Residents' Perception of Low Impact Development in Berkeley

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ABSTRACT

Low Impact Development (LID) has gained credibility in recent decades as a new approach for sustainably managing stormwater in urban cities. Its benefits exceed those of traditional stormwater management by reducing impacts of stormwater runoff on the built environment and restoring natural hydrological processes. In this study, I investigated factors that influence Berkeley residents' perception of LID using surveys with questions about people's knowledge, interest, and concerns about LID and stormwater best management practices (BMPs). I also created a stormwater management conceptual design to locate potential sites for future BMP pilot projects and help facilitate LID and its implementation throughout the city. In general, the survey results showed that Berkeley residents supported LID concepts, but had concerns about costs and other factors. To change residents' perception of LID, education and financial programs can be used to address their concerns and create incentives and opportunities for BMPs. The proposed street BMPs and Aquatic Park constructed wetland designs identified opportunities and choices of implementing BMPs to address impacts of urban stormwater runoff. LID can be adopted in a citywide scale implementation for planning and design of stormwater management and achieving sustainable urban development.

KEYWORDS

urban development, stormwater management, best management practices (BMPs), pilot projects, conceptual design

INTRODUCTION

Sustainable urban development is inextricably linked with stormwater management (Davis and McCuen 2005). Water during excess rain and storm events is one major source of runoff in urban cities. Stormwater runoff can cause erosion and deposition on roads and other infrastructures, also localized flooding in a short period of heavy rain. It can cause pollution of the city's water resources with contaminants permeating aquifer and flowing into nearby creeks and rivers. Managing stormwater is a critical municipal responsibility that has a direct impact on public health and safety, surface water quality, and wildlife habitat (SFPUC 2009).

Traditional stormwater management and Low Impact Development (LID) take different approaches to these issues. Traditional stormwater management develops efficient drainage system to collect stormwater quickly and move it off site through inlets, piped networks, and outlets (DPW 2011). However, surface ponding and flooding occur frequently once peak flow of stormwater exceeds capacity of the storm drain. Traditional stormwater management fails to recognize how watersheds hydrologically and ecologically function, and misses opportunities to use stormwater as a valuable resource (DPW 2010). It interferes with natural hydrological processes and does not mitigate urbanization impacts on watersheds (Moreau 2006). LID, which is a new strategy of stormwater management emerged over the past decades, combines site design with runoff and pollution control measures. Its goal is to mimic the predevelopment hydrological regime and recreate ecologically functional and aesthetic landscape features of urban watershed (Coffman 1999). LID employs best management practices (BMPs) such as green roofs, rain gardens, and permeable pavements to reduce the quantity and improve the quality of stormwater runoff, and lower the cost of maintenance of storm drain infrastructure (SFPUC 2009). LID reduces impacts of stormwater runoff on the built environment of cities and restores natural hydrological processes. It exceeds traditional stormwater management in achieving sustainability of urban development and has gained credibility as an acknowledged stormwater management in recent years (EPA 2000).

Several cities in the United States have already implemented LID to manage stormwater and a few cities began taking steps lately. Chicago, for example, used concept of LID in the Green Alley program to improve alleys and sewer systems in the city (CDOT 2007). Portland installed permeable pavements, swales, and rain gardens in school and community projects to promote infiltration and remove pollutants of stormwater in open spaces (Metro 2002). San Francisco constructed green roofs and various bioretention structures in high-rises and public plazas to reduce or eliminate pollutants in urban stormwater runoff (SFPUC 2009, 2010). Berkeley is currently planning to renovate buildings, open spaces, and infrastructures with LID. The city government strived to ensure functionality, safety, and aesthetics of the city's aging facilities (DPW 2011). The city made progress by passing Measure M on the ballot of November 6th, 2012. Measure M authorized the City of Berkeley to incur bonded debt and issue a general obligation bond for street and related watershed improvements (Appendix A). Measure M will raise $30 million from Berkeley homeowners and fund street repaving and installation of Green Infrastructure (GI) programs. The city government also developed the Watershed Management Plan to identify and prioritize infrastructure needs associated with aging facilities (DPW 2011). The plan served as a city guideline of future GI programs and strategies to manage and promote watershed health and urban environment.

Despite Measure M and Watershed Management Plan the City of Berkeley lacks enough public education of LID, which results in slow planning process and limited support from local residents (DPW 2011). Well-informed public increases the demand for LID and offers developers and city staff more cost-effective opportunities and choices in implementing LID as well (Bowman and Thompson 2009, Bowman et al. 2012). It is therefore critical to collect information and understand Berkeley residents' perception of LID to inform the city government in stormwater management.

This study seeks to investigate and examine factors that influence residents' perception of LID in Berkeley. I will survey people's knowledge, interest, and concerns about LID and BMPs implementation in Berkeley. Based on survey results and review of other cities' stormwater management designs, I will create a conceptual design to locate potential sites for future BMP pilot projects and help facilitate LID and its implementation for stormwater management throughout the city.

METHODS

Study system

Berkeley has ten watersheds and eight major creeks within the city limits (DPW 2011). The watersheds drain out of the Berkeley Hills to the west across the city plain before discharging into the Bay. Because Berkeley is highly urbanized, much of the watersheds are paved and covered for roadway construction and housing. There are approximately 16 miles of creeks in the city and the majority of open creeks are on private property. The developers culverted a significant portion of creeks, about 7.4 miles, during the early 1900's (DPW 2011). At present, Strawberry Creek and Codornices Creek are the two most publicly accessible creeks in Berkeley.

