’
Licania michauxii	Gopher Apple	Groundcover	1-1.5’
Liatris elegans	Blazing Star Liatris	Perennial	2-4’
Melanthera nivea	Cat’s Tongue	Perennial	5’
Monarda punctata	Spotted Horsemint	Perennial	2-5’
Mulenbergia capillaris	Muhly Grass	Grass	1-5’
Mimosa strigillosa	Powderpuff Mimosa	Groundcover	6”

PLANT LIST FOR FULL SUN AND DRY SOILS			
Botanical Name	**Common Name**	**Notes**	**Size**
Penstemon australis	Slender Beardtongue	Perennial	3’
Penstemon multiflorus	Manyflower Beardtongue	Perennial	3’
Piloblephis rigida	Pennyroyal	Perennial	2’
Pityopsis tracti	Narrowleaf Silkgrass	Perennial	2’
Pityopsis graminifolia	Silkgrass	Perennial	3’
Plumbago zeylanica	Wild Plumbago	Low shrub	1’
Rudbeckia hirta	Black Eyed Susan	Perennial	1-3’
Ruella caroliniensis	Wild petunia	Perennial	1-2’
Salvia azurea	Blue Sage	Perennial	5’
Salvia coccinea	Tropical Sage	Perennial	2-5’
Salvia lyrata	Lyre-leaved Sage	Perennial	1.5’
Salidago spp.	Goldenrods	Perennial	2-6’
Scutellaria integrifolia	Rough Scullcap	Perennial	2’
Silphium asteriscus	Starry Rosinweed	Perennial	5’
Sorghastrum secundum	Lopsided Indiangrass	Herbaceous grass	3-6’
Spartina bakeri	Sand Cordgrass	Grass	4’
Sporobolus junceus	Pineywoods Dropseed	Grass	2’
Symphyotrichum elliotii	Elliot’s Aster	Perennial	4’
Tradescantia spp	Spiderwort	Perennial	3’

Sources: Florida Native Plant Society, Florida Association of Native Nurseries, Florida Natural Areas Inventory, University of Florida Institute of Food and Agricultural Services.

APPENDIX B

LID Practice Selection

LID Practice Selection

It is noted that the County plans to proceed with the development of practice details and design examples for most, if not all the practices discussed above. Priority LID practices are included in Volume 2 of this manual and additional practices will be developed later. The practices currently included in Volume 2 have been chosen based on their applicability throughout the County. To determine which LID practices are to be further developed currently, the practices were evaluated based on a decision matrix that was intended to identify the relative suitability of different LID practices for use in Orange County (**Table B.1**, **Table B.2**). This included the evaluation of several decision variables which are further discussed in this section. It is noted that the decision variables were chosen based on a review of literature and other relevant BMP/LID/GSI manuals in the state, guidance documents from SJRWMD, SFWMD, FDEP, and the EPA, as well as input from the County. The decision variables were also weighted with the intent of finding practices that work throughout the County, not on a site-by-site basis, which may have different weights. The following decision variables were considered for this analysis where a higher point score equates to a higher suitability for recommendation:

- Approved for TMDL/BMAP Credit by FDEP
    - Practices that have been used and approved by FDEP for BMAP credit are desired to be weighted higher due to precedence of receiving water quality credit. Therefore, practices that meet this criterion received a score of 1 and those that do not received a score of 0.
- Provides Volume Reduction
    - Practices that provide a volume reduction via infiltration or harvesting are desired to be weighted higher as they tend to provide a larger water quality benefit as well as could provide some flood risk mitigation. It is noted that practices that are approved for volume reduction by the water management district are assigned a score of 1 and those that do not received a score of 0.
- Flood Risk Mitigation
    - Practices that provide a flood risk mitigation are desired to be weighted higher as they provide protection from potential property damage due to extreme rain events. Therefore, practices that meet this criterion receive a score of 1 and those that do not received a score of 0.
- Effective for Dissolved Nutrient Removal
    - Practices that provide a water quality improvement benefit associated with removing dissolved nutrients are desired to be weighted higher as dissolved nutrients tend to be the bio-available form, i.e., available for plant and algal growth. Dissolved nutrients are also more difficult to remove than particulate forms, so an LID practice that only is effective for particulate removal will be limited in pollutant removal potential by the amount of nutrients associated with particulates. Additionally, since these practices remove nutrients, they provide a means to help meet TMDL requirements. Therefore, practices that meet this criterion receive a score of 1 and those that do not received a score of 0.

