CITY OF AUBURN
Low Impact Development Cost Analysis

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LOW IMPACT DEVELOPMENT MAINTENANCE COST ANALYSIS

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ABOUT THE CITY OF AUBURN

The City of Auburn is well-positioned to take advantage of many of the opportunities in the Puget Sound region. Centrally located between Seattle and Tacoma, Auburn is home to more than 77,000 residents. It is the land of two rivers (White & Green), home to two nations (Muckleshoot Indian Tribe & City of Auburn) and spread across two counties (King & Pierce).

Auburn was founded in 1891 and has retained an historic downtown while also welcoming new, modern development. Known for its family-friendly, small-town feel, Auburn was initially an agricultural community, the city saw growth due to its location on railroad lines and, more recently, became a manufacturing and distribution center. Auburn is situated near the major north-south and east-west regional transportation routes, with two railroads and close proximity to the Ports of Seattle and Tacoma.

Auburn has more than two dozen elementary, middle and high schools, and is also home to Green River College, which is known for its strong international education programs. The city is one hour away from Mt. Rainier, and has many outdoor recreational opportunities.

The mission of the City of Auburn is to preserve and enhance the quality of life for all citizens of Auburn, providing public safety, human services, infrastructure, recreation and cultural services, public information services, planning, and economic development.

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01 EXECUTIVE SUMMARY

In January 2017, the City of Auburn was issued a declaration of covenant for the maintenance and operation of Low Impact Development (LID) facilities, as part of the Western Washington Phase II Municipal Stormwater permit provided by the Washington State Department of Ecology. This permit required Auburn to begin maintenance best management practices of the existing 22 facilities within city limits and to develop new budgetary allocations for these facilities to fulfill permit requirements. Maintenance and Operation (M&O) costs are new to Phase I and Phase II permittees. Data from other areas remains limited, which challenges cost forecasting accuracy.

WE SPECIFICALLY FOCUS ON EXPLORING TWO MAIN TYPES OF LID FACILITIES FOUND IN THE CITY OF AUBURN: BIORETENTION AND PERMEABLE PAVEMENTS TO EVALUATE MAINTENANCE AND OPERATION COSTS

This report offers an analysis of costs derived from a literature review and Phase I permittee respondents' data from western Washington to evaluate anticipated costs and help streamline investments in LID. We specifically focus on exploring two main types of LID facilities found in the City of Auburn: bioretention and permeable pavements to evaluate M&O costs. We then offer suggestions for moving forward, and a detailed outline for further research.

Cost analysis for bioretention facilities (pages 19-20), permeable pavement units (page 20), and general materials and equipment (pages 23 - 24) provide information for cost forecasting. M&O practices are contingent on the integrity of LID facilities and weather; consequently, definitive cost predictions are not possible. This report therefore offers a method to calculate cost ranges based on best available information; these calculations can be refined as data collection continues and definitive LID facilities' sizes are collected.

02 INTRODUCTION

Conventional stormwater management seeks to control the flow of water throughout densely populated areas to combat the accelerated movement and increased volume of contaminated runoff resulting from impervious surfaces. Numerous efforts have sought to educate and inform the public of these risks. Efforts to mitigate pollutants and contaminants entering public waterways and infrastructure carried by stormwater runoff have also been undertaken. However, these efforts have not been able to effectively mitigate the consequences of increased stormwater runoff as associated cleanup costs often exceed available resources. Studies on costs associated with public health repercussions and biophysical remediation of stormwater runoff estimate approximately $1 billion to compensate for the effects of polluted runoff into the Puget Sound over the next decade (Booth et al. 2006). The United States' Environmental Protection Agency (EPA) estimates controlling Combined Sewer Overflows (CSO) to cost $56 billion with an additional $11-22 billion investment in stormwater management plans and urban runoff controls using conventional stormwater management techniques (Kloss and Calarusse 2006).

