INNOVATIONS IN STORMWATER CAPTURE

ALTERNATIVE DELIVERY, O&M SCENARIOS & BEST MANAGEMENT PRACTICES, MULTI-AGENCY COLLABORATION AND WORKFORCE DEVELOPMENT

SOUTHERN CALIFORNIA WATER COALITION 2019 WHITEPAPER

SOUTHERN CALIFORNIA WATER COALITION

SCWC STORMWATER TASK FORCE
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Executive Summary

The Passage of Measure W in Los Angeles County in 2018, and the subsequent creation of the Safe, Clean Water Program, has created a comprehensive, regional approach to address how Los Angeles County captures water and reduces reliance on imported water, improves water quality, and enhances communities. This program will provide approximately $300 million annually in Los Angeles County, representing a substantial public investment in stormwater infrastructure. Additional increases in funding are also anticipated in the coming years as jurisdictions follow Los Angeles County's lead with their own funding programs.

With these growing public investments in stormwater, there is an increased responsibility for agencies to efficiently use them through innovative delivery approaches to increase the cost-efficiency of these projects (to build more with less resources), and improve performance, such as mitigating the impacts of climate change, drought, addressing emerging regulatory issues, and other water supply and water quality challenges. An additional challenge, as with all infrastructure, is providing sustainable and ongoing operation and maintenance (O&M) to cost-effectively provide the full suite of benefits in perpetuity.

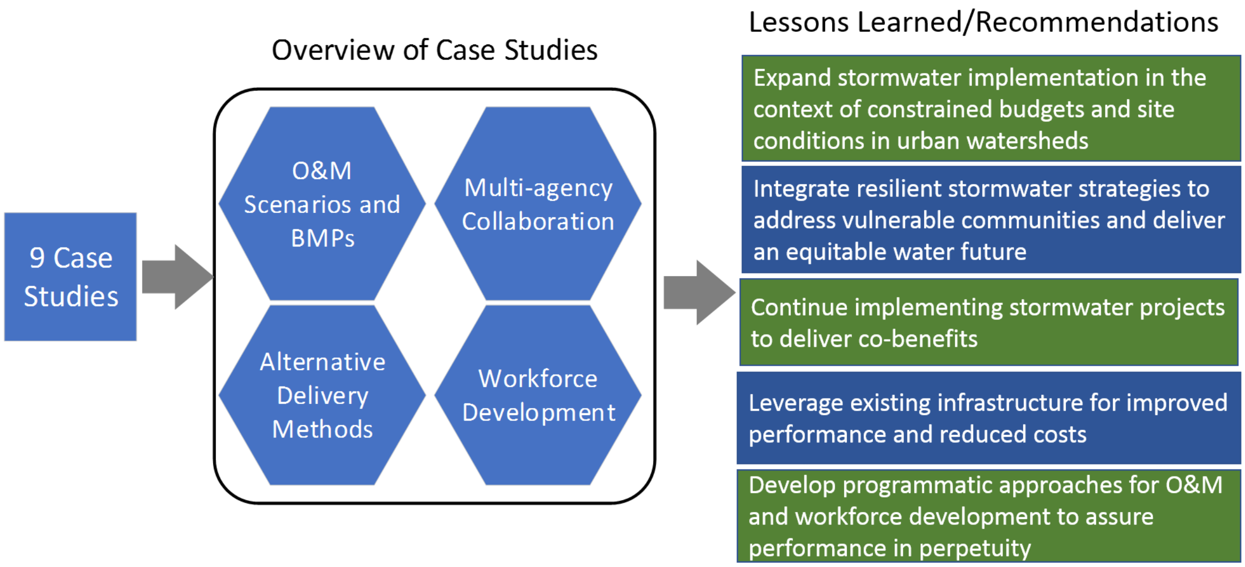
This white paper gathers experience from projects describing innovations in implementation of stormwater projects related to enhanced O&M strategies and best management practices (BMPs), alternative delivery options, multi-agency collaboration, and workforce development. The overall goal of this white paper is to gather information and lessons learned from other local, regional, and national stormwater projects to benefit Southern California Water Coalition (SCWC) agencies by fostering collaboration and sharing lessons learned from experiences. Nine case studies covering a range of local, regional, and national stormwater management projects are presented with a number of successful innovations that can help guide the implementation of stormwater management projects in Southern California (see Figure ES-1).

Key findings of this white paper and recommendations include:

1. Expand stormwater implementation in the context of constrained budgets and site conditions in urban watersheds
2. Integrate resilient stormwater strategies to address vulnerable communities and deliver an equitable water future
3. Continue implementing stormwater projects to deliver co-benefits
4. Leverage existing infrastructure for improved performance and reduced costs
5. Develop programmatic approaches for O&M and workforce development to assure performance in perpetuity

These case studies provide a framework of successful and innovative stormwater management options and identify additional research needs on a case-by-case basis to further develop innovative strategies that manage stormwater to reduce cost, increase environmental and community benefits, and enhance collaboration across partners and agencies. These strategies linking partners and communities can result in successful stormwater management projects to provide environmental, community, and economic benefits.

Figure ES-1: White Paper Overview



Introduction

Emerging regulations, stressors to imported water deliveries, stormwater quality standards, longer droughts, and more intense rainfall events in California are driving significant expansion of stormwater management investments in the region. In recent years, stormwater is increasingly being viewed as a component of Southern California's sustainable water supply portfolio. Stormwater capture not only provides an opportunity to enhance water supply resiliency in the region in some locations but also offers a multitude of benefits.

Many Southern California agencies are implementing stormwater projects under Enhanced Watershed Management Programs to meet the total maximum daily load (TMDL) requirements in the region. The passage of Measure W in Los Angeles County in 2018, and the subsequent creation of the Safe, Clean Water Program, has created a comprehensive, regional approach to how Los Angeles County captures water and reduces reliance on imported water, improves water quality, and enhances communities. This program will empower communities to increase stormwater capture, improve water quality, remove trash and pollutants before it reaches our beaches and coastal water, protect creeks and rivers streams, and create green space for our communities. The successful implementation of this program will rely on input from multiple committees which will include participation from a broad spectrum of interested and knowledgeable stakeholders. This program will provide approximately $300 million annually in Los Angeles County, representing a substantial public investment in stormwater infrastructure. Additional increases in funding are also anticipated in the coming years as jurisdictions follow Los Angeles County's lead with their own funding programs.

Local governments have adopted regulations to encourage strategies such as low-impact development (LID), including green infrastructure designed to capture, clean, and store stormwater using onsite best management practices (BMPs) to lessen the impacts on stormwater quality and quantity. The goal of LID is to manage developed sites to mimic natural runoff conditions through evaporation, infiltration, or reuse. Rather than losing stormwater through ocean outfalls in Southern California, stormwater, when appropriately captured, can augment water supply and result in an improvement in environmental water quality. Many local agencies in Southern California have already implemented regional and distributed (also known as neighborhood-scale) stormwater projects to increase local water supply, improve water quality, and address flood risks. Further expansion of these projects requires innovative O&M strategies, alternative delivery methods, and multi-agency collaboration to meet the needs of the future in a sustainable way.

Utilities, municipalities, and private developers are undergoing a paradigm shift from simply providing infrastructure to meet technical performance goals to also integrating community benefits and addressing equity. While public water suppliers must still relate their expenditures to State cost-of-service standards, they are identifying ways to meet the State standards and participate in multi-benefit projects through partnerships with private and non-profit entities, as well as other public agencies.

In order to maximize the benefits of stormwater projects, innovations in implementation of stormwater projects and workforce development with a pipeline for new talent for O&M of these facilities are needed. This will help increase the cost-effectiveness of stormwater project delivery, establish creative financing and strategies to maximize the benefits of stormwater investments as well as strategies for O&M to achieve efficiency while maintaining performance.

In this white paper, we first provide the background of stormwater management activities of the SCWC. Next, we discuss the goals and objectives of the white paper and the activities conducted to gather case studies of projects to gain knowledge from local and regional experience and practices. These case studies are intended to demonstrate a wide range of options and practices employed by agencies at the local (e.g., city, neighborhood, and project site) and regional levels to inspire utilization of successful processes. These exemplary projects offer guidance to develop partnerships and lessons from the methods and strategies employed. These projects will also help generate ideas to maximize the resources to harness stormwater as a water supply source that was once considered a “wastewater”.

SCWC and Stormwater Task Force Background

The SCWC spans Los Angeles, Orange, San Diego, San Bernardino, Riverside, Ventura, Kern, and Imperial counties, and comprises approximately 200 member organizations, including leaders from business, regional and local government, agricultural groups, labor unions, environmental organizations, water agencies, as well as the general public. Key technical support is provided by flood control district staff, city engineers, urban planners and redevelopment staff, water resource planners, real estate development professionals, hydrogeologists, and experts from consulting firms.

In January 2011, the SCWC formed the Stormwater Task Force (Task Force), to develop regional, consensus-based strategies and recommendations for using stormwater effectively as an emerging new local water supply and to reduce water pollution from urban runoff within the region. This includes identifying potential issues, constraints, and opportunities related to the management of stormwater and providing a forum for discussion and evaluation of challenges for individual watersheds within the coastal plain of Southern California.