- Effective for Solids Removal
  - Practices that provide a water quality improvement benefit associated with removing solids such as particulates and larger debris can provide nutrient removal, as nutrients are frequently associated with particles. As such, removal of the particulates will result in removal of any nutrients associated with them. Therefore, practices that remove solids are desired to be weighted higher as they provide a means to help meet TMDL requirements. Therefore, practices that meet this criterion receive a score of 1 and those that do not received a score of 0.
- Preservation of Natural Site Features and/or Provides Tree & Habitat Protection
  - Practices that preserve natural site features and provide tree and habitat protection are desired to be weighted higher as they protect natural habitats which increase biodiversity, provide protection of the function of the natural processes occurring to benefit water quality (interception, infiltration, plant uptake, microbial transformations, and bioaccumulation), and provide an amenity for residents. Therefore, practices that meet this criterion receive a score of 1 and those that do not received a score of 0.
- Suitability for New Development
  - Practices that are suitable for new development are weighted higher as they are easier to implement without facing significant sizing constraints. Therefore, practices that meet this criterion receive a score of 1 and those that do not received a score of 0.
- Does not Require Pretreatment
  - Practices that do not require pretreatment are desired to be weighted higher as they do not require going through a separate LID practice for treatment first. If space is an issue, choosing a practice that does not require pretreatment allows for more flexibility. Therefore, practices that meet this criterion receive a score of 1 and those that do not received a score of 0.
- Effective for Nitrate Removal to Groundwater
  - The County has certain regions that have more karst geologies that may result in springs and nearby surface waterbodies being more sensitive to nitrate loading. This is because nitrate is a dissolved form of nitrogen that does not readily adsorb to soil particles, so it is very mobile in groundwater. Based on this, practices which are able to provide nitrate removal from stormwater as it infiltrates into the surficial aquifer is desired to be weighted higher as it provides options for sensitive groundwater regions of the County. Based on this, practices that meet this criterion receive a score of 1 and those that do not received a score of 0.
- Requires Well Drained, High Infiltrating Soils
  - Practices that rely on infiltration to treat stormwater and mitigate flood risks are desired in the regions of the County where soil and groundwater conditions allow for these practices (i.e., some western areas of the County). Therefore, practices that meet this criterion receive a score of 1 and those that do not received a score of 0.

- Can be Used in Shallow Groundwater Table
  - Practices that rely on other processes besides infiltration to treat stormwater and mitigate flood risks are desired in the regions of the County where soil and groundwater conditions allow for these practices (i.e., some eastern areas of the County). Therefore, practices that meet this criterion receive a score of 1 and those that do not received a score of 0.
- No Soils Requirements
  - Practices that do not have soil requirements provide more flexibility and widen the range of applicability since it can be used in a variety of soils. Therefore, practices that meet this criterion receive a score of 1 and those that do not received a score of 0.
- Cost Benefit of LID Practice
  - As previously mentioned, cost benefit is the practice of normalizing the capital, operating, and maintenance costs (in terms of net present value) by the anticipated water quality benefit. This provides a consistent basis to evaluate the benefit of different practices, i.e., the cost to remove 1 pound of pollutant. For the cost benefit, the lower the cost benefit the cheaper it is to provide a benefit. Therefore, to determine a cost benefit score the different practices discussed above were ranked based on the TP cost benefit. The practices were assigned a score based on what quartile they fell in, namely the lowest cost quartile were assigned a score of 4, next most low cost quartile were assigned a score of 3, next low cost quartile were assigned a score of 2, and the highest cost quartile were assigned a score of 1, see **Table B.3**.

Table B.1: LID Practice Decision Variable Matrix and Suitability Ranking

Decision Variable	LID Practice																			
	Biosorption Activated Media (BAM) Enhancements*	**Green Roofs**	**Stormwater & Rainwater Harvesting**	**Underground Storage & Exfiltration**	**Pervious/ Permeable Pavement**	**Bioretention Swales**	**Vegetated Buffer Strips**	**Tree Box Filters**	**Planter Boxes**	**Bioretention/ Rain Garden**	**Filtration with BAM**	**Street Sweeping**	**Nutrient Separating Baffle Boxes**	**Dry Retention Ponds**	**Wet Detention Ponds**	**Living Shorelines**	**Managed Aquatic Plant Systems (MAPS)**	**Constructed Wetlands**	**Florida-Friendly Landscaping**	**Interceptor Trees**
Approved for BMAP Credit by FDEP	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0
Provides Volume Reduction	1	1	1	1	1	1	0	0	1	1	0	0	0	1	1	0	0	1	0	1
Flood Risk Mitigation	1	1	1	1	1	1	0	0	1	1	0	0	0	1	1	0	0	0	0	0
Effective for Dissolved Nutrient Removal	1	1	1	1	1	1	1	1	1	1	1	0	0	1	1	1	1	1	1	0
Effective for Solids Removal	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1	0	0
Preservation of Natural Site Features and/ or Tree & Habitat Protection	1	0	0	0	0	1	1	0	0	1	0	0	0	1	1	1	0	1	1	1
Suitability for New Development	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Does Not Require Pretreatment	1	1	0	0	1	1	1	1	1	1	0	1	1	1	1	1	1	0	1	1
Effective for Nitrate Removal to Groundwater	1	0	0	0	0	1	0	1	1	1	1	0	0	0	0	0	0	1	0	0
Can be Used in Well Drained, High Infiltrating Soils	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	0	1	1
Can be Used in Shallow Groundwater Table	1	1	1	0	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1
No Soils Requirements	1	1	1	0	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1
Cost Benefit	2	2	4	4	1	1	3	4	3	3	3	4	1	3	3	4	1	2	3	4
Total Score	14	**12**	**13**	**11**	**11**	**13**	**12**	**13**	**14**	**15**	**11**	**11**	**8**	**12**	**13**	**12**	**7**	**11**	**10**	**11**
Rank	2	**8**	**4**	**12**	**12**	**4**	**8**	**4**	**2**	**1**	**12**	**12**	**19**	**8**	**4**	**8**	**20**	**12**	**18**	**12**

