Designing for Impact: Promoting Low Impact Development Implementation

Final Report, Contract 582-18-80339

Prepared by the Houston-Galveston Area Council Prepared in cooperation with the Texas Commission on Environmental Quality and U.S. Environmental Protection Agency

December 1, 2019

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Executive Summary

The communities within the Galveston Bay watershed are home to more than 16,000 miles of slow-moving waterways and shorelines that flow into the Gulf of Mexico. As the region prepares for considerable population growth – and the resultant construction of new homes, businesses, and roads – it is critically important to develop land in a way that preserves waterways, reduces the risk of damage from flooding, adds to the visual appeal of new construction, and even restores degraded coastal ecosystems. The goal of this project is to provide designers, policymakers, developers, and most importantly- local communities-- with the tools they need to implement low impact development (LID).

LID can help reduce the negative impacts of new development on water quality and ecologically-sensitive areas, improving the region's quality of life, natural systems, and resiliency. LID is a design and development approach that reduces the impacts of flooding by slowing runoff during rain events and simultaneously enhances water quality. LID features provide these services by reducing and filtering stormwater runoff before it enters waterways. LID also adds value to development projects by reducing infrastructure costs, reducing downstream flooding, and adding aesthetic value.

Over the course of this project, Houston-Galveston Area Council (H-GAC) held two focus-group meetings with the City of Pearland's planning, engineering, and public works staff. From this process, H-GAC discovered the primary barriers are the proper maintenance practices for LID features, installation inspections, and ordinance driven design requirements.

To remove these barriers, H-GAC conducted a thorough review of the city's code of ordinances. H-GAC and a legal consultant developed a set of recommendations and resources to address and remove these barriers. The recommendations and resources included the following:

- Maintenance agreements, maintenance schedules, and installation checklists;
- Opportunities to reduce impervious surfaces and incorporate LID features;
- Recommended design requirement adjustments in ordinances;
- Examples of financial incentives for developers;
- Examples of LID requirements & design provisions in the region; and
- Examples of completed LID projects near Pearland.

On November 7, 2018, H-GAC held a LID implementation workshop where best practices for maintenance of LID features were showcased. Communities learned how to identify underperforming features, how to address maintenance related problems, and were advised on region-specific best practices. The maintenance agreements, maintenance schedules, and installation checklists were also discussed, and communities were taught how to integrate the agreements into their development review process. All resources will be posted online and integrated with the Designing for Impact Guide interactive tool.

Introduction

The Houston-Galveston region is forecast to grow by 78% or 3.5 million people in the next 25 years. With that growth will come new homes, businesses, and roads, bringing billions of square feet of impervious surface area and stormwater drainage infrastructure that will alter natural drainage patterns and impact stormwater quality. As it stands, 90% of the region's waterways fail to meet state water quality standards. Conventional stormwater management includes acres of concrete-lined detention ponds and expensive underground infrastructure that does little to improve water quality. This anticipated growth gives the region an opportunity to better integrate LID and natural features into new developments in ways that will reduce infrastructure costs, improve water quality, reduce the risk of damage from flooding, and enhance the visual appeal of our communities.

Background & Project Significance

The Houston-Galveston Area Council (H-GAC) completed Designing for Impact, an Environmental Protection Agency (EPA) Gulf of Mexico-funded project including the publication of a LID guide for local governments; education through workshops; and creation of a LID webpage and interactive mapping tool highlighting LID projects in the region. This project also supports Back the Bay goals and initiatives to improve water quality through outreach efforts and coordination with local governments. H-GAC distributed over 400 copies of the LID guide since its release in May 2016 and has reached over 200 people through the workshops. Demand for more information on LID continues in the region as citizens and municipalities aim to improve water quality and increase water conservation efforts.

In 2017, H-GAC was awarded a grant from the Galveston Bay Estuary Program to evaluate existing ordinances, policies, and the development review process for the City of Pearland. The project objective was to support the implementation of LID at the municipal level and produce practical resources and recommendations for communities to use.

This project is especially impactful because municipalities and community organizations now have access to LID resources to facilitate all stages of the LID development and implementation process. The project addresses common challenges that communities face when integrating LID and provides a roadmap to address those obstacles. Because of the Designing for Impact and LID Implementation work, we have added to the regional repertoire of flood mitigation and sustainable design resources while also strengthening local knowledge and relationships.

Methods

H-GAC staff first met with the City of Pearland staff in October 2017. The goal was to identify barriers to LID within the development process and ordinances. While those topics were discussed, Pearland staff expressed that maintenance problems and improper installation and inspection practices were a struggle for the community. H-GAC then partnered with a legal consultant, Randle Law Office Ltd., to draft maintenance agreements Pearland could use to mitigate some of the issues they face on a regular basis. Another focus group session was held with the legal consultant and City of Pearland staff to develop an enforceable maintenance agreement for LID features, maintenance schedules, and installation checklists for city staff to use as a guide.

H-GAC staff conducted a thorough review of Pearland's development codes, transportation and parking design requirements, subdivision ordinances, and the stormwater infrastructure manual. Within these documents, H-GAC identified opportunities to reduce impervious surface, and recommended practices that would incentivize developers to use LID features. H-GAC then met with City of Pearland staff again and discussed additional ideas and practices that could lead to increased and effective use of LID. A final set of recommendations, example projects, and best management practices were then added to the final deliverable provided to the City of Pearland.

Results & Observations

The result of this project is an exciting collection of resources that can be used universally by any community in the Gulf Coast region to promote, implement, and maintain LID. The maintenance agreements, maintenance schedules, and inspection schedules are paired with the corresponding LID features in the online version of the Designing for Impact guide. This compilation of online resources provides local municipalities and developers a complete guide to LID design, implementation, and upkeep. These deliverables can be found in Appendix A, pages 21-49.

The detailed review of the City of Pearland's codes and ordinances also provided the community with unique and tailored suggestions to remove barriers to LID and develop a more LID friendly code of ordinance. City staff were also provided additional resources such as the standardized LID practices and requirements used by Harris County and their method to reduce impervious surfaces with shared parking allowances. H-GAC staff also researched local examples of LID used in nearby commercial, residential, recreational, and roadway applications. These deliverables can be found in Appendix A, pages 1-20.

H-GAC split the project work plan into five distinct tasks and objectives. Each objective included individual tasks which yielded (and continue to yield) outputs and outcomes that encourage more LID friendly practices throughout the region.

TASK 1: PROJECT ADMINISTRATION

Objective: To effectively administer, coordinate, and monitor all work performed under this project including technical and financial supervision and preparation of status reports.

Output:

- QPRs;
- Reimbursement forms;
- Contract orientation meeting and meeting minutes; and
- Project article.

Outcome: Project deliverables and tasks were completed on schedule, and changes to the contract were jointly coordinated between Galveston Bay Estuary Program (GBEP) and H-GAC. A stronger and more effective partnership between H-GAC and GBEP was developed.

TASK 2: KICK-OFF MEETING WITH PARTNER MUNICIPALITY

Objective: To establish effective lines of communication, set project expectations, and obtain information about the municipality's codes and regulations.

Output:

- Kick-off meeting and meeting minutes;
- List of municipal contacts;
- List of current building codes and regulations from municipalities; and
- Draft description of existing codes and regulations

Outcome: A Kick-off meeting with the City of Pearland was held on October 2, 2017. Staff described their previous struggles with LID implementation and provided guidance on the existing codes and regulations for H-GAC staff to examine. City of Pearland staff also discussed their need for maintenance agreements, inspection training, and maintenance resources.

TASK 3: BARRIER IDENTIFICATION AND RECOMMENDATIONS

Objective: To evaluate present City of Pearland building codes, plat requirements, and plat approval process, to identify direct and indirect impediments to LID, and to offer recommendations to overcome impediments.

Output

- Initial draft findings report;
- Procurement of consultant services; and
- Draft findings report updated per consultant review.

Outcome: H-GAC staff identified and compiled a list of potential obstacles and opportunities to promote LID in the City of Pearland. Randall Law Office, Ltd. was procured as the consultant to draft maintenance agreements, inspection checklists, and maintenance schedules. Consultant and H-GAC coordinated efforts and findings and scheduled an additional meeting with City of Pearland.

TASK 4: MUNICIPALITY REVIEW

Objective: To actively engage the City of Pearland to solicit feedback on the findings report, tailor the report to fit the municipality, review the likelihood for implementing the recommendations, and discuss compatible LID practices for the municipality.

Output:

- Revised findings report per the City of Pearland review;
- Implementation strategy; and
- List of recommended LID practices.

Outcome: Another meeting between H-GAC and the City of Pearland was held on August 16, 2018 to discuss the initial findings. Using feedback from the meeting, a final draft of ordinance adjustment recommendations and legal documents were produced and provided to the City of Pearland on October 16, 2018. No additional feedback was submitted by the City of Pearland.

TASK 5: PROMOTING LID IMPLEMENTATION

Objective: To convene a community LID workshop that conveys the findings, recommendations, and expected implementation strategy for the City of Pearland to a broader set of stakeholders within and outside of the municipality.

Output:

- Community LID workshop; 26 attendees,
- Presentations on Maintenance Best Practices,
- Presentation on Maintenance Agreements,
- Workshop summary provided to GBEP.

WORK PLAN MODIFICATIONS

Most tasks were completed on-schedule specified in the original work plan. Due to delays caused by Hurricane Harvey, the project began approximately 30 days later than anticipated, but the final project delivery schedule was met. An additional $30,000 to continue the work in 2019 was not approved, and the contract was amended to reflect project completion by 2018. The original contract identified three communities: Pearland, Mont Belvieu, and Manvel. Due to the funding adjustment, the work for Mont Belvieu and Manvel could not be completed. H-GAC

was able to complete the work with City of Mont Belvieu under a watershed protection plan grant, and both Manvel and Mont Belvieu were provided with all of the resources developed for Pearland. Other project modifications included amending the contract to accommodate a legal consultant. The legal consultant drafted the maintenance agreements and installation inspection documents at the City of Pearland's request.

Discussion & Summary

Success & Achievements: The project goals and objectives were achieved, and the City of Pearland has a tailored set of recommendations to promote LID in their community. The continued in-depth review of individual communities' development process is necessity for increasing the use of LID throughout the region. Without this customized approach, communities and developers alike will continue to struggle with the implementation of LID in this region. This project is impactful due to the ongoing discussion and evolution of deliverables for communities. As communities discover new obstacles and implement new solutions, we hope to catalogue these successes and continue to grow the program.

The greatest success of this project emerged from the dialogue between the City of Pearland and H-GAC staff and the eventual development of the maintenance agreements. Maintenance agreements were not initially identified by H-GAC staff as a tool to help implement LID in Pearland. Through conversations with the City of Pearland staff, it became evident to H-GAC this tool could also serve the greater region. Not only was Pearland able to have their needs met, but other communities will too. Without the extended and impactful conversations between H-GAC and the City of Pearland, this would have been a missed opportunity.

Failures, Challenges, & Lessoned Learn: The greatest challenge for this project was providing recommendations that were feasible. It is much easier to identify an ordinance that obstructs the installation of LID than it is to identify a solution that allows city staff to meet the variety of responsibilities they are held accountable for. There are many layers of concerns to address beyond adjusting a site development requirement. For example, communities strive to create a certain character or land development pattern, and the amendment of ordinances can contradict those goals. There are also budgetary and staffing limitations that communities must consider before implementing certain practices.

The primary lessoned learned is that every community faces a different set of challenges. The appropriate solution(s) require thoughtful and creative applications of the fundamental strategies of LID. Some solutions will be universal, such as maintenance agreements, while others will be unique and personalized to a specific community.

Next Steps: The resources from this project have been shared with the City of Mont Belvieu, and a review of their ordinances was conducted as part of their Cedar Bayou Watershed Protection Plan. A follow-up meeting with the City of Mont Belvieu is scheduled for December of 2018. H-GAC staff hopes to learn which resources provided to Pearland that are also useful for Mont Belvieu. They will discuss why some recommendations are appropriate while others are not. Ultimately, H-GAC staff hope to discover more resources, like the maintenance agreements, that can serve as universal solutions for many communities. All resources from Mont Belvieu and Pearland will be shared with the City of Manvel.

Appendix A

City of Pearland

Low Impact Development

IMPLEMENTING & INCENTIVIZING LID

October 2018

Low Impact Development

IMPLEMENTING & INCENTIVIZING LID

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Low Impact Development

IMPLEMENTING & INCENTIVIZING LID

Introduction

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In 2017, H-GAC was awarded a grant from the Galveston Bay Estuary Program to evaluate existing ordinances, policies, and the development review process for the City of Pearland.

Low Impact Development (LID) is a design and development approach that reduces the impacts of flooding by slowing runoff during rain events and simultaneously enhances water quality. LID features provide these services by reducing and filtering stormwater runoff before it enters waterways. LID also adds value to development projects by reducing infrastructure costs, reducing downstream flooding, and adding aesthetic value.

A significant limitation of LID development are codes and ordinances that unintentionally act as barriers. To remove these barriers, H-GAC met with city staff and officials at the City of Pearland and conducted a thorough review of the city's code of ordinances. From this process, H-GAC discovered the primary barriers are proper maintenance of LID features, installation inspections, and ordinance driven design requirements dedicated to impervious services. H-GAC and a legal consultant developed a set of recommendations and resources to address and remove these barriers. The recommendations in this report are outlined as follows:

- Maintenance Agreements, Schedules, and Installation Checklists
- Reduce Impervious Surfaces
- Adjust Design Requirements in Zoning Code
- Financial Incentives
- Additional Resources & Information

Maintenance Agreements, Schedules, and Installation Checklists

The staff at the City of Pearland identified maintenance practices and enforcement as a key limitation to implementing LID in their community. To remedy this barrier, a nation-wide search and review of practices employed by other local governments was conducted, and a set of best practices was tailored for the City of Pearland. The practices reflect and account for the region's unique coastal characteristics. A legal consultant with a specialization in municipal government drafted a LID Development Facilities Maintenance Agreement, Inspection and Maintenance Schedules and Inspection and Maintenance Checklists for:

- Green Roofs
- Wetlands
- Bioretention Systems: Rain Gardens, Bioswales, and Planter Boxes
- Cisterns
- Swales
- Vegetative Filter Strip

To help Pearland implement the maintenance agreements, an ordinance to adopt a LID maintenance agreement was also drafted. The ordinance provides for the following:

- Adoption of LID features in development of land,
- Establishes a permitting and registration requirement,
- Establishes an annual inspection reporting requirement to the City from the landowner, and
- Incentivizes LID by providing development credit or tax refund in addition to increasing the developable footprint

Detailed documents and resources are provided in the Appendix.