SCWC’s key focus areas are:

- Enhancing local water resiliency and adapting to climate change through stormwater capture
- Promoting stormwater capture, flood risk mitigation, and groundwater conjunctive use
- Advancing regional integrated water resources management strategies and plans
- Developing synergies in new local supplies including groundwater, recycled water, and stormwater within the coastal plain of Southern California
- Improving stormwater management as related to water quality and protection of beneficial uses of receiving waters
- Assessing the relationship between regulatory compliance and need for stormwater management and groundwater recharge
- Evaluating LID standards and development incentives

Purpose of White Paper

In January 2012, the SCWC published its first white paper on stormwater, “Stormwater Capture: Opportunities to Increase Water Supplies in Southern California” (SCWC 2012). The purpose of the 2012 white paper was to examine existing statewide policies, goals, and regional plans related to integrated stormwater management; trends, structure, and requirements of municipal separate storm sewer system (MS4) permits as they pertain to both opportunities and constraints to maximizing stormwater capture for water supply purposes; and the advantages and disadvantages of two strategies of stormwater management: onsite LID and regional stormwater capture and infiltration. The 2012 white paper largely focused on conceptual stormwater projects and technical strategies for increasing stormwater capture.

In April 2018, the SCWC published its next white paper on stormwater, "Stormwater Capture: Enhancing Recharge and Direct Use Through Data Collection" (SCWC 2018). The purpose of the 2018 white paper was to gain a better understanding of actual stormwater runoff capture volumes, costs, benefits, and project performance across the region to inform future discussions.

In recent years, emerging regulations and pertinent water needs in California are driving significant expansion of stormwater investments in the region. This expansion requires innovations in stormwater project implementation to increase the cost-effectiveness of stormwater project delivery, establish creative financing and strategies to maximize the benefits of stormwater investments, and enhanced strategies for O&M to achieve efficiency while maintaining performance.

The purpose of this 2019 white paper is to provide examples of projects describing the innovations in implementation of stormwater projects that exemplify enhanced O&M strategies, workforce development, alternative delivery options, and multi-agency collaboration. For these important areas, the overall goal of this white paper was to gather information and lessons learned from other local, regional, and national stormwater projects to benefit SCWC agencies by fostering collaboration and sharing lessons learned from experiences.

Approach for Developing this White Paper

In May 2019, a schedule and process for developing this white paper were developed and were presented at the SCWC Committee meeting. Following the approval from the SCWC committee, a "Call for Abstracts" was distributed to the SCWC members, California Stormwater Quality Association technical committee, Southern California stormwater managers, and the Water Environment Federation Stormwater Program to gather case studies of projects and funding mechanisms that have shown themselves to be effective in delivering stormwater projects. The technical review team reviewed all submittals and notifications were sent to the authors for inclusion of their case studies in the white paper along with the instructions to develop final papers. This white paper is prepared summarizing and compiling the following case studies:

1. Bolivar Park Stormwater and Urban Runoff Capture Project by Fussel J. and Watson R.
2. Case Studies on the Intersection of Green Stormwater Infrastructure and Workforce Development by Johnson V., Atchison D., Kaur J., Williams J., Tam W., and Simson C.
3. Financing Resilience in Atlanta using an Environmental Impact Bond by Hallauer A., Behrend G., Bell D., Tyagi A., and Cohen, B.
4. Innovative Design Turning Parks into Green Stormwater Infrastructure Community Attractions by Bryant R., and Stein J.
5. Multi-agency Collaboration: Carriage Crest Park by Passanisi M., Moon TJ., and Gonzalez J.
6. O&M Scenarios and Best Management Practices by Beck S., Williams J.
7. Stormwater Biofiltration System Promotes O&M Efficiencies, Innovative BMP Design, and Environmental Stewardship of San Diego Bay by Yescas A., and Braun C.
8. Stormwater Capture Parks Program by Pettijohn D.
9. Tujunga Spreading Grounds Enhancement Project by Pettijohn D.

Appendix A includes the case studies. The case studies summarized in this white paper will be presented in three panel discussions at a workshop titled "Innovative Solutions for Stormwater Capture" on September 27, 2019 at Los Angeles County Public Works. The panels are organized as:

- Panel 1: Multi-Agency Collaboration to Achieve Co-Benefits and Cost-Sharing
- Panel 2: Programmatic Innovations to Enhance Communities and Delivery Efficiency: Alternative Delivery and Financing
- Panel 3: Assuring Sustainable Operations and Maintenance of Stormwater

Appendix B includes the workshop agenda. This workshop will include presentations discussing enhancing water resiliency in Southern California, creating the Clean Water Program, regional stormwater innovations and stormwater quality and regional water sustainability. The workshop will also present the findings of a related white paper on tapping the available capacity in existing infrastructure to create water supply and provide water quality benefits (Jacobs, 2018 & Jacobs, 2019).

Overview of Case Studies

This white paper presents nine case studies covering a range of local, regional, and national projects that include the following areas:

- O&M scenarios and BMPs
- Alternative delivery methods, including financing and programmatic innovations
- Multi-agency collaboration, incorporating multiple benefits and cost-sharing strategies
- Workforce development to deliver and maintain stormwater infrastructure

O&M Scenarios and Best Management Practices

O&M of stormwater management projects is featured in this white paper through a case study of a project at the Port of San Diego (Yescas and Braun, 2019) that required significant consideration of O&M strategies during the design and implementation to address challenges, such as accessibility of the system due to the high-traffic nature of the Port terminal, high tidal influence, and need for adjustability to reduce clogging issues in the system. Additionally, a national overview of O&M Scenarios and BMPs (Beck and Williams, 2019) is also provided and summarizes two successful green infrastructure O&M projects: Onondaga County, New York, and Lancaster, Pennsylvania. These projects provide a plethora of information on successful implementation of O&M, including a number of programmatic elements such as developing low-maintenance design elements, standard materials and specifications, standard operating procedures, staff training, and partnerships.

Lessons highlighted in these case studies include shifting resources and skills to maintain vegetation, setting community expectations, identifying specialty skills and equipment, considerations of access and required precision, standard versus customized materials, maintenance frequency, and asset management.

Alternative Delivery Methods

Alternative delivery can take many forms including alternative forms of financing and non-traditional implementation strategies such as grants and partnerships (public-private, public-public and community-based) to deliver projects and strategies to develop a diverse workforce to deliver and maintain projects. This white paper includes an innovative financing structure using environmental impact bonds in Atlanta, Georgia, examples of emerging alternative delivery forms in Southern California, and a summary of local and national case studies on the intersection of workforce development with green stormwater infrastructure delivery and implementation.

In the City of Atlanta, Georgia (Hallauer et al., 2019), the development of an Environmental Impact Bond (EIB) is providing a creative source of funding to address the lack of dedicated funding sources that can be a barrier to implementation. The EIB provides the Department of Watershed Management (DWM) with access to private investment capital by tapping into a unique sector of community-oriented investors focused on environmental and social impact. EIBs are a form of debt characterized by a Pay for Success component that determines the amount that investors are repaid based on environmental outcomes. Investors in the EIB take on a portion of the risk of project performance and are rewarded in the case of overperformance. While DWM requires the use of green infrastructure projects to cover the impacts of private development and redevelopment that are concentrated in areas of economic investment, the EIB allows for DWM to meet their commitment of adopting equitable water policies and practices to meet the needs of underserved areas of the city.

The city of Atlanta has presented an efficient approach to financing innovative and resilient green infrastructure projects that best mitigate growing stormwater challenges while meeting the needs of local communities that lacked funding and a path to implementation through traditional channels (Hallauer et al., 2019). The funding strategies for these projects have a unique ability to tie the project outcomes with the access to a different and growing set of investors seeking to align their financial returns with environmental and social ones. The public bond issuance represents a major step forward in making this innovative and resilient form of financing more accessible to the broader capital markets.

The Los Angeles Department of Water and Power (LADWP) is developing an alternative delivery program to develop stormwater capture parks through programmatic collaboration between City departments and the community to streamline delivery by pooling potential funding and in-kind services from multiple sources while providing regional benefits (Pettijohn, 2019b). This is accomplished through a programmatic Memorandum of Agreement (MOA) between LADWP and the City's Bureau of Engineering (BOE), as well as individual project MOAs. Another example project includes leveraging the Caltrans Cooperative Implementation Agreement (CIA) Program to fund an $11-million stormwater project in the City of Lakewood, California, to capture up to 623 acre-feet of stormwater per year while achieving benefits for the Los Cerritos watershed, meeting TMDL targets, and providing compliance units for Caltrans to achieve the requirements under their National Pollutant Discharge Elimination System (NPDES) permit (Fussel and Watson).

Additional resources on alternative delivery and funding options can be found at the following locations:

- https://www.epa.gov/G3/financing-green-infrastructure-community-based-public-private-partnerships-cbp3-right-you
- https://www.epa.gov/green-infrastructure/green-infrastructure-funding-opportunities
- https://www.nrdc.org/sites/default/files/stormwater-credit-trading-programs-ib.pdf

Key considerations and lessons common to all of these case studies and alternative delivery programs include the need for high levels of collaboration among partner agencies and stakeholders, assessment and assignment of risk, aligning funding with needs, and developing and tracking performance metrics across both environmental and community objectives.

Multi-agency Collaboration

Three regional and one national case studies on multi-agency collaboration were received:

- Tujunga Spreading Grounds Enhancement Project, Los Angeles, CA (Pettijohn, D., 2019b),

- Bolivar Park Stormwater and Urban Runoff Capture Project, Lakewood, CA (Fussel and Watson, 2019)
- Carriage Crest Park, Carson, CA (Passanisi et al., 2019)
- Historic Fourth Ward Park, Atlanta, GA (Bryant and Stein, 2019)

These case studies demonstrate the tremendous opportunity to achieve multiple benefits through multi-agency collaboration. These include environmental benefits such as water quality improvements (by addressing nutrients, toxins, trash, debris, and sediment problems), runoff reduction, flood and combined sewer overflow abatement, groundwater recharge, generation of supplemental water supply and/or reduced water demand, climate resiliency, TMDL compliance, and, in some cases, remediation of contaminated sites. These case studies also highlight community and economic benefits achieved through collaboration with stakeholders, communities, and partner agencies, such as neighborhood economic revitalization, address vulnerable communities in need, increase aesthetics and recreation opportunities (incorporating trails, new parks, playfields, etc.), increase habitat, increase community connections and, in most cases, provide significant cost savings.