CONTROLLING COMBINED SEWER OVERFLOWS (CSO) IS ESTIMATED TO COST $56 BILLION WITH AN ADDITIONAL $11-22 BILLION INVESTMENT IN STORMWATER MANAGEMENT PLANS AND URBAN RUNOFF CONTROLS

Credit: Robert Lawton, Wikimedia Commons

STORMWATER DRAIN DURING RAIN EVENT

Environmental degradation and high costs associated with environmental remediation caused by polluted stormwater runoff has propelled increased use of LID facilities to better manage water flow through cities and offer cleaner infiltration and on-site management of stormwater. As LID facilities have become more commonplace, research has sought to examine comparative costs associated with construction as well as the effectiveness, availability, and reliability of various forms of LID stormwater management practices as an alternative to conventional practices (ECONorthwest 2007). While costs and impact assessments are slowly emerging, most are centered on construction and the early stages of LID facilities' development and do not delve into projected costs associated with maintenance and operation (M&O). The goal of this report is to assess routine and non-routine M&O practices required to maintain LID facilities, discuss elements that contribute to cost, and address variables that will affect M&O cost evaluations; these findings should influence further research into bioretention and permeable pavement facilities' maintenance costs within the City of Auburn.

Credit: Shannon Howard

BIORETENTION DRAIN BEFORE MAINTENANCE (above)

CLEAN BIORETENTION DRAIN (left)

Credit: US Air Force by Kimberley Powell

03 METHODS

Who we contacted

Our cost evaluation research began with identifying several Phase I permittees within western Washington. These permittees began maintaining existing LID facilities within their jurisdictions one year prior to the City of Auburn's covenant as a Phase II permittee. Seven Phase I permittees were contacted to gather information over the course of last year's pilot phase of recorded maintenance. The contacted permittees included the following:

- Port of Seattle
- City of Seattle
- Snohomish County
- Pierce County
- King County
- University of Washington Sustainability
- Clark County

Phase I and II permittees may be found on the Washington State Department of Ecology's (WSDOE) list of municipal stormwater permits. The largest difference between Phase I and II permittees is that Phase I permittees are jurisdictions serving 100,000 people or more. Municipal permittees were drawn from WSDOE and contact phone numbers were found via phone directories. In some cases, direct phone numbers could not be found for stormwater management help lines; in others, more time was required to identify pertinent points of contact. Referrals to other names and numbers within that specific contact's county were often exchanged prior to distributing the survey to ensure answers were ascertained from the stormwater management expert within each unit of LID facility management.

Procedures for data collection

A list of 16 questions was devised and a questionnaire was sent to each Phase I permittee. Initial contact with each permittee was made by phone; however, out of respect for the contact's time, surveys were also emailed to allow them to fill out the questionnaire during available hours rather than immediately over the phone. The questionnaire sought information regarding frequency and costs of maintenance. With more time, it would have been preferred to also ask for size and specifications of the respondents' facilities designs. As surveys were returned, answers were processed for information aiding the determination of direct costs, trends, and derivatives of costs for this analysis. All returned surveys were partially filled out, but offered a starting point to begin synthesizing results. A literature review and local price rates for materials and equipment rental fees were identified to reflect pricing for King and Pierce counties as accurately as possible. The survey consisted of the following questions:

1. How many people does it take to maintain a single bioretention facility? What is the frequency of required maintenance?

2. How many people does it take to maintain a street paved with porous asphalt? What is the frequency of required maintenance?

3. How many people does it take to maintain a block of sidewalk paved with permeable concrete? What is the frequency of required maintenance?

4. Is the current schedule of maintenance too much or too little for these facilities, if so what recommendations can be made to address this?

5. What is the average annual cost of equipment used in maintaining permeable pavements? Bioretention?

6. What kind of equipment is needed to maintain a bioretention facility? A permeable pavement facility?

7. If some equipment is used irregularly, what is this equipment and how often is this required (i.e. specialty equipment required for repairs or possible deep cleanings)?

8. What materials are used for maintaining a bioretention facility? A permeable pavement facility?

9. How often are these materials required?

10. What other costs do you anticipate and budget for when considering LID facilities like bioretention facilities and permeable pavement?