REDUCE IMPERVIOUS SURFACES

As Pearland grows and develops, an increase in impervious surfaces will increase stormwater runoff volumes and degrade water quality. The additional stormwater runoff requires larger detention facilities and the need to mitigate pollutant loadings into waterways. LID can offset or help mitigate these impacts.

There is an opportunity to integrate LID features, such as pervious pavement, rain gardens, or bioswales, into required design features outlined in Pearland's Code of Ordinances. When LID is incorporated into site designs, it also reduces the need for large onsite detention facilities. By reducing the size and costs of stormwater management facilities, more land and more capital become available to develop additional units or public amenities. This incentivizes developers to voluntarily use LID features.

Harris County and the City of Houston have regulations and recommendations that specifically address LID. Because soil types and drainage needs are similar to Pearland, Harris County can serve as an example for LID implementation. The *Harris County Low-Impact Development & Green Infrastructure Design Criteria for Storm Water Management Guide* states, "The minimum detention rate for gravity drained detention basin systems is 0.55 acre-foot per acre. Any reductions to this rate will be based on approved hydraulic methodology based on low impact design techniques such as reduced impervious cover, increased time of concentration, etc. However, the minimum detention rate with approved low impact techniques is 0.35 ac-ft per acre. Acceptable low impact techniques and analysis methodology must be discussed and agreed upon at a pre-project meeting with Harris County Flood Control District.[1]"

Harris County and the City of Houston identified the following LID techniques that qualify to reduce traditional detention:

- Bioretention & Engineered Soil
- Vegetated Swale
- Permeable Pavement
- Tree Box Filter
- Stormwater Planter

The chart below is an example of Harris County's reduced detention requirements if a developer chooses to use LID detention instead of traditional detention methods.

EXAMPLE: HARRIS COUNTY

Requirement	Traditional	Low-Impact Development
Gravity Drained Detention	0.55 ac-ft per acre	0.35 ac-ft/ac
Detention for Gravity Flow to Roadside Ditch	0.75 to 1.0 ac-ft per acre	0.55 to 1.0 ac-ft/ac
Detention for Gravity Flow to Storm Sewer	0.65 ac-ft/ac	50% of Required Rate
Peak Flow Rates	Post-Project < Pre-Project	Post-Project < Pre-Project

[1] Harris County Flood Control District, (2011). https://www.hcfcd.org/media/1543/2011-final_lid_gidc.pdf

ADJUST DESIGN REQUIREMENTS IN ZONING CODE

Within Pearland's *Code of Ordinances*, there are opportunities to adjust design requirements to reduce impervious surfaces and create space for LID features. The charts below identify ordinances that can be modified to either require or incentivize LID. Many of these design recommendations allow flexibility to meet the proposed ordinances and alleviate the need for additional infrastructure to accommodate increased runoff.

ROADWAYS

Not only does incorporating LID features into streetscapes and roadways improve water quality and reduce flooding, but it is also cost effective and is an aesthetic amenity in a community. LID features can be integrated into required roadway elements such as medians, drainage ditches, on-street parking, sidewalks, and required vegetative buffers.

The right-of-way requirements in the City of Pearland provide ample space and flexibility to incorporate LID into streetscapes or roadway drainage. The design recommendation below proposes LID become a required element within every street or road right-of-way rather than an option. The specific LID feature and integration method can be chosen by the developer or city officials on city property.

	CURRENT DESIGN REQUIREMENT	RECOMMENDED DESIGN REQUIREMENTS
Roadways	Pavement Widths and Right-of Ways	Pavement Widths and Right-of Ways
	Major thoroughfare streets shall have a right-of-way width of at least one hundred and twenty feet (120') with a pavement width of at least two (2) thirty-six-foot (36') sections with a fourteen-foot-wide (14') raised median.	Add: Minimum of 8 feet (8') of raised median width must to be dedicated to LID features.
	Secondary thoroughfare streets shall have a right-of-way width of at least one hundred feet (100') with a pavement width of at least two (2) twenty-four-foot (24') sections and a twenty-foot-wide (20') raised median.	Add: Minimum of 10 feet (10') of raised median width must to be dedicated to LID features
	Primary collector streets shall have a right-of-way width of at least eighty feet (80') with a pavement width of at least forty-four feet (44').	Add: Minimum of 12 feet of right of way width must be dedicated to LID features.
	Secondary collector streets shall have a right-of-way width of at least sixty feet (60') with a pavement width of at least thirty-eight feet (38').	Add: Minimum of 12 feet of right of way width must be dedicated to LID features.

PARKING

Conventional parking standards and parking minimums can result in a high percentage of impervious surfaces, increased runoff, and lower water quality. Large parking lots generate a need for additional stormwater detention and renders much of a site undevelopable for its primary use. This is especially true for many commercial developments.

The recommendations below propose shared parking agreements between adjacent commercial developments, reduced parking minimums, and incentives for new development to use porous pavement in parking areas. Some recommendations also propose requiring that parking lot landscapes be LID features. In the additional resources section of this document, the share parking requirements and ratio used by the City of Houston are provided.

	CURRENT DESIGN REQUIREMENT	RECOMMENDED DESIGN REQUIREMENTS
Parking	*Single Family Residential, Townhome, and Duplex* – 2 spaces per dwelling unit, 1 additional space for each bedroom over 3	Provide tax incentive for developers that use porous pavement is used for off-street parking and/or driveways; Provide monthly water and sewer credit to home owners that install porous pavement in driveways.
	Apartment, apartment hotel - 2.5 parking spaces per unit	*Renter Occupied Apartment* - 1.4 spaces per unit [2] *Owner Occupied MFR* - 2.25 spaces per unit
	Theater - 1 parking space for every 3 seats Bowling Alley – 4 parking spaces per lane Retail Stores or Shops – 1 space for every 200 sq. ft. of floor area. Café, restaurant, cafeteria, and all other eating or drinking establishments – 1 space per 125 sq. ft. of floor area	*Theater* - 1 parking space for every 5 seats Bowling Alley – 2.5 parking spaces per lane Retail Stores or Shops – 1 space for every 250 sq. ft. of floor area. Café, restaurant, cafeteria, and all other eating or drinking establishments – 1 space per 200 sq. ft. of floor area
	N/A	Shared parking agreements between adjacent and compatible commercial uses may waive or reduce parking requirements at a ratio of 1:1. The agreed on shared parking spaces located on an existing or proposed adjacent development must be within 500 feet of the proposed commercial building. Parking agreement must be submitted during site plan review.

[2] Litman, Todd (2016). http://www.vtpi.org/park_man_comp.pdf

FINANCIAL INCENTIVES

To further support LID implementation, Pearland can foster market-driven LID development. Developers will quickly discover that LID is both marketable and cost effective. For example, if LID is designed to maximize its dual functionality as stormwater infrastructure and an attractive, natural amenity, LID can increase property values and the marketability of developments. Studies reveal that lots in LID neighborhoods sell for $3,000 more than lots in competing areas not using LID[3].

NATIONAL STORMWATER MANAGEMENT CALCULATOR

One resource that developers or engineers unfamiliar with LID might find useful is the National Stormwater Management Calculator. This tool is designed to help developers, "quickly compar[e] the performance, costs, and benefits of Low Impact Development (LID), to conventional stormwater practices. The tool is designed to take you step-by-step through a process of determining the average precipitation at your site, choosing a stormwater runoff volume reduction goal, defining the impervious areas of your site under a conventional development scheme, and then choosing from a range of Green Infrastructure Best Management Practices (BMPs) to find the combination that meets the necessary runoff volume reduction goal in a cost-effective way.[4]"

TCEQ BOND REIMBURSEMENT

The Texas Commission on Environmental Quality allows developer reimbursement using utility bond funds for costs associated with eligible stormwater quality structures (i.e. LID and Green Infrastructure projects). Eligible projects need to provide evidence of a clear water quality attribute. Each project is reviewed on a case by case basis and should be identified in the bond application materials. Applicants are encouraged to schedule pre-application meetings with Districts staff to discuss the projects and their eligibility for reimbursement[5].

REIMBURSE OR REDUCE FEES

Pearland's *Code of Ordinances* requires nonrefundable application and impact fees. The Pearland can incentivize LID for builders, developers, and residents by offering refunds, credits, or waivers as appropriate.

Recommendations:

- Offer monthly credits on utilities to residents and businesses who install cisterns and rain barrels for 60 gallons or more on their property.
- Reduce permitting fees.
- Offer stormwater fee discounts.
- Waive application fees for variances to incorporate LID features onto sites.

[3] ECONorthwest, The Economics of Low-Impact Development; (2007). https://s3-us-west-2.amazonaws.com/econw-publications/2007-Economics-of-Low-Impact-Development-Lit-Review.pdf

[4] Green Values, National Stormwater Management Calculator; (2009). http://greenvalues.cnt.org/national/calculator.php

[5] Texas Commission on Environmental Quality; (2018). https://www.tceq.texas.gov/waterdistricts

Additional Resources & Information

ACCEPTED LID PRACTICES: Harris County & City of Houston

Integrated Management Practices (IMPs) are LID-based practices that reduce stormwater runoff volume and pollutant loading from developed sites. IMPs function by slowing runoff, promoting infiltration, and utilizing evapotranspiration through plantings

LID practices that Harris County allows for satisfying stormwater quality and detention requirements:

Integrated Management Practices (IMPs)	Stormwater Quality	Detention	Time of Concentration
Bioretention & Engineered Soil	X	X	X
Vegetated Swale	X	X	X
Vegetated filter strip	X		X
Permeable Pavement	X	X[6]	X
Tree Box Filter	X	X	X
Storm Water Planter	X	X	X
Green Roof	X		X
Disconnection	X		X
Soil Amendment	X		X
Rainwater Harvesting	X[7]	X[8]	

DETENTION & RUNOFF DESIGN PROVISIONS: Harris County

The minimum detention rate for gravity drained detention basin systems is 0.55 ac-ft per acre. Any reductions to this rate will be based on approved hydraulic methodology based on LID techniques such as reduced impervious cover, increased time of concentration, etc. However, the minimum detention rate with approved LID techniques is 0.35 ac-ft per acre. Acceptable LID techniques and analysis methodology must be discussed and agreed upon at a pre-project meeting with HCFCD.

Requirement	Traditional	Low-Impact Development
Gravity Drained Detention	0.55 ac-ft per acre	0.35 ac-ft/ac
Detention for Gravity Flow to Roadside Ditch	0.75 to 1.0 ac-ft per acre	0.55 to 1.0 ac-ft/ac
Detention for Gravity Flow to Storm Sewer	0.65 ac-ft/ac	50% of Required Rate
Peak Flow Rates	Post-Project < Pre-Project	Post-Project < Pre-Project

[6] Voids within the permeable pavement itself cannot be counted for detention.
[7] Acceptable for Storm Water Quality if re-used for irrigation or other non-potable uses.
[8] Various LID practices will be considered, so long as sufficient volume reductions and the design approach are proven. Applies only to commercial sites and non-single family residential structures in limited circumstances

SHARED PARKING ALLOWANCES: City of Houston

	Weekday	Weekday	Weekday	Weekday	Weekend	Weekend	Weekend	Weekend
	Midnight to 7AM	7AM to 5PM	5PM to 9PM	9PM to Midnight	Midnight to 7AM	7AM to 5PM	5PM to 9PM	9PM to Midnight
Office	5%	100%	30%	5%	0%	10%	0%	0%
Financial Facility	0%	100%	10%	0%	0%	25%	0%	0%
Apartment	100%	25%	50%	95%	100%	65%	50%	85%
Hotel	100%	10%	50%	85%	100%	10%	50%	75%
Clinic (Medical Complex)	5%	100%	50%	5%	0%	10%	0%	0%
Clinic (Medical or Dental)	0%	100%	25%	0%	0%	25%	0%	0%
Veterinary Clinic	0%	100%	5%	0%	0%	25%	0%	0%
Industrial/Warehouse/ Manufacturing	10%	100%	50%	10%	10%	25%	10%	0%
Church	0%	5%	25%	0%	10%	100%	40%	0%
Day Care	0%	100%	5%	0%	0%	5%	0%	0%
School	0%	100%	5%	0%	0%	10%	0%	0%
Library	0%	100%	10%	0%	0%	25%	0%	0%
Art Gallery	0%	75%	50%	0%	0%	100%	60%	0%
Movie Theater	0%	10%	50%	75%	0%	50%	80%	100%
Bowling Alley	0%	10%	50%	85%	0%	40%	75%	100%
Gym/Health Spa	50%	25%	100%	10%	10%	50%	10%	5%
Dessert Shop	0%	25%	100%	75%	0%	25%	100%	85%
Small Restaurant	10%	50%	75%	40%	15%	75%	100%	50%
Neighborhood Restaurant	10%	50%	75%	40%	15%	75%	100%	50%
Restaurant	10%	50%	75%	40%	15%	75%	100%	50%
Tavern	0%	0%	25%	75%	0%	10%	80%	100%
Small Bar	0%	0%	25%	75%	0%	10%	80%	100%
Bar, club or lounge	0%	25%	75%	75%	0%	40%	80%	100%
Retail (excluding shopping center)	5%	50%	75%	10%	5%	100%	75%	10%
Auto Parts and Supply Store	0%	50%	75%	0%	0%	100%	50%	0%

PERVIOUS PAVEMENT/CONCRETE INFORMATION

In most storm events, the detention services provided by the pervious payment allow slower soils to drain at predicted performance rates.[9] Due to the volume of storage of porous pavements, water is held on site. There is 5 to 8 inches of pervious pavement on top of 6 to 12 inches of sub-base. The 12 inches of subbase contain 40% voids in addition to the 5 to 8 inches of pervious pavement. The voids in the pervious pavement and subbase serve as short term detention and allows the water to percolate into the soil.

RULE OF THUMB

If soil has sufficient percolation to support a septic system then pervious pavement can function on your soil type.

