REPORTED COSTS AND EXPERIENCED DESIGN PRACTITIONER'S OPINIONS ABOUT LOW IMPACT DEVELOPMENT (LID) STORMWATER TREATMENT METHODS IN FLORIDA

By

DANIEL C. PENNIMAN

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To all the people that have motivated me in this world to pursue my passions both big and small, especially my mom

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LIST OF ABBREVIATIONS

ADA	Alternative Development Approach
BMP	Best Management Practice
ERP	Environmental Resource Permit
LID	Low Impact Development
SWM	Stormwater Management
SWMF	Stormwater Management Facility
TMDL	Total Maximum Daily Load
WMD	Water Management Districts

Abstract of Thesis Presented to the Graduate School
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Daniel C. Penniman

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Low impact development (LID) is a green infrastructure stormwater management (SWM) method that has been studied and found to help decrease runoff and associated non-point source pollution issues. Although LID has begun to gain traction in Florida, most private practitioners have not adopted it; one main reason is the perception that LID may cost more. The objectives of this study are (1) to identify the primary barriers for design professionals that have attempted to implement LID in Florida and (2) to determine the relative capital costs of LID in comparison with the conventional methods for constructing stormwater treatment systems in Florida. Using a snowball sampling method, I identified and interviewed 29 professionals from firms that had knowledge/experience with LID practices. I administered an online survey about barriers to LID and an associated questionnaire on LID versus conventional costs for actual stormwater design projects. Participants reported that costs associated with LID were a barrier, but the permitting process was the main barrier hindering the consideration and use of LID methods in Florida. Overall, 41% of respondents thought LID was more

expensive than conventional methods, 32% thought it was less expensive, and 27% could not give a definitive answer as to whether they believed LID to be more or less expensive. The latter group thought the relative cost of LID is dependent on the permitting process, site conditions and which particular LID tools were used in the design. For the five projects collected, the LID design option (compared to a conventional design) had a capital cost savings that ranged from -$294,000 to $2,925,000 for stormwater management. Variation in cost savings was primarily due to the types of LID features used in the stormwater treatment system and site conditions. Results indicate that practitioners need to be well experienced with LID to realize possible significant cost savings. In order to encourage LID, Florida stormwater regulators should focus their attention on smoothing the permitting process and accepting properly designed LID stormwater management options.

CHAPTER 1
LITERATURE REVIEW OF STORMWATER TREATMENT SYSTEMS

In the United States more than one million acres of land are developed each year and much of this is transferred into roads, parking lots, and other surfaces which are impermeable to precipitation. A great deal of research has been done that concludes water quality greatly declines in aquatic systems/resources when the impermeable areas of a watershed exceed 10% due to increases in stormwater runoff (Center for Watershed Protection 1998). The management of stormwater, with a focus on water quality outcomes is a fairly recent practice. Historically, urban stormwater runoff was almost entirely thought of as a quantity problem (flooding) with the solution being rapid draining into sewers, centralized ponds, or directly into natural receiving bodies of water (Heaney 2012, Rushton 2001, Civic Federation 2007, Merriam 2011). Stormwater runoff loads often carry urban contaminants such as automobile oils, fertilizers/pesticides, heavy metals and pet wastes (Macmullen and Reich 2007, Clark and Acomb 2008, USEPA 2003). The National Water Quality Inventory found that urban runoff is the main cause for impairment to studied estuaries and the third highest cause of impairment to inventoried lakes (USEPA 2003). In Florida, research has shown since the 1970’s more than half the pollutant loads inundating the state’s waterways come from non-point, stormwater sources (Rushton n.d., Livingston and McCarron n.d.).

The dominant method for managing stormwater prior to the 1970’s involved construction of large conveyance systems made up of concrete curbs, gutters, and pipe systems intended to transport water running off impervious surfaces directly into natural receiving waters. In accordance with the 1987, Clean Water Act (CWA) and associated state stormwater management plans, some regulations required the use of “conventional” best management practices (BMPs) in order to improve the stormwater runoff quality before re-entering natural systems. Florida was particularly ahead of the curve in adopting stormwater regulations which relied mostly on pipe-and-pond management practices to control, store, and treat stormwater runoff in centralized retention ponds (Merriam 2011, personal communication, Mark Clark, personal communication, June 11 2012). However, much of the pollutant removal efficiencies developed for conventional BMPs were based on sediment removal/settling rates and research indicates that they have been over credited for mitigating water quality impacts and often do not meet assumed pollutant removal levels (Harper and Baker 2007, Kloss and Calarusee 2006). Therefore, compliance with current stormwater permits often does not assure the results of surface water protection/restoration goals. Also, Centralized pipe-and-pond conveyance systems have been associated with negative impacts such as bank and channel erosion and impairment of aquatic habitats. Environmental degradation of water resources impacts the publics’ interests when aquatic systems are no longer suitable for fishing, recreating, or drinking.

A relatively new practice used to treat stormwater, known as low impact development (LID), focuses on maintaining the pre-development hydrologic function of the area and managing stormwater in ways closer to the natural rainfall-runoff cycle (Prince George’s County 1999, USEPA 2000, Powell et al. 2005). LID strategies manage stormwater in three main ways. The first is through decentralized storage in which stormwater is contained on a temporary or permanent basis. The second is infiltration in which the water is encouraged to enter the soil to be treated through biophysical processes. The third is through evapotranspiration which moves water to the air from the soil, plants, and the built environment. Some LID tools only perform a single one of these beneficial functions, whereas others can perform all three (MMSD 2010). Research on the functional capabilities of LID to reduce stormwater runoff from developed sites and decrease water pollution has been conducted in the US since the early 1990’s (Coffman 2000, MacMullen and Reich 2007, Prince George's County 1999). In most cases, results indicate that LID performs better than conventional stormwater management (Harper and Baker 2007, Hood et al. 2007, Rushton 2001, USEPA 2000, Willis 2012). Additionally, LID adds flexibility to where and how stormwater management occurs, unlike large, centralized systems (Kloss and Calarusee 2006, USEPA 2005).

Green infrastructure and stormwater management techniques have been widely employed in other countries such as Japan, Australia, and Germany, but are still fairly infant in the US (Kloss and Calarusee 2006). LID has been termed a couple of different things, especially in older literature before the envelope term low impact development was deemed. Some of these terms synonymous with LID include green infrastructure, sustainable urban drainage systems (SUDS), best management practices (BMPs), source control, natural drainage systems, sustainable stormwater management, and conservation site design (MacMullen and Reich 2007, CRI 2005). LID has been slow to come to Florida for a couple of main reasons. One of the major reasons is that Florida’s physical conditions are unique from many other areas in which LID practices have been well tested. Heavy rainfall, geology and hydrological characteristics such as high water tables are the most often cited physical conditions which make using LID difficult in Florida. Research and practical knowledge have been instrumental in adapting LID techniques for Florida conditions (Clark and Acomb 2008, Merriam 2011). Our research explores what some of the other issues have faced the private development industry and impeded the use of LID.

The Economics of LID

Developers will most likely utilize construction practices which make the greatest economic sense for their company, often with only limited concern for water resource protection (Williams and Wise 2009). While LID may be an appropriate stormwater treatment system to address water quality and runoff issues, concerns have been expressed by private developers about higher costs associated with implementing LID (Bowman and Thompson 2009, CRI 2005, Macmullen and Reich 2007, Powell et al. 2005). Although this perception is still strong, data is beginning to show that LID practices can lead to reduced costs and other economic benefits (Kloss and Calarusee 2006, Liptan and Brown 1996, USEPA 2005, USEPA 2007).

The economic benefits of utilizing LID go beyond potential construction cost savings. The literature cites benefits that have major economic implications associated with improved air and water quality, decreased urban heat island effect, improved groundwater recharge, and increased aesthetics (CWP 1998, Hubbart 2011, Montalto et al. 2007, Williams and Wise 2009). A important note from the literature is the finding that many development companies and municipalities which have realized cost savings from using green infrastructure practices, did so to achieve an environmental goal or because of an environmental ethos, not because of an initial cost analysis (Civic Federation 2007, Macmullen and Reich 2007).

Below, I (1) outline prior research focused on identifying barriers to using LID nationally, and (2) review cost research which has been done to compare LID and conventional stormwater management.