Berkeley has a storm drain system of nearly 100 miles of underground pipelines and other supporting facilities. The collection system includes manholes, curb and valley gutters, inlets, catch basins, cross drains, and outlets. The stormwater runoff from property, streets, and sidewalks are collected and conveyed down to pipelines running into the San Francisco Bay. However, Berkeley's drainage system was not sized enough to deal with rain events that caused overflow problems whereas much of city's storm drain is over 80 years old and past its life expectancy (DPW 2011). Aging pipes result in shrinking conveyance capacity and cause frequent localized flooding, which require immediate inspection and repair.

Survey

Survey collection

To understand how much people know about LID and which factors influence their perception of LID, I administered survey to residents in Berkeley. I distributed survey by paper and electronic form. I mailed paper survey to 100 randomly picked households in the city. I sent out online survey in social network of friends and students and forwarded them using the snowballing technique to receive as many responses as possible. The survey collected people' general knowledge of LID, interest and concerns about LID and BMPs implementation, and demographics and personal information.

Survey questions

The survey (Appendix B) included categorical and ranking questions in three sections. To determine the extent of general knowledge of LID, I asked if people knew about the current condition of creeks and storm infrastructure in the city, the city watershed management plan, and concept of LID. I also asked which stormwater BMPs they knew most about, how they voted for Measure M, and why they supported or rejected it. To understand people's interest and concerns about LID and BMPs implementation, I asked if they visited existing LID projects in the city, their opinions of the projects, types of BMPs they favored for pilot projects on their property or street, and any concerns they had related to implementation of BMPs. The last section of the survey gathered information about people's living location, education and income level, property ownership, water and sewer bill, and willingness of receiving LID information.

Survey analysis

To understand people's perception of LID, I used chi-square tests to examine various relationships between their knowledge, interest, and demographics. To test if increasing LID education would help facilitate people's participation and support in LID policy, I examined knowledge of LID and voting decision on Measure M. To test if demographics relate with people's choices and attitude in LID implementation, I examined living location, education and income level, interest of BMPs, and willingness of receiving LID information.

To identify opportunities and barriers of improving LID in the city, I used bar charts and pie charts because they are good descriptive statistics of categorical responses. To find out opportunities for the city government in piloting LID projects, I used pie charts to show BMPs that people were most familiar with and BMPs that they were most interested in implementing on their property or street. To find out barriers that the city government needs to overcome in piloting LID projects, I used bar charts to show people's concerns about implementing BMPs.

Stormwater management conceptual design

Data collection and processing

To create a stormwater management conceptual design for locating future BMP pilot projects, I used the ArcMap 10.1 to conduct a geographic information systems (GIS) data processing and analysis. I collected data layers of trees, parks, streets, open creeks, storm drains, culverts, watersheds, topography, and land use zones of Berkeley. I downloaded data from the City of Berkeley website database and the UC Berkeley RESIN database.

I projected all data layers to NAD 1983 StatePlane California III FIPS 0403 Feet. I examined both natural and built environment features for potential BMP project sites. I categorized residential, commercial, and industrial areas by zoning codes. I joint them with city parks and made a city land use map. I also identified open creeks, culverts, storm drain, and trees to examine their distribution throughout the city.

Data analysis

I selected major streets because they were close to trees, culverts, and storm drain, and they had median buffers and large intersections. Wide major streets would provide opportunities for flow-based BMPs such as vegetated swale, curb extension, rain garden, and permeable pavement. They can infiltrate and attenuate peak flows, facilitate groundwater recharge, and provides aesthetic amenity (SFPUC 2010).

I selected open spaces near the shoreline because they were large and less urbanized. Large open spaces would provide opportunities for volume-based BMPs such as constructed wetland and detention pond. They can store stormwater, remove pollutants, create wildlife habitat, and function as recreational parks (SFPUC 2010).

RESULTS

Survey

Survey collection

Overall I received a total of 80 survey responses, 60 from the online and 20 from the mail. Sixty-four (80%) responses were from residents living in north and south sides of the city and the remaining 16 (20%) from downtown. Mail survey respondents were all homeowners while online survey respondents were all tenants.

General knowledge of LID

The survey identified that the majority of respondents lacked information related to LID in the city. Two-thirds of respondents were not sure or did not know about the current condition of creeks and storm infrastructure in the city. About 90% of respondents had not heard of the city watershed management plan, and 75% knew little or nothing about LID. In response to stormwater BMPs that they were most familiar with, 42% of respondents chose green roofs and 21% chose constructed wetlands (Fig. 1). I found 56 respondents (70%) voted yes on Measure M in the city ballot of November, 2012. Among these supporters, 34 respondents were most concerned about stormwater runoff and flooding and 22 were most concerned about city's degrading storm infrastructure.

Interest and concerns about LID implementation

Over 70% of respondents had not visited LID or water-related projects in the city. Forty-nine (61%) respondents were most interested in having a green roof and permeable pavement on their property or street (Fig. 2). Yet 40% of them would not like the city government to conduct pilot projects on their property or street. The survey revealed 45%

and 39% of respondents believed that costs and lack of interest and information respectively limited their support for implementing BMPs (Fig. 3).