Percent Reduction of Runoff Volume Relative to Rainfall Volumes[10]

PAVEMENT TYPE	MEAN (%)	MEDIUM (%)	MINIMUM (%)
Standard Asphalt	34.6	29.4	0
Pervious Concrete *	99.9	99.9	99.0
PICP – Type 1 *	99.3	99.4	97.8
PICP – Type 2 *	99.5	99.7	96.9

**Clay soils cause a 10% rise in runoff values during high intensity rainfall (greater than 2" of rainfall per hour); Infiltration from subgrade to clay soils maintain runoff rates as stated above if rainfall is low intensity (less than 2" rainfall per hour).*

HIGH INTENSITY RAINFALL

In areas that commonly receive intense rain events, it is effective to install underdrains below pervious concrete to help mitigate flash flooding. These drains are typically small plastic pipes, 4 to 8 inches in diameter. These drainage lines are at or near the bottom of the sub-base to collect water and convey it to the storm sewer network. Underdrains are most often used when permeable pavements are in soils that contain high percentages of clay. The benefits of slowed runoff rates and significant infiltration of rainwater into soil can be achieved when underdrains are present.[11]

[9] National Ready Mixed Concrete Association; http://www.perviouspavement.org/downloads/WhenItRains.pdf

[10] Journal of Hydrologic Engineering, Hydrologic comparison of four types of permeable pavement and standard asphalt in eastern North Carolina. (2008).

[11] Urban Waterways, North Carolina Cooperative Extension Service; (2008). https://nacto.org/docs/usdg/urban_waterways_permeable_pavement_hunt.pdf

EXAMPLES OF LID PROJECTS

Commercial Examples

EVELYN MEADOR LIBRARY

Address: *2400 N Meyer Ave, Seabrook, TX 77586*

Summary: The City of Seabrook worked with the county and variety of partners to design and build a new library after hurricane Ike. The final design and construction of the library incorporated a variety of low impact development elements. A variety of native plants, bioswales, and a wetland on the site all help detain 31,980 gallons of rainwater and retain 74,918 gallons of rainwater. The entire project was 4.3 million dollars to complete.

LID Methods Utilized:

Bioswales, preamble pavement, native plantings, wetland, and rain gardens

FEDERAL RESERVE BANK DALLAS- HOUSTON BRANCH

Address: 1801 Allen Parkway, Houston, Texas 77019

Summary: Recent updates to the Federal Reserve Bank's parking lot provide an additional example of low impact design at a commercial development. The Asakura Robinson Company retrofitted the site to allow for storm water to be captured through a series of bioswales throughout the parking lot; the captured storm water flows into a pond at the site. The pond, native plants, and fruit trees provide a unique gathering spot for visitors and staff. Additionally, this project includes a terrace with native plantings and living wall demonstrating the Bank's commitment to sustainability.

LID Methods Utilized:

Bioswales, natural detention pond, living wall, green roof, and fruit trees

Residential Examples of LID Projects

COTTAGE GROVE

Address: 2100 Arabelle St, Houston, TX 77007

Summary: Cottage Grove was selected to be a part of a LID demonstration project by TCEQ in 2016 when Cottage Grove was expanding from a low to high density neighborhood. TCEQ researched the potential impact LID elements may have on water quality in White Oak Bayou. Six rain gardens and 20 tree boxes were constructed throughout the neighborhood. The project cost 1.7 million. The project received the ACEC Texas Chapter Gold Award of Excellence, and the National Recognition Award from ACEC National.

LID Methods Utilized:

Native plantings, rain gardens, and tree boxes

NEW HOPE MULTIFAMILY DEVELOPMENT

Address: 2424 Sakowitz St. Houston, Texas 77020

Summary: In 2010, this single room occupancy apartment complex was built to LEED platinum standards. LID elements were a part of the overall design to obtain LEED certification. LID elements include native trees, rain barrels, bioswales, and permeable pavements.

LID Methods Utilized:

Native trees, rain barrels, bioswales, and permeable pavements

Recreational Examples of LID Projects

GHIRARDI WATERSMART PARK

Address: 1910 Louisiana Ave, League City, TX 77573

Summary: The Smart Park in League City has won numerous awards for its low impact development elements. The park includes a variety of native plants, trees, and shrubs, a green roof, a cistern for collecting rain water, bioswales, and preamble parking spaces and trails. The park is 3 acres including play, picnic areas, and an outdoor classroom. The park was designed to demonstrate the benefits of LID elements and was in part funded through a federal grant.

LID Methods Utilized:

Green roof, native plantings, rain gardens, bioswales, permeable pavement, and cistern

GENE GREEN BELTWAY 8 REGIONAL PARK

Address: 6500 East Sam Houston Pkwy N Houston, Texas 77049

Summary: Precinct one in Harris county along with a variety of partners and stakeholders designed and built this 250 acre park including hiking trails, dog parks, a skate park, and an amphitheater. The majority of the park serves as a detention basin and a buffer between Liberty Lake subdivision and Carpenter's Bayou. The project was completed in 2008 at a total cost of 5.5 million dollars.

LID Methods Utilized:

Bioswales, detention basin and native plantings

BAYTOWN NATURE REFUGE

Address: 6213 Bayway Drive 1724 Market Street Baytown, TX 77520

Summary: The City of Baytown and various partners and stakeholders came together to build this refuge on 450 acres of an abandoned residential site. The natural and constructed wetlands act to filter and retain water. Storm water runoff is slowed through preamble pavement on trails and walkways, and native plants.

LID Methods Utilized:

Constructed wetlands, permeable pavement, native plants and trees

Roadway Examples of LID Projects

Sjolander Road

Address: Sjolander Road, Baytown, Texas

Summary: In 2016, Harris County and a variety of partners increased this road from 2 to 5 lines. Increasing the width of the road provided the opportunity to incorporate LID elements throughout the site, including a bioswale along the west side of the road. The bioswale collects storm water runoff acting to detain and filter storm water. The bioswale replaced a traditional storm drain system for this project and saved 20 million dollars.

LID Methods Utilized:

Bioswales and native plants

BAGBY STREET

Address: Bagby Street, Houston, Texas, 77002

Summary: This road in Houston's Midtown neighborhood is often cited as a successful LID project. City of Houston and a variety of partners incorporated rain gardens, preamble pavements, and a diversity of native trees and plants into the final design. Overall, 33 percent of the stormwater drains into the rain gardens removing a significant proportion of bacteria, phosphorus, and oil. Bagby Street was the first GreenRoads certified project in Texas.

LID Methods Utilized:

Rain gardens, preamble pavements, native trees and plants

APPENDIX

LOW IMPACT DEVELOPMENT FACILITIES MAINTENANCE AGREEMENT

City of _____, Texas

THIS AGREEMENT, made and entered into this_____day of_____, _____, by and between_____, hereinafter called the "Landowner," and the City of _____, Texas hereinafter called the "the City."

WITNESSETH:

WHEREAS, the Landowner is the owner in fee simple of certain real property described on_____, as recorded by deed in the real property records of _____ County, Texas, Instrument Number _____, hereinafter called the "Property."

WHEREAS, the Site Plan/Subdivision Plan known as

_____,
(Name of Plan/Development)

hereinafter called the "Plan," as approved by the City and which is expressly made a part hereof, provides for the management of stormwater runoff within the confines of the Property; and

WHEREAS, the Property noted above contains low impact development facilities ("LIDs"), often called Best Management Practices ("BMPs"), and their accompanying components and structures; and

WHEREAS, a plat or plan identifying such areas is attached hereto for reference; and

WHEREAS, the stormwater facilities Inspection and Maintenance schedule for such areas is attached hereto for reference; and

WHEREAS, the Landowner is proceeding to build on and develop the Property; and

WHEREAS, the City and the Landowner, its successors and assigns, including any property owner's association, agree that the health, safety, and welfare of the residents of _____, Texas, require that on-site low impact development facilities be constructed and maintained on the Property; and

WHEREAS, the City requires that on-site low impact development facilities, as shown on the Plan, be constructed and adequately maintained by the Landowner, its successors and assigns, including any property owner's association; and

WHEREAS, a Inspection and Maintenance schedule has been included on the Plan and is attached for reference, which details the requirements to perpetually maintain the structural integrity and the proper functioning of the LID and all of its components.

NOW, THEREFORE, in consideration of the foregoing premises, the mutual covenants contained herein, and the following terms and conditions, the parties hereto agree, as follows:

1. The Landowner, its successors and assigns, shall construct the required on-site LIDs, as shown on Exhibit 1 and listed on Exhibit 2, at its sole expense and in strict accordance with the approved Plan and the associated specifications identified in the Plan.

2. The Landowner, its successors and assigns, shall, at its sole expense, make such changes or modifications to the LIDs as may, in the City's sole discretion, be determined necessary to insure that the LIDs are properly maintained and are continuing to operate as designed and approved.

3. The Landowner, its successors and assigns, including any property owner's association, shall perpetually and adequately maintain the LIDs. This includes all pipes and channels built to convey stormwater to or from the facilities, as well as all structures, improvements, and vegetation provided to control the quantity and quality of the stormwater. Adequate maintenance is herein defined as that which is necessary to maintain the structural integrity of the facilities and to insure good working condition so that the facilities are performing their intended design functions. The Inspection and Maintenance Schedule is shown on Exhibit 3.

4. The Landowner, its successors and assigns, shall periodically inspect the LIDs, as shown on Exhibit 3. The purpose of the inspection is to assure safe and proper functioning of the facilities. The inspection shall cover the facilities in their entirety and all related components, including but not limited to berms, outlet structure, pond areas, incoming or outgoing pipes or channels, side slopes, access roads, etc. Deficiencies shall be noted in the inspection report.

5. The Landowner, its successors and assigns, shall document all inspections, maintenance activities, and repairs that are performed on the LIDs on the Inspection Checklist attached as exhibit 4. Documents shall be maintained by the Landowner, its successors and assigns, for a minimum period of five (5) years and said documents shall be made available for review by, or copies shall be provided to, the City upon request.

6. The Landowner, its successors and assigns, hereby grant to the City, its authorized agents, employees, and contractors the perpetual right of ingress and egress over the Property for the purpose of inspecting the LIDs. Such inspections shall be conducted periodically and whenever the City deems necessary. Such inspections may be conducted for a variety of reasons, including the following: (a) to insure that the LID is being properly maintained and is continuing to function as designed and

approved by the City, (b) to ensure that adequate maintenance is occurring, (c) to follow-up on reported deficiencies, and (d) to respond to citizen complaints. The City shall provide the Landowner, its successors and assigns, copies of the inspection findings and a directive to commence with maintenance or repairs, if necessary. The City shall specify in the directive a time frame in which the work shall be completed.

7. In the event the Landowner, its successors and assigns, fail to maintain the LIDs in good working condition acceptable to the City, the City may enter upon the Property to correct all deficiencies, make all repairs, and to perform all maintenance, construction, and re-construction, as deemed necessary by the City, and to charge the costs of such repairs to the Landowner, its successors and assigns, and to any or all persons or entities served by the LIDs. This provision shall not be construed to allow the City to erect any permanent structure on the Landowner's land outside of the easement or property wherein the LIDs and their related components reside. It is expressly understood and agreed that the City is under no obligation to routinely maintain or repair said facilities, and in no event shall this Agreement be construed to impose any such obligation on the City.

8. The Landowner, its successors and assigns, shall perform the necessary work to comply with the attached Inspection and Maintenance Schedule, including sediment removal, and as otherwise required to keep the LIDs in good working order, as appropriate.

9. In the event the City, pursuant to this Agreement, performs work of any nature, or expends any funds in performance of said work for labor, use of equipment, supplies, materials, etc., the City may assess the Landowner, its successors and assigns, and all landowners served by the LIDs for their proportionate share of the actual costs incurred by the City hereunder. In collecting such charges, the City shall have available to it all remedies accorded by law for the collection of unpaid debts.

10. The Landowner, its successors and assigns, shall indemnify, save harmless, and defend the City against any and all claims, demands, suits, liabilities, losses, damages, and payments, including reasonable attorney fees claimed or made by persons not party to this agreement, against the City that are alleged or proved to result or arise from any construction, operation, or maintenance of the LIDs by the Landowner, its successors and assigns.

11. This Agreement and the covenants and agreements contained herein shall run with the title to the land and whenever the Property shall be held, sold, conveyed, or otherwise transferred, it shall be subject to the covenants, stipulations, agreements, and provisions of this Agreement which shall apply to, bind, and be obligatory upon the Landowner hereto, its administrators, executors, assigns, heirs and any other successors in interests, including any homeowners association, and it shall bind all present and subsequent owners of the Property described herein.

12. Initially, the Landowner is solely responsible for the performance of the obligations required hereunder and, to the extent permitted under applicable law, the payment of any and all fees, fines, and penalties associated with such performance or failure to perform under this Agreement. Notwithstanding any provisions of this Agreement to the contrary, upon the recordation of a deed or other instrument of sale, transfer, or other conveyance of fee simple title to the Property or any portion thereof (a "Transfer") to a third party (the "Transferee"), the Landowner shall be released of all its obligations and responsibilities under this Agreement accruing after the date of such Transfer to the extent such obligations and responsibilities are applicable to that portion of the Property included in such Transfer, but such release shall be expressly conditioned upon the Transferee assuming such obligations and responsibilities by recorded written agreement for the benefit of the City. Such written agreement may be included in the Transfer deed or instrument, provided that the Transferee joins in the execution of such deed or instrument. A certified copy of such deed, instrument, or agreement shall be provided to the City. The provisions of the preceding three sentences shall be applicable to the original Landowner and any successor Transferee who has assumed the obligations and responsibilities of the Landowner under this Agreement, as provided above.

13. Nothing in this Agreement shall be construed to prohibit a transfer of the Property by the Landowner to subsequent owners and assigns.

14. Provisions of this Agreement shall be severable and if any phrase, clause, sentence, or provision is declared unconstitutional, or the applicability thereof to Landowner held invalid, the remainder of this Agreement shall not be affected thereby.

15. This Agreement shall be recorded among the real property records of _____ County, Texas, at the expense of the Landowner.

16. In the event that the City shall determine, at its sole discretion at any future time, that the LIDs are no longer required, the City shall, at the request of the Landowner, execute a release of this Low impact development facilities Maintenance Agreement.