Barrier Research

As low impact development practices have become more accepted as an alternative to conventional stormwater management, researchers have attempted to identify factors impeding its use. Due to the unique characteristics of the development enterprise, which include huge expenses and risks necessitating major financial and time investments, most any cited barrier is a concern for the developer because it translates back to cost one way or another. There is inherent uncertainty with the early use of not-well-tested practices such as LID which hinders proper consideration for these approaches (Bowman and Thompson 2009, David Glunt, personal communication, 2011). Therefore, even if the alternative development approach is estimated to be the lowest cost option developers inexperienced with LID will often choose an approach which is known to achieve revenue goals without necessarily maximizing them (CRI 2005, Bowman and Thompson 2009). Therefore, development companies are inclined to use conventional practices, especially in an unfamiliar or tumultuous construction market (Williams and Wise 2009).

The Civic Federation (2007) released a report which reviewed and summarized the main issues with attempting to implement LID projects for five U.S. local governments. One of the major findings was that the decentralized nature of LID creates some major difficulties. Because LID uses a suite of practices which are distributed throughout the landscape questions of funding, and accountability for operation and maintenance become much more complex than for centralized systems.

Also, a decentralized approach to stormwater management usually causes design effort to increase compared to conventional systems because the need to model and monitor many stormwater infiltration and storage controls versus one large retention pond (Gordon 2010, Heaney and Sansalone 2012).

Due to the infancy of LID in major practice, a lack of knowledge and training on the part of planners and regulators has been another major obstacle for the progression and use of LID. Because of LIDs heavy reliance on natural processes and systems, the predictability of flood control performance and pollutant removal function of these strategies becomes much difficult than with highly engineered centralized systems (Heaney and Lee 2006). Real-world performance data, technical information, and experience with LID practices will help to alleviate these uncertainties (Civic Federation 2007, Godwin 2008). Because citizen safety is usually the prime concern of regulatory bodies, previously mentioned concerns over flood control are one of the major issues which often leads to inflexible development rules (codes, zoning regulations, construction standards and local ordinances) concerning stormwater infrastructure which necessitate special permits and variances to approve LID practices (CWP 1998). Combined these issues often increase project approval/permitting times which equates to risk and cost for developers (Bowman and Thompson 2009, Ryan 2006).

Major challenges to the implementation of LID in Florida were identified by a survey and collected comments from Florida developers, design professionals, and government officials who attended workshops/training programs concerning LID practices (Kipp et al. 2011). These practitioners ranked “Insufficient and/or unclear LID BMP design and approval criteria” and “lack of public awareness and acceptance of

LID" as the first and second main challenges. "Uncertainty regarding costs and benefits of LID features" were cited as the third overall challenge to LID implementation in Florida.

Cost Comparative Research

Research to compare LID and conventional costs is currently limited and preliminary but growing quickly. Because LID is still an emerging technology in practice, a major portion of LID cost estimates are not standardized and are largely varied (Sample et al. 2003, CRI 2005). A variety of economic evaluations have been used to quantify and compare its cost to conventional stormwater management. These evaluations include estimated capital cost comparisons, life-cycle comparisons and cost-benefit comparisons (MacMullen and Reich 2007, Powell et al. 2005). One challenge to developing direct cost comparisons is that LID methods are most often used in combination with conventional design techniques. Therefore an apples to apples, line-item comparison is usually not achievable and total project costs must be considered (CRI 2005). Although direct capital cost comparisons are least favorable for the overall consideration of LID practices, development companies favor this type of economic evaluation. This is due to the fact that development companies most often sell development projects once they are completed with little consideration for long-term costs or benefits of the site.

From capital cost comparative research, one of the greatest advantages of LID is that it allows for decreased spending on pipes, inlet structures, large stormwater ponds, curb and gutters, roadway paving, and clearing and grading. It does so by replacing highly manufactured, centralized conveyance systems with less material-intensive, more natural techniques such as bioswales, rain gardens, and mitigation wetlands (Coffman 2000, Lehner et al. 2001, CWP 1998, USEPA 2007). Permeable surfaces are arguably the most widely used LID tool thus far, and a good example to demonstrate how economies of scale come into play when comparing the costs of LID and conventional centralized stormwater management. Conventional style paving is often $2-5 cheaper per unit (Doug Buch, personal communication, December 14, 2011); but if designed properly and given accurate storage credits porous/permeable materials can reduce the need for piping and ponds, therefore reducing construction material costs by as much as 30% (CRI 2005). Coffman (2001) reports that in favorable conditions, stormwater and site development construction costs can be reduced by 25-30% using LID techniques compared to conventional approaches. Areas where construction costs are often higher for LID projects are plant material, site preparation, soil amendments, and underdrains (USEPA 2007).

National Cost Comparative Research: A report released by the US EPA (2007) examined 17 case studies of development projects that included LID tools and compared the costs of using LID to using conventional stormwater management tools (Table 1-1). The majority of projects identified in this research showed that LID cost less than conventional development. Estimated total capital cost savings ranged from 15-80% in this group of case studies. The reviewed case study which LID realized a much higher cost than the comparable conventional design was because of the use of green roofs which are well documented as being capital cost intensive (MMSD 2010). To date, USEPA (2007) is the most extensive research that examines projects which were actually constructed using a LID approach. Although this is true, some of the case studies were modeling studies in which a LID and conventional stormwater design were developed for the same site and costs were estimated and then compared.

Florida Specific Cost Comparative Research: A 44-acre residential subdivision in Gainesville, Florida was designed initially using LID in order to better stormwater issues, lower water consumption, and increase biodiversity in the area (Acomb 2009). A model home in the subdivision was designed using an extensive suite of LID practices including natural buffers, rain gardens, pervious pavers, soil moisture sensors, minimized turf, native plants, an exfiltration tank, a shared driveway and others. Turf reinforcement was used in some areas of the LID design in order to accommodate guest parking and reduce paving. An in-depth capital cost and maintenance cost comparison was performed at the site-level for the Madera Model home. It was compared to a conventional home and lot in a subdivision nearby which had similar soils and vegetative canopy. The LID model's built costs were overall about $1,500 (7.6%) less expensive compared to the similar sized conventional home/lot design. The bulk of savings associated with the LID approach came from reduced clearing/grading, a shared driveway, and a reduction in the use of turf grass. Increased mulching, the exfiltration tank, and the reinforced turf were line-items in which the LID design cost more. A qualified landscape maintenance contractor was consulted in order to develop and compare maintenance costs. The LID site realized overall maintenance savings of about $1,900 a year mostly attributed to the reduction of turf and required care.

A two-year cost modeling study was published in 2009 which used a hypothetical residential neighborhood to compare construction costs and buyer valuation for four alternative approaches to stormwater management and land-development in Florida

(Williams and Wise 2009). It used cost functions from several sources to tabulate capital construction costs and compare the four scenarios deemed; 1) traditional development, 2) cluster development, 3) partial LID, 4) full LID. The full LID scenario yielded the lowest construction costs followed second by the cluster development scenario. The majority of cost savings was due to the decrease in curb and gutter, storm sewer, and sidewalks. A hedonic price model was used to compare buyer valuation for the four scenarios. It was found that the full LID option had the highest return on investment (ROI) for the first year of the study but in the second year the cluster alternative had the highest ROI.

Redevelopment/Retrofit Cost Comparative Research: The literature shows that LID has been most widely used in new residential developments but it has also proven to be an environmentally and financially smart way to retrofit existing development (USEPA 2000). In the redevelopment or retrofit scenario, LID is used in several different main ways. The first is in ultra-urban settings to control and treat stormwater before it is discharged directly into receiving waterways. For this situation, it has been used to reduce the necessary size of, or in some cases, eliminate the need for the addition of centralized storage ponds in redevelopment projects (Gordon 2010, USEPA 2005). LID has also been used to decrease the load and stress on aging stormwater infrastructure. The decentralized and flexible nature of LID allows for it to be utilized in stormwater retrofit project plans ranging from single-lot to citywide. Research conducted by city officials in Seattle and Vancouver concluded that using green infrastructure to retrofit locations with existing conventional stormwater management systems will be only marginally more expensive than rehabilitating/fixing the conventional systems; but they found that it would be less expensive in new developments (Kloss and Calarusse 2006).