Workforce Development

The increased focus on green stormwater infrastructure (GSI) and stormwater management through regulations and other environmental factors has become a driver requiring the development of a skillful workforce through training and education to design, implement, and maintain stormwater projects. A number of case studies presented (Johnson, et al., 2019) demonstrate the importance of workforce development in delivering green stormwater infrastructure and the opportunities to concurrently drive economic growth, generate green jobs, address equity, and employ communities where infrastructure investments are located. The case studies present successful workforce development efforts in Louisville, Atlanta, Los Angeles, Honolulu, and Seattle and range from programmatic workforce development through water sector capital investment portfolios, training programs, and contractor development. The City of Los Angeles' GSI O&M Certificate Program is designed to educate and train the next generation of workers on sustainable/green practices to improve water quality and stormwater management. The development of this certification program is a way to create a balance between the job demand and supply of skilled young adults in Los Angeles while improving watershed health through the construction and O&M of GSI projects (Johnson, et al. 2019).

Challenges and Lessons Learned

The case studies presented in this paper share common challenges and lessons learned from multi-agency collaboration, such as:

- The need for early and consistent collaboration among agencies, stakeholders, and the community to develop an integrated project approach to deliver multiple benefits. Examples include weekly design meetings with key stakeholders.
- The need for agencies to be adaptive to respond to opportunities that are presented by partners or the community when a collaborative project is identified and developed.
- The challenges of aligning schedules of multiple agencies to integrate projects, regulatory, and funding timelines and funding sources. For example, regulations require spending within a set time frame of receipt of award, which may require full consideration of the procurement life-cycle and creative solutions such as procuring materials prior to bidding a project.
- Development and collaborative amendment of memorandums of agreement to set expectations but respond to potential changes due to issues such as construction bids, project requirements, and

stakeholder interests. This also highlights the advantage of developing cost-sharing agreements that are based on the full design or bids on projects rather than limited to early planning level costs.

- Consideration of overlapping functions in site design, such as determining the location and the frequency of flooding areas in portions of the site where there are multiple uses. For example, allowing passive recreation areas to flood during frequent storms but siting pedestrian facilities outside of the inundation areas to maintain mobility and safety.
- Delegation of O&M responsibilities through interdepartmental partnerships and incorporation of those considerations in the planning and design phases.
- Understanding likely more complex permitting of facilities that serve multiple uses.

Summary and Recommendations

This white paper provides examples of projects describing innovations in implementation of stormwater projects through enhanced O&M strategies, including workforce development to fulfill the needs of project development and implementation to ensure full performance of projects to provide the intended benefits, alternative delivery options, and multi-agency collaboration. The case studies were compiled to gather information and lessons learned from other local, regional, and national projects for implementation of stormwater management projects to provide the benefits to SCWC agencies to foster collaboration and learn from others' experiences (see Figure 1).

The case studies provided a glance of a few example projects showcasing agencies' strong commitment toward innovation, alternate delivery approaches, the environment and communities, and collaborative partnerships to meet stormwater management challenges. The case studies serve as examples for others in the water industry to implement sustainable and multi-beneficial water supply projects. Additional research is needed on a case-by-case basis to further develop innovative strategies that manage stormwater to reduce cost, increase environmental and community benefits, and enhance collaboration across partners and agencies. These strategies linking partners and communities can result in successful stormwater management projects to provide environmental, community, and economic benefits.

Recommendations and Next Steps

The following are recommendations and next steps for expansion and innovation in stormwater project implementation in the region to achieve efficiency while maximizing and maintaining performance that are inferred from the case studies:

1. **Expand stormwater implementation in the context of constrained budgets and site conditions in urban watersheds by:**
    a. **Developing and building innovative BMPs that can be sited to integrate multiple functions and operations in constrained sites that serve competing needs (Yescas and Braun 2019, Passanisi et al. 2019, Pettijohn 2019a)**. Based on the case studies, approaches such as biofiltration units to target pollutants of concern in stormwater along with construction efficiencies need to be explored. Innovative functional and operational components that are integrated with the sites can save significant money and space.
    b. **Developing and leveraging creative funding mechanisms to deliver high-impact, innovative stormwater projects to access non-traditional or partner funding sources (Hallauer et al. 2019, Pettijohn 2019, Fussel and Watson 2019).** Successful implementation of projects hinges on going beyond the traditional approaches to fund green infrastructure projects. Novel

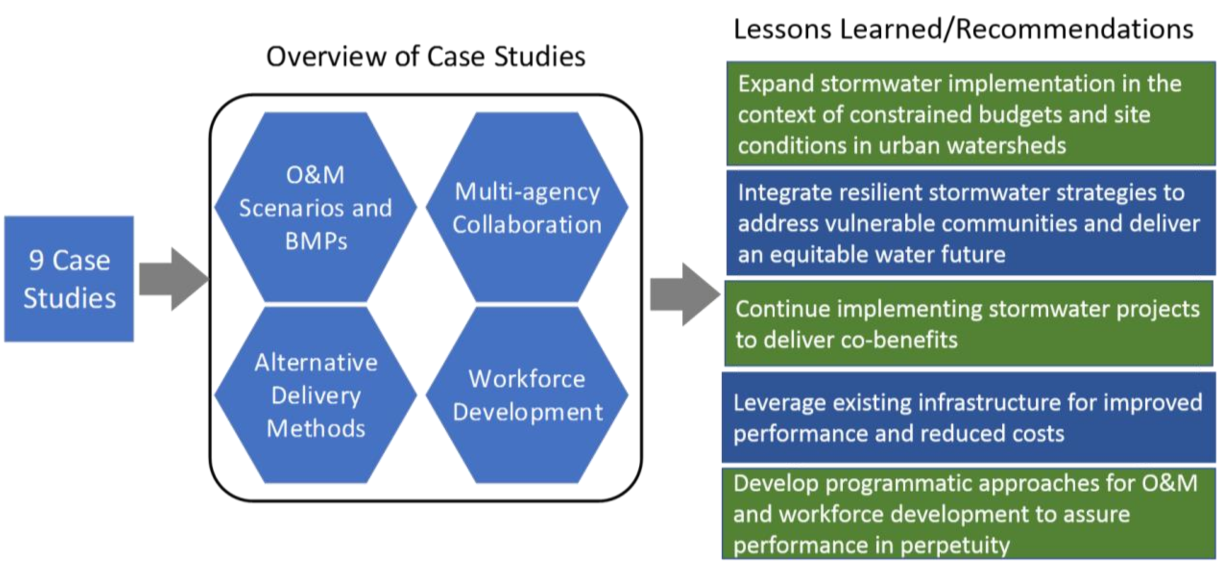
approaches to financing high-impact, innovative resilience projects that lack funding should be developed and used to benefit vulnerable neighborhoods. More accessible innovative finance options for broader capital markets can provide options for resilient solutions.

2. **Integrate resilient stormwater strategies to address vulnerable communities and deliver an equitable water future by:**
    a. **Developing a workforce within communities in need to build, operate, and maintain stormwater management facilities (Beck and Williams 2019; Johnson et al. 2019).** Studies show that water infrastructure and related projects tend to occur in underserved communities that experience inequitable factors that impact their quality of life. The need to train a new workforce to service these projects provides a great opportunity to address these inequities by inviting community member to learn new skills to fill water sector jobs.
    b. **Developing equitable project funding, delivery practices, partnerships, and compliance approaches to maximize project outcomes and benefits by siting improvements not just where development opportunities exist but in underserved communities (Passanisi et al. 2019, Beck and Williams 2010; Pettijohn 2019a, Yescas and Braun 2019, Bryant and Stein 2019).** To meet the needs of underserved areas in the Los Angeles Basin, there is a need for a range of partnerships (public-private, public-public and community-based) to develop sustainable projects that benefit all parties involved.
3. **Continue implementing stormwater management projects to deliver co-benefits through:**
    a. **Pursuing and maintaining multi-agency collaboration including leveraging lessons learned within this white paper regarding cost-sharing, early and consistent coordination with project partners and aligning outreach efforts, permitting and schedules (Fussel and Watson 2019, Passanisi et al. 2019, Pettijohn 2019a, 2019b, Yescas and Brown 2019, Bryant and Stein 2019).** Project proponents can achieve the goals of their stormwater management projects, which broadly relate to water quality, protection of beneficial uses of receiving waters, and water supply. The stormwater management projects also bring maximum economical value with limited environmental impacts. The projects may also include elements to promote public health, educational signage/information, amenities to improve quality of life such as open space, and habitat restoration for environment awareness.
    b. **Engaging communities in the development, planning, and design of projects to address community needs and concerns (Bryant and Stein 2019, Pettijohn 2019a).** A growing trend in stormwater management is the development of multi-beneficial stormwater parks that address insufficient infrastructure that can affect vulnerable communities while providing additional environmental and community benefits.
4. **Leverage existing infrastructure to optimize and improve performance while reducing costs and impacts to communities, for example:**
    a. **Optimizing groundwater basins for recharge to maximize supplemental local supplies (Pettijohn 2019a 2019b).** Optimization of groundwater recharge facilities is needed to infiltrate stormwater and recycled wastewater through spreading basins to supplement Southern California water supplies that will enhance urban water resiliency. Using stormwater to produce replenishment water, which can be used at the groundwater recharge basins, promotes a diversified water portfolio approach to generate sustainable water supplies with minimal risk, less energy, and smaller carbon footprints compared to the imported water supplies.

   b. **Maximizing the use of existing wastewater systems to capture urban runoff/stormwater to generate recycled water (Passanisi et al., 2019).** To enhance the generation of recycled water with diverted stormwater by utilizing the available capacity of the wastewater infrastructure, Jacobs completed Phase 1 of a study that provided a high-level analysis to understand the possibilities of connecting the stormwater collection system to the sewage collection and treatment systems at strategic locations (Jacobs, 2018). Phase 2 of the study is in progress (Jacobs, 2019).