17. In the event of any dispute arising under the provisions of this Agreement, the laws of the State of Texas shall apply and jurisdiction over such dispute shall be in the _____ County, Texas.

IN WITNESS WHEREOF, the parties hereto have caused this agreement to be executed on their behalf.

LANDOWNER:

_____
(Full Name of Company, Corporation, or Partnership)

By: _____ **(SEAL)**
(Duly Authorized Officer Signature)

As: _____**(TITLE)**
(Duly Authorized Officer Title)

LANDOWNER ACKNOWLEDGMENT

State of Texas,

City of:_____, to wit:

The foregoing instrument was acknowledged before me this____, day of_____,_____,

by:_____as_____on
(Duly Authorized Officer Printed Name) (Duly Authorized Officer Printed Title)

behalf of _____
(Insert Full Name of Company/Corporation/Partnership)

_____ / _____
(Notary Public Signature) (Notary Public Printed Name)

My Commission expires:_____Registration #_____

Approved as to Content and Form:

_____ By:_____(SEAL)
City Attorney

CITY ACKNOWLEDGMENT

State of Texas
City of _____, to wit:

The foregoing instrument was acknowledged before me this____, day of_____, 20__

by_____on behalf of the City of _____, Texas.

_____ / _____
(Notary Public Signature) (Notary Public Printed Name)

My Commission expires:_____Registration #_____

EXHIBIT 1

Plat or Plan Depicting Location of Low impact development facilities

INSERT A PLAT OR A PLAN THAT CLEARLY SHOWS THE LOCATION OF ALL LOW IMPACT DEVELOPMENT FACILITIES FOR THE SITE. LEAVE "EXHIBIT 1" AT THE TOP OF THIS PAGE.

EXHIBIT 2
Listing of Low impact development facilities

Facility Name as Shown on the Plan	***Facility Type***	***How many?***	***Tax Map/Parcel I.D.***
Ex., LID- 1 or BMP-1	Ex., Bioretention	2	000.00-00-00.00-0000

EXHIBIT 3
Inspection and Maintenance Schedule

PROVIDE AN INSPECTION AND MAINTENANCE SCHEDULE FOR EACH **TYPE** OF LOW IMPACT DEVELOPMENT FACILITY SERVING THE SITE. MANUFACTURER'S MAINTENANCE LITERATURE MAY BE SUBMITTED FOR MANUFACTURED TREATMENT DEVICES.

Low Impact Development Facility Type: _____

EXHIBIT 4
Inspection and Maintenance Checklist

PROVIDE A MAINTENANCE AND INSPECION CHECKLIST FOR EACH **TYPE** OF LOW IMPACT DEVELOPMENT FACILITY SERVING THE SITE. MANUFACTURER'S MAINTENANCE LITERATURE MAY BE SUBMITTED FOR MANUFACTURED TREATMENT DEVICES.

Low Impact Development Facility Type: _____

Inspection and Maintenance Checklist

PLANTER BOX

Property Address _____

Property Owner _____

Treatment Measure No. _____ Inspection Date _____

Inspector(s) _____

Type of Inspection:

☐ Monthly ☐ Pre-wet season ☐ Post-wet season ____ ☐ After heavy runoff

☐ Other: _____

Defect	Conditions when maintenance is needed	Maintenance needed?	Comments[a]	Results expected when maintenance is performed
1. Standing water	When water stands in the planter box between storms and does not drain within 24 hours after rainfall.			There should be no areas of standing water after inflow has ceased. Any of the following could apply: sediment or trash blockages removed, mulch replaced, soil media surface scarified, underdrains flushed.
2. Trash and debris	Trash and debris accumulated in the planter box and around the inlet and outlet.			Trash and debris removed and disposed of properly.
3. Sediment	Evidence of accumulated sediment in the planter box.			Material removed so that there is no clogging or blockage. Material is disposed of properly.
4. Erosion	Channels have formed around inlets, there are areas of bare soil, or there is other evidence of erosion.			Obstructions and sediment removed so that water flows freely and disperses over a wide area. Obstructions and sediment are disposed of properly.
5. Vegetation	Vegetation is dead, diseased, or overgrown.			Vegetation is healthy and attractive. Grass maintained at least 3 inches in height.
6. Mulch	Mulch is missing or patchy; areas of bare earth are exposed, or mulch layer is less than 3 inches deep.			All bare earth is covered, except mulch is kept 6 inches away from trunks of trees and shrubs. Mulch is even at a depth of 3 inches.
7. Inlet/outlet	Sediment or debris accumulations.			Inlet/outlet is clear of sediment and debris and allows water to flow freely.
8. Affected impervious areas or structures	Obvious effects on surrounding impervious areas or structures.			Hydraulic restriction layers prevent impacts from infiltration to surrounding structures.
9. Miscellaneous	Any condition not covered above that needs attention for the planter box to function as designed.			The design specifications are met.

a Describe the maintenance completed; if the needed maintenance was not conducted, note when it will be done.

Inspection and Maintenance Checklist

GREEN ROOF

Property Address _____

Property Owner _____

Treatment Measure No. _____ Inspection Date_____

Inspector(s) _____

Type of Inspection:

☐ Monthly ☐ Pre-wet season ☐ Post-wet season ____ ☐ After heavy runoff

☐ Other: _____

Defect	Conditions when maintenance is needed	Maintenance needed?	Comments[a]	Results expected when maintenance is performed
1. Standing water	Roof drainage system is clogged.			There should be no areas of standing water on the green roof. The drainage system is inspected for clogging conditions and repaired or replaced as needed.
2. Erosion	Areas of scoured media or bare roof.			Green roof media stays in place and does not migrate across or erode from roof surface. Eroded media replaced and re-vegetated. If problem is recurrent, consider media more resistant to wind erosion or installing media retention components.
3. Vegetation	Vegetation is dead, missing, incorrect or unwanted.			Areas of missing vegetation replanted. Plant species are appropriate to conditions and drainage system is functioning properly. If problem is recurrent, consider irrigation during establishment or use alternative species. Unwanted vegetation removed and replaced with appropriate species. Evaluate growing conditions for cause of invasive vegetation.
4. Leaking roof	Roof liner has failed.			Evaluate liner for cause of leaks. Repair or replace as necessary.

a Describe the maintenance completed; if the needed maintenance was not conducted, note when it will be done.

Inspection and Maintenance Checklist

BIOSWALE

Property Address _____

Property Owner _____

Treatment Measure No. _____ Inspection Date _____

Inspector(s) _____

Type of Inspection:

☐ Monthly ☐ Pre-wet season ☐ Post-wet season ____ ☐ After heavy runoff

☐ Other: _____

Defect	Conditions when maintenance is needed	Maintenance needed?	Comments[a]	Results expected when maintenance is performed
1. Standing water	Water stands in the bioswale between storms and does not drain within 24 hours after rainfall.			There should be no areas of standing water once inflow has ceased. Any of the following could apply: sediment or trash blockages removed, grade from head to foot of bioretention area improved, media surface scarified, underdrains flushed.
2. Trash and debris	Trash and debris accumulated in the bioswale and around the inlet and outlet.			Trash and debris removed from the bioswale and disposed of properly.
3. Sediment	Evidence of accumulated sediment in the bioswale.			Material removed so that there is no clogging or blockage. Material is disposed of properly.
4. Erosion	Channels have formed around inlets, there are areas of bare soil, or there is other evidence of erosion.			Obstructions and sediment removed so that water flows freely and disperses throughout the bioswale. Obstructions and sediment are disposed of properly.
5. Vegetation	Vegetation is dead, diseased, or overgrown.			Vegetation is healthy and attractive. Grass is maintained at least 3 inches in height.
6. Mulch (if used)	Mulch is missing or patchy. Areas of bare earth are exposed or mulch layer is less than 3 inches deep.			All bare earth is covered, except mulch is kept 6 inches away from trunks of trees and shrubs. Mulch is even at a depth of 3 inches.
7. Inlet/outlet	Sediment or debris accumulations.			Inlet/outlet is clear of sediment and debris and allows water to flow freely.
8. Miscellaneous	Any condition not covered above that needs attention for the bioswale to function as designed.			The design specifications are met.

a Describe the maintenance completed; if the needed maintenance was not conducted, note when it will be done.

Inspection and Maintenance Checklist

BIORETENTION

Property Address _____

Property Owner _____

Treatment Measure No. _____ Inspection Date_____

Inspector(s) _____

Type of Inspection:

☐ Monthly ☐ Pre-wet season ☐ Post-wet season ____ ☐ After heavy runoff

☐ Other: _____

Defect	Conditions when maintenance is needed	Maintenance needed?	Comments[a]	Results expected when maintenance is performed
1. Standing water	Water stands in the bioretention area between storms and does not drain within 24 hours after rainfall.			There should be no areas of standing water once inflow has ceased. Any of the following could apply: sediment or trash blockages removed, grade from head to foot of bioretention area improved, media surface scarified, underdrains flushed.
2. Trash and debris	Trash and debris accumulated in the bioretention area and around the inlet and outlet.			Trash and debris removed from the bioretention area and disposed of properly.
3. Sediment	Evidence of accumulated sediment in the bioretention area.			Material removed so that there is no clogging or blockage. Material is disposed of properly.
4. Erosion	Channels have formed around inlets, there are areas of bare soil, or there is other evidence of erosion.			Obstructions and sediment removed so that water flows freely and disperses over a wide area. Obstructions and sediment are disposed of properly.
5. Vegetation	Vegetation is dead, diseased or overgrown.			Vegetation is healthy and attractive. Grass is maintained at least 3 inches in height.
6. Mulch	Mulch is missing or patchy. Areas of bare earth are exposed or mulch layer is less than 3 inches deep.			All bare earth is covered, except mulch is kept 6 inches away from trunks of trees and shrubs. Mulch is even at a depth of 3 inches.
7. Inlet/outlet	Sediment accumulations.			Inlet/outlet is clear of sediment and debris and allows water to flow freely.
8. Miscellaneous	Any condition not covered above that needs attention for the bioretention area to function as designed.			The design specifications are met.

a Describe the maintenance completed; if the needed maintenance was not conducted, note when it will be done.

Inspection and Maintenance Checklist

STORMWATER WETLAND

Property Address _____

Property Owner _____

Treatment Measure No. _____ Inspection Date_____

Inspector(s) _____

Type of Inspection:

☐ Monthly ☐ Pre-wet season ☐ Post-wet season ____ ☐ After heavy runoff

☐ Other: _____

Defect	Conditions when maintenance is needed	Maintenance needed?	Comments[a]	Results expected when maintenance is performed
1. Sediment	Evidence of accumulated sediment in the forebay or wetland body.			Accumulated sediment is excavated and disposed of properly.
2. Erosion	Evidence of erosion or sloughing on embankment.			Eroded areas filled with suitable material and vegetation established.
3. Vegetation	Embankment vegetation is dead, diseased, or overgrown; trees or shrubbery are growing on the embankment; there are areas of unwanted or inappropriate vegetation. There are visible dead plants or extensive bare areas in the wetland area.			Vegetation reestablished, trees or shrubs removed from the embankment and replaced with grass; embankment vegetation is mowed, invasive vegetation removed. Dead or missing wetland plants replaced with appropriate species.
4. Clogged orifice	Debris or vegetation is restricting flow through the orifice.			Debris is removed from orifice to allow desired drawdown.
5. Clogged riser or bypass structure	Debris or vegetation is impeding flow.			Debris is removed from the riser; consider trash rack installation.
6. Riser, barrel, or embankment failure	Separation of structural components.			Professional Engineer should conduct analysis of structural condition and recommend repairs.
7. Low water level	Low-level release valve is leaking or liner has failed.			Low-level release valve replaced or repaired; liner repaired.
8. Outfall	Outfall exhibits erosion and scour.			Scoured areas repaired.

a Describe the maintenance completed; if the needed maintenance was not conducted, note when it will be done.

Inspection and Maintenance Checklist

RAIN GARDEN

Property Address _____

Property Owner _____

Treatment Measure No. _____ Inspection Date _____

Inspector(s) _____

Type of Inspection:

☐ Monthly ☐ Pre-wet season ☐ Post-wet season ____ ☐ After heavy runoff

☐ Other: _____

Defect	Conditions when maintenance is needed	Maintenance needed?	Comments[a]	Results expected when maintenance is performed
1. Standing water	Water stands in the bioretention area between storms and does not drain within 24 hours after rainfall.			There should be no areas of standing water once inflow has ceased. Any of the following could apply: sediment or trash blockages removed, grade from head to foot of bioretention area improved, media surface scarified, underdrains flushed.
2. Trash and debris	Trash and debris accumulated in the bioretention area and around the inlet and outlet.			Trash and debris removed from the bioretention area and disposed of properly.
3. Sediment	Evidence of accumulated sediment in the bioretention area.			Material removed so that there is no clogging or blockage. Material is disposed of properly.
4. Erosion	Channels have formed around inlets, there are areas of bare soil, or there is other evidence of erosion.			Obstructions and sediment removed so that water flows freely and disperses over a wide area. Obstructions and sediment are disposed of properly.
5. Vegetation	Vegetation is dead, diseased or overgrown.			Vegetation is healthy and attractive. Grass is maintained at least 3 inches in height.
6. Mulch	Mulch is missing or patchy. Areas of bare earth are exposed or mulch layer is less than 3 inches deep.			All bare earth is covered, except mulch is kept 6 inches away from trunks of trees and shrubs. Mulch is even at a depth of 3 inches.
7. Inlet/outlet	Sediment accumulations.			Inlet/outlet is clear of sediment and debris and allows water to flow freely.
8. Miscellaneous	Any condition not covered above that needs attention for the bioretention area to function as designed.			The design specifications are met.

a Describe the maintenance completed; if the needed maintenance was not conducted, note when it will be done.