In Austin, Texas, city plans focused on buffering streams in order to protect the Edwards Aquifer (USEPA 2005). Large amounts of subdivision runoff was being concentrated and discharged directly into local streams by curb-and-gutter practices. The conventional style, sedimentation-filtration, retention pond which would have been required to manage the runoff would have cost $250,000. Instead of employing a pipe-and-pond design, engineers directed the stormwater discharge as sheet flow to a series of shallow biodetention areas before entering the receiving streams. The redesign was done at a total cost of $65,000, which saved $185,000 compared to the large pond which would have been dug. This cost difference does not include savings from reduced drain pipe sizes and trenching.

Table 1-1. A partial summary of cost comparisons between conventional and low impact development project designs reported by the US Environmental Protection Agency (2007).

Project	Conventional Development Cost	LID Cost	Cost Difference	% Difference in Costs
2nd Avenue SEA Street	$868,803	$651,548	$217,255	25%
Auburn Hills	$2,360,385	$1,598,989	$761,396	32%
Bellingham City Hall	$27,600	$5,600	$22,000	80%
Gap Creek	$4,620,600	$3,942,100	$678,500	15%
Garden Valley	$324,400	$260,700	$63,700	20%
Kensington Estates	$765,700	$1,502,900	-$737,200	-96%
Laurel Springs	$1,654,021	$1,149,552	$504,469	30%
Mill Creek	$12,510	$9,099	$3,411	27%
Prairie Glen	$1,004,848	$599,536	$405,312	40%
Somerset Subdivision	$2,456,843	$1,671,461	$785,382	32%
Tellabs Corp. Campus	$3,1262,160	$2,700,650	$461,510	15%
Bellingham Bloeden Donovan Park	$52,800	$12,800	$40,000	76%

CHAPTER 2
EXPERIENCED DESIGN PROFESSIONAL'S PERCEPTIONS ON LID AND REPORTED COSTS

Introduction

In the United States more than one million acres of land are developed each year and much of this space is transferred into roads, parking lots, and other surfaces which are impermeable to precipitation. These impermeable areas are collectively known as impervious surfaces. Due to symptomatic issue of urbanization, increased stormwater runoff, water quality greatly declines in aquatic systems/resources when the impermeable areas of a watershed exceed 10% (Center for Watershed Protection 1998). Urban areas often consist of 45% or more of impervious surfaces (Kloss and Calarusee 2006). The National Water Quality Inventory found that urban runoff is the main cause for impairment to studied estuaries and the third highest cause of impairment to inventoried lakes (USEPA 2003). In Florida, stormwater runoff is the major source of pollutants to lakes, estuaries, and streams and has been since the 1970's (FDEP 2008, Livingston and McCarron n.d., Rushton n.d.).

In accordance with the 1987, Clean Water Act (CWA) and associated state stormwater management plans, some regulations required the use of best management practices (BMPs) in order to improve the stormwater runoff quality before re-entering natural systems. Florida was particularly ahead of the curve in adopting stormwater regulations which relied mostly on pipe-and-pond management practices to control, store, and treat stormwater runoff in centralized retention ponds (Merriam 2011, personal communication, Mark Clark, personal communication, June 11 2012). Much of the pollutant removal efficiencies developed for these "conventional" BMPs were based on sediment settling rates and research indicates that these have been over credited for mitigating water quality issues (Harper and Baker 2007, Kloss and Calarussee 2006). Therefore, compliance with current stormwater permits often does not assure the results of surface water protection/restoration goals.

Low Impact Development (LID) is a green infrastructure stormwater management method which has been studied and found to help minimize runoff from developed sites, and remove most water pollutants better than conventional methods (Hood et al. 2007, Rushton 2001, USDOT 1996, USEPA 2000, Willis et al. 2012). Some other benefits of LID practices include better groundwater recharge, improved surface water hydrology, and increased biodiversity (CWP 1998, CRI 2005). LID focuses on managing stormwater in smarter ways that maintain or mimic the natural rainfall-runoff cycle (Civic Federation 2007, Prince George's County 1999). LID practices range from structural systems such as permeable pavers, to non-structural practices such as low-impact landscaping, to site-layout designs such as cluster development (also known as conservation design). The tools of LID control and treat stormwater in three main ways. The first is through decentralized storage in which stormwater is contained on a temporary or permanent basis in shallow, vegetated depressions. The second is infiltration in which the water is encouraged to enter the soil instead of running across impervious surfaces. In some cases infiltration tools can be used to treat stormwater through biophysical and filtering processes. The third is through evapotranspiration which moves water to the air from the soil, plants, and the built environment. Some LID tools only perform a single one of these beneficial functions, whereas others can perform all three (MMSD 2010).

Although LID has begun to gain some traction, the majority of private development practitioners have been slow to adopt LID practices (Merriam 2011). Because of inexperience and unknown costs associated with it, practitioners are reluctant to use LID which hinders adequate consideration for these approaches (Bowman and Thompson 2009, David Glunt, personal communication, 2011). Due to the unique characteristics of the development enterprise, which include massive expenses and risks necessitating major financial and capital investments, any obstacles or hiccups in the development process translates back to cost one way or another. Therefore, the majority of private companies are inclined to use tried-and-true practices, especially in an unfamiliar or tumultuous construction market (CRI 2005, Williams and Wise 2009).

LID is still an emerging technology in practice therefore a major portion of LID cost estimates are not standardized and are largely varied (MacMullen and Reich 2007, Sample et al. 2003). The most extensive capital cost comparative research to date, USEPA (2007), gives a national view of how using LID can lead to reduced capital costs. In this research 17 case studies were reviewed, which compared LID and conventional capital construction costs using both built projects and modeling methods. A large majority of the examples had lower construction costs with the LID approach and total capital cost savings ranged from 15-80%. Coffman (2000) reports that with favorable site conditions, stormwater management and site development construction costs can be reduced by 25-30% using LID techniques compared to conventional approaches. These studies, and others, show how LID allows for decreased capital spending on pipes, inlet structures, large stormwater ponds, curb and gutters, roadway paving, and clearing and grading. It does so by replacing highly manufactured, centralized conveyance systems with less material-intensive, and more natural techniques such as bioswales, rain gardens, and mitigation wetlands (Coffman 2000, CWP 1998, Lehner et al. 2001, Liptan and Brown 1996). Areas where construction costs are often reported as being relatively higher for LID projects are plant material, site preparation, soil amendments, and underdrains (USEPA 2007). Economic data has been collected from projects mainly in the northwest and northeast US, leaving a void of economic data for Florida and other southeastern states.

Practicing design professionals (engineers, architects, landscape architects) are often tasked with devising early estimates of probable construction costs and finding the most effective methods of achieving a goal in order to minimize overall project costs (Glenn Acomb, personal communication, Heaney 2012). They also play a large role in the up-front, early consideration of unconventional or alternative techniques (David Glunt, personal communication, 2011). Design firms and associated professionals who have attempted to use LID methods in Florida projects are a knowledgeable group about the most pertinent issues impeding greater adoption of LID. Identifying what they believe to be the main barriers to LID, and their perceptions on the relative costs of LID compared to conventional practices will help identify significant issues a to encourage the use of LID in future development. Sampling from knowledgeable practitioners in Florida, our objectives were (1) to identify the primary barriers for design professionals that have attempted to implement LID in Florida and (2) to determine the relative capital costs of LID in comparison with the conventional methods for constructing stormwater treatment systems in Florida.

Methods

Selection of Participants: A snowball sampling method (Castillo 2009) was used to obtain contacts for design firms who have incorporated LID methods in their Florida projects. A group of thirty-three (33) design firms and associated professionals were obtained and contacted by phone for an initial interview. This interview was partially scripted (Appendix A) regarding willingness to participate in the research, knowledge/experience with LID, availability of cost data on LID projects, and references for other firms who have utilized LID in Florida project designs. Professionals from the firms were required to be experienced with LID and have used two or more LID methods in a project design within the last three years to be included in the study. Twenty-nine (29) of the interviewed firms were chosen for the final sample.

Survey on Barriers and Perceptions about LID: A survey was designed to collect data from the selected design professionals concerning issues with the use of LID. A combination of 13 multiple choice and open-ended questions were asked on the survey. The questions in the survey were developed using a combination of information found in a review of the literature and collected responses from the initial conversation with professionals (Appendix B). Demographic questions addressed which Water Management Districts (WMD) the firms submit the most environmental regulatory permits (ERPs) to. Environmental Resource Permits are the approval method of stormwater management system based on water quality and quantity aspects. Demographic questions also addressed how long the firms had been in operation and an estimated number of design projects which incorporate LID. The bulk of the survey focused on obtaining information on the barriers to adoption of LID practices (respondents were asked to select up to three primary barriers they had experienced when trying to use LID) and perceptions about relative costs of LID stormwater management practices compared to conventional practices. Responses to open-ended questions were reviewed and summarized to develop generalized categories for the professionals' opinions (Table 2-2). Some open-responses included more than one piece of information; therefore they were placed into multiple categories.