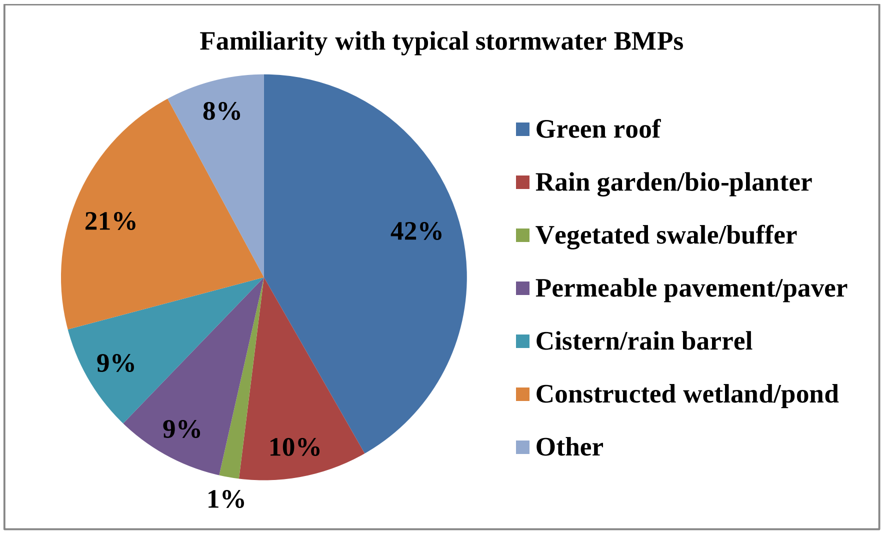

Fig. 1. Percentage of respondents who they were most familiar with each BMP.

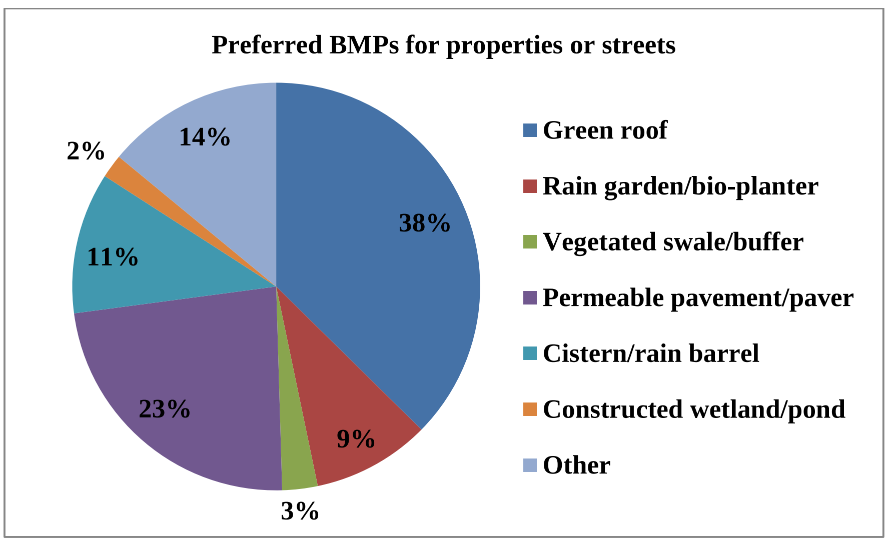

Fig. 2. Percentage of respondents who they were most interested in each BMPs for their property or street.

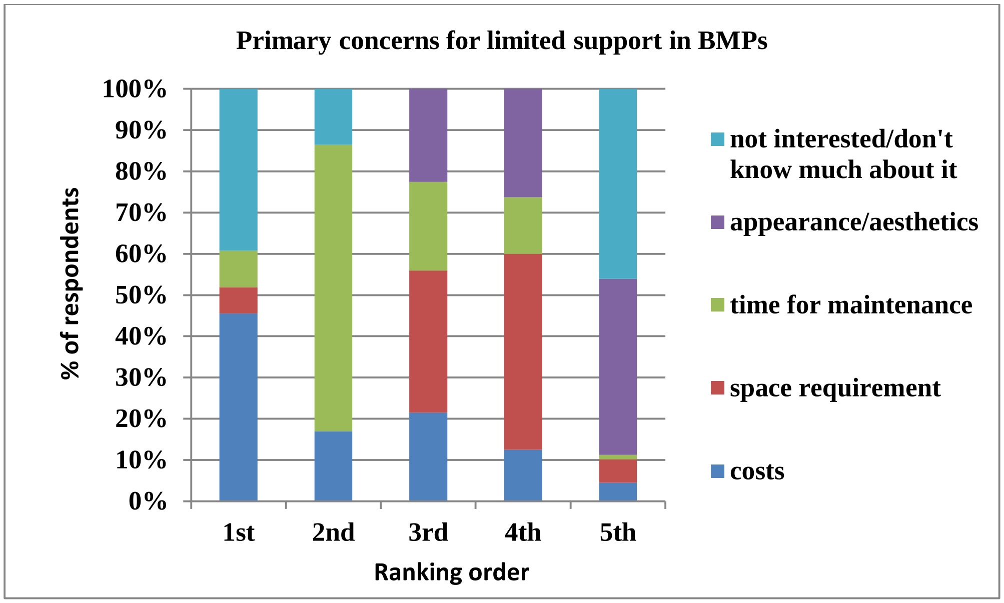

Fig. 3. Percentage of respondents with concerns about LID implementation (1st= the most concerned, 5th= the least concerned).

Demographics and personal information

Four-fifth of respondents (64) had completed college or higher degree and 30% of them were considered as high income earners (more than $100,000 annually). I found 40 respondents lived within 1/2 to 1 mile from the nearest creek in the city. 50% of respondents paid their water and sewer bill. Only 30% of respondents were willing to receive more information about LID via mail and email.