5. **Develop programmatic approaches for O&M of stormwater infrastructure to assure performance in perpetuity while reducing costs, such as:**
   a. **Developing demand-led workforce development strategies including training of contractors, inspection and maintenance staff (Beck and Williams 2019, Johnson et al. 2019).** With the growing need for the development of stormwater management projects, there is a shortage of staff for O&M of those facilities. Training and certification programs, which offer a way to create a balance between the job demand and supply of skilled young adults in Los Angeles while improving watershed health through the construction and O&M of GSI projects, need to be prioritized. Professional training and recruiting, development of small contractors, and partnering with community-based organizations provides capacity for maintaining this infrastructure.
   b. **Integrating O&M considerations throughout the life-cycle of projects (Beck and Williams 2019, Yescas and Braun 2019).** To improve life-cycle cost efficiency and increase performance, long-term O&M of stormwater projects should be considered during from planning through implementation.
   c. **Developing standardized procedures, equipment, materials, details and specifications that may be adapted to lessons learned but drive consistency (Beck and Williams 2019).** Such standardization is benefited by collaboration across regional entities to provide more consistent supplies and suppliers to support long-term maintenance. Programmatic approaches for O&M may help improve consistency and reduction of the maintenance burden in the long run.

Figure 1: White Paper Overview



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Additional Information

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http://waterresilience.ca.gov/

https://www.socalwater.org/stormwater/

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Appendix A: Case Studies

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Bolivar Park Stormwater and Urban Runoff Capture Project

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Executive Summary

The Bolivar Park Stormwater and Urban Runoff Capture Project (Project) is a multi-benefit project whose intent is to capture all dry-weather flows and the first flush of wet-weather flows, comply with copper and zinc total maximum daily load (TMDLs), assist with meeting bacteria removal goals, and reduce the amount of potable water use for park irrigation.

The Project was the first to be completed through the California Department of Transportation (Caltrans) Cooperative Implementation Agreement (CIA) Program. The Project site was not originally identified in the Los Cerritos Channel (LCC) Watershed Management Plan (WMP) due to its distance from the LCC. Through initial 10 percent design and research, the site was determined to be feasible and a preferred site since it could replace nearly all the onsite potable water used for irrigation and provide infiltration. In the end, the Project addresses water quality, water resiliency, and flood control.

The Project captures discharges from 3,018 acres of the Los Cerritos Channel Watershed. Refer to Figure 1 for the project drainage area. In addition to the City of Lakewood, the tributary area includes portions of four other municipalities. The overall watershed draining to Bolivar Park includes Bellflower (7 percent), Downey (8 percent), Lakewood (30 percent), Long Beach (27 percent), and Paramount (29 percent). The total construction cost was approximately $8.8 million. The cost per year for operation and maintenance (O&M) is estimated to be approximately $90,000 per year.

Figure 1. Drainage Area

Project Description

<u>Project Background</u>

The LCC Watershed is a largely urbanized watershed of approximately 17,711 acres in the Los Cerritos and Alamitos Bay Watershed Management Area. The LCC Watershed Management Group consists of the cities of Bellflower, Cerritos, Downey, Lakewood, Long Beach, Paramount, and Signal Hill, as well as the Los Angeles County Flood Control District (LACFCD). Caltrans participates with the group on an informal basis.

The Los Cerritos Watershed Group developed a WMP as a collaborative effort pursuant to the National Pollutant Discharge Elimination System (NPDES) Municipal Permit. The WMP was developed to ensure that discharges from the watershed will achieve compliance with the water quality goals, including applicable TMDLs, of the NPDES Permit. On April 28, 2015, the LCC Watershed WMP was conditionally approved by the Los Angeles Regional Water Quality Control Board (LARWQCB).

The highest priority pollutants addressed by the WMP are the metals in LCC, metals TMDLs established by the U.S. EPA, and the metals and legacy organics in the Harbor Toxics TMDL adopted by the LARWQCB. The WMP addresses these and other pollutants through a multifaceted strategy that includes water capture and infiltration, as well as water capture and use. For the Bolivar Park study area, zinc and bacteria were found to be the limiting pollutants.

The Watershed Group chose to emphasize dry-weather urban runoff and stormwater capture and infiltration or use over treatment to comply with metals TMDLs while addressing other pollutants and water supply issues. To provide the flexibility to use captured dry- and wet-weather urban runoff in case infiltration is infeasible, the Watershed Group proposed locating water capture facilities under parks and golf courses.

Project Objective

The main objective of the Project is to improve water quality and help the City of Lakewood meet the requirements set by the WMP. A secondary objective is to reduce the amount of potable water use for the irrigation of the park and nearby public open spaces.

Project Details

The Project consists of an inflatable rubber dam and a grated drop inlet located within the channel to capture dry-weather flows and a portion of wet-weather flows. The captured stormwater is conveyed through an actuated valve to a pretreatment device, then to a 20 cubic feet per second (cfs) pump station. The diverted stormwater is then pumped into an underground cistern where it can be stored for water harvesting and infiltration. During non-rain events, the stormwater is stored, then pumped and treated by a water treatment system. The system is tied to the City of Lakewood's supervisory control and data acquisition (SCADA) system and has the ability to read weather information to preemptively move water from the storage area to the infiltration area to make storage available for an upcoming storm.

Among metals and bacteria, zinc was identified as the pollutant of concern for the Project study area and was used as the basis for water quality benefits and performance evaluation. The zinc load entering the LCC varies depending on the size of the storm and the number of dry days between storms. The Critical Water Year 2003 was used in accordance with the LCC WMP to analyze zinc loading and potential water quality improvement.

Water quality improvement is dependent on the amount of runoff volume that can enter and be treated by the system. To establish the diversion rate, the underground cistern was assumed to be built at the maximum possible footprint as identified by the City of Lakewood. Doing so determined the maximum possible pollutant removal achievable at the site and the recommended diversion. An analysis to compare diversion rates and the expected pollutant removal was performed to determine the optimal diversion rate using the U.S. EPA System for Urban Stormwater Treatment and Analysis Integration (SUSTAIN). Based on the diversion rate analysis, the maximum recommended diversion rate was 20 cfs. The water quality impacts begin to diminish while cost and channel impacts increase at diversion rates beyond 20 cfs. Figure 2 presents the results of the diversion rate analysis.

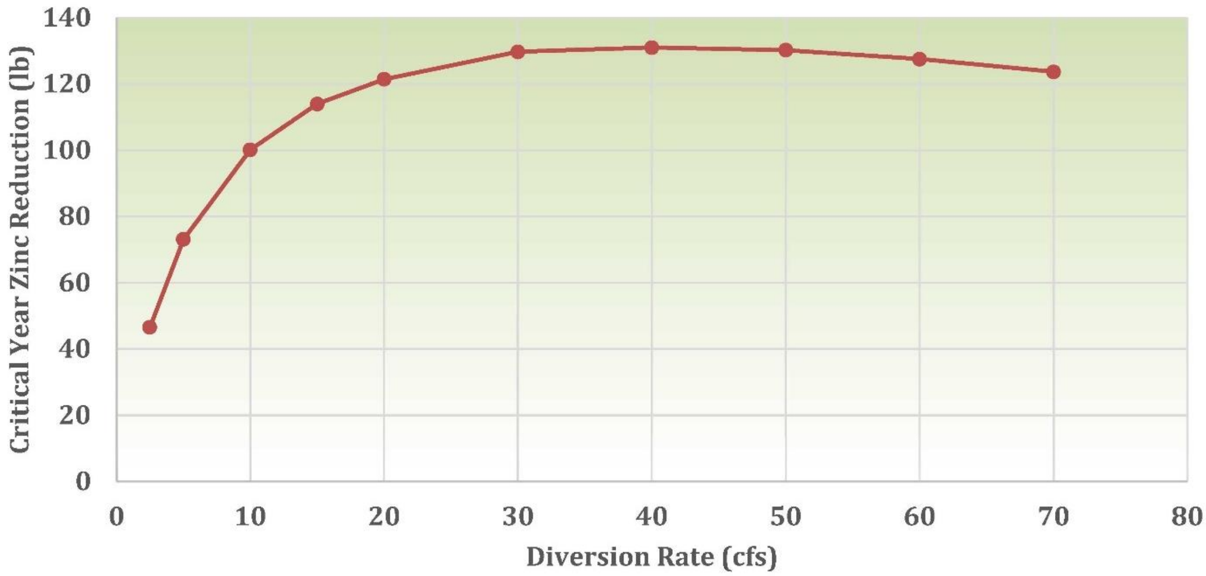

Figure 2. Diversion Rate versus Zinc Removal

The pretreatment device selected for this project was the debris separating baffle box (DSBB) by Bio Clean Environmental Services. The DSBB system uses screens suspended above sedimentation chambers to capture and store trash and debris in a dry state, thus reducing potential nutrient leaching and bacteria growth. Total suspended solids (TSS) are removed by routing the flows through the triple-chambered system. An oil skimmer with hydrocarbon booms traps and absorbs oil. The DSBB can remove more than 80 percent of TSS.