Inspection and Maintenance Checklist

CISTERN

Property Address _____

Property Owner _____

Treatment Measure No. _____ Inspection Date_____

Inspector(s) _____

Type of Inspection:

☐ Monthly ☐ Pre-wet season ☐ Post-wet season ____ ☐ After heavy runoff

☐ Other: _____

Defect	Conditions when maintenance is needed	Maintenance needed?	Comments[a]	Results expected when maintenance is performed
1. Low flow	Gutters are full of debris and overflowing.			Gutters should be clear and free-flowing when gutters are cleaned and gutter guards or screens are installed.
2. Inlet	Filters are clogged or full.			Filters are clean and free of trash and debris.
3. First flush diverter	First flush filter is full or clogged causing permanent flow to the cistern.			First flush is diverted away from the cistern when the first flush diverter valve is removed and cleaned.
4. Cistern does not drain within 48 hours	Outlet is clogged.			Cistern completely drains in less than 48 hours.
5. Cistern drains in less than 24 hours	Cistern leaks or outlet allows excessive flows.			Cistern drains in 24 to 48 hours.
6. Miscellaneous	Any condition not covered above that needs attention for the cistern to function as designed.			The design specifications are met.

a Describe the maintenance completed; if the needed maintenance was not conducted, note when it will be done.

Inspection and Maintenance Checklist

VEGETATED FILTER STRIP

Property Address _____

Property Owner _____

Treatment Measure No. _____ Inspection Date _____

Inspector(s) _____

Type of Inspection:

☐ Monthly ☐ Pre-wet season ☐ Post-wet season ____ ☐ After heavy runoff

☐ Other: _____

Defect	Conditions when maintenance is needed	Maintenance needed?	Comments[a]	Results expected when maintenance is performed
1. Sediment	Sediment depth exceeds 2 inches or covers vegetation.			Sediment deposits removed and surface re-leveled to maintain sheet flow over the filter strip.
2. Erosion	Eroded or scoured areas due to flow channelization or high flows.			No erosion or scouring evident. For ruts or bare areas less than 12 inches wide, damaged areas repaired by filling with crushed gravel. Over time the grass will start to cover the rock.
3. Trash and debris	Trash and debris accumulated on the filter strip.			Trash and debris removed from filter strip and flow spreading devices.
4. Visual contaminants and pollution	Any visual evidence of oil, gasoline contaminants, or other pollutants.			No visual contaminants or pollutants present.
5. Vegetation	When grass becomes excessively tall (greater than 10 inches). Evidence of nuisance weeds and other unwanted vegetation. Vegetation seems crowded or overgrown.			Grass mowed to a height of 2–5 inches and clippings removed. Nuisance vegetation controlled such that flow is not impeded using Integrated Pest Management (IPM) techniques if applicable. For more information, see http://www.ipm.ucdavis.edu. Minor vegetation removal and thinning. Mowing berms and surroundings. Facility looks well kept.
6. Flow spreader	Flow spreader uneven or clogged so that flows are not uniformly distributed through the entire filter width.			No visual erosion in the filter strip or ponding behind the flow spreader.

a Describe the maintenance completed; if the needed maintenance was not conducted, note when it will be done.

Inspection and Maintenance Checklist

VEGETATED SWALE

Property Address _____

Property Owner _____

Treatment Measure No. _____ Inspection Date_____

Inspector(s) _____

Type of Inspection:

☐ Monthly ☐ Pre-wet season ☐ Post-wet season ____ ☐ After heavy runoff

☐ Other: _____

Defect	Conditions when maintenance is needed	Maintenance needed?	Comments[a]	Results expected when maintenance is performed
1. Standing water	When water stands in the swale between storms and does not drain freely.			There should be no areas of standing water after inflow has ceased. Outlet structures and underdrain (if installed) should drain freely.
2. Trash and debris	Trash and debris that exceeds 5 cubic feet per 1,000 square feet (one standard garbage can).			Trash and debris are removed from the swale.
3. Visual contaminants and pollution	Visual evidence of oil, gasoline, contaminants, or other pollutants.			No visual evidence of contaminants or pollutants present.
4. Sediment	Sediment depth exceeds 2 inches or covers vegetation.			Sediment deposits removed without significant disturbance of the vegetation. Swale is level from side to side and drains freely toward outlet.
5. Erosion	Eroded or scoured areas due to flow channelization or high flows.			No erosion or scouring in swale bottom. For ruts or bare areas less than 12 inches wide, damaged areas repaired by filling with crushed gravel. Over time the grass will start to cover the rock.
6. Vegetation	Grass is sparse or bare or eroded patches occur in more than 10% of the swale bottom.			Vegetation coverage is in more than 90% of the swale bottom. Poorly vegetated areas of the swale bottom are re-planted with plugs of grass from the upper slope and reseeded in locations where plugs were taken. Plugs are planted in the swale bottom with no gaps, or reseeded into loosened, fertile soil.

Inspection and Maintenance Schedule: Green Roofs

Task	Frequency	Indicator maintenance is needed	Maintenance notes
Media inspection	2 times/year	Internal erosion of media from runoff or wind scour, exposed underlayment components	Replace eroded media and vegetation. Adopt additional erosion prevention practices as appropriate.
Liner inspection	1 time/year	Liner is exposed or tenants have experienced leaks	Evaluate liner for cause of leaks. Repair or replace as necessary.
Outlet inspection	2 times/year	Accumulation of litter and debris around the roof drain or scupper or standing water in adjacent areas.	Litter, leaves, and debris should be removed to reduce the risk of outlet clogging. If sediment has accumulated in the gravel drain buffers, remove and replace the gravel.
Vegetation inspection	1 time/year	Dead plants or excessive open areas on green roof	Within the first year, 10% of plants can die. Survival rates increase with time.
Invasive vegetation	2 times/year	Presence of unwanted or undesirable species	Remove undesired vegetation. Evaluate green roof for signs of excessive water retention.
Temporary watering	Every 2–3 days for first 1–2 months	Until established and during severe drought	Watering after the first year might be required.

Inspection and maintenance Schedule: Stormwater Wetlands

Task	Frequency	Indicator maintenance is needed	Maintenance notes
Forebay inspection	Weekly or biweekly	Internal erosion or excessive sediment, trash, or debris accumulation	Check for sediment accumulation to ensure that forebay capacity is as designed. Remove any accumulated sediment.
Basin inspection	1 time/year	Excessive sediment, trash, and/or debris accumulation in the wetland	Remove any accumulated sediment. Adjacent pervious areas might need to be regraded.
Outlet inspection	Weekly or biweekly with routine property maintenance	Accumulation of litter and debris in wetland area, large debris around outlet, internal erosion	Remove litter, leaves, and debris to reduce the risk of outlet clogging and to improve facility aesthetics. Erosion should be repaired and stabilized.
Mowing	2–12 times/year	Overgrown vegetation on embankment or adjacent areas	Frequency depends on location and desired aesthetic appeal.
Embankment inspection	1 time/year	Erosion at embankment	Repair eroded areas and revegetate.
Remove and replace dead vegetation	1 time/year	Dead plants or excessive open areas in wetland	Within the first year, 10% of plants can die. Survival rates increase with time.
Temporary watering	1 time/2–3 days for first 1–2 months	Until establishment and in severe drought	Watering after the initial year might be required.
Nuisance wildlife management	Biweekly or as needed	Animals, feces, or burrows evident in or around wetland. Excessive mosquitos.	Maintain diverse vegetated shelf around entire basin. Eliminate monocultures and replace with diverse, flowing vegetation. Employ qualified wildlife management professionals if needed.
Fertilization	1 time initially	Upon planting	One-time spot fertilization for first year vegetation.

Inspection and Maintenance Schedule: Bioretention Systems (rain garden, bioswale, and planter box)

Task	Frequency	Indicator maintenance is needed	Maintenance notes
Catchment inspection	Weekly or biweekly with routine property maintenance	Excessive sediment, trash, or debris accumulation on the surface of bioretention.	Permanently stabilize any exposed soil and remove any accumulated sediment. Adjacent pervious areas might need to be regraded.
Inlet inspection	Weekly or biweekly with routine property maintenance	Internal erosion or excessive sediment, trash, and/or debris accumulation	Check for sediment accumulation to ensure that flow into the bioretention is as designed. Remove any accumulated sediment.
Litter and leaf litter removal	Weekly or biweekly with routine property maintenance	Accumulation of litter and leafy debris within bioretention area	Litter and leaves should be removed to reduce the risk of outlet clogging, reduce nutrient inputs to the bioretention area, and to improve facility aesthetics.
Pruning	1–2 times/year	Overgrown vegetation that interferes with access, lines of sight, or safety	Nutrients in runoff often cause bioretention vegetation to flourish.
Mowing	2–12 times/year	Overgrown vegetation that interferes with access, lines of sight, or safety	Frequency depends on location and desired aesthetic appeal.
Mulch removal and replacement	1 time/2–3 years	Less than 3 inches of mulch remains on surface	Mulch accumulation reduces available surface water storage volume. Removal of decomposed mulch also increases surface infiltration rate of fill soil. Remove decomposed fraction and top off with fresh mulch to a total depth of 3 inches
Temporary Watering	Every 2–3 days for first 1–2 months, sporadically after established	Until established and during severe droughts	Watering after the initial year might be required.
Fertilization	1 time initially	Upon planting	One-time spot fertilization for first year vegetation.
Remove and replace dead plants	1 time/year	Dead plants	Plant die-off tends to be highest during the first year (commonly 10% or greater). Survival rates increase with time.
Outlet inspection	Once after first rain of the season, then monthly during the rainy season	Erosion at outlet	Remove any accumulated mulch or sediment.
Miscellaneous upkeep	12 times/year	Tasks include trash collection, plant health, spot weeding, removing invasive species, and removing mulch from the overflow device.	

Inspection and Maintenance Schedule: Cisterns

Task	Frequency	Indicator maintenance is needed	Maintenance notes
Gutter and rooftop inspection	Biannually and before heavy rains	Inlet clogged with debris	Clean gutters and roof of debris that have accumulated, check for leaks
Remove accumulated debris	Monthly	Inlet clogged with debris	Clean debris screen to allow unobstructed stormwater flow into the cistern
Structure inspection	Biannually	Cistern leaning or soils slumping/eroding	Check cistern for stability, anchor system if necessary
Structure inspection	Annually	Leaks	Check pipe, valve connections, and backflow preventers for leaks
Add ballast	Before any major wind-related storms	Tank is less than half-full	Add water to half full
Miscellaneous upkeep	Annually		Make sure cistern manhole is accessible, operational, and secure

Inspection and Maintenance Schedule: Vegetated Swale

Task	Frequency	Maintenance notes
Inlet inspection	Twice annually	Check for sediment accumulation and erosion in the swale.
Mowing	2–12 times / year	Frequency depends on location and desired aesthetic appeal.
Watering	1 time/2–3 days for first 1–2 months. Sporadically after establishment	If droughty, watering after the initial year may be required.
Fertilization	1 time initially	One-time spot fertilization for first year vegetation.
Remove and replace dead plants	1 time/year	Within the first year 10% of plants can die. Survival rates increase with time.
Check dams	1 time before the wet season(s) and monthly during the wet season(s).	Check for sediment accumulation and erosion around or underneath the dam materials.
Miscellaneous upkeep	12 times/year	Tasks include trash collection, spot weeding, and removing mulch from overflow device.

Inspection and maintenance Schedule: Vegetated Filter Strip

Task	Frequency	Maintenance notes
Mowing	2–12 times/year	As needed to maintain aesthetics. Grass height should be a minimum of 4 inches.
Inlet inspection	Once after first major rain of the season, then monthly during the rainy season(s)	Check for sediment accumulation to ensure that flow into the system is as designed. Remove any accumulated sediment.
Miscellaneous upkeep	12 times/year	Tasks include trash collection, spot weeding, and irrigation as necessary.

ORDINANCE NO. 2018-_____

AN ORDINANCE OF THE CITY OF _____, ADOPTING _____ (Chapter___ Section___) "LOW IMPACT DEVELOPMENT OPERATION AND MAINTENANCE", SETTING FORTH AND ADOPTING THE STANDARDS OF LOW IMPACT DEVELOPMENT INSPECTION AND MAINTENANCE BEST MANAGEMENT PRACTICES; PROVIDING FOR SEVERABILITY; PROVIDING FOR REPEAL; AND PROVIDING FOR AN EFFECTIVE DATE.

Section I. Intent and Purpose

This Ordinance establishes methods for implementing Low Impact Development operations and Best Management Practices (BMPs) within the city of _____. The objectives of this ordinance are to:

A) encourage the use and implementation of Low Impact Development Operations and Best Management Practices within the city of _____;

B) receive and collect information, such as Low Impact Development, inspection reports, and other information deemed necessary to assess compliance with this section, from Landowners and Developers; and

C) establish legal authority to implement inspection and enforcement procedures to ensure compliance with this Ordinance;

Section II. Maintenance Agreements

A) The City of _____ has the authority to enter into Low Impact Development Maintenance Agreements in order to allow (Landowners or Developers) to implement Low Impact Development practices.

B) The City shall establish permitting standards and requirements and issue permits pursuant to such standards and requirements for Landowners or Developers who choose to enter into a Maintenance Agreement under the provisions of this ordinance.

C) Easements and covenants shall be provided by the Landowner for access for facility inspections and maintenance. Easements and covenants shall be reflected within the Low Impact Development Maintenance Agreement.

D) Landowners (or Developers) who enter into a Low Impact Development Maintenance Agreement with the City, comply with the requirements therein, and maintain the required permit under this ordinance shall receive a _____(tax credit or development credit) of _____.

Section III. Maintenance

A) All Low Impact Development BMPs shall be maintained according to the measures outlined in the Low Impact Development Inspection and

Maintenance Schedule maintained by _____ (ex. city secretary).

B) The person(s) or organization(s) responsible for maintenance shall be designated in the maintenance agreement.

C) Maintenance agreements shall specify responsibilities for financing maintenance.

D) In order to receive the _____ (tax credit or development credit) under this Ordinance, the landowner must comply with all requirements contained in the Maintenance Agreement, Inspection and Maintenance Schedule, as well as any and all permitting requirements.

Section IV. Inspections

A) The person(s) or organization(s) responsible for maintenance shall inspect Low Impact Development BMPs on a regular basis as outlined in the corresponding Maintenance Agreement.

B) Authorized representatives of_____(*the City*) may enter at reasonable times to conduct on-site inspections or routine maintenance as provided in the Maintenance Agreement.

C) For BMPs maintained by the (Landowners or Developers), Inspection and Maintenance reports shall be performed and maintained in compliance with the terms of the Maintenance Agreement.

D) Authorized representatives of_____(*the City*) may conduct inspections to confirm the information in the reports under Section C.