11. About how much is the average labor cost annually for maintenance per worker per hour?

12. How many laborers are on a typical crew that maintains bioretention facilities? Permeable pavement facilities?

13. How long does it take the crew to perform scheduled maintenance to a bioretention facility, on average? A permeable pavement facility?

14. On what basis is scheduled maintenance performed (weekly, bi-weekly, monthly) to a bioretention facility? Permeable pavement?

15. What are the unforeseen challenges with the maintenance and management of LID facilities you have, specifically permeable pavement or bioretention facilities?

16. Finally, is there anything you would like to comment on that we may have missed that might aid in more accurately estimating maintenance costs of LID systems?

Limitations

Research was inhibited by the number of total respondents as not all questionnaires were returned and those that were contained incomplete information. Initiating and maintaining contact with respondents was also a challenge during the fact-finding stage as the survey required time from already busy respondents. Given that LID facilities are still a relatively new element of urban infrastructure systems, there are very few supporting research data points specifically related to M&O practices. Further research should provide more accurate figures of expenses and identify common trends of experiences in cities responsible for M&O on LID facilities.

04 PRECURSORS TO ANALYSIS

Size of the facility

Facility size can have a significant effect on associated M&O costs. For the purpose of this report, when a single facility is referenced the size of that facility is defined in the following terms:

> Facilities' physical size tends to range from 0.1 – 2.5 acres. Design elements such as slope, vegetation, filter media depth, and maximum pooling depth are often categorized into Level 1 and Level 2 designs, where Level 1 designs are much less intensive than Level 2; these differences can impact both frequency and amount of maintenance or material required to follow best management practices (BMPs) and are often associated with the size of the facility (Virginia DEQ 2011).

Permeable pavement units are defined as one side of a street block; the average length of street blocks in the City of Auburn is 650 feet per survey results.

Cost calculators

Cost calculators of LID facilities can offer guidance when estimating cumulative costs. The guides for bioretention facilities can account for high, medium, and low levels of maintenance and capital cost volume. Permeable pavement calculators offer those options in combination with different selections of pavements to yield results which follow BMPs (EPA 2009). Cost calculators rely on initial construction costs to account for the size of each facility. Calculators can only offer estimates if this information is available for each individual facility, which sometimes makes them inaccurate in cases where complete information is not available. They also do not factor in key design elements chosen during construction that may have a drastic impact on expected M&O costs such as slope or public valuation of a facility's aesthetic appeal.

Expectations of jurisdictions to maintain LID facilities

Jurisdictions are required to uphold four core requirements:

1. Maintain public LID facilities
2. Handle all routine and non-routine maintenance of those facilities per BMPs
3. Schedule regular inspections at seasonally timed intervals to inhibit deterioration of the facility and promote early detection of problems
4. Assist private landowners in hiring private parties to aid corrective maintenance of facilities at landowner's expense

Note, the expectations of LID facilities for jurisdictions are different than that for private parties and property owners. While cost calculations often only include the items for which jurisdictions are solely responsible, jurisdictions also, when requested, are required to aid private parties and property owners. However, this usually involves education or basic training related to system functions regarding LID facilities.

Climate and topography considerations

Because LID stormwater facilities are a relatively new tool, there is not abundant data on the relevant effects of topography, climate, and weather patterns similar to western Washington. It is important to note that areas that have had more

extensive experience with these facilities are located in a variety of different regions; therefore, cost projections associated with monetary values may be dissimilar to actual costs due to levels of rainfall, existing vegetation, land availability, and soil conditions. These factors may be valuable additions to future surveys to further develop data collection of LID facilities.

05 QUESTIONNAIRE RESULTS
Costs of LID Maintenance

Questionnaire responses yielded interesting information regarding cost expectations and how to define spending in these facilities. The survey garnered a low response rate overall, and many of the contacts expressed concerns of having adequate expertise in the field or hesitation to provide concrete data points in addition to subjective information on both permeable pavements and bioretention facilities. Permeable pavements resulted in even sparser answers as most contacts had fewer permeable pavement facilities than bioretention facilities. Based on the responses collected, a more standardized form of data collection could be useful in making the information on M&O practices more accessible. Also, more time could be leveraged to gather more information on expected M&O costs for LID facilities.