Perception of LID and implementation

The survey identified different levels of correlations between respondents' knowledge, interest, and demographics (Table 1). Respondents' interest in BMPs implementation was strongly correlated with their income level ($p = 0.006031$). I found the knowledge of LID was correlated with willingness to receive LID information ($p = 0.03793$), income level ($p = 0.05549$), and creek proximity ($p = 0.04943$). I found living location was correlated with interest in visiting LID project sites ($p = 0.03757$), which was also correlated with willingness to support city government pilot projects ($p = 0.031$).

Knowledge of LID and voting decision on Measure M (p = 0.1014) was weakly correlated. The willingness to support city government pilot projects was also weakly correlated with income level (p = 0.1413) and creek proximity (p = 0.1102). I found no other significant correlations between factors.

Table 1. Correlations between factors that contribute to residents' perception of LID and its implementation.

Factors	**p-value**
Knowledge of LID and voting decision on Measure M	0.1014
Knowledge of LID and willingness to receive LID information	0.03793
Knowledge of LID and income level	0.05549
Knowledge of LID and creek proximity	0.04943
Income level and interest in BMPs implementation	0.006031
Willingness to support city government pilot projects and income level	0.1413
Willingness to support city government pilot projects and creek proximity	0.1102
Willingness to support city government pilot projects and visit of LID project sites	0.031
Living location and interest in visiting LID project sites	0.03757

Stormwater management conceptual design

Site selection

I chose four streets in Strawberry and Potter/Derby Watersheds and one city park as potential sites for future BMP pilot projects (Fig. 4). I chose Shattuck Avenue, Sacramento Street, San Pablo Avenue, and University Avenue. These wide major streets were ideal for many types of flow-based BMPs. I chose the Aquatic Park to implement volume-based BMP, in this case, constructed wetland. The park was large and near the shoreline. It was connected by storm drain outlets and could be used for detention and treatment of stormwater before it discharges into the Bay.

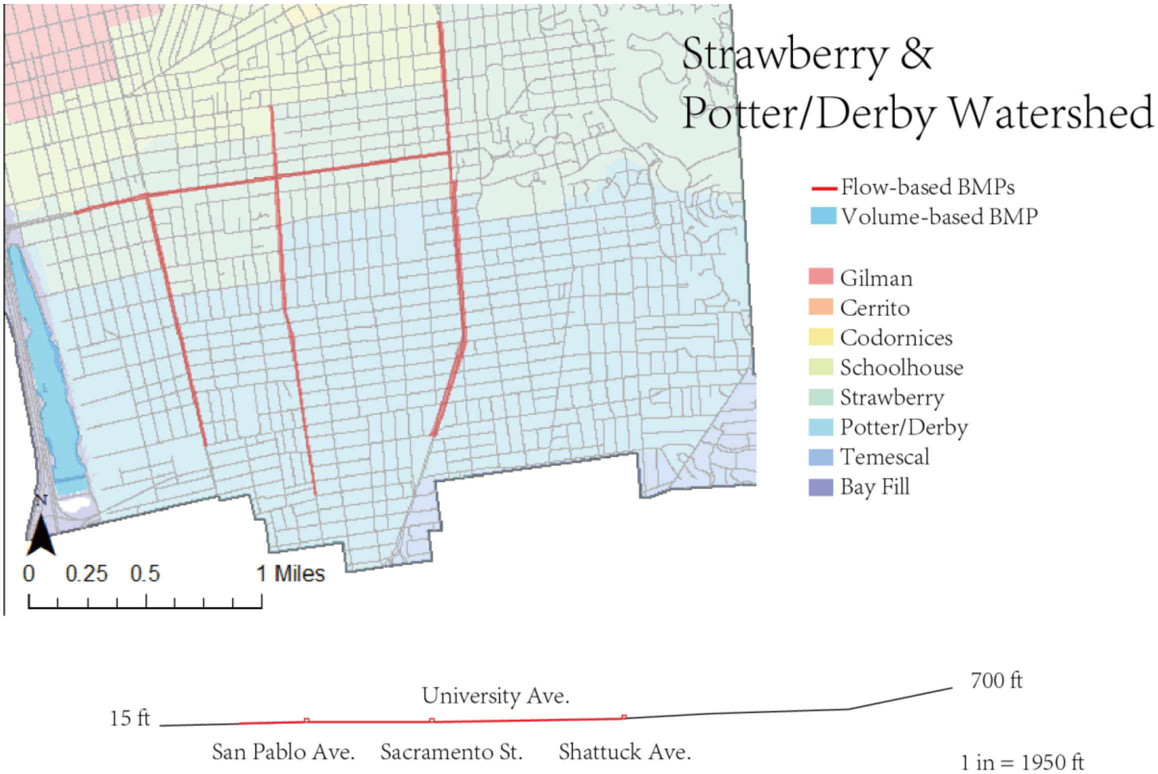

Fig. 4. Strawberry and Potter/Derby Watersheds and potential sites of BMP pilot projects shown as red lines (flow-based BMPs) and blue area (volume-based BMP).

Sizing BMPs

Strawberry and Potter/Derby Watersheds are 3,500 acres in areas total. Land use consists of around 330 acres of commercial areas, 200 acres of industrial areas, 170 acres of open space, 900 acres of streets, and remaining 1900 acres of residential areas. The composite runoff coefficient is 0.52. To comply with SF Bay Area standards (SFPUC 2009) for filter-based BMPs, bioretention areas are to be sized a minimum of 74 acres (Appendix C). The proposed street area of flow-based BMPs are 82 acres which is 2.3% of the drainage area. The Aquatic Park is 74 acres accounting for 2.1% of the drainage area. It is sized to retain about 2.2 acre-feet of water quality volume for standards of volume-based BMPs (Appendix C).