Firms who indicated using LID in <15% of project designs were deemed less experienced and those who used LID in ≥15% of project designs were experienced. A fisher's exact test was performed on the data to see if there was a statistically significant relationship between the design practitioners' experience level with LID and their perception of whether LID costs more or less than conventional methods. A λ value of 0.05 was used.

The survey was tested by a focus group of academic and practicing design professionals for content and timing. It was distributed as a link in an email directly to the professionals who agreed to participate. Up to four email reminders and two calls were made concerning the completion of the survey. Twenty-two (22) professionals completed the survey.

Cost Data Questionnaire: Associated with the online survey, a questionnaire was devised to collect cost data on projects in which both a conventional and LID design approach were completed for the same development project (Appendix C). The location, specific site conditions (major soil type and height of water table), LID tools used, and cost data were requested for each case study. The questionnaire was primarily designed based on the breakdown of results reported in the USEPA (2007) study on LID costs. We sought out total project costs and apportioned cost data on planning/permitting, site grading and preparation, stormwater infrastructure, paving/surfacing, and maintenance. We also inquired about notable economic benefits associated with the LID projects such as increased buildable space, permit breaks, grants, and incentives. The questionnaire was reviewed and edited by the same focus group as the survey and given to participants as an email attachment. The questionnaire was distributed to design professionals who indicated they had comparative cost data.

Results

Online Survey

Of the 22 professionals who completed the survey, 16 were engineers and 6 were landscape architects. Thirty-nine percent (39%) of respondents had the most experience applying for ERPs in the St. Johns WMD, 23% in the Southwest WMD, 13% in the South WMD, 16% in the Northwest WMD, and 9% in the Suwannee River WMD. Most (73%) firms had been in business for 11 or more years. Based on the estimated percent of projects designed using LID methods, 12 respondents were deemed experienced, and 10 were deemed less experienced.

The primary barrier selected by respondents was approval and permitting issues (33%). Higher costs ranked fourth (12%), close behind issues with operation and/or maintenance (14%) and client disapproval (14%) (Figure 2-1). When directly asked about overall development costs, a large portion (41%) of respondents indicated that LID costs more than conventional methods. Combining the respondents who believed LID to be less and much less expensive, 32% perceived LID as a cost-effective method of stormwater management (Figure 2-2). In the original survey, there were separate equal, and cannot answer categories; these categories were combined due the similar nature of responses in a follow-up, open-response survey question described later. The resulting combined category yielded 27% of responses and these professionals could not give a definitive answer because they believed the costs of LID were too variable (Figure 2-2).

Statistical analysis was performed on data for the respondents who gave a definitive answer whether LID costs more or less than conventional practices. A value of .07 was calculated for the Fisher's exact test. Although close, there was not a significant relationship between experience level and perceptions on the relative cost of LID compared to conventional methods. Taking this into consideration, the fact that five of the seven (71%) experienced professionals thought that LID costs less, and seven of the nine (78%) less experienced professionals thought that LID costs more, gives a glimpse that respondents experience level with LID tended to affect perception on the relative costs of LID compared to conventional methods.

After the question about overall costs of LID, the participants were given an open-response question, "Based on your answer for Q8, why is LID more or less expensive than conventional stormwater management techniques" (Appendix B). The responses to this question were reviewed and summarized to develop categories for the professionals' opinions (Table 2-1). From the responses, we believe the participants who gave definitive answers that LID costs more or less were primarily addressing actual capital costs, and were not considering hard-to-quantify issues like permitting delays. For the sub-group of participants who answered that LID costs more, they mainly thought it was the intricate and spread out nature of LID controls, requiring more time and effort that caused construction and design costs to make LID overall more expensive. Although operation and maintenance (O&M) was mentioned as a reason for why LID costs more, the engineers may not be giving proper consideration to the fact that for proper function, conventional systems require far more O&M than they often receive (Harper and Baker 2007). The respondents who answered that LID costs less, attributed it to the ability to reduce earthwork for large stormwater ponds, reduce hard infrastructure, and increase buildable space due to smaller/eliminated centralized stormwater management facilities.

Individual Case Study's Cost Data and Summary

The estimated/cited capital cost figures in Table 2-2 do not include design costs, labor costs, or non-pertinent construction costs such as mobilization, maintenance of traffic, and utility reworking. The results showed the amount of detailed comparative data was not as fully available as was first indicated from the interviews. All cost comparative data received was supplied by engineers. The five case studies collected indicated an LID design scheme to be the lowest cost option for <u>base</u> stormwater management needs (Table 2-2). Each of the projects used several different LID treatment practices (Table 2-3).

Typically for cost estimates on private projects there is a single, early estimate at the beginning of the project to get a base cost. These are fairly broad, conceptual calculations of the entire design which are used to decide whether or not to move the project forward and acquire the land. While designing municipal projects, engineers must develop more cost estimates in order to establish fees or bond amounts. Engineering firms must calculate and refine estimates throughout the stages of the design process. Late estimates are submitted over halfway through the design process and most often use historical, line-item cost data from similar projects in the area. Late cost estimates compared to early ones for the same project represent greater precision and incremental changes to site layout/design. Built projects have been designed, permitted, and construction has been completed.

Central Florida Residential Project, Lake County

- Stage of Design: early
- Type: new residential
- Size of Project: 170 acres
- Major soil type: B
- Average depth of water table on site: 3-6 feet

The conventional design utilized three centralized retention basins whereas the LID design incorporated 26 shallow storage basins. The conventional design required 750,000 cubic yards (CY) of excavation/grading and 14,000 linear feet (LF) of storm pipe, whereas the LID design only required 450,000 CYs of excavation/grading and 2,000 LF of storm piping. The LID design was estimated to save $1,000,000 (40%) in excavation costs and about $1,020,000 (92%) in stormwater piping. Additionally, the LID design maintained much of the hydrological signature and natural capital (wetlands and forested areas) of the original land plan, which provided a great deal of the necessary stormwater storage. Overall, this design was able to save approximately 51 acres of green space (includes wetlands, forested areas, and other natural space), and created a walkable community with a high level of recreational sense of place. Approximately half of the green space was effectively designed with the dual purpose of community recreation and dry retention SWM. No development units were lost or gained in the LID design.

Central Florida Corporate Center, Seminole County

- Stage of Design: early
- Type: New Commercial/Office

- Size of Project: 28 acres
- Major Soil Type: C
- Seasonal high water table on site: 2 feet

The corporate center is made up of five retail lots, 14 office lots, and one hotel. All required buffers in-between lots were used as storage and conveyance swales which eliminated the need for any on-site dry retention ponds. This increased the buildable space by approximately 10% per lot. The largest cost savings came from reduced need for excavation and grading, and the second largest savings came from a decreased need for piping and structures. The majority of dry retention areas double as parks and open space for community recreation. A vegetated pond was incorporated into the plan for attenuation flow but was designed to be very infrequently used. The increased buildable space per lot allowed for an additional one to two lots compared to the conventional design. Design plans have been approved, but construction has not begun yet.

North Central Florida, Newberry

- Stage of Design: early
- Type: mixed residential/commercial
- Size of Project: 250 acres
- Major Soil Type: A
- Average depth of water table on site: 10+ feet

This project was originally designed using conventional pipe-and-pond techniques which required 34 acres of space for retention ponds throughout the property. The pond space in the conventional design held no recreation or community value other than the control and retention of stormwater. An LID based re-engineering proposal was performed for the project design which utilized existing wetlands for digressional storage of pre-treated (through LID practices) stormwater. The major savings came from

$1,225,000 in reduced excavation/grading and $1,700,000 in reduced stormwater structures (gutters, piping, etc.). The LID design preserved 55 acres of open/green space, which included 100% of the old growth hammock (~8.67 acres) on the property. Thirty-seven of the 55 acres were effectively designed with the dual use of recreation and stormwater detention. The design allowed for a walkable community, with interconnected park spaces linked through “storm trails” (an innovative concept which combines dry detention areas, with linear pathways). No development units were lost or gained in the LID design.