The underground pump station was designed to have three duty pumps, each capable of pumping 50 percent of the peak design flow. In the event of a single pump failure, the two remaining pumps will be capable of conveying the design flow. Operations will allow for routine cycling of the pumps to evenly maintain operations for all pumps equally. Additionally, a single low-flow pump is provided to dewater the pump station.

The underground cistern was constructed with StormTrap modular concrete units. During the diversion analysis, it was determined that the cistern should be built to the maximum footprint size at a 20 cfs diversion rate since it is on the rising limb of the zinc reduction curve, shown in Figure 3. The cistern footprint is approximately 0.89 acres and can hold up to 8.93 acre-feet (2.9 MG). Approximately 30 percent of the cistern allows for storage while approximately 70 percent of the cistern allows for infiltration. The storage and infiltration areas are separated with a weir wall.

The water treatment system for this project, provided by Water Harvesting Solutions (Wahaso), was designed to filter and sanitize stormwater and urban runoff for irrigation use, complying with National Sanitation Foundation (NSF) 350 standards for non-potable water, as well as Los Angeles County Department of Health Tier IV water quality standards. Treatment involves a two-step filtration process and sanitation. First, a mechanical filter removes most of the sediment and particulates greater than 50 microns. Then, a second filter removes the remaining particulates down to 5 microns. Finally, the captured stormwater is sanitized using ultraviolet (UV) treatment. The treated water is then distributed to the irrigation system via pumps.

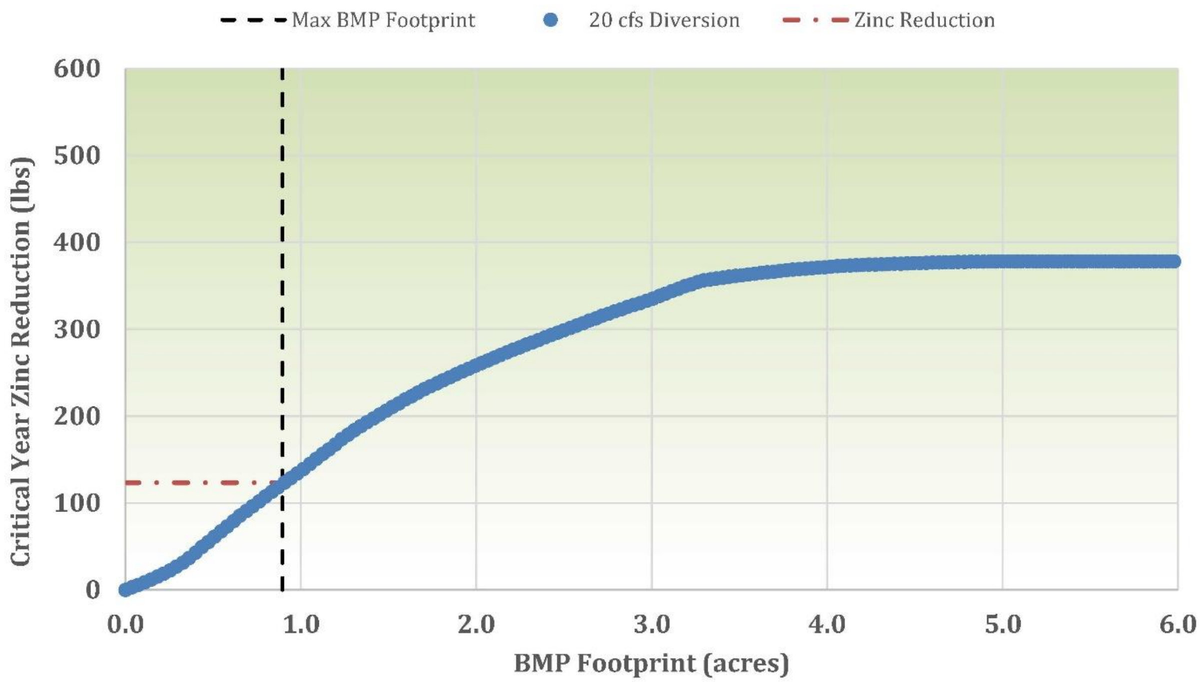

Figure 3. Underground Cistern Footprint versus Zinc Removal

It is projected that the Project will capture approximately 623 acre-feet of stormwater per year. Table 1 summarizes the anticipated water quality improvements of the Project. Groundwater recharge is estimated to range from 150 to 500 acre-feet per year. Approximately 98–100 percent of potable water use for irrigation is offset by the Project, resulting in an annual savings of about $45,000.

Table 1. Critical Year Removal Statistics

Constituent	Units	Critical Water Year 2003 Inflow	Reduction	% Reduction
Volume	ac-ft	3,421.4	623.0	18.2%
Zinc	lbs	3,857.7	220.0[1]	5.7%[1]
Copper	lbs	596.4	15.4	2.6%
Lead	lbs	489.0	14.8	3.0%
Bacteria	MPN	2.95×10^{15}	1.74×10^{14}	5.9%

[1] With the implementation of real-time controls

<u>Funding Sources</u>

The City of Lakewood entered a CIA with Caltrans to accept up to $11 million to fund the design and construction of a water capture facility to comply with the metals TMDLs for the LCC. The Watershed Group was fortunate to be able to work with Caltrans on initial implementation of the CIA Program that was added to the Caltrans Statewide Stormwater Permit in 2014 as part of an amendment to address TMDL requirements. In the amendment, the Department was encouraged to establish agreements for cooperative implementation efforts with other parties with TMDL responsibilities. The amendment contained a requirement to achieve a minimum of 1,650 compliance units per year and provided an economic incentive for Caltrans to achieve some of these units through CIAs. The Watershed Group worked with Caltrans to develop and implement the first two CIAs in the state. The CIA funds were used for the design and construction of a facility at Bolivar Park. The construction cost of the Project was approximately $8.8 million. In turn, Caltrans was credited with compliance units from the State Water Resources Control Board as specified in the Caltrans NPDES Permit.

Collaboration

As part of the CIA, there are strict schedule requirements to keep the Project on schedule and meeting funding milestones. The team was able to complete the concept design in 3 months and the detailed design in 6 months.

Some of the challenges associated with the schedule were working with LACFCD and the Los Angeles County Department of Public Health (LACDPH). LACFCD permits and easements were required for the work in the channel and to construct the pump station within their parcel. Since this Project was one of the first regional stormwater capture and reuse projects in Los Angeles County after the 2012 municipal stormwater permit was adopted, there was a lot of collaboration with LACDPH during design and throughout construction. Richard Watson & Associates and Tetra Tech met with LACDPH to discuss LACDPH's concerns with the treatment and use for spray irrigation of the captured stormwater. The LACFCD also required the team to collaborate with and obtain approval from agencies such as the Drinking Water Division of the California State Water Resources Control Board, LARWQCB, Los Angeles County Sanitation District, and the Greater Los Angeles County Vector Control District. The LACDPH also required sampling of the treated stormwater to ensure NSF 350 standards are met.

Project Delivery Model

The City of Lakewood used the design-bid-build project delivery model for the Project. The Project was designed by Tetra Tech and constructed by Reyes Construction.

Project Status

Construction of the project was completed in the summer of 2018 and has been in full operation since.

Lessons Learned

In working with Caltrans, the Watershed Group learned a great deal about Caltrans' procedures and CIA criteria, making it possible for cities to secure two additional CIAs when most other agencies across the state were not able to do so. The Group also learned that Caltrans needs a dedicated revenue stream for implementation of CIAs to improve the process statewide.

This Project was one of the first regional stormwater capture and reuse projects to be constructed in Los Angeles County after the current stormwater permit was adopted. Therefore, several lessons were learned during the design process.

One such lesson is how to appropriately integrate real-time controls (RTCs) into a water capture project. RTCs operate by relaying real-time monitoring data, such as water level and flow, from onsite sensors to cloud-based software. Based on predicted rainfall forecast downloaded from National Weather Service climate models, the software automatically regulates onsite control hardware (such as valves, gates, or pumps) based on configurable and adaptable logic. Rapid, predictive, and responsive control provides "hard" infrastructure with flexibility and resiliency that could not otherwise be achieved through traditional hydraulic structures, such as orifices, weirs, and manually operated gates. Through WMMS and SUSTAIN modeling, the design team determined that RTC can boost zinc reduction by 20 percent. Although costs are increased for instrumentation and controls, RTC technology enables the 0.89-acre cistern to perform as if it were a 1.6-acre cistern, maximizing the return from capital investments.

Another lesson was gaining a better understanding of the permitting process. From this project experience, we are more aware of the components required by various agencies for the system to operate appropriately. For example, the Vector Control District required flap gates at various locations as well as maintenance hole covers without pick holes to eliminate entry points for mosquitos. Another example is LACFCD's request for actuated valves to have a manual override. As a result of this Project experience, we are able to include such components early on to other similar projects to eliminate potential comments and decrease review time.

The Project serves multiple jurisdictions. The rubber dam and diversion structure are located in the LCC, which is owned and maintained by the LACFCD. The actuated valve, pretreatment device, and pump station are within an LACFCD parcel. Since the project is for the City of Lakewood, a maintenance agreement was required. The agreement had to clearly spell out maintenance terms, identifying who was responsible for maintaining the system and its various components.

Case Studies on the Intersection of Green Stormwater Infrastructure and Workforce Development

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Introduction

Implementing a stormwater infrastructure capital program requires a significant increase in workforce to deliver the necessary infrastructure assets and maintain them in perpetuity. A challenge facing developing programs is finding the workforce to deliver cost-effective, quality work. This, however, also presents an opportunity for workforce program development to drive economic growth, generate green jobs, address equity, and employ the communities where infrastructure investments are located.