DISCUSSION

Survey

This study examined different factors which affected residents' perception of LID in Berkeley using survey. The survey perceived contradiction in respondents' voting decision and knowledge of LID, and identified opportunities for support of BMPs implementation based on concerns by respondents. Survey results suggested that education and financial programs could be useful incentives to influence residents' perception of LID and increase their participation, interest, and support in LID and BMPs implementation.

Residents' general knowledge of LID

The votes on Measure M indicated respondents' support of the city government in improving stormwater management and infrastructure in Berkeley. A few respondents with some knowledge of LID voted down on Measure M. On the contrary, those who had no or little knowledge of LID voted yes most of the time. Respondents' voting decision of Measure M contradicted with their knowledge of LID. It suggested other factors besides knowledge affected respondents' voting decision in policy that promotes LID. It implied that respondents made their voting decisions on Measure M based on personal interest and concerns about city infrastructures and watersheds, or even without understanding the bond questions and the context of stormwater management.

Residents' interest and concerns about LID implementation

Costs and lack of interest and information were two factors that most affected respondents in implementing BMPs on their property or street (Fig. 3). It suggested low-cost BMPs would be more attractive to residents for individual household implementation. Large-scale implementation was likely to be possible in a neighborhood if residents were interested and familiar with types of the BMPs (Bowman et al. 2012). It offered opportunities for the city government to conduct BMP pilot projects that are popular and inexpensive to gain residents' support of implementation. The city government can help reduce the costs of purchase and construction for individual residents who want BMPs on their houses (ARC 2008). It can also distribute pamphlets of LID information and manual of BMPs implementation to households.

Residents' perception of LID and its implementation

Strong correlation between income level and interest in BMPs implementation suggested high income residents were likely to be more interested in LID than low income residents. This indicated that high income residents were more willing to invest in BMPs for their property or street. High income residents were likely to have more knowledge of LID (Table 1), suggesting they were more willing to receive LID information. It also suggested high income residents were more supportive to city government pilot projects. The city government can first target wealthy communities to expand larger-scale BMPs to citywide implementation. It can also develop rebate programs to reduce costs of BMPs for low income residents and communities, and change and increase their interest in BMPs implementation (ARC 2008).

The weak correlation between knowledge of LID and voting decision on Measure M suggested increasing residents' knowledge of LID affects their voting decision in stormwater management policy. Although it increases residents' participation in LID policy, the effectiveness of winning yeas cannot be determined. On the other hand, residents who had visited LID project sites tended to support city government pilot projects. It suggested encouraging residents to visit LID project sites gain their support for city government pilot projects. The city government can improve education and information of LID to indirectly influence residents' support in LID policy and future BMP pilot projects. It can also recruit volunteers and organize tours to visit LID project sites to receive public attention and approval of LID.

Stormwater management conceptual design

Proposed designs: street BMPs

For a 160 feet wide four-way street with median buffer and planter boxes on sidewalks (Fig. 5), I extended curb on each side outward by 10 feet to accommodate space for bioretention cells and pedestrian way. Bioretention cells provide larger area of vegetation growth for more stormwater infiltration and increase the safety of pedestrians from cars on the road. I increased the median buffer by 10 feet in width for vegetated swale which reduces stormwater runoff on road surface more effectively than turf strip. I proposed permeable pavement on streets to facilitate groundwater recharge and remove oil and grease and metals.

At the intersection, I proposed implementation of rain garden because it is easy and inexpensive to install and has wide range of scales and site applicability (SFPUC 2010). I extended the curb by 5 feet more for small-scale of rain gardens in the street corner. They facilitate stormwater infiltration, provide aesthetic amenity, and create wildlife habitat in the urban city. I also used large-scale rain garden to replace traffic circle to slow drivers and route direction.