E) In order to maintain a permit under this ordinance, a Landowner must submit an annual inspection report to _____ (the City). Such inspection report must be performed by a licensed engineer. The annual inspection report must be submitted _____(days) prior to each anniversary of such permit being issued. The annual inspection report is in addition to any and all inspection requirements contained in the Inspection and Maintenance Schedule.

Section V. **Severability**.

In the event any clause, phrase, provision, sentence or part of this Ordinance or the application of the same to any person or circumstances shall for any reason be adjudged invalid or held unconstitutional by a court of competent jurisdiction, it shall not affect, impair or invalidate this Ordinance as a whole or any part or provision hereof other than the part declared to be invalid or unconstitutional; and the City Council of the City of _____ declares that it would have passed each and every part of the same notwithstanding the omission of any part thus declared to be invalid or unconstitutional, or whether there be one or more parts.

Section VI. **Repeal**.

All other ordinances or parts of ordinances inconsistent or in conflict herewith are, to the extent of such inconsistency or conflict, hereby repealed.

Section VII. **Effective date**.

This Ordinance shall be and become effective immediately upon its adoption.

PASSED, APPROVED, and ADOPTED on this, the _____ day of _____, 2018.

Appendix B: Workshop Summary

TASK 5: PROMOTING LID IMPLEMENTATION

Objective: To convene a community LID workshop that conveys the findings, recommendations, and expected implementation strategy for the City of Pearland to a broader set of stakeholders within and outside of the municipality.

Sub-task 5.1: Workshop Planning – The Performing Party will select a workshop location. The Performing Party will develop a workshop attendee list that includes representatives from the City of Pearland, the City of Manvel, and the City of Mont Belvieu, communicate workshop purpose and logistics with potential attendees, and mail out workshop announcement and registration information.

Pearland Representatives: Martin Griggs, John McDonald, and Lawrence G. Provins

Mont Belvieu Representative: Ricardo Villareal

Manvel Representatives: None in attendance

Event Invite: Sent via email to 868 contacts within the region.

Sub-task 5.2: Workshop Materials – The Performing Party will develop workshop presentation(s), agenda, website page, announcement and handouts.

- All workshop materials provided on following pages

Sub-task 5.3: LID Workshop and Summary – The Performing Party will host a LID workshop at the selected location using the materials developed. The Performing Party will provide a workshop summary to include the number of attendees and notes on any deviations from the agenda no later than 15 days after the workshop date.

- 26 Attendees; Sign in sheets and attendee on pages 4-6.
- No deviations from the agenda; Agenda on page 3
- All additional workshop materials begin on Page 7 of this document.

DESIGNING FOR IMPACT

LOW IMPACT DEVELOPMENT IMPLEMENTATION WORKSHOP

Agenda

1:30 pm - Welcome & Introductions

1:40 pm - Designing with Maintenance in Mind; David Batts

2:30 pm - Break

2:45 pm - Maintenance Agreements, Inspection Schedule, & Ordinances; Grady Randle

3:30 pm - Closing Remarks

HOUSTON-GALVESTON AREA COUNCIL

WEDNESDAY, NOVEMBER 7, 201811

First Name:	Last Name:	Company:	City:
Chris	Chavis	City of Baytown	Baytown
Jeremy	Chesnutt	City of Cleveland	Cleveland
Kelly	Lawrence	City of Cleveland	Cleveland
Goldberg	Larry	CivilTech Engineering, Inc.	Cypress
Jeannie	Kubricht	City of El Lago	El Lago
David	Batts	EcoServices Construction	Houston
Vince	DeCapio	Arcadis	Houston
Catherine	Elliott	HCFCD	Houston
Maurice	Gonzales	Harris County Engineering	Houston
Eli	Gonzales	EcoServices Construction	Houston
Valeria	Keese	Texas Community Watershed Part	Houston
Cassidy	Kempf	TCEQ	Houston
Joshua	Owens	H-GAC	Houston
Andy	Palermo	EHRA	Houston
Michelle	Randon, P. E.	City of Houston	Houston
Pat	Shevlin	Eco-Options, LLC	Houston
Grady	Randle	Randle Law Office	Memorial City
Ricardo	Villagrand	City of Mont Belvieu	Mont Belvieu
Aimee	Schultze	Harris County Public Health	Pasadena
Martin	Griggs	City of Pearland	Pearland
John	McDonald	City of Pearland	Pearland
Lawrence G.	Provins	City of Pearland	Pearland
Jim	Messer	Timber Lane UD	Spring
Nuttapol	Chumnitulakarn	The City of Sugar Land	Sugar Land
Maggie	Dalton	Fort Bend County	Sugarland
Celina	Gauthier Lowry	Texas A&M AgriLife Extension Ser	Webster

DESIGNING FOR IMPACT

LOW IMPACT DEVELOPMENT IMPLEMENTATION WORKSHOP

First Name	Last Name	Signature
Jim	Messer	Timber Lane U.D.
Joshua	Owens	
Andy	Palermo	
Lawrence G.	Provins	
Michelle	Randon, P. E.	
Aimee	Schultze	
Aubrey	Semien	
Pat	Shevlin	Eco-options, LLC
Nancy	Sullins	
Donald	Thompson	
Ricardo	Villagrand	
Natalie	Weiershausen	

Name	Organization	Email Address
Maggie Dalton	Fort Bend County	maggie.dalton@fortbendcountytx.gov
John McDonald	City of Pearland	jmcdonald@pearlandtx.gov
Martin Griggs	city of pearland	mgriggs@pearlandtx.gov
Mauricio Gonzalez	Harris County Engineering	mauricio.gonzalez@hcpid.org

David Batts
Eli Gonzalez

DESIGNING FOR IMPACT

LOW IMPACT DEVELOPMENT IMPLEMENTATION WORKSHOP

First Name	Last Name	Signature
Paula	Atchison	
Mohamed	Bagha	
Ethan	Beeson	
Chris	Chavis	
Luis	Chen	
Jeremy	Chesnutt	
Nuttapol	Chumnitulakarn	
Vince	DeCapio	
Catherine	Elliott	
Celina	Gauthier Lowry	
Valeria	Keese	
Cassidy	Kempf	
Jeannie	Kubricht	
Goldberg	Larry	
Kelly	Lawrence	
David	Lopez III	
Gibran	Lule-Hurtado	
Cheryl	Mergo	

DESIGNING FOR IMPACT

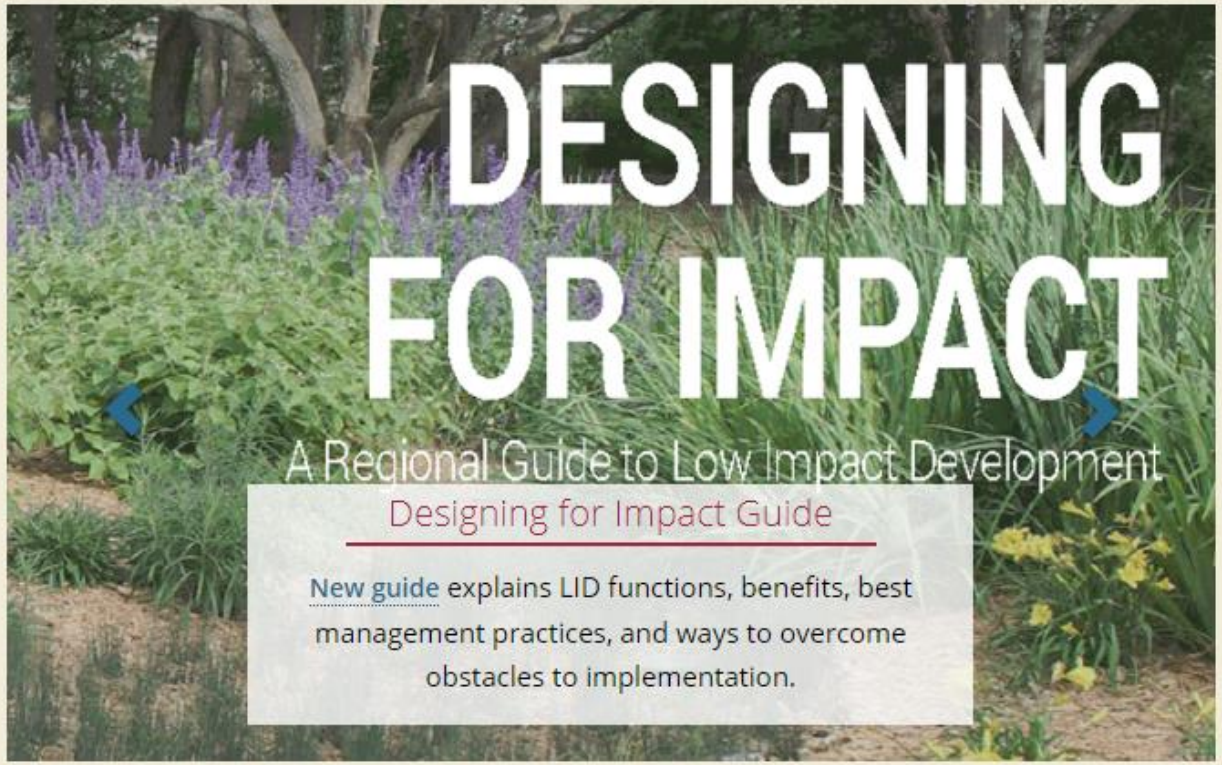
LOW IMPACT DEVELOPMENT IMPLEMENTATION WORKSHOP

-LID Guide

-Map Tool

-Toolbox

Low Impact Development (LID)



Contact

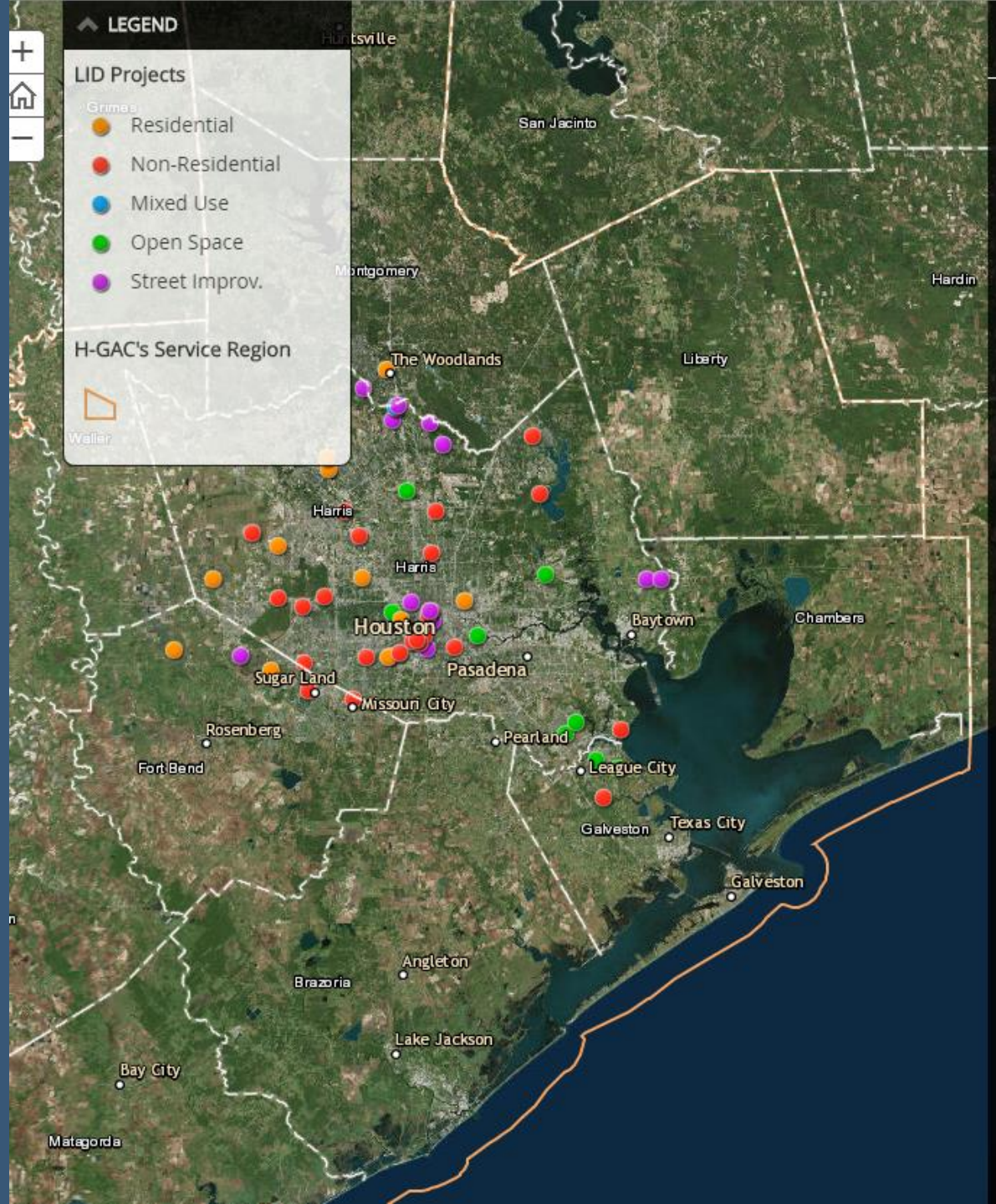
Cheryl Mergo
Manager
Cheryl.Mergo@h-gac.com
713-993-4520

Sign Up for LID News

Receive news about Low Impact Development, including the Designing for Impact project.

SIGN-UP

- LID Guide
- Map Tool
- Toolbox



-LID Guide

-Map Tool

-Toolbox

Low Impact Development (LID) Toolbox

Low Impact Development (LID) practices mimic the natural processing of stormwater runoff and can create more attractive communities. Most LID techniques and strategies are applicable throughout the Houston-Galveston region.

Click on a thumbnail to view a brief description of the technique. To download a PDF with more details about each technique, click on "More Information."