This white paper highlights programs where comprehensive, demand-led workforce development programs created by utilities support capital infrastructure investments, mitigate impacts on diverse communities, and address preexisting inequities. This white paper presents case studies that explore multiple approaches, from programmatic planning for workforce development to professional training and recruiting, developing small contractors, and partnering with community-based organizations to provide capacity for planning, building, and maintaining green infrastructure.

Project Description

Communities prosper when all people have access to clean water; good jobs; and viable, economic opportunities. Water sector leaders nationwide are maximizing the capital spent on water infrastructure to work toward equity by being intentional about providing employment, job opportunities, and economic revival. Water and wastewater agencies are anchor institutions in cities nationwide with untapped potential to drive economic growth and create jobs in the communities they serve. In collaboration with contractors, workforce agencies, and community-based organizations, utilities are in a unique position to impact the workforce through mandated federal consent decree projects and capital improvement programs worth billions of dollars.

According to a recent water workforce study by the Brookings Institution,[1] 50 percent of the nation's utility workforce will retire in the next 5 to 10 years, and approximately 64,000 utility employees may need to be replaced over the next 5 years due to retirement and attrition. This mass exodus of talent

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[1] Joseph W. Kane and Adie Tomer, "Renewing the Water Workforce: Improving Water Infrastructure and Creating a Pipeline to Opportunity," Brookings Institution, June 2019, https://www.brookings.edu/research/water-workforce/

creates a tremendous need to replace the current water workforce with new, skilled talent. Utilities nationwide face a human resources gap because water professionals, who tend to be older, have not trained younger people to develop the necessary skills to design, construct, operate, or maintain water infrastructure. This resource gap has created a need for workforce development in the water sector.

Coupled with this need, studies also show that water infrastructure and related projects tend to occur in underserved communities that experience inequitable factors that impact their quality of life. Water-related challenges such as storm events, flooding, water quality, and the location of water infrastructure projects have disproportionately impacted vulnerable communities throughout the United States for decades due to historic redlining. The U.S. Water Alliance defines vulnerable communities as those that face historic or contemporary barriers to economic and social opportunities and a healthy environment, with some of the key factors being income, race or ethnicity, age, language ability and geographic location. These communities tend to have lower income, limited education, affordability challenges, and high unemployment. Equitable workforce development is needed to address and correct the disproportionate impact of these factors on underserved communities.

The need to train a new workforce to service the water sector is a great opportunity to address these inequities by inviting community members to learn new skills to fill water-related jobs. Doing so is mutually beneficial to both the water sector and underserved communities because it provides the resources utilities need; creates jobs for residents and ratepayers, equipping them with new skills that increases their access to a variety of career opportunities; improves their ability to make a living wage; and improves their overall quality of life. Communities benefit through reduced unemployment rates; increased local, qualified talent; reduced recidivism; and improved economy.

Workforce Development Approach for Green Stormwater Infrastructure

Identifying the Demand for Workforce Development

The key to successfully employing community members on water infrastructure projects is identifying the demand and skills needed and developing a demand-led workforce development program to ensure there are real job opportunities available. Forecasting job needs also ensures that utilities are providing training in high-demand skill areas.

To develop a demand-led workforce program, utilities must evaluate their capital improvement and consent decree needs, identify specific projects and related skill craft areas necessary to complete them, develop a list of projects over a specified time frame (e.g., 1 to 5 years), and identify the number of staff required. Next, utilities must partner with local stakeholders and training centers to train local residents in the skill areas needed prior to project execution.

Evaluating the Available Supply

Utilities can find supply resources within their service area. There are diverse communities with a variety of residents, skill sets, and needs. Utilities can evaluate the available resource supply by conducting a local landscape assessment to identify residents interested or in need of training and job opportunities and assess their current skills.

Conducting a Gap Analysis

Once supply and demand is identified, utilities can complete a gap analysis to determine training needs and prepare the available pool of candidates for upcoming projects or ongoing maintenance. Utilities can fill gaps through training and mentorship opportunities for residents in their service, particularly in underserved neighborhoods with high unemployment. Working with local, community-based organizations; workforce boards; and stakeholders is a critical step to assessing gaps and successfully engaging, training, and employing local residents.

Monitoring and Adaptive Management

Developing systems and workforce reporting tools to manage supply and demand pools is critical to the success of a water workforce development program. After completing a gap analysis, utilities must set performance metrics and goals and document the performance and effectiveness of the program. Executing a water workforce program with a detailed approach and a community lens is critical to achieving results and making a meaningful positive impact.

Utilities Successfully Executing Water Workforce Programs

Utilities have a unique opportunity to go beyond their traditional mandate of providing clean water to rate payers and serving as anchor institutions that can boost the economy, create jobs, and expose a new generation to careers in the water sector.

Louisville Metropolitan Sewer District

The Louisville Metropolitan Sewer District (MSD) is a utility leader in workforce development and community benefits. MSD is a premiere example of a utility maximizing investments in water infrastructure to improve the quality of life in communities throughout its service area. A regional wastewater, sewer, and storm utility serving nearly 750,000 residents, Louisville MSD's service area includes vulnerable communities facing a variety of challenges related to water—including aging infrastructure and flooding due to storm events—accompanied by high unemployment. Due to the disproportionate impact of these and other related factors, Louisville MSD is leveraging its $4.3-billion capital investment in water infrastructure to address inequity through economic inclusion, job creation, and workforce development.

To meet the workforce needs of the utility and local contractors, Louisville MSD developed a Community Benefits Program to provide skill training opportunities for residents to prepare them to work on local capital improvement projects. The Louisville MSD has also adopted a community benefits policy in its procurement practices that incentivizes consultants to contribute resources, volunteer hours, or funding to local communities in conjunction with water infrastructure projects. Louisville MSD's programmatic approach to workforce development encompasses several elements, including a water equity roadmap illustrating a path to increasing opportunities for underserved communities; an annual workforce convening with local and national stakeholders; *MSDJobLink,* an online job portal to connect contractors to the community; and education and training programs for youth, second-chance citizens, and underserved communities. Louisville MSD's unique approach to merge utility workforce needs with the economic needs of diverse communities has produced emerging results that other utilities are modeling nationwide.

City of Atlanta Department of Watershed Management

The City of Atlanta Department of Watershed Management (DWM) is a regional water, wastewater, and stormwater authority serving 1.2 million customers daily. The DWM manages one of the largest water capital improvement programs in the country at an estimated cost of approximately $4 billion. With a staff of 1,500, DWM has an annual vacancy rate of 10 to 12 percent in its employee workforce, in addition to a 44.9 percent vacancy rate in operations. DWM also has an aging workforce, in which nearly 50 percent of its employees are eligible for retirement. As a result, DWM aims to accomplish several workforce objectives, including developing a local pool of resources for contractors and a green infrastructure strategic action plan to incorporate environmentally sound engineering best practices into stormwater management planning.

In 2015, City of Atlanta DWM developed a workforce development program titled STREAM WORK: Superior Training, Recruitment and Access to Meaningful Work. The goal of this program is to develop an internal and external workforce plan to create a sustainable pipeline of new candidates and improve professional development and training opportunities for existing employees. STREAM WORK has six workforce objectives: professional development, educational training, job analysis, position analysis, supervisory training, and performance management training. City of Atlanta DWM has developed several workforce tracts in support of STREAM WORK, with the goal of implementing a comprehensive workforce program where each tract contributes to accomplishing the utility's overall strategic workforce goals.

DWM has proposed six separate projects, employing a variety of green infrastructure practices that were identified through community planning efforts. The project objectives identified by the community include creating jobs for local residents and increasing community resilience.

LA Sanitation and Environment

The City of Los Angeles' LA Sanitation and Environment (LASAN) has implemented a broad array of green stormwater projects to improve water quality and provide other community benefits. LASAN's mission is to lead by example in the implementation of green infrastructure best management practices for urban runoff management through education and technical project implementation.

To enhance and strengthen the existing institutional capacity of LASAN's watershed protection program, the agency has developed a "Green Stormwater Infrastructure Academy." In coordination with Los Angeles Trade Technical College, the certification program helps to provide a career path and gain credentials necessary for job readiness and to fulfill the workforce needs of the City to operate and maintain green stormwater infrastructure (GSI) projects. The training curriculum provides a foundation of practical and technical information needed for the operation and maintenance (O&M) of GSI facilities.

A pilot training program in partnership with Los Angeles Trade Technical College was conducted, and City staff of various job classifications were invited to provide feedback on the curriculum and to share knowledge and experiences from their current roles and responsibilities in GSI maintenance.

City and County of Honolulu Stormwater Inspection Training

As implementation of GSI increases in the City and County of Honolulu, the City recognized the need to train staff for construction and post-construction inspection of green infrastructure, to provide additional technical resources to field staff, and to train property owners and managers who must maintain best management practices on private property.

While City staff are well trained and adept at plan review and inspection for traditional "gray" stormwater infrastructure, they have less experience and institutional knowledge of plan review and construction inspection for GSI. Staff received a combination of classroom lectures, design exercises, and mock field inspection to learn the unique aspects of GSI design and construction.

Private property owners and managers with permitted green infrastructure must inspect and maintain that green infrastructure to ensure long-term performance. The City's stormwater program created an on-line training to educate property owners about appropriate O&M procedures and provided classroom and field training to City staff to identify if green infrastructure facilities require maintenance.