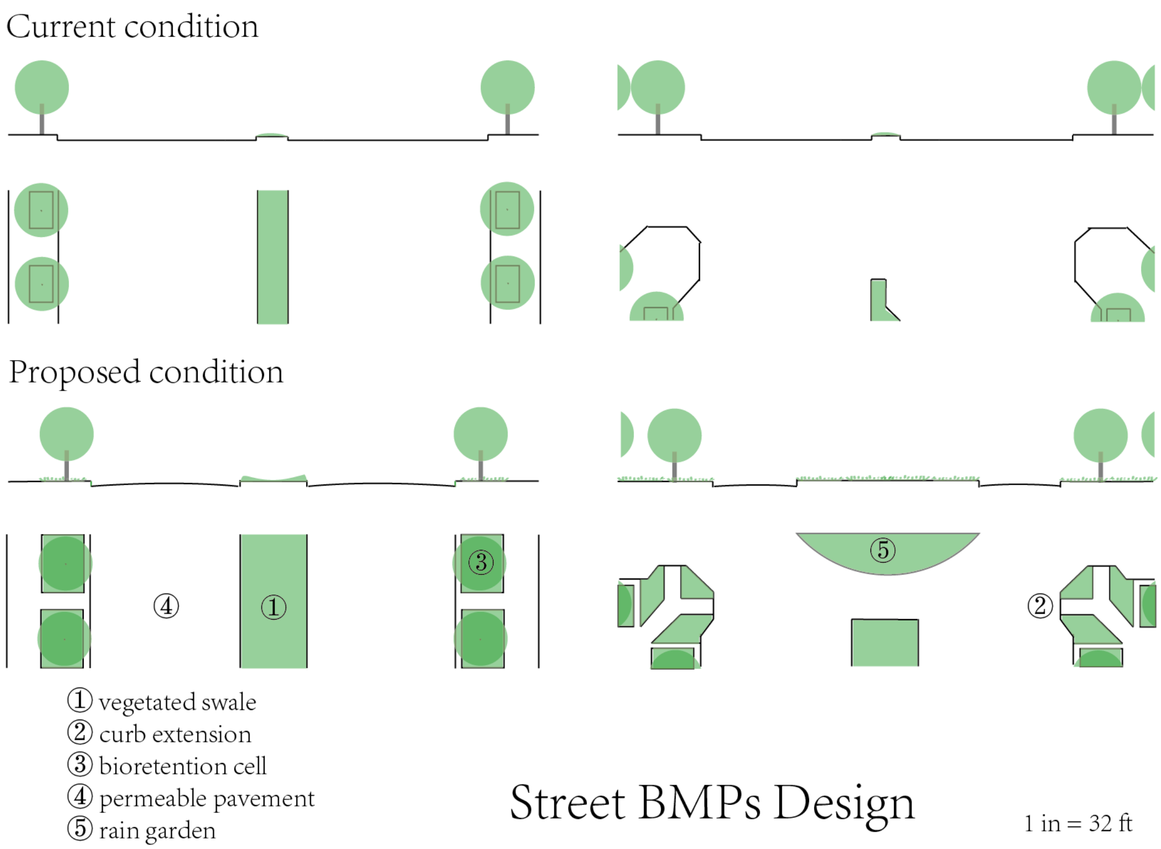

Fig. 5. Street BMPs design.

Proposed designs: Aquatic Park constructed wetland

The Aquatic Park has an elevation difference of 5 feet and about 5900 feet in length, which was flat for the implementation of constructed wetland (Fig. 6). I proposed to elevate the forebay to have a depression for pretreatment and energy dissipation of stormwater from the inlet. Biofiltration type BMPs can be constructed in the forebay to remove sediment and litter from water prior to its entry into the wetland (SFPUC 2010). I assigned large area for wetland to settle stormwater for detention and absorption. I chose common plants such as cattail, bulrush, and reeds in the wetland to filter and purify stormwater. In case of flood and overflow events, the outlet discharges the water through perforated pipe to control water level with adjustable standpipe (SFPUC 2010).

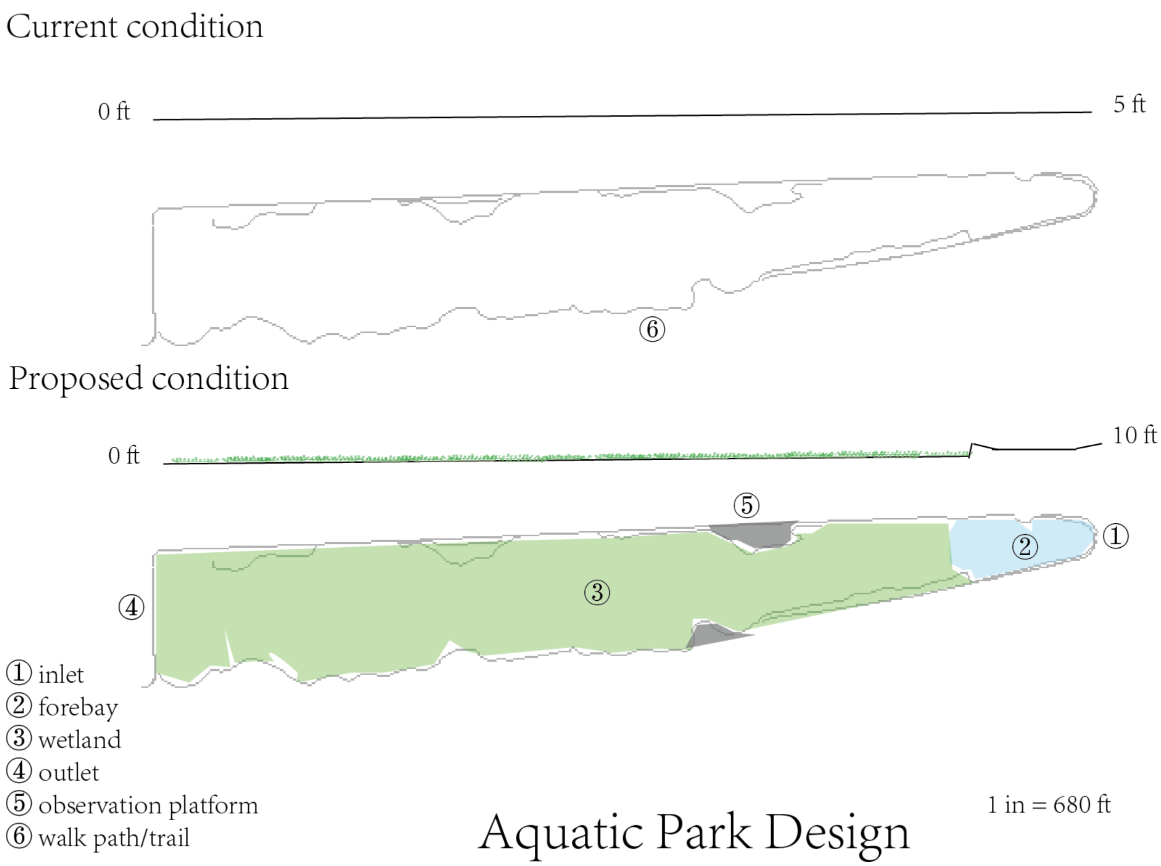

Fig. 6. Aquatic Park constructed wetland design.