LID Toolbox

Bioswale

Cistern

Constructed Stormwater Wetlands

Green Roof

Permeable Pavement

Rain Barrel

H-GAC News & Events

See More

Low Impact Development

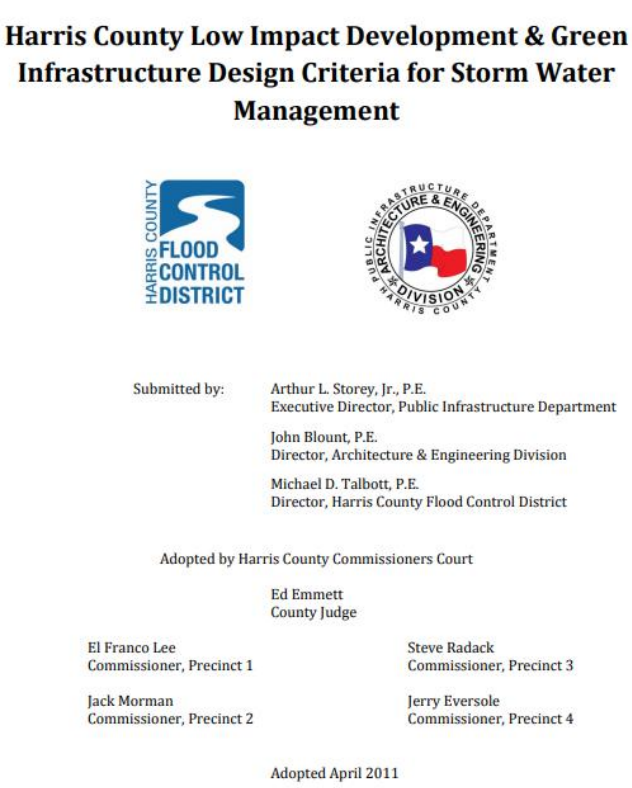
Innovative, Maintenance Minded Solutions

David Batts, LEED AP

Director, Stormwater Systems

Why Low Impact Development?

Did You Know…



Harris County Low Impact Development & Green Infrastructure Design Criteria for Storm Water Management

HARRIS COUNTY FLOOD CONTROL DISTRICT

PUBLIC INFRASTRUCTURE DEPARTMENT HARRIS COUNTY ARCHITECTURE & ENGINEERING DIVISION

Submitted by:

Arthur L. Storey, Jr., P.E.
Executive Director, Public Infrastructure Department

John Blount, P.E.
Director, Architecture & Engineering Division

Michael D. Talbott, P.E.
Director, Harris County Flood Control District

Adopted by Harris County Commissioners Court

Ed Emmett
County Judge

El Franco Lee
Commissioner, Precinct 1

Steve Radack
Commissioner, Precinct 3

Jack Morman
Commissioner, Precinct 2

Jerry Eversole
Commissioner, Precinct 4

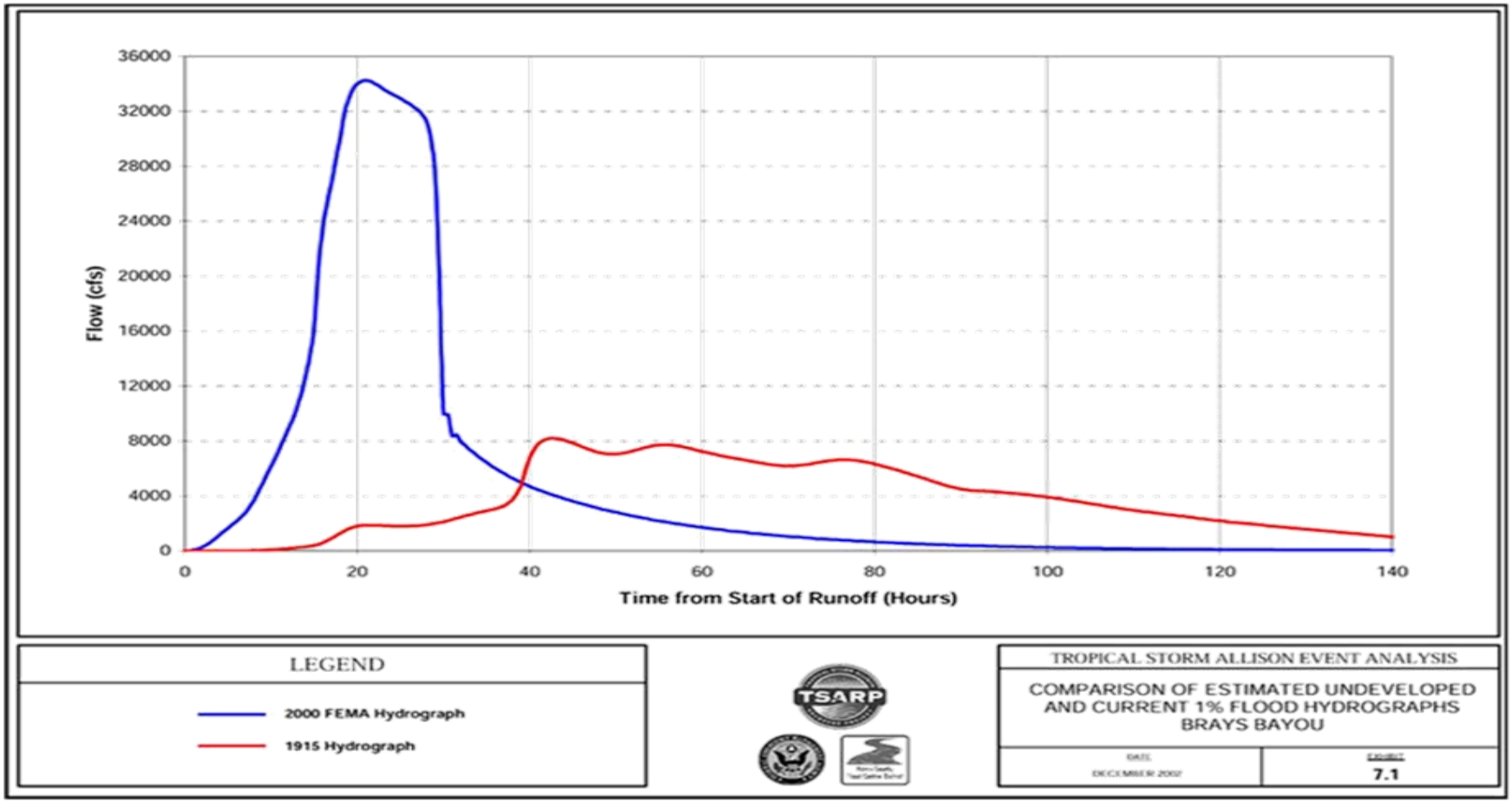
Adopted April 2011

45% Detention Reduction!

Why Low Impact Development?

- **Increased Lot Yield**
- **Lower Overall Cost of Development**
- **Increased Revenue**
- **No Design Delays / No Construction Delays**

Mimic Predevelopment Hydrology…



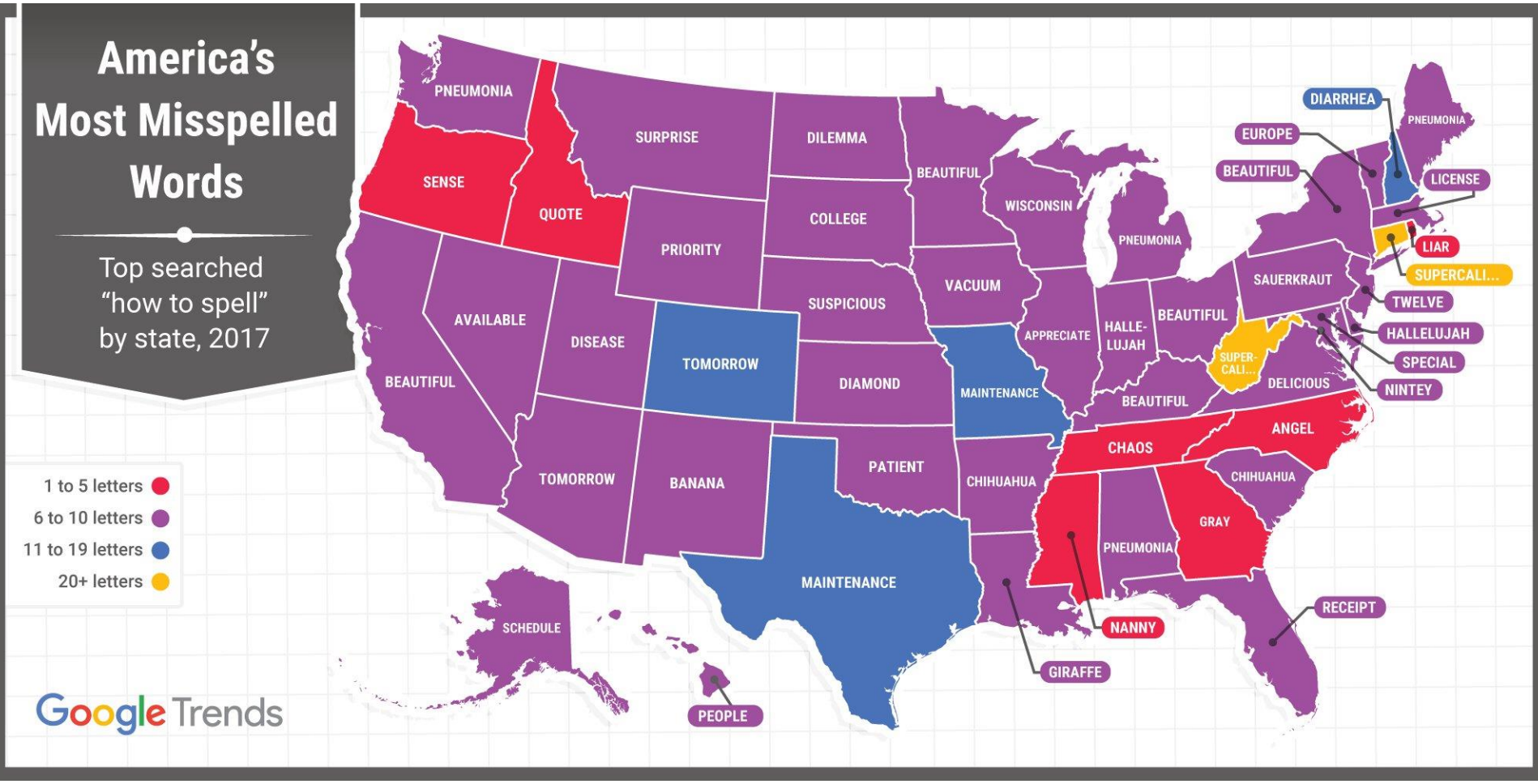
White Oak and Brays Hydrographs: 1915 & 2000

Blue line shows 2000 concentrated urban runoff; red line shows 1915 pre-urbanized runoff

…Let’s Save That Story for Next Time

America's Most Misspelled Words

Top searched "how to spell" by state, 2017



Google Trends

If Stormwater Quality is the #1 Goal

Maintenance Should be the #1 Priority

Start With the End in Mind

Think Maintenance First

Start With the End in Mind

DESIGNERS MUST….Think Maintenance First

Maintenance

Maintenance has to be Simple / Cost Effective

Maintenance

Maintenance has to be Simple / Cost Effective

Maintenance

Maintenance has to be Simple / Cost Effective

Maintenance

Maintenance has to be Simple / Cost Effective

Maintenance

Maintenance has to be Simple / Cost Effective

CONSTRUCTION ECO SERVICES

Provides Maintenance

On 500+ Properties

The Struggle is Real

We Feel Your Pain

#MakeMaintenanceGreatAgain

an **ounce of prevention** is worth a pound of cure

- Benjamin Franklin

nd

ng

CONSTRUCTION ECO SERVICES

Property Owners Nightmare

Managing The Struggle

- Maintenance Can’t be an Afterthought
- Provide a Stormwater Quality Management Plan
- Monthly Site Inspections With Photo Documentation
- Annual Recertification by a Licensed Professional Engineer
- Photo Documentation of Maintained System

MAKE THE PROPERTY OWNER DO IT

CONSTRUCTION ECO SERVICES

Property Owner's Best Interest

- $400 Month on Inspections
- $400 Month on Mowing / Weeding / Trash Pick Up

$50,000 / $800 month / 12 months = 5.2 Years of Maintenance

But What About Performance?

CONSTRUCTION ECO SERVICES

The Maintenance Win-Win-Win

Never Allow the System to Fail
Make the Owner Take Responsibility

How We Work

Core Value #6: Build Partnerships

CONSTRUCTION ECO SERVICES


SWPPP
CONSTRUCTION
ECO
SERVICES

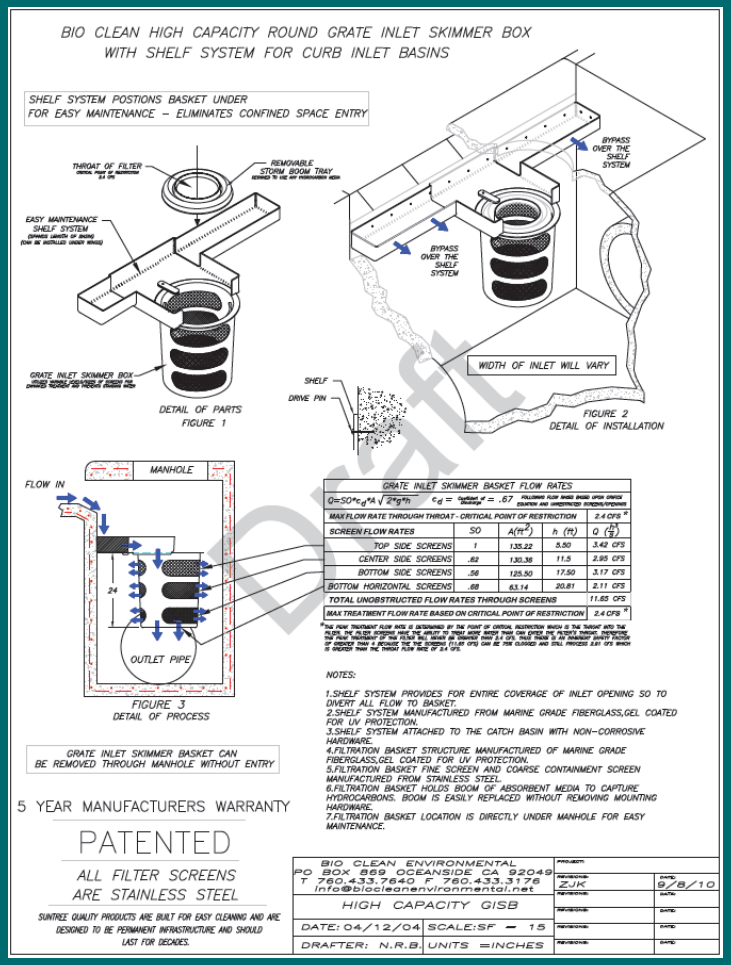

BIO CLEAN
Sunree
Technologies Inc.
ECO


SIXTH STREET
HISTORIC DISTRICT
E. 6TH STREET
(PECAN ST.)
100


ROCKY LOVES EMILY
SXSW
SOUTH BY SOUTHWEST
MUSIC · FILM · INTERACTIVE
AUSTIN, TX


ECOPOCALYPSE
CONSTRUCTION
ECO
SERVICES
5TH AND TRINITY
THE END IS NEAR
© Gene Inman Photography

Suntree Curb Inlet Basket



Make Modifications Quickly!