Washington State Department of Ecology

As permit requirements have changed in western Washington to require the implementation of low-impact development, the professional design community has needed new skills to implement the permit requirements. The Washington State Department of Ecology supported new permit requirements by creating trainings to educate designers, plan reviewers, and maintenance staff regarding design and construction of green infrastructure. Particularly valuable were small group classroom exercises that gathered class participants in small teams to practice the skills presented.

Seattle Case Study: Dirt Corps

The City of Seattle and King County Race and Social Justice Initiative, and the Equity and Social Justice Strategic Plan, respectively, are seeking opportunities to develop meaningful and community-driven approaches, with a focus on health and employment while providing improvements to green infrastructure and open spaces. One of the main determinants of health is access to employment. This effort can be extended to include a more inclusive approach to green infrastructure design, construction, and O&M through employment development, recruitment, apprenticeship, and training.

Nationally, regionally, and locally, green infrastructure is critical to decreasing the incidents of flooding, polluted runoff, erosion, or other manifestations of climate change on the built environment. In the Seattle and Puget Sound region, successful planting and ongoing plant maintenance efforts are critical to increasing neighborhood resilience to the effects of climate change and absorbing stormwater runoff. Seattle's Duwamish Valley, which is a predominantly low-income residential area in close proximity to industrial properties, carries a higher burden of social, environmental, and economic impacts.

In 2015, as part of the 2018 Combined Sewer Overflow Long-term Control Plan Update, Urban Systems Design (USD) published "Duwamish Valley Green Infrastructure Job Training Program" to explore the creation of a locally focused Green Infrastructure Job Training Program and the financial and logistical establishment of a permanent green infrastructure job training program for Duwamish Valley residents. Since 2005, USD has worked with Duwamish Valley neighbors, agencies, and organizational partners to design and install four voluntary "green street" roadside rain garden projects in the road right-of-way.

To address the need for ongoing maintenance of community-led green infrastructure, USD created the DIRT Corps program in 2015 as part of its consulting firm and wrote grants and received fee-for-service contracts to fund the training program. With educational and training partners as part of the program development, DIRT Corps provided hands-on training to young women, people of color, LGBTQ people, and others outside of the typical landscape or construction career paths. To date, over 90 people have successfully completed the program and gone on to start their own businesses, join landscaping firms, work for municipalities, return to school, or other pursue other opportunities. In 2019, DIRT Corps LLC separated from USD and became a licensed and bonded design and construction company and continues to seek ongoing funding to run the training program.

Recommended sustainable financing approaches to provide GSI training and ongoing maintenance could include a local nonprofit acting as a fiscal sponsor for funding from foundations, governments, or private sector donors; a private company providing classroom and field-based curriculum with on-the-job training toward employment; and a public-private partnership model where a private firm is hired to train workers to design, build, and maintain large areas of green infrastructure to meet a municipality's requirements for preventing discharges. Additionally, academic institutions or technical trade programs could also partner with municipalities to provide accreditation and certification of program graduates.

As multiple agencies and stakeholders proceed with implementing infrastructure improvements, sediment cleanups, and habitat restoration activities across the Duwamish Valley and the wider Puget Sound region, there is an opportunity to develop a strategy to sustainably fund a green infrastructure job training program in disadvantaged communities impacted by these projects. Green infrastructure can provide employment opportunities that are readily accessible to young adults. Creating a locally focused green infrastructure job training program for design, construction, and maintenance would support multiple social, economic, and environmental outcomes of importance in the community.

Seattle Conservation Corps:

Seattle Public Utilities (SPU) has a history of working with the Seattle Conservation Corps (SCC), which has been in operation since 1986 as a division of Seattle Parks and Recreation. SCC focuses on employment training and supportive services for homeless adults in Seattle who are racially diverse, in a wide range of ages. SCC enrolls members into a 1-year work training program, paying minimum wage plus premium pay for 40 hours a week. SCC provides work experience, education, training, and support services that lead toward stability and self-sufficiency. After 11 months in the program, members transition to job search and job placement. SCC has an impressive placement in full-time jobs with benefits. Additionally, several SCC members are hired into permanent employment at the City, in an ongoing effort to strengthen the employment pathway from SCC to SPU.

SCC has supported the City's GSI program for over 16 years and conducts vegetation management of GSI, concrete work, hydrant and irrigation system management, large capital improvement program retrofit projects, problem solving, and working with the community in diverse neighborhoods that are highly impacted by homelessness. The crew offers improvements to SPU projects, takes pride in SPU's work, and always looks for efficiencies. The SCC program teaches participants how to build schedules and routes; they learn to be nimble and work in unforeseen conditions and develop patience and drive to see projects through. At times they work alongside SPU drainage and wastewater crews, and they learn and excel at communication skills in a team environment and with our community, which can be challenging. SCC members develop budgets, including tracking, invoicing, and developing scopes and clarifying work.

SCC supports the Race and Social Justice Initiative to deliver inclusive and equitable service to customers across the City. In this way, Seattle's Environmental Justice and Service Equity Division plays an important role in delivering SPU's promise to customers. SPU's three key strategies to GSI asset management are as follows:

- Embed race and social justice and service equity across SPU
- Work to include under-represented groups when working with communities
- Continue to align efforts within SPU with other City, County, and community efforts

RainWise Program and Multicultural Contractor Mentoring with ECOSS (formerly known as the Environmental Coalition of South Seattle)

The RainWise program, a partnership between SPU and King County Water Treatment Division (WTD), is nationally recognized as a leader in providing incentives for private property owners to install small-scale GSI (rain gardens and cisterns) to help control stormwater pollution. ECOSS is a nonprofit in South Seattle, providing multilingual and multicultural outreach to diverse communities across western Washington. ECOSS provides targeted outreach and training to diverse landscape contractors so they can become RainWise contractors, so that customers who speak these languages feel comfortable participating in the government rebate program. As a result of an ongoing effort to maintain a diverse contractor pool and provide support through training and coaching, RainWise now has four Vietnamese-speaking contractors, two Chinese-speaking contractors, and nine Spanish-speaking contractors in the RainWise contractor pool.

Summary

The increased focus on GSI and stormwater management through Clean Water Act regulations and other environmental factors has become a driver requiring the development of more skills training and education to design, implement, and maintain stormwater projects. Public agencies across the country have developed a range of workforce development strategies, depending on each agency's particular need.

The water sector is a viable network of anchor institutions with capital spending in the billions of dollars and the ability to impact workforce development, economic inclusion, and equitable employment in meaningful and measurable ways. Workforce development in the water sector is a great opportunity to increase income, access, and upward mobility for underserved communities. Water sector leaders play a key role in this space and have incredible stories and best practices to share.

Financing Resilience in Atlanta using an Environmental Impact Bond

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Introduction

The City of Atlanta Department of Watershed Management (DWM) has identified a $40-million to $60-million annual need for stormwater and watershed capital improvement projects, as well as operations and maintenance. These projects are needed to keep up with aging infrastructure, manage growth, and adapt to climate change. The City and DWM recognize that stormwater problems, if left unaddressed, may impede economic development and the quality of life for the citizens of Atlanta. Unfortunately, like many communities, lack of dedicated funding sources is a barrier to implementing the full range of stormwater management strategies (ASCE, 2014), which necessitates finding creative sources of capital. One avenue DWM identified was an Environmental Impact Bond (EIB).

High volumes and velocities of stormwater runoff degrade waterways, affect public health, and cause flooding and infrastructure and property damage, threatening the City's resilience. Further, due to climate change, Atlanta is experiencing more frequent and severe storms (NOAA, 2019). The City is committed to the use of green infrastructure (GI) as a best management practice (BMP) to supplement traditional gray infrastructure projects for stormwater management. GI projects incorporate natural systems into the built environment and/or seek to restore the natural hydrology of watersheds prior to urbanization. GI projects can be more cost-effective than gray infrastructure approaches and better address neighborhood-scale impacts of stormwater, as well as providing multiple additional benefits, including air quality, access to greenspace, community enhancement, and economic and workforce development. In 2017, the Atlanta City Council adopted a GI Strategic Action Plan to advance the use of GI across departments. To cover the impacts of private development and redevelopment, DWM now requires the use of GI practices, resulting in millions of gallons of stormwater runoff reduction City-wide. However, projects permitted via this regulation are concentrated in areas of economic investment and are not equitably distributed throughout the City. As the member utility for one of six cities on the U. S. Water Alliance's Water Equity Taskforce, DWM is committed to adopting equitable water policies and practices and, as such, must seek alternative strategies and partnerships to meet the needs of underserved areas of the City.

In 2018, through a partnership with 100 Resilient Cities pioneered by the Rockefeller Foundation, the City of Atlanta was selected to launch Green Stormwater Infrastructure (GSI) and other resilience projects using innovative EIB financing –the first municipality to do so through a public offering and only the second municipality, after Washington, DC, to take advantage of the new EIB model (Barrios and Cohen, 2018). A Rockefeller Foundation grant funded the services of impact investment firm, Quantified

Ventures, to help Atlanta coordinate and structure the deal, and municipal finance specialists, Neighborly Corporation, to underwrite and market the bonds (Neighborly Corp., 2018). This financing model provided DWM access to a new source of private investment capital by tapping into a unique sector of community-oriented investors focused on environmental and social impact. DWM will use the $13.5 million in proceeds to finance six GI projects in the combined and separate sewer areas of the upper Proctor Creek watershed, an area on the Westside of the City with high rates of poverty that has been disproportionately impacted by flooding, combined sewer overflows, and environmental degradation (Park Pride 2010, GreenLaw, 2012). The EIB-funded projects consist of a mix of ecosystem restoration and urban stormwater BMPs (bioretention in parks and streetscapes and constructed wetlands) aimed at improving the health and resilience of Westside communities.