M&O lifetime assessments and cost analysis surveys have yet to be detailed in full, and many other sources suggest more research is needed to more fully understand expected M&O costs for the lifetime of LID facilities. The lack of research is partially due to the lack of data points collected in the field (Field and Field 2006; Gramlich 1990; Harberger; Jenkins 2002). Additionally, developers who are only involved in the construction of facilities often perceive M&O related costs as irrelevant to cost analysis of the facilities (ECONorthwest 2007). Therefore, both actual and expected M&O costs are still yet to be determined over an extended period; this can be achieved through data being collected on BMPs carried out by each city annually.

Routine and non-routine costs

Expected costs associated with maintenance of LID facilities is broken down into several categories, which include routine and non-routine costs. These cost categories were determined through the interviews with Phase I permittees to offer pricing specific to King and Pierce Counties. Average expected costs related to facility maintenance, such as general labor or machinery rental, have been supplemented by contractor rates found from material or equipment rental companies. Calculations will be most accurate if the size of the facility is known.

Bioretention maintenance

Routine bioretention facilities' maintenance can include watering during dry seasons, debris removal, plant pruning, weeding, mulching, trash removal, and clearing access points to the facility on a variable annual basis. Non-routine procedures include replanting lost vegetation, damage control, erosion correction, soil replacement, underdrain cleaning, and rebuilding structures. Non-routine tasks can be expected to happen as needed via inspections or as infrequently as five years for procedures such as soil replacement.

BIORETENTION

Routine Maintenance and Operation	Frequency	Average Cost/Unit
Watering	2-3 times annually	Assume pricing around seasonal events
Debris removal	2-3 times annually	Labor x hours x equipment used x materials
Plant pruning	2-3 times annually	Labor x hours x equipment used x materials
Weeding	Twice annually	Labor x hours x equipment used x materials
Mulching	Once every two years	$3.50 - $7.00/cu. yard x area or use arborist chips left over from city tree maintenance
Trash removal	2-3 times annually	Labor x hours x equipment used x materials
Access point clearing	Once Annually	Labor x hours x equipment used x materials

BIORETENTION (CONTINUED)

Non-Routine Maintenance and Operation	Frequency	Average Cost/Unit
Re-planting lost vegetation	Once every three to five years	Labor x hours x equipment used x materials
Damaging remediation	As needed	Labor x hours x equipment used x materials
Erosion control	As needed	Labor x hours x equipment used x materials
Soil replacement	Once every five years minimum	Labor x hours x equipment used x materials
Underdrain cleaning	Once every five years minimum	Labor x hours x equipment used x materials
Rebuilding structures	As needed	Labor x hours x equipment used x materials

PERMEABLE PAVEMENTS

Routine Maintenance and Operation	Frequency	Average Cost/Unit
Street sweeping	Twice annually	$350/hour x rental x labor x additional equipment
Pressure washing	Twice annually	$150/hour x rental x labor x additional equipment
Snow removal	As needed	$350/hour x rental x labor x additional equipment

Non-Routine Maintenance and Operation		
Deep Cleaning	Once every two years	labor x additional equipment
Utility Cutting	Upon inspection	labor x additional equipment
Pavement Replaced	Upon inspection	labor x additional equipment
Soil/Erosion Control	Upon inspection	labor x additional equipment

Permeable pavement maintenance

Routine M&O for permeable pavements includes soil/erosion control, snow removal, street sweeping, pressure washing, and deep cleanings at least once or twice annually. Non-routine maintenance includes utility cutting or replacing the pavement, a need that can be determined upon inspection. There are multiple types of permeable pavements, including eco-stone and gravel pavements, as well as permeable asphalts and concretes. M&O procedure requirements differ by pavement type, but all require fine silt and moss/lichen removal to avoid clogged pores.