*BAM gets a point for volume reduction because it can be a component of a BMP that can address flooding.

Table B.2: LID Practice Suitability Ranking Summary

LID Practice	Rank
Bioretention/Rain Garden	1
BAM Enhancements	2
Planter Boxes	2
Bioretention Swales	4
Stormwater & Rainwater Harvesting	4
Tree Box Filters	4
Wet Detention Ponds	4
Dry Retention Ponds	8
Green Roofs	8
Living Shorelines	8
Vegetation Buffer Strip	8
Constructed Wetlands	12
Filtration System with BAM	12
Interceptor Trees	12
Pervious/Permeable Pavement	12
Street Sweeping	12
Underground Storage & Exfiltration	12
Florida Friendly Landscaping	18
Nutrient Separating Baffle Box	19
MAPS	20

Table B.3: Summary of LID Practice TP Cost Benefit and Assigned Score

LID	$/lb TP	Basis for Cost Benefit Numbers	Cost Benefit Score
Living Shore Lines	$57	Adapted From Geosyntec Shoreline Vegetation Methodology, 2020	4
Street Sweeping	$257	Florida Stormwater Association Educational Foundation, 2011	4
Stormwater harvesting	$570	Gulf Coast Community Foundation, 2020	4
Underground Storage and Exfiltration	$2,967	City of Winter Park CRA Stormwater Master Plan, 2020	4
Inceptor Trees	$3,127	Assumed to be Similar to Tree Box Filters without Media	4
Tree Box Filter	$3,156	Adapted From Lake Morton BMP Feasibility Study, City of Lakeland, 2022	4
Dry Retention Ponds	$3,651	Florida Stormwater Association Educational Foundation, 2011	3
Wet Detention Ponds	$3,651	Florida Stormwater Association Educational Foundation, 2011	3
Filtration/ Biofiltration System	$4,398	Priority Basin 1329 Outfall Proposed BMP Project, Brevard County, 2017	3
Vegetation Buffer strip	$5,024	Assumed To Be the Same as Rain Gardens	3
Infiltration Planter Box	$5,024	Assumed to be the same as a Rain Garden	3
Rain Garden	$5,024	Burris Way Alley West Stormwater- LID improvement Design, City of Cocoa Beach, 2021	3
Florida- Friendly Landscaping	$5,024	Assumed To Be the Same as Rain Gardens	3
Constructed Wetlands	$6,040	Best Management Practice Alternatives Analysis Report Bystre Lake Watershed, Hernando County, 2016	2
Biosorption Activated Media (BAM) Enhancements	$6,891	Best Management Practice Alternatives Analysis Report Weeki Wachee Prairie Watershed, Hernando County, 2017	2
Green Roof	$7,302	Assumed to be twice the cost benefit of Dry Retention due to the additional engineering required	2

LID	$/lb TP	Basis for Cost Benefit Numbers	Cost Benefit Score
Bioretention Swale	$7,710	Lake Conway Stormwater Quality Management Master Plan, Orange County, 2020	1
Nutrient Separating Baffle Box	$10,747	Lake Morton BMP Feasibility Study, 2022	1
Permeable Pavement	$11,345	Burris Way Alley West Stormwater- LID improvement Design, City of Cocoa, 2021	1
Managed Aquatic Plant Systems (MAPS)	$27,614	Adapted from Lake Conway Stormwater Quality Management Master Plan, Orange County, 2020	1

Note: Costs are based on the best available information at the time of publishing.

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