Roadway Project, Bradenton

- Stage of Design: late
- Type: roadway redevelopment
- Size of Project: 1.25 miles
- Seasonal High Water Table on site: 1-2 feet

On this site the stormwater from the section of roadway currently discharges directly into nearby Whitaker Bayou with no treatment or control (a “grandfathered in” drainage system). Due to current Southwest Florida WMD stormwater rules, the roadway improvement triggered regulations which require the treatment of runoff from the site. In 2008, the redevelopment project was designed using conventional pipe-and-pond practices. Land availability space was extremely limited for this type of system and a major utility relocation (not included in the compared costs) was required for the large storm sewer necessary in this design. In 2010, an LID design was used to eliminate the need for the large retention pond and help reduce the cost by more than one million dollars. The LID design allowed for a reduction in excavation and grading costs of $72,130. Both the conventional and LID designs were 60% complete at the time of the cost estimates but the project did not make it to construction because the proposal was still deemed too costly for the city.

Florida Aquarium, Tampa

- Stage of Design: built
- Type: parking lot redevelopment
- Size of Project: 11.25 acres

This project was originally designed using conventional methods of stormwater management. The project was re-engineered utilizing LID elements as a demonstration site for the beneficial effects of sustainable design elements on stormwater runoff quantity and quality. The money saved from reduced curbing and piping was used for re-invested for landscaping in the bioswales and rain gardens, and the addition of pervious concrete. For base stormwater management needs the LID option allowed a 19% reduction from the conventional design's budget. The addition of natural system improvement such as enhanced landscaping, low volume irrigation, and shoreline improvements to Ybor Channel added $275,000 to the base LID stormwater management cost. Adding pervious pavement to the parking areas cost an additional $268,000 to the base LID costs. With enhancements the LID option cost about 11% more than the conventional design. The additional expenses over the initial budget were funded by grants from United States Environmental Protection Agency, Florida Department of Environmental Protection, and Southwest WMD. The site has been a model example of the benefits of alternative stormwater methodologies because it allowed for a unique experimental opportunity which compared pollutant loads associated with LID (porous paving with a swale) practices to conventional (asphalt paving with no swale) practices. When sampling was performed post-construction the

LID design saw a 42% load reduction in total Nitrogen, a 3% reduction in total Phosphorus and a 91% reduction in suspended solids compared to the conventional design (Rushton 2001, USEPA 2000).

Discussion

Design practitioners indicated that project approvals/permitting was the largest barrier impeding the use of LID in Florida and higher LID costs was a secondary concern. This finding was similar to a recent survey of practitioners concerning LID adoption in Florida (Kipp et al. 2011). In this study, researchers surveyed and collected comments from a large sample Florida developers, design professionals, and government officials who attended training programs concerning LID practices. They found that insufficient and/or unclear LID design and approval criteria was ranked as the overall most critical challenge to using LID and economic and cost factors regarding LID was ranked third. Approval through regulatory agencies is crucial as any delays in the design or permit process equates to risk and cost for developers and greatly discourages up-front consideration and implementation of LID (Ryan 2006). To design and present a LID stormwater treatment plan is very costly and if there is a perception that it would not be permitted, the LID project would likely never be considered within the design firm. These findings combined make a clear argument that the removal of regulatory barriers must be the center focus in order to encourage LID.

Florida’s diverse geological and hydrological conditions combined with the presence of five semi-independent water management districts, all having their own permitting requirements, seems to be a recipe for disaster in attempting to smooth out regulatory issues on stormwater management (Merriam 2011). Instead, we believe this presents an opportunity to encourage LID adoption. The regional nature of the five

WMDs enhances specialized knowledge of the physical conditions and the most pertinent water quality issues within their specific district (Cammie Dewey, personal communication, May 29, 2012). In order to reduce risk and confusion for developers, the WMDs regulations concerning LID should focus on design standards for specific tools prime for the regional conditions of the state and for the water quality goals of the area. In the sand-dominated soils of the state, mostly the south coast, panhandle, and some central areas, intercept tools such as permeable surfaces or swales could be focused on because the soils will be able to percolate large quantities of water quickly. Research on low-intensity grassed swales in southwest Florida has shown that compared to a conventional style curb-and-gutter system, end of the pipe loads were 93% lower in total Nitrogen, 82% lower in total Phosphorous, and 95% lower in total suspended solids (Willis et al. 2012). Inland areas, such as central Florida around Lake Okeechobee, heavily organic soils provide high storage capacity and nutrient removal capabilities that are ideal for bioretention and other storage tools. In areas where the soils are too sandy and water may percolate too fast, or there is insufficient space above the water table for proper treatment, non-structural practices such as low-impact landscaping or above ground storage such as cisterns could be the focus.

When asked to compare LID versus convention stormwater management designs, a large portion (41%) of the professionals indicated that they believed LID to be more expensive than conventional methods. This group tended to be those that have limited practice in designing and implementing LID projects. The 27% that thought LID cost less or much less, these respondents tended to be the ones with more experience in using LID. We believe that given a more robust sample, statistical analysis would help to support this finding. Therefore, it is our suggestion that design/development firms who are concerned or uncertain about LID costs, and want to use these practices, should highly consider investing time and resources into gaining specialized knowledge and experience to fully understand the possible capital cost savings available. The respondents who were in the variable category (27%) thought that LID costs were mostly dependent on permitting process unknowns, location/site conditions, and LID tools considered in the design. This is not surprising, as from the early discussions with respondents and a review of the literature indicated that LID costs are often dependent on site specific characteristics (Sample et al. 2003).

The multitude of products and design strategies associated with LID allow for cost-effective alternatives to be developed during the design process. Typically earthwork is the biggest expense on a land development project and the quantities are reevaluated throughout the design to manage the overall cost. Savings associated with LID are usually the result of reduced centralized stormwater infrastructure which allows for less earthwork (excavation and grading), less clearing and grubbing, and less hard piping/conveyance structures (Kloss and Calarusee 2006, USEPA 2007). In order to realize these savings, individual LID practices must be viewed as part of the overall stormwater system. For example, permeable surfaces usually cost $2-8 more than conventional surfacing per square foot. But when combined with good underlying soils (>0.5 in/hr. infiltration capacity) or aggregate storage space, and given proper credits, they can decrease stormwater conveyance and retention costs by as much as 30% (LIDC 2002, Clark and Acomb 2008). Overall, permeable paver stormwater management system costs approximately $4.50-10 per sq ft. whereas conventional concrete systems cost $9.50-11.50 per sq ft. (to manage the same quantity of water) (CRI 2005). The Florida Aquarium case study is an excellent example of how pervious surfaces add costs to the project when they are viewed simply as an alternate surfacing option and not incorporated into the stormwater storage needs. Additionally, in Florida, high water tables sometimes force expansive, shallow, dry retention areas to be incorporated into the site design that have little functional value. Pervious surfacing stormwater management systems can be incorporated into parking lots to help allow expansive, shallow storage into a functional space. Another popular LID tool used in the case studies was bioretention areas, which have estimated costs of $3-15 per square foot (USEPA 2000). Bioretention areas are often combined with swale conveyance which ranges from $5 (good soil) to $18 (poor soil) per linear foot. It is well documented that swale conveyance is two to three times less costly than hard piping/structural conveyance which costs $24-50 per running foot (USEPA 2000, CWP 1998). When comparing the LID options of a structural pervious paving system to a swale-conveyance/bioretention system it can be seen how the costs are comparable and site-conditions will truly dictate which LID schemes are most functional and cost-effective.

A review of the collected case studies offers some reference for local site conditions, which may make it easy to reduce manufactured or centralized retention pond space therefore reducing costs. Development sites with natural storage (wetlands, low-land areas) capabilities, such as the Central Florida Residential and North Central Florida projects present an opportunity for large excavation cost savings when used for storage at the end of a LID treatment train. In these situations, the wetlands offer an area to store water that has already been treated by other LID practices such as swales and bioretention areas. Excavation costs range from $6-20 per cubic yard to dig large retention ponds and these foregone costs helped keep capital costs down. In the Central Florida Commercial case study, swales designed with the multiple purposes of infiltration, retention and conveyance allowed for the elimination of all on-site dry retention ponds. This smart use of required buffer areas not only saved a great deal in excavation costs and piping costs, but it also increased the buildable space enough to gain an additional lot or two.