Contingency costs

Irrespective of LID facility type, contingency costs include all unforeseen circumstances requiring further maintenance, including destruction or damage of the facility. Due to facilities being in urbanized areas, they are at risk for accidental damage caused by motorists and pedestrians. Additionally, high traffic rates leading to overall wear of the facility, particularly for pavements or other surface materials, may warrant premature replacement. Destruction of property or repairs for similar events cost approximately 10-15% of the annual budget.

Waste disposal

The engineered soil, or filtration media, in bioretention facilities accumulates contaminants and metals and is consequently treated as hazardous waste per EPA and WSDOE regulations. The soil can be expected to be replaced ideally every two to three years and every five years at minimum. The size of the facility will affect the cost of soil replacement. Most facilities' filtration media is estimated to be about 18 – 36 inches deep if an underdrain is used (Virginia DEQ 2011), so the square footage of the facility and actual depth will determine how many cubic yards of media the bioretention facility contains. Disposal costs of contaminated soil is approximately $40/cubic yard.

Infrequent and other costs

Some costs of LID maintenance are difficult to quantify on a discrete annual basis; this is especially the case with labor-related costs. Based on the responses received through the questionnaire, two to three new employees are hired annually to carry out M&O on average. The average turnover rate for labor per

year is about two people at a standard hourly wage in addition to the number of hours it takes to fully train new personnel. The average labor charge applies to training new employees as well; two to three new employees are hired annually to carry out M&O on average. Average employee wage is approximately $40/hour which includes insurance, wage, and sick pay costs.

Materials

We compared prices for common materials by evaluating rental companies near Auburn as well as questionnaire responses. Materials for LID facilities are largely purchased in bulk at contractor rates. These rates can typically be approximately three times cheaper than that of retail pricing which is supported by multiple price comparisons of rental companies near Auburn and responses received from the questionnaire. Materials are one of the largest budget draws in continual routine maintenance of LID facilities. The frequency of suggested BMPs and the specialty materials used in LID elements can also affect costs; however, as LID elements become increasingly common one may expect corresponding standardization and drops in price. Material costs depend on the following details:

- Concrete mix:
    - Patching for permeable pavement does not need to be done if costs are too expensive or too little is purchased.
    - Permeable pavement is about $100 per cubic yard. One cubic yard fills 16-24 potholes with an average diameter of 8-18 inches. Pothole patches can be expected to last one year and use about one cubic yard per year on patch work.
- Engineered soil mix:
    - Complete replacement of bioreplacement soils should happen every five years; partial replacement should happen at least once a year. Cedargrove, Coldwell, and Pacific Topsoil all offer wholesale pricing.
- Mulch:
    - Mulch can ensure water retention, build soil health, and mitigate weeding (Chalker-Scott 2015). Mulch is usually available from the same wholesalers that also produce engineered soils. It can be obtained for free from arborists performing regular city maintenance.
- Plants:
    - The number of plants used depends on the size of the facility. The plants used in LID facilities are advised to be drought-resistant and native, maturing at a small to medium size.
    - Plant spacing can be determined through the Rain Garden Handbook for Western Washington; presuming most plants added are small shrubs, 4 – 6’ spacing between plants is considered average (Hinman 2013).
    - Plant costs range from $2-6 per plant, plant spacing can be determined through the Rain Garden Handbook for Western Washington (Hinman 2013) presuming most plants added are small shrubs. A 4–6’ spacing between plants would be considered average per the Rain Garden Handbook for Western Washington (Hinman 2013). The number of plants needed will depend on the size of the facility.
    - A 10 – 20 % death rate is expected in bioretention facilities, all plants used are recommended to be native and drought-resistant plants will have a lower death rate and will require less watering through dry seasons. Concerted plant care and maintenance, particularly at the beginning of planting, can dramatically reduce death rates. Watering practices that allow for occasional deep soakings are better than frequent low-volume watering. Additionally, mulched planting areas with either bulk mulch or arborist chips are key to mitigating high soil temperatures that accelerate water loss via plant evapotranspiration and soil evaporation.