Limitations

The survey was restricted to a small proportion of residents and did not include perception of developers and city staff. The wording of survey questions were designed to expect high knowledge and support of LID implementation from respondents. Results might not be well applicable and duplicated to other cities with similar demographics. The study was not able to detect all statistical relationships and significance and had a limitation to offer guidance to city planning and stormwater management with a conceptual design.

Future directions

More research is needed in larger scale to investigate residents' perception of LID as well as that of developers and city staff. Specifically, it is critical to research viable programs to promote LID in the context of city's financial budget and educational institutions. In addition, the City of Berkeley needs to draft its own stormwater management plan enforcing regulatory codes and providing design guideline for LID and its implementation (BES 2008, NYSDEC 2010).

Broader implications

This study will help the City of Berkeley facilitate LID and its implementation based on residents' perception of LID. It will encourage the city government to take into consideration residents' interest, opinion, and concerns in planning and policy-making of the city stormwater management. By advocating public participation in LID the study will raise public awareness in health of urban watersheds and function of city's storm infrastructure. The study will also encourage the city government to conduct BMP pilot projects throughout the city. By locating potential sites and identifying opportunities of BMPs implementation the study will inform the city government of improving urban watersheds and stormwater infrastructure with LID.

CONCLUSION

The study provides a preliminary investigation and analysis of factors that affect residents' perception of LID in Berkeley. It indicates residents' support in LID concepts, however, barriers such as costs and lack of education and information of LID may limit their participation, interest, and support for implementation of pilot projects by the city government. The survey identifies the significance of improving residents' knowledge of LID and developing incentives to facilitate LID and its implementation throughout the city. The study suggests the City of Berkeley advance education and information of LID and finance rebate programs to gain public acknowledgement and reduce costs for LID implementation.

The study also provides a stormwater management conceptual design to locate potential sites for future pilot projects and offers opportunities for implementation of BMPs. It proposes street BMPs and Aquatic Park constructed wetland designs, which indicates that LID concepts provide natural and aesthetic features in the built environment to address impacts of urban stormwater runoff. The conceptual design identifies opportunities and choices of implementing BMPs. It recognizes LID as a complement to city's storm drain system and an effective approach to planning and design of urban stormwater management. The study suggests the City of Berkeley adopt LID in a citywide scale implementation to recreate hydrologically functional landscape and achieve sustainability in urban development.

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APPENDIX A: ballot question and full text

BALLOT QUESTION

Shall the City of Berkeley issue general obligation bonds not exceeding $30,000,000 for street improvements and integrated Green Infrastructure such as rain gardens, swales, bioretention cells and permeable paving, to improve roads, reduce flooding and improve water quality in the creeks and Bay?
Financial Implications:
The average annual cost over the 30-year period the bonds are outstanding would be approximately $38, $81, and $116, respectively, for homes with assessed valuations of $330,500, $700,000 and $1,000,000.

FULL TEXT OF BOND MEASURE

AUTHORIZING THE CITY OF BERKELEY TO INCUR BONDED DEBT AND ISSUE A GENERAL OBLIGATION BOND FOR STREET AND RELATED WATERSHED IMPROVEMENTS

WHEREAS, this resolution is adopted pursuant to and in conformance with Chapter 7.64 of the Berkeley Municipal Code; and

WHEREAS, the City has developed a 5 year street repaving plan, which it updates annually; and

WHEREAS, the City has developed a Watershed Management Plan to manage and improve overall watershed health within the City's boundaries by identifying and prioritizing infrastructure needs associated with aging facilities and capacity needs, and in particular utilizing Green Infrastructure elements (such as rain gardens, swales, bioretention cells, permeable paving) within the public right-of-way and streets; and

WHEREAS, because the City's streets, with their curbs and gutters, are an integral part of the City's storm water management system, storm water management improvements consistent with the Watershed Management Plan should be integrated into street improvements where they will enhance water quality and flood control; and

WHEREAS, existing annual funds and funding sources are insufficient to adequately improve the City's streets, aged storm drains and storm water management systems and improve water quality in the City's creeks and the Bay; and

WHEREAS, the City needs to repair its failing streets by significantly accelerating implementation of its 5 year street repaving plan, but existing funds and funding sources are inadequate to do so; and

WHEREAS, the City Council has therefore determined that the public interest requires additional funding for acceleration of the 5 year street repaving plan, as it is updated annually.

NOW THEREFORE, BE IT RESOLVED by the People of the City of Berkeley that the public interest requires the issuance of a general obligation bond in the amount of $30,000,000 to fund construction of the Improvements described below.

BE IT FURTHER RESOLVED the People of the City of Berkeley that:

A. Proceeds of bonded indebtedness shall be used to construct the following facilities ("Improvements"):

1. Street repaving and rehabilitation consistent with the 5 year street repaving plan as it is updated annually, and sufficient to significantly accelerate the implementation of that plan.

2. Installation of Green Infrastructure (GI), as it is defined in the Watershed Management Plan as part of the street work described in the preceding paragraph, when appropriate. GI includes, but is not limited to: (a) surface level bio-retention measures (rain gardens, swales, bio-retention cells, permeable paving, etc.) within the parking strip, planter area of sidewalks, red zone curb-extensions, and in street medians as feasible; and (b) large underground storage pipes, which would fill during storm events and then discharge metered flows into the existing storm drain pipelines.

For purposes of this measure, "Improvements" shall also include design, permitting, administrative and overhead costs.