The collected economic data from projects in our study presented ways to look at the cost-effectiveness of using LID in retrofit or redevelopment projects. Nationally, many water rich states like Florida have dense, urban areas with old roadways and parking lots, from which stormwater runoff is discharged directly into receiving waterways. The Bradenton Roadway case study is a example of how redevelopment projects, of aging infrastructure, will often trigger regulations requiring the control and treatment of runoff due to updated stormwater rules. In ultra-urban environments like the Bradenton Roadway, there is little or no space for the addition of centralized storage ponds or the input requires large utility reworking (Tim Foushee, personal communication, January 3, 2012). The Bradenton Roadway project incorporated decentralized, LID tools into medians and underneath the bike lane to eliminate the need for pond space and was found to be the low-cost estimate.

There is no denying that changing development rules and procedures to accept innovative practices is a lengthy process which takes a numerous resources and much collaboration (Gordon 2011). Some regulations have been altered to allow LID practices and economic benefits were realized (CWP 1998, Kloss and Calarusee 2006, MMSD

2010). In the long run LID could be incentivized and incorporated into future development plans for controlling our biggest stormwater issues. Nationally, zero effect drainage discharge ordinances and stormwater tax credits have been incorporated and proposed to increase the voluntary usage of LID practices (Romero and Hostetler 2007). These incentives often detail specific LID practices which will be granted acceptance in the cities/municipalities which helps clarify the process. This being said, they have had little effect to date because of lack of familiarity with LID on the part of practitioners and that simply allowing LID to be permitted may not be enough of an incentive for the practice to spread.

A point repeated in the literature is that most development companies and municipalities which have realized cost savings from using green infrastructure practices did so to achieve an environmental goal or because of an environmental ethos, not because of an initial cost analysis (Civic Federation 2007, Macmullen and Reich 2007). A similar sentiment was gathered from the early interviews and survey questions/responses from our research. When the sample was asked about their reasons for using/considering LID, water quality protection, reduced runoff volume, and their firm's environmental/sustainability ethics were the three primary ones (Appendix B, Q7). Combining this with our findings that more experienced firms tended to think that LID costs less, shows that firms must take a comprehensive approach to using LID to realize its full benefits. Also, because of its on-site management focus, LID could be a cost-effective method which assists in achieving state and federal regulations, such as the proposed statewide Stormwater Rule and numerous Total Maximum Daily Load (TMDL) designations (Merriam 2011). Municipalities which have undertaken a forward thinking approach to using LID and related green infrastructure have often seen better environmental results, but also ancillary savings due to suspension/exemption from TMDL litigation requirements or foregone environmental restoration costs (Perry 2012).

Given the findings of this research, Florida policy makers and stormwater regulators need to focus attention and funds on researching and promoting the most applicable LID tools for the regional conditions of the state. A smoother and more clearly defined permitting process associated with using LID tools will help attenuate concerns about delays and project approvals and increase up-front consideration for LID. Although this will not completely dismiss perceptions of higher costs, it will help clarify the true capital costs associated with the alternative approach to stormwater management. Our research indicates that LID has the opportunity to reduce capital costs for the private development industry. Combined with research showing the ability of LID to control stormwater pollution issues prevalent in the state, better than conventional practices, makes an argument to begin incorporating and transitioning towards decentralized, green infrastructure approaches (Harper and Baker 2007, Hood et al. 2007, Prince George's County 2000, Rushton 2001, Willis et al. 2012). This being said, our water resources in the state of Florida are arguably the most important in an economic sense due to their draw for tourism and recreation, ability to supply drinking water to a large population, and support of many livelihoods. There must be greater attention focused on a multi-faceted approach to land development that not only considers economic profits, but also stewardship and protection of our waters. LID is a method of managing and treating stormwater which provides an answer to these goals better than our current ways.

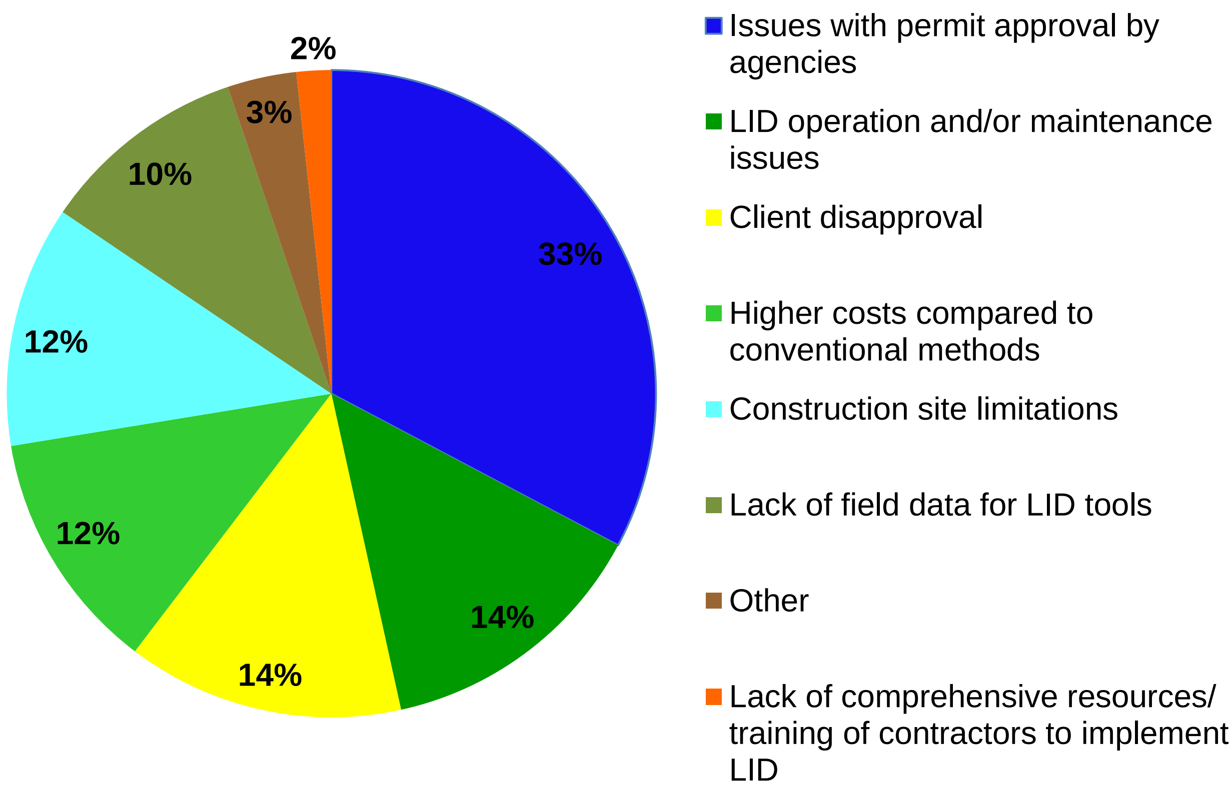

Figure 2-1. Percent of total responses from design professionals concerning perceptions on the primary barriers to using low impact development in Florida. (n=22)