I **didn't fail the test** I just found 100 ways to do it wrong

- Benjamin Franklin

Core Value #8: Own It

CONSTRUCTION ECO SERVICES

EcoAssurance

First Years Maintenance Included

Core Value #8: Own It

CONSTRUCTION ECO SERVICES

EcoAssurance

Long Term Contracts Available

CONSTRUCTION ECO SERVICES

Designing with Maintenance in Mind

- Bioretention (Bioswales, Rain Gardens, Etc)
- Permeable Pavements
- Traditional Means

What We ***Know*** About Bioretention…

Requires Large Footprint

Sizing Bioretention…

- Stormwater Quality Volume
- Infiltration Rate = k Sat
- Draw Down Time
- Ponding Depth Allowed
- Detention Volume Required, If Any

Sizing Bioretention…

Media Blend	K Sat (ft/day)	Drainage Time	Bioretention Required
City of Austin	5 ft/day	24 hours	5041 SF
SARA	12 ft/day	24 hours	1200 SF
FocalPoint	200 ft/day	24 hours	171 SF

* Sizing Associated with 10 acre site with WQv of 34,485

Realities of Bioretention…

Realities of Bioretention…

Media Selection Dictates Size

Realities of Bioretention…

What We ***Know*** About Bioretention…

Maintenance Intensive

What We ***Know*** About Bioretention…

What We ***Know*** About Bioretention…

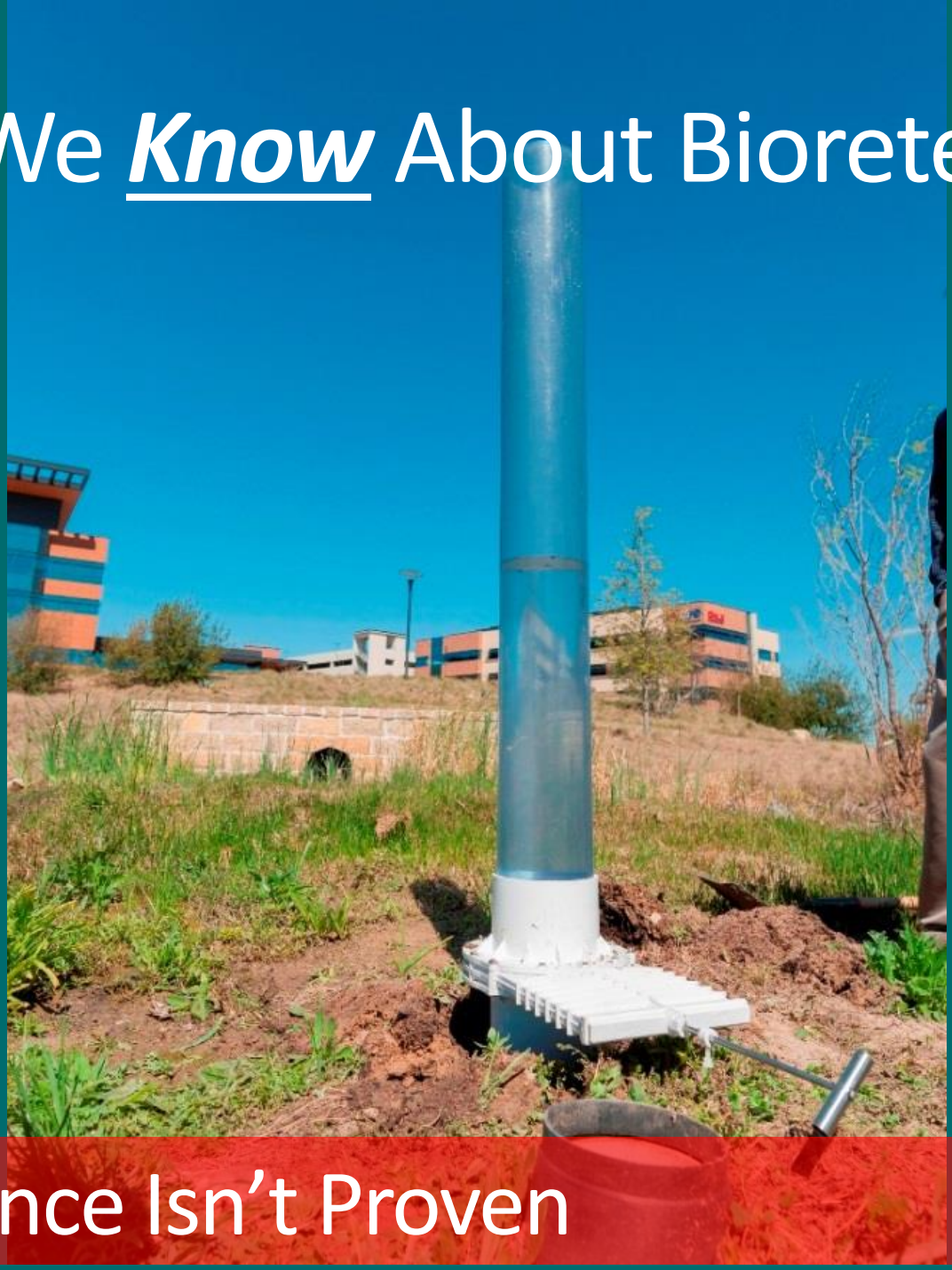
What We ***Know*** About Bioretention…

Can Only Manage Small Storms

What We ***Know*** About Bioretention…

Can Only Manage Small Storms

What We ***Know*** About Bioretention…



Performance Isn’t Proven

Managing Outcomes with CES

- 100 in/hr Media
- Performance Specification
- Highest Level of QA/QC
- In Situ Performance Testing
- Reduced Maintenance Burden
- First Year Free
- Simple

QUESTIONS?

Challenges with Permeable Pavements…

Challenges with Permeable Pavements…

Construction Phasing

Challenges with Permeable Pavements…

Construction Phasing

Challenges with Permeable Pavements…

Maintenance

Challenges with Permeable Pavements…

Maintenance

Challenges with Permeable Pavements…

maintenance is not the same.

Types of Street Sweepers

There are three main classes of street sweepers: (1) mechanical, (2) regenerative air, and (3) vacuum. Examples of mechanical and vacuum sweepers are shown in Figure 5.

Mechanical street sweepers are the most common street sweeper on the market. By some accounts, approximately 70 percent of street sweepers in the U.S. are mechanical street sweepers (Mark Kinter[1]). Mechanical sweepers employ a multiple brush approach to first move sediment and trash to the middle and then lift the deposits onto a conveyor belt for temporary storage. The brush bristles can penetrate some types of permeable pavements, but not most.

Regenerative air street sweepers are the second most common street sweeper, accounting for roughly 20 percent of street sweepers in use in the U.S. They work by shooting air at an angle to the pavement, which effectively loosens dust and other fine particles at and near the surface of the pavement. Because air is blown across the carriage of the truck, a relatively minor vacuum is created, which then lifts the loosened particles into a [illegible] surface-deposited sediments from all pavement types.

Vacuum street sweepers are the least common and most expensive type of sweepr, and account for 10

Figure 5. A small mechanical street sweeper (top) and the underpinnings of a vacuum sweeper (bottom).

percent of street sweepers in the U.S. They function by applying a strong vacuum to a relatively narrow area that lifts particles both at and below the surface of the pavement. Vacuum sweepers have demonstrated their ability to suction 3 to 4 inches of gravel from PICP and have the ability to restore infiltration to some types of pavements that have been grossly neglected.

Where do permeable pavements clog?

Permeable pavement systems clog at different locations in their cross-section. Because of this, not one type of street sweeper is recommended for all types of permeable pavements. Based upon anecdotal observation and research, here are the observed zones or depths of surface clogging.

Concrete grid pavers, because their gaps are filled with sand, act like a sand filter and trap most of the fine

[1]Mr. Kinter is an Elgin Street Sweeper marketing director. Conversation took place in May 2009.

Maintenance

Challenges with Permeable Pavements…

Maintenance

Challenges with Permeable Pavements…

Challenges with Permeable Pavements…

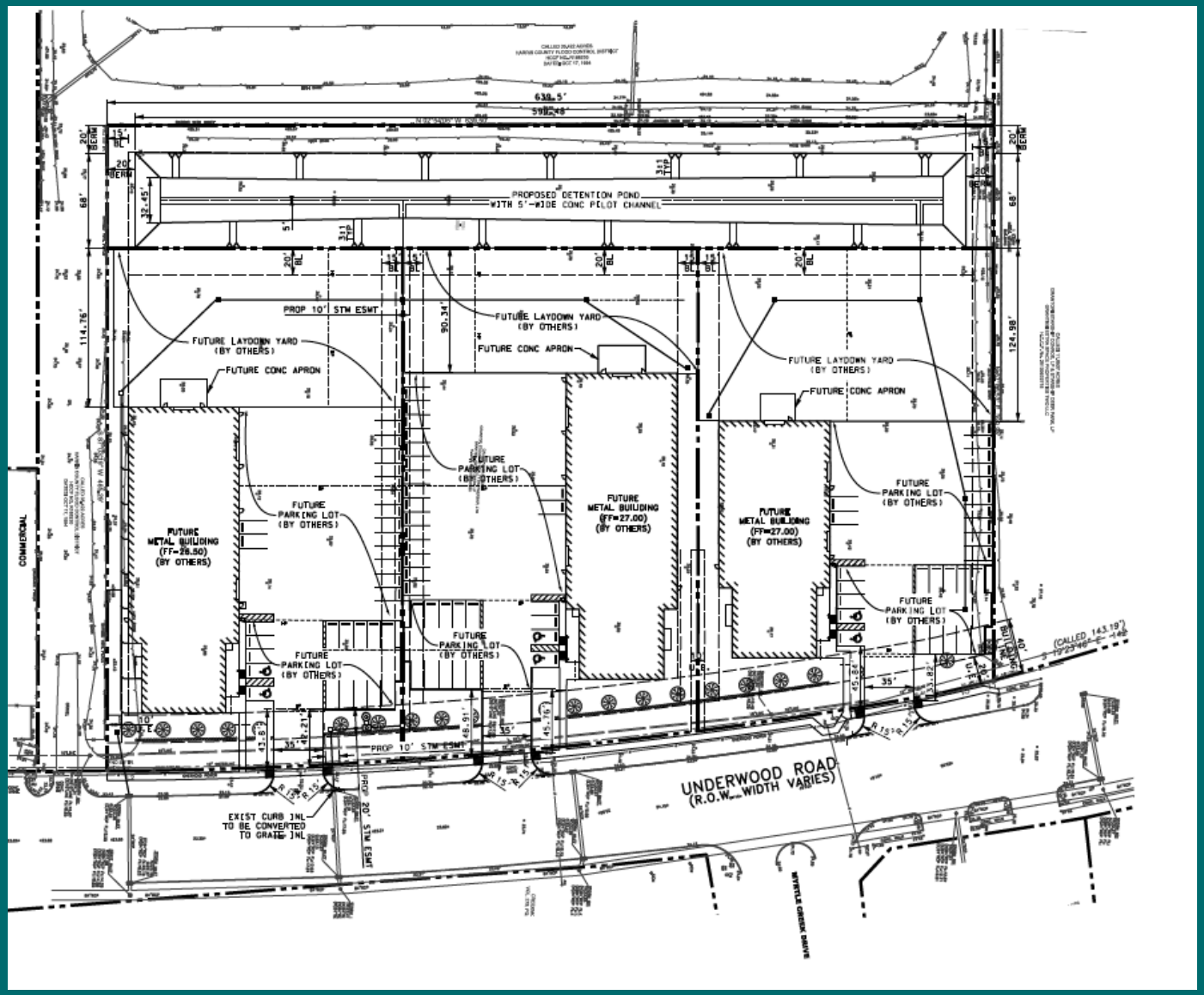
Product	Installed Price ($/SF)	Maintenance Price ($/SF)	Maintenance Equipment	Maintenance Interval (Months)	Additional SWM Infrastructure Price ($/SF)	Life Expectancy (Years)	Life Cycle Price ($/SF/YR)
Conventional Asphalt	$5.00	$0.18	Street Sweeper	12	$15.00	15	$1.51
Conventional Concrete	$7.00	$0.18	Street Sweeper	12	$15.00	25	$1.06
Porous Asphalt	$6.00	$0.25	Vacuum Truck	3	$0.00	10	$1.60
Pervious Concrete	$8.00	$0.25	Vacuum Truck	3	$0.00	20	$1.40
Permeable Pavers	$7.00	$1.00	Vacuum Truck & Joint Fill Replacement	6	$0.00	35	$2.20
P-ACB/M (PaveDrain)	$10.00	$0.50	PaveDrain Vac-Head	24	$0.00	50	$0.45

Expensive

QUESTIONS?

Challenges with Traditional Means…

Challenges with Traditional Means…



Challenges with Traditional Means…

Challenges with Traditional Means…

Managing The Struggle

- Maintenance Can’t be an Afterthought
- Provide a Stormwater Quality Management Plan
- Monthly Site Inspections With Photo Documentation
- Annual Recertification by a Licensed Professional Engineer
- Photo Documentation of Maintained System

ENFORCEMENT HAS TO COST MORE THAN COMPLIANCE

QUESTIONS?

Questions?

David Batts, LEED AP

Director, Stormwater Systems

DESIGNING FOR IMPACT

LOW IMPACT DEVELOPMENT IMPLEMENTATION WORKSHOP