MATERIALS

Mulching	about $3.50 - $7.00/cubic yard
Permeable concrete	$100/cubic yard
Standard concrete	$20-35/cubic yard
Plants	assumes 50 - 70 plants per facility at $2-$6/plant + 10 - 20% death rate
Engineered Soil	$50-60/cubic yard
Waste disposal	$40/cubic yard
Labor	$40/hour (includes insurance, wage and sick pay)
Contingency value	10 - 15% of total annual budget

Equipment

We surveyed multiple rental companies within King and Pierce County to identify average equipment rental costs based on industry standards of 30-40 hour per week. Equipment rentals fell within the following ranges:

EQUIPMENT	
Pickup truck	$175 (includes insurance, vehicle maintenance, gas and payments)
Mini-excavator	$200/hour
Pressure washer	$150/hour
Pump truck	$200/hour
Street sweeper	$350/hour

06 SUPPORTING RESEARCH

We examined other M&O cost analyses to inform this report. The most comprehensive public documentation we found was for Bellevue, a small city in Michigan. While not climatically identical to Auburn, Bellevue, MI had publicly provided the most thorough breakdown of comparative costs for LID facilities and traditional facilities. An overall cost analysis for LID facilities done in Bellevue, MI found that keeping up with LID BMPs ($17,775,649) was more cost effective compared to traditional facilities ($18,083,815). However, the analysis assumed that the funding used in traditional cases would be directed to LID facilities rather than traditional stormwater management facilities. Essentially, money used in traditional methods such as wet ponds would be reverted to funding for LID facilities like permeable pavements and bioretention. Moving the funds from traditional management to LID not only covers the costs of LID systems but also equates to about $600,000 in savings over the course of a 30-year management plan because of lower M&O costs of LID facilities compared to traditional methods (City of Bellevue, MI 2017). In this case, LID facilities M&O over a 30-year plan was estimated to be $3,948,852; while conventional practices were expected to cost approximately $4,729,490 (City of Bellevue, MI 2017). The LID facilities evaluated in this cost analysis were constructed in areas that would have typically been assigned to general landscaping designations; therefore, their conversion to bioretention facilities for stormwater management was accomplished at costs similar to what landscaping those areas would have required. It was found that M&O costs for LID facilities compare to typical landscaping practices on land that does not have LID facilities (City of Bellevue, MI 2017).

MOVING THE FUNDS FROM TRADITIONAL MANAGEMENT TO LID NOT ONLY COVERS THE COSTS OF LID SYSTEMS BUT ALSO EQUATES TO ABOUT $600,000 IN SAVINGS OVER THE COURSE OF A 30-YEAR MANAGEMENT PLAN

Residential stormwater management utility fees can also be leveraged to reduce M&O costs associated with facility maintenance, as the fees are typically calculated by the amount of non-permeable surface like rooftops and pavements in residents' lots. An increase in the amount of permeable surface in an area through both permeable pavement and bioretention facilities will lead to reduced utility fees for conventional forms of stormwater management. The reduction of utility fees for traditional stormwater management may offer a viable amount of funding to allocate to new LID facilities and landowner education and outreach.

07 POSSIBLE COURSE OF ACTION
for the City of Auburn

While challenges remain in cultivating comprehensive data to refine BMP's and their attending M&O costs, we believe that Auburn has productive ways forward. The city can generate a targeted ability to track and predict M&O costs through collaboration, sustained data gathering, and community outreach. These long-term strategies may also offer opportunities for the city to cultivate public awareness and valuation of LID facilities. Continued data gathering may also help the city realize how costs compare to traditionally landscaped areas and typical stormwater management elements to best strategize M&O costs and the siting of LID facilities.

Plan routine maintenance and oversight practices

A monitored maintenance schedule can help to generate regular cost expectations. Regular scheduling can keep these facilities working for longer and ultimately reduce expenditures compared to irregular and more costly maintenance and extended time commitments per visit. A regular schedule allows for a low amount of maintenance per visit to maintain expected effectiveness.

Share information

The city's continued collection of annual cost data associated with each facility within Auburn, including size of the facility, maintenance frequency, labor values, equipment and materials used, will allow for more accurate cost tabulation and future cost expectations. Such data collection, when combined with monitored price fluctuations over time, can reveal trends in both regular and infrequent costs incurred at LID facilities. Collaboration and data sharing of LID M&O costs with neighboring cities can help further guide and compare costs as well as identify trends in cost patterns for LID facilities.