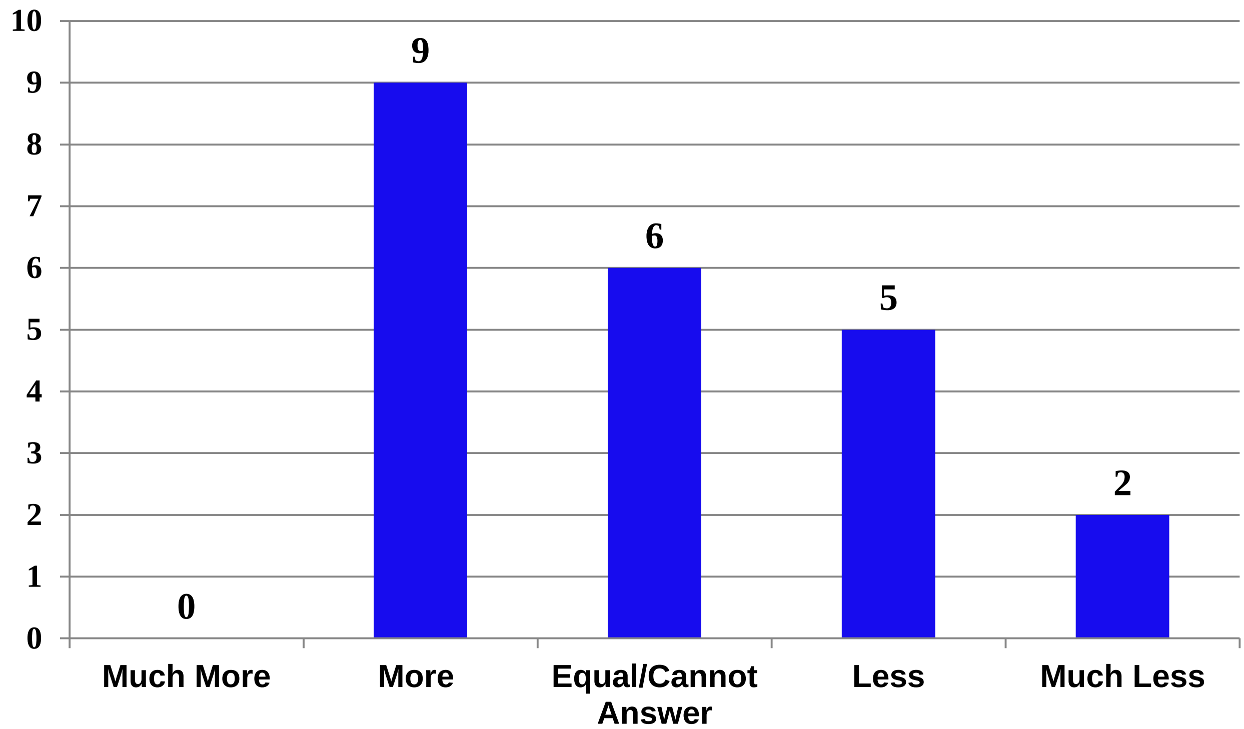

Figure 2-2. Surveyed design professional's opinion on relative cost of low impact development compared to conventional stormwater management in Florida projects. (n=22)

Table 2-1. Surveyed Florida design professional’s summarized/categorized responses on why low impact development costs more, less, or is variable compared to conventional stormwater management.

Response Categories	% of Total Responses in each Category
Much More (n=0)	
No responses	-
More (n=9)	
Construction costs	37.50%
Design costs	31.25%
Maintenance costs	18.75%
Loss of development density	12.50%
Equal/Could Not Determine (Variable) (n=6)	
Dependent on the specification/location of development project	21.43%
Dependent on regulation/permitting process unknowns	21.43%
Dependent on LID tools used/considered	21.43%
Information costs	14.29%
Dependent on degree of up front planning for LID implementation	7.14%
Dependent on underlying land value	7.14%
Dependent on client's willingness to consider/accept the tradeoffs in project design	7.14%
Less (n=5)	
Construction Costs	57.14%
Increased buildable space due to decreased SWMF	28.57%
Lack of understanding by practitioners	14.29%
Much Less (n=2)	
Construction Costs	40.00%
Increased buildable space due to decreased SWMF	40.00%
Increased market value	20.00%

Table 2-2. Summary of total cost savings associated with a low impact development approach compared to a conventional approach for five Florida case studies.

Project	Total LID cost savings
Central Florida Residential[a]	$2,020,000
Central Florida Corporate Center[b]	$1,200,000
North Central Florida[c]	$2,925,000
Bradenton Road Project (2010)[d]	$1,051,264
Florida Aquarium Base SWM[e]	$249,000
Florida Aquarium Base SWM + Enhancements	-$294,000[f]

[a,b,c] General project names at request of engineer
[d] Adjusted back to 2008 dollars for the comparison
[e] Compared to the original budget for the conventional design
[f] Negative number indicates a higher cost for the LID scheme

Table 2-3. A summary of low impact development practices employed in the 5 Florida case studies.

LID Tools Used in the Design	Central FL Res.	Central FL Corp.	North Central FL	Bradenton Road Project	Florida Aquarium
Permeable Surfaces	x	x	x	x	x
Vegetated Swales	x	x	x	x	x
Bioretention Areas	x	x	x	x	x
Minimized Grading and Filling	x	x	x		
Cluster Building	x				
Green Roofs		x			
Stem Walls	x		x		
Narrow Road Design	x	x	x		
Minimized Soil Compaction and/or Topsoil Stripping	x	x	x		
Soil Amendments		x			
Low-impact landscaping water/fertilizer/energy	x	x	x		x
Stormwater Wetlands	x		x		
Rain Barrels/Cisterns			x		
Underdrains	x				
Clarification Pond					x

APPENDIX A
CALL SCRIPT

Good (Morning) Afternoon Mr/Mrs. (Name)

My name is Daniel C. Penniman and I am a Masters student at the University of Florida. I am conducting thesis research on costs of low impact development (LID). Do you have about 5 minutes or should I call back at a different time? Through a snowball survey I was referred to your firm and specifically you by (refers name).

Particularly, I am collecting data to develop a Florida-specific cost comparison between LID and conventional means of stormwater treatment.

Are you familiar with LID?

I will give you a short description of LID and a list of tools so we can be on the "same page"

Low Impact Development (or LID) is a fairly new design technique which strives to replicate the pre-development hydrologic scheme of a development site. The focus of LID is to use a variety of tools to help better control flood events and remove impurities picked-up by stormwater in a more natural manner than conventional pipe-and-pond management. For my research, a project (new or retrofit) which uses any **two or more** of the following tools will be considered an LID project.

- Permeable Surfaces
- Bioswales (Vegetated Swales)
- Bioretention Areas (Rain Gardens)
- Subsurface Retention Facilities
- Decreased Grading or Filling
- Cluster Building
- Green Roofs
- Stem Walls
- Disconnected Downspouts
- Decreased Soil Compaction and Minimal Stripping of Topsoil
- Tree Box Filters
- Narrow Road Design
- Soil Amendments and/or Aeration
- Low-impact landscaping (e.g., plants that require less water)
- Rain Barrels/Cisterns or other storage practices

A. I am calling to inquire about:

1. Has your firm considered utilizing **two or more** LID tools within any of your projects in the last 3 years?

2. If you have, was a cost comparison between conventional and LID stormwater techniques performed for any of the projects (*this analysis can include any of the development phases*)?

3. Are the results from that analysis available for any projects (*even if the project was not built at all or with the use of LID*)?

If you were able to answer yes to one or more of these questions it would be a great benefit to my research if you or another professional from your firm, informed on these LID projects, could complete a specialized survey and questionnaire (if applicable) at a later time…

(possible responses)

- ***I do not know anything about LID/ Have never considered LID in a project design*** *– ask for contact information of another professional from their firm who may be able to help with this*
- ***Our firm considered LID in a design*** *–*
    - *Ask if LID cost evaluation is available.*
      If yes - confirm that this information is important for you
      If no – thank the person for their time, and the call
- ***Yes, our firm has considered LID and conducted cost analysis*** *– keep going*

I will quickly explain the makeup of the questionnaire…

1. The questionnaire is in electronic format (but we can send you a hard copy if you prefer)
2. The first part (a survey) includes a few questions about your firm's general experience and perceptions anbout LID, and it should take about 5 - 10 minutes.
3. The second portion of the questionnaire is designed to get some hard cost data on projects where a cost comparison between LID and conventional stormwater management was performed. I am asking for data on **up to 4** projects.

I understand that as a professional your time is extremely precious and limited. This data is fully intended to better inform the Florida design/construction community on LID costs and could be beneficial to progressive firms like your own.

As a disclaimer, I would like to assure you that I will make the draft and final results available for your review. I will also maintain confidentiality if you do not wish the names, locations, or other information to be disclosed in my *study (There will be a place on the questionnaire where you can choose to keep each projects specifics confidential).*

Would you be willing to participate in my research?

- If **YES** – within the next couple weeks, I will send the data collection tools in an email, there will be a link to the survey, and an excel document attached to fill in cost data… (Confirm email, or ask what email is)

- If NO – ask if another person in their firm would be able to help. If yes – record the name and phone number.

Do you have any questions for me?

APPENDIX B
SURVEY

Dear Survey Participant,

Thank you for taking part in this important study about low impact development (LID).

This survey is designed to get a better understanding of the opinions and experiences that Florida design, engineering, and development firms have had with LID use. The study is intended to better inform the Florida design/construction community.

The survey includes (13) questions about your firm's past experience with, and opinions on various aspects of LID stormwater management. **For my research, if 2 or more of the tools in the list below were included in the project analysis, it is considered an "LID" project.**

If you are interested, the draft and final study results will be shared with you for review. I will also maintain confidentiality of your responses.