BE IT FURTHER RESOLVED by the People of the City of Berkeley that:

A. The estimated cost of the Improvements to be funded by any bonds issued pursuant to this measure is $30 million, although the total cost of all Improvements needed to address all of the City's street-related capital needs is in excess of that amount.

B. The amount of the principal of the general obligation indebtedness (the "Bonds") to be incurred shall not exceed $30 million.

C. The estimated cost may include legal and other fees and the cost of printing the Bonds and other costs and expenses incidental to or connected with the issuance and sale of the Bonds.

D. The proceeds of the Bonds authorized to be issued by this resolution shall be used to finance construction of the Improvements and to pay any fees and costs in connection with the issuance of the Bonds, including but not limited to, legal fees and bond printing costs.

E. The maximum rate of interest to be paid on the Bonds shall not exceed eight percent (8%).

APPENDIX B: survey design and questions

Berkeley Low Impact Development Survey

Thank you for taking the time to complete this survey created by Qi Huang. Your feedback is important to my senior research on Residents' Perception of Low Impact Development (LID) in Berkeley.
This survey will only take about 5-10 minutes and your responses and information will be confidential for academic uses.
Any questions marked with an asterisk (*) require an answer in order to progress through the survey.
If you have any questions, please contact me at doahuang@berkeley.edu, thank you.

SECTION ONE: GENERAL KNOWLEDGE
Low Impact Development (LID) is a new approach of stormwater management to mimic predevelopment hydrological regime by recreating natural and aesthetic landscape features through best management practices (BMPs) such as green roofs, rain gardens, and permeable pavements.

***1. What do you think of the current condition of creeks and storm infrastructure in the city?**

Good
Moderate
Bad
Don't know/not sure

***2. What do you think of the Berkeley Watershed Management Plan?**
http://www.cityofberkeley.info/Public_Works/Sewers_-_Storm/Watershed_Management_Plan.aspx

Positive
Neutral
Negative
Don't know/not sure/never heard of

***3. How much did you know about LID before taking this survey?**

None
Little
Some
Very well

***4. What are the stormwater BMPs you are familiar with?**

Green roof
Rain garden/bioretention cell/flow-through planter
Vegetated swale/buffer strip
Permeable pavement/paver
Cistern/rain barrel
Constructed wetland/detention pond/infiltration pond
Other (please specify)

***5. How did you vote on Measure M of the City of Berkeley on November 6, 2012 general election?**

Measure M issues general obligation bonds for street improvements and green infrastructure

Yes
No
Did not vote

6. If you voted yes, why?

Check all that apply

Concern about pollutants and water quality
Concern about runoff and flooding
Concern about neighborhood aesthetics
Concern about watershed health/sustainability
Concern about degradation of infrastructures
Concern about property value
Concern about recreational opportunities
Other (please specify)

SECTION TWO: INTEREST AND CONCERNS ABOUT LID IMPLEMENTATION

***1. Have you visited any of the following LID or watershed management project sites in Berkeley?**

Strawberry Creek park/daylighting
Codornices Creek restoration/daylighting
Green roof/bioretention pond/permeable pavement on UCB campus
No
Other (please specify)

2. If yes, what is your opinion of the site or structure?

***3. What are the stormwater BMPs you are interested in for your street or property?**

Green roof
Rain garden/bioretention cell/flow-through planter
Vegetated swale/buffer strip
Permeable pavement/paver
Cistern/rain barrel
Constructed wetland/detention pond/infiltration pond
Other (please specify)

4. And why?

***5. Are you willing to see the city government conducting pilot projects on your street or property?**

Yes
No
Not sure/don't know

***6. Please rank the reasons/concerns that you will NOT support BMPs implementation on your street or property:**

Costs

Space requirement
Time for maintenance
Appearance/aesthetics
Not interested/don't know much about it

SECTION THREE: DEMOGRAPHICS AND PERSONAL INFORMATION

***1. Where do you live in the city?**
North Berkeley
Downtown Berkeley
West Berkeley
South Berkeley

***2. How far do you live approximately from the nearest creek?**
< 1/2 mile
1/2 - 1 mile
> 1 mile

***3. Do you ___ the house/apartment/etc.?**
Own
Rent
Other (please specify)

***4. Do you pay water and sewer bill?**
Yes
No

***5. What is the highest level of education you have completed?**
High school or below
Some college or above

***6. What is your annual income?**
< $100,000
> $100,000

***7. Would you like to learn more about LID?**
Yes
No
Not sure/don't know

8. If yes, what is your most preferred learning method?
Flyers
City website/projects
Magazine/newspaper
Email/mailbox
Other (please specify)

9. Do you have any comments?

APPENDIX C: calculations

Table 2. Land use and runoff coefficient.

Land use	**Runoff coefficient**
Residential	0.35
Commercial	0.8
Industrial	0.65
Streets	0.8
Open space	0.2

Composite runoff coefficient:
330*0.8+0.65*200+170*0.2+900*0.8+1900*0.35 = 1813
1813/3500 = 0.52

Flow-based BMPs: capture and treatment of at least 0.2 inch per hour storm

Qrunoff = Qinfiltration
a/r = CiA
a/A = Ci/r = 0.52*0.2/5 = 0.021
a = A*0.021 = 3500*0.021 = 74 acres

Volume-based BMPs: 80% capture of annual runoff for 48 hours

Unit volume is 0.35 inches determined from SF unit basin storage volume curves
Water quality volume = area*unit volume = 74*0.35/12 = 2.2 acre feet