Follow and evolve BMPs

In addition to maintaining existing facilities to ensure continuous acceptable levels of performance, following BMPs for both bioretention and permeable pavements can increase the overall lifetime of these facilities (Pezzaniti et al. 2009), allowing adequate stormwater drainage, improving water quality, meeting legal standards, and upholding community values (EPA 2017). As Auburn applies BMPs to its facilities, fine-tuning practices will most likely occur as the city adjusts practices to their local climate, infrastructure elements, and available resources.

Engage community and volunteers

The City of Auburn already partakes in elements of community engagement for stormwater utilities by outsourcing to organizations like Environmental Coalition of South Seattle and engaging citizens during development processes. Community engagement and volunteer efforts to maintain or raise funds for these facilities can help distribute the financial burden. Cultural shifts towards sustainability can propel higher levels of community engagement and valuation of LID facilities. The City of Auburn may benefit from enhanced community engagement by allowing community members to volunteer to steward or fund city sustainability efforts. Considering existing robust programs, such as RainWise, may help serve as a model to develop a stronger connection between the City of Auburn and its community members around stormwater concerns. Programs similar to RainWise may also help alleviate municipal stormwater burden as private property owners install their own LID facilities.

08 FUTURE STEPS

Despite the growing popularity of LID stormwater management and M&O practices by cities rather than by WSDOE, further research is needed to identify trends and expected values of LID within the City of Auburn. While literature indicates specific costs related to construction values, to yield the most accurate cost expectations over time, sustained data collection on specific facilities will be most helpful in forecasting M&O costs. We recommend the following steps:

1. Interviewing and contacting more respondents and extending these types of surveys into further areas will assist in building a stronger baseline for economic analysis of costs associated with LID M&O.

2. After a cost analysis is conducted for each LID facility's construction, keeping those specifics in mind, draft outlines of projected M&O costs for each specific facility based on construction parameters. An outline of even five or 10 years can help further advise the transition of ownership from WSDOE to municipalities of these facilities.

3. Alternatively, after construction has been completed, and before the transfer of ownership, conduct data point collection of M&O costs by the WSDOE to provide to the next owner.

4. Utilize specific costs associated with the elements of M&O for King and Pierce counties and collect comparative data on other counties to offer a range of base values such as equipment rental and material costs each facility will require.

09 CONCLUSION

LID stormwater management techniques are still new technologies, and more time is needed to analyze the exact costs associated with M&O costs for the City of Auburn. Due to a high degree of variance across different ecosystems, patterns of land use, and local site conditions, specific figures are difficult to determine. Cost management strategies include following BMPs, community education and engagement, proper M&O scheduling and further research into data collected overtime on the existing LID facilities throughout the city. Preliminary findings from Bellevue, MI indicate that LID investment strategies can reduce costs over time compared to conventional stormwater controls. To build on this research, we believe that continued and, potentially, collaborative collection of data from cities with comparative situations can further help determine the most efficient M&O practices as well as BMPs for new site designs and installations. The outcome of these steps can begin a shift in city spending related to stormwater management from conventional methods to LID management and offer a more exact estimation of total costs of annual spending for LID facility M&O.

THE OUTCOME OF THESE STEPS CAN BEGIN A SHIFT IN CITY SPENDING RELATED TO STORMWATER MANAGEMENT FROM CONVENTIONAL METHODS TO LID MANAGEMENT

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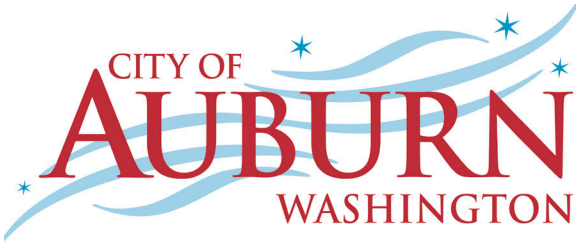

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