As a professional, I understand your time is extremely precious so I extend the greatest amount of gratification to you for helping me make my research the best it can be in generating important information for the Florida design/construction community and development regulatory agencies. Your participation in this survey is completely voluntary and you do not have to answer any questions you do not feel comfortable with.

List of LID tools considered in the study:

- Permeable Surfaces
- Bioswales (Vegetated Swales)
- Bioretention Areas (Rain Gardens)
- Subsurface Retention Facilities
- Minimized Grading or Filling
- Cluster Building
- Green Roofs
- Stem Walls
- Tree Box Filters
- Narrow Road Design
- Minimized Soil Compaction and Topsoil Stripping
- Soil Amendments and/or Aeration
- Low-impact landscaping (e.g., plants that require less water)
- Rain Barrels/Cisterns or Other Storage Practices

Q1. What is the name of your firm?

Q2. How many years has your firm been in operation?

- Opened this year
- 1-5 years
- 6-10 years

11+ years

Q3. To which Water Management District (WMD) does your firm (or office) submit the majority of stormwater permit applications for Florida projects?

- Northwest
- Suwannee
- St. Johns
- Southwest
- South
- Not possible to answer (Please explain why)

Q4. For the past 5 years, please estimate the percentage of your firm's total design projects which have included LID tools (at any stage from planning to construction).

- < 1%
- 1-5%
- 6-10%
- > 10% (please estimate % in the space below)
- Not possible to answer (Please explain why)

Q5. Select the 5 LID tools most frequently used by your firm in Florida projects.

- Permeable Surfaces
- Bioswales (Vegetated Swales)
- Bioretention Areas (Rain Gardens)
- Subsurface Retention Facilities
- Minimized Grading and Filling
- Cluster Building
- Green Roofs
- Stem Walls
- Tree Box Filters
- Narrow Road Design
- Minimized Soil Compaction and/or Topsoil Stripping
- Soil Amendments and/or Aeration
- Low-impact landscaping (e.g., plants that require less water)
- Rain Barrels/Cisterns or Other Storage Practices

- [ ] Others (Please Specify): ____

Q6. For your firm, what have been the primary barriers to utilizing LID in projects? Please select up to 3 choices below.

- [ ] Approval issues (calculation of water quality/reduction credits, slowed permitting process, etc.)
- [ ] Flood control performance issues/uncertainties
- [ ] Higher costs compared to conventional methods
- [ ] Lack of comprehensive resources/ training of contractors to implement LID
- [ ] LID operation and/or maintenance issues
- [ ] Construction site limitations
- [ ] Lack of field data for LID tools (nutrient removal efficiency, flood control, etc)
- [ ] Client disapproval
- [ ] Other (please specify): ____

Q7. For the projects in which your firm incorporated LID tools (at least into the design phase), what were the primary reasons to use LID? Please select up to 3 choices below.

- [ ] Reduce runoff volume or flooding
- [ ] Local or downstream water quality protection
- [ ] Lower costs compared to conventional methods
- [ ] My firm's environmental or sustainability ethics
- [ ] LEED certification credits
- [ ] Increased lot/functional space yield
- [ ] Expedited project approvals
- [ ] Increased property value due to improved aesthetics/amenities
- [ ] Client request
- [ ] Current/possible requirements for TMDL designations or other environmental regulations
- [ ] Other (please specify): ____

Q8. In your professional opinion, for the overall development process, using LID for stormwater management in Florida is ___________________ expensive compared to conventional stormwater management techniques.

Much More	More	Equally	Less	Much Less	Cannot Answer (please explain) ____

Q9. Based on your answer for Q8, why is LID more or less expensive than conventional stormwater management techniques (Ex. construction costs, reduced stormwater infrastructure, etc)? Please give explanation.

Q10. What type regulatory or incentive policy can increase the rate of LID implementation the most?

Q11. Please estimate the # of employees in your firm/company (all offices).

Q12. Is there specific information that you/your firm would like to learn about in order to be more effective at implementing LID?

Q13. Please include the names of any other Florida design firms or professionals, that you know have incorporated LID tools in a project design. This information will be used to make the study more comprehensive.

APPENDIX C
COST QUESTIONNAIRE

This questionnaire focuses on individual projects for which your firm calculated a documented LID (vs conventional) cost comparison. There are multiple tabs of formatted worksheets at the bottom, please provide data on up to 4 different projects. Please include available cost data for projects of any following designation. 1.) built/being built using LID tools and a cost comparison was developed; 2.) built/being built not using LID tools but LID was considered in planning and a cost comparison was developed; 3.) still in planning but LID is being considered and a cost comparison has been developed; 4.) not built at all but LID was considered and a cost comparison was developed; ***Notes:*** ***-If it is more convenient or saves time to return cost data in a different/raw format through mail/email that is encouraged. My mailing information is included in the sent email.*** ***-For my research, a project which uses 2 or more LID tools is an "LID Project."*** ***-If any data is not available, leave cell blank*** ***-I will follow-up to your response with a very short call to clarify any data and/or to answer any follow-up questions*** ***-There are comment areas in all of the sections in-case any data needs to be clarified*** I understand that finding the data may take some time but the comprehensive results will be powerful in helping understand the barriers to, and provide additional knowledge for LID usage in the state of Florida. Your response is critical to my research due to the relatively small sample size available for this study. Please note any information which needs to remain confidential in comments. I hope the product will be useful to progressive firms such as yours. Thank You!		
1. Project Specifications	**Answer in this column**	**Comments:**
Project designation (1/2/3/4, see introduction above)		
Name of project		
Location of project (county, city)		
Does the name and location of this project need to remain confidential? (yes or no: please specify in comments any other data that needs to be kept confidential)		

Type of project (Residential/Commercial/Office/Industrial)		
Size of project (in acres or square feet)		
Major soil-type(s) of project (A/B/C/D)		
Average depth of water table in developable areas of site		
<u>3. LID Tools Incorporated Into the Project Design</u>	**Place an X in this column if used in Design**	**Comments:**
Permeable Surfaces		
Bioswales (Vegetated Swales)		
Bioretention Areas (Rain Gardens)		
Subsurface Retention Facilities		
Minimized Grading and Filling		
Cluster Building		
Green Roofs		
Stem Walls		
Tree Box Filters		
Narrow Road Design		
Minimized Soil Compaction and/or Topsoil Stripping		
Soil Amendments and/or Aeration		
Low-impact landscaping (e.g., plants that require less water)		
Rain Barrels/Cisterns or Other Storage Practices		
Others (Please Specify):		

<u>4. Conventional vs. LID Cost Comparison</u> *Please Note:* *-There is a space for comments in case any data figures need to explained or clarified.* *-See bottom section for areas to enter data for unique economic benefits of LID not comparable to conventional management.*	**Conventional Development Cost**	**LID Cost**	**Comments:** Please briefly explain how you calculated these numbers. Include descriptions like: *Just materials, materials+construction, just construction, etc.*
Lot/Building size yield (This will not be a cost figure, please include # of units, sq. ft., etc)			
Planning and Permitting			
Site grading and preparation			
Stormwater infrastructure (pipes, ponds, curbs, versus swales and bioretention, etc.)			
Paving/surfacing (roadways, driveways, and sidewalks. Please include type of surfacing for LID in comments)			
Landscaping			
Stormwater fees for municiple stormwater control			
Maintenance (Please specify for what period of time ex. $/month, or $/year)			
Other (please specify):			
Total Project Costs			

<u>5. Notable Economic Benefits of LID</u> *Note: LID may have some additional benefits that are not comparable to conventional. If possible, please give an estimated dollar amount*	**Dollar Amount**	**Comments:** Please give a brief description and/or any information you feel is important. If there is not an associated dollar amount please try to qualify.
Permit breaks		
Grants		
Incentives (tax break, expedited approval, etc.)		

Other (Please Specify)		
Total		
END (move to next tab for additional projects)		

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BIOGRAPHICAL SKETCH

Daniel Penniman earned his undergraduate degree from the University of Florida in international food and resource economics. While attending UF in undergrad from 2004-2008, he was a member of the varsity swimming and diving team earning 14 all-American and 14 all-SEC titles. Some of his future research interests include optimization and promotion of decentralized stormwater management and re-use practices in highly urbanized and developing coastal areas.