EIB Structuring and Performance Terms

EIBs are a form of debt characterized by a pay for success component that determines the amount that investors are repaid based on environmental performance. Investors take on a portion of the risk of project performance and are rewarded in the case of overperformance. Investors in EIBs, or purchasers, receive principal and interest as with a traditional debt issuance. In addition, an EIB is structured with performance tiers bounded by key performance thresholds of a designated outcome metric – in Atlanta's case, the cumulative new volume of stormwater storage capacity of all six projects. The payment of a performance payment is tied to the achievement of these pre-determined environmental outcomes, as verified by a third-party evaluator. Figure 1 depicts a schematic overview of how the Atlanta EIB is organized.

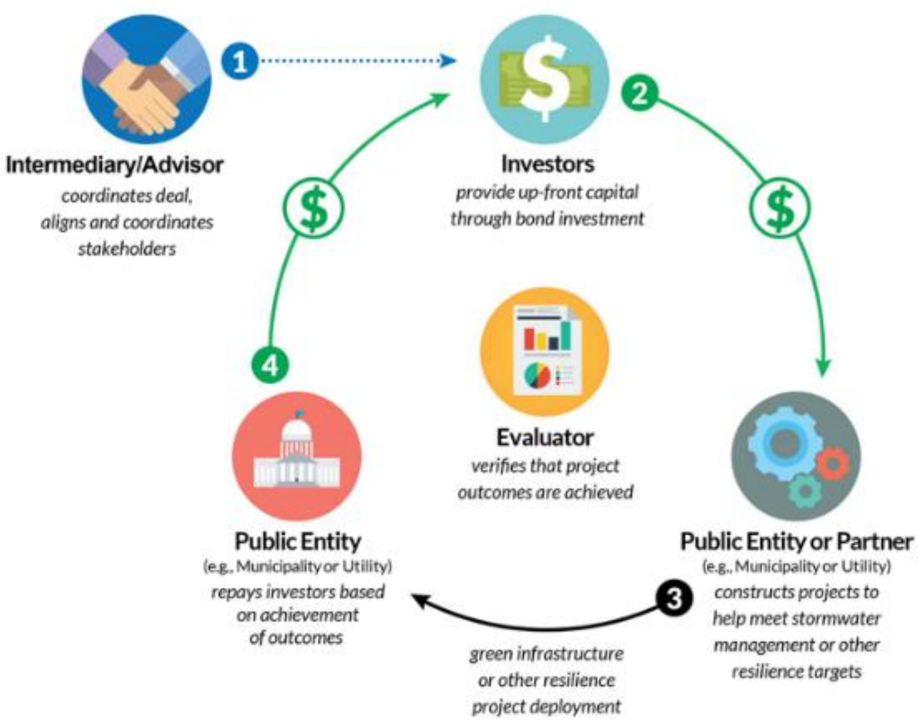

Figure 1. General Structure of an Environmental Impact Bond

There are multiple ways to structure the risk- and reward-sharing component fundamental to an EIB. In the DC Water and Sewer Authority's 2016 EIB, also used to finance GI, the Authority used three tiers of performance, with an additional upside performance payment made from the issuer to the investors that is mirrored symmetrically – both in size and probability of achievement – by an additional downside risk sharing payment made from the investors to the issuers (DC Water, 2016). In contrast, DWM decided to use a new, simpler two-tiered structure in issuing its EIB, which minimizes the number of possible returns for which investors need to prepare and is logistically easier to execute. As depicted in Figure 2, the Atlanta DWM EIB defines two performance tiers based on the overall stormwater volume capture capacity of the installed green infrastructure practices: “base,” and “high.” Only in the case of a “high” performance outcome will a performance payment be paid by the City (the “issuer”) to purchasers, if the environmental outcomes achieved are greater than expected. To compensate the Issuer, the EIB also features a discounted interest rate that reduces overall return to purchasers if environmental outcomes achieved meet or are lower than expected. Greater volume capture is equivalent to greater efficacy of the GSI in terms of flood mitigation and water quality, reducing treatment costs to the City as well as damage and disruptions related to flooding. Thus, payment of the performance payment can be considered as sharing a percentage of the added financial benefits with investors in exchange for the investors’ willingness to take on risk, and not as punitive for successful projects.

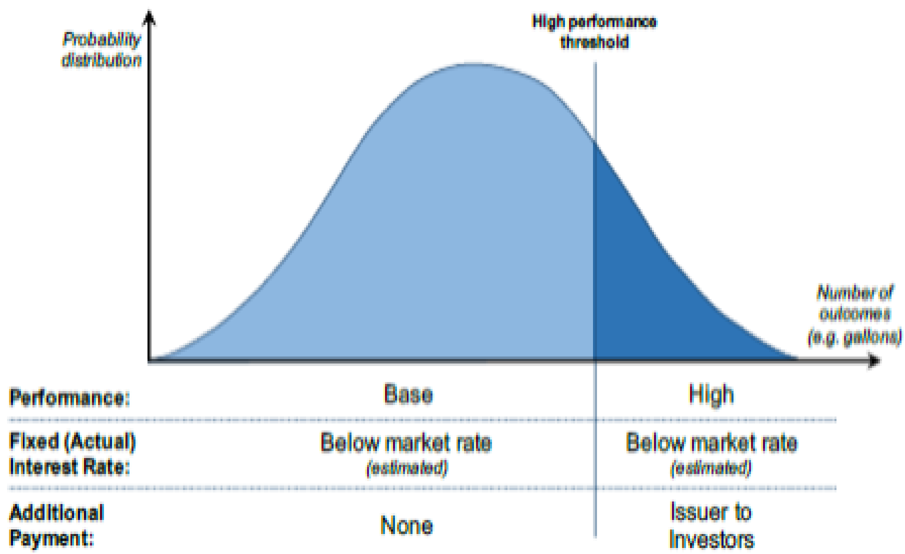

Figure 2: Representative Payment Structure of the City of Atlanta DWM EIB

To choose the high-performance threshold, two inputs were required: (1) a probability analysis, and (2) an economic model. For the former, DWM contracted CH2M (now Jacobs), the engineering firm tasked with designing the EIB-funded GI projects, to determine the expected range, uncertainty, and probability distribution associated with the outcome metric. Considering various factors that influence volume capture, including chance of encountering unforeseen underground utility during construction, contractor price, and contractor performance, CH2M developed an exceedance probability (Figure 3), or the likelihood that the aggregate volume capture capacity of all six projects will reach a certain number of gallons or greater, and established a mean expected volume.

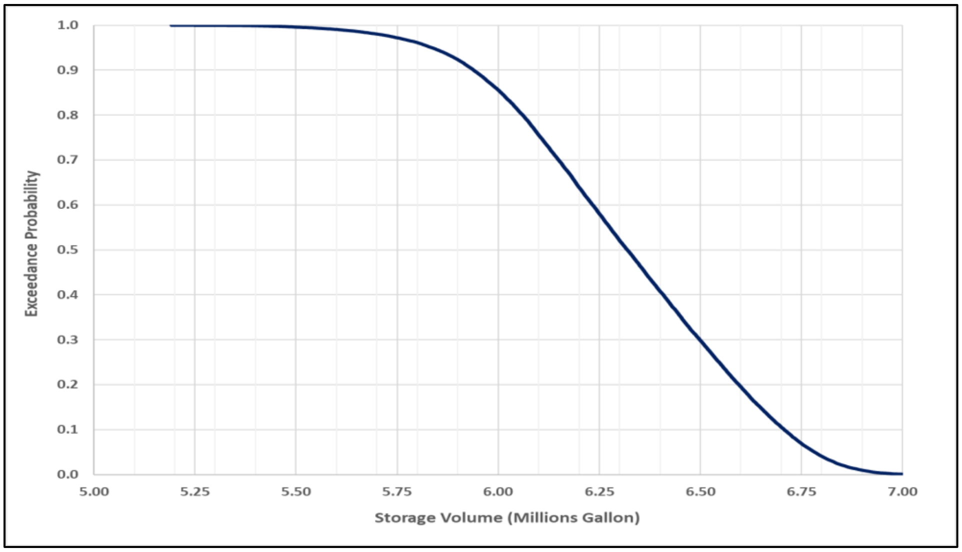

Figure 3. Exceedance Probability Curve of Storage Volume for EIB Projects

Working with DWM, Quantified Ventures developed an economic model that quantifies the value of the expected outcomes from the projects, and how this value changes with greater or lesser volume capture of stormwater – the primary outcome metric. The economic modeling accounts for the value of certain outcomes that are directly linked to volume (flood risk reduction and water quality outcomes) and ones that are independent of volume (such as air quality, urban heat island mitigation, and job creation), which can be directly tied to the Department and City Government's new revenues or avoided costs. The valuation excludes additional intangible, indirect, or difficult to quantify benefits from GI, such as educational opportunities, public and mental health, or enhanced neighborhood cohesion and urban connectivity. The results of the economic model indicated that at the as-designed volume capacity for the GI projects, the $13.5 million EIB is expected to generate roughly $19 million in environmental and social benefits, in addition to the numerous non-monetizable benefits to the affected communities and society at large.

By combining and considering both the economic and probabilistic analysis (Figure 4), as well as other financial considerations, the size of the performance payment could be set such that at the performance threshold, the payment represents a fraction of the incremental value to DWM and thus a true benefit- and risk-share payment with investors. DWM selected a threshold of 6,520,000 gallons of volume capture, which corresponds to the top 27.74 percent of possible outcomes, as the triggering point for a "high performance outcome." DWM set a performance payment size of $1 million as the share of the benefits that would be paid to investors following the 6-year evaluation period if the projects exceed the threshold. The value of any additional benefits over this volume threshold accrue solely to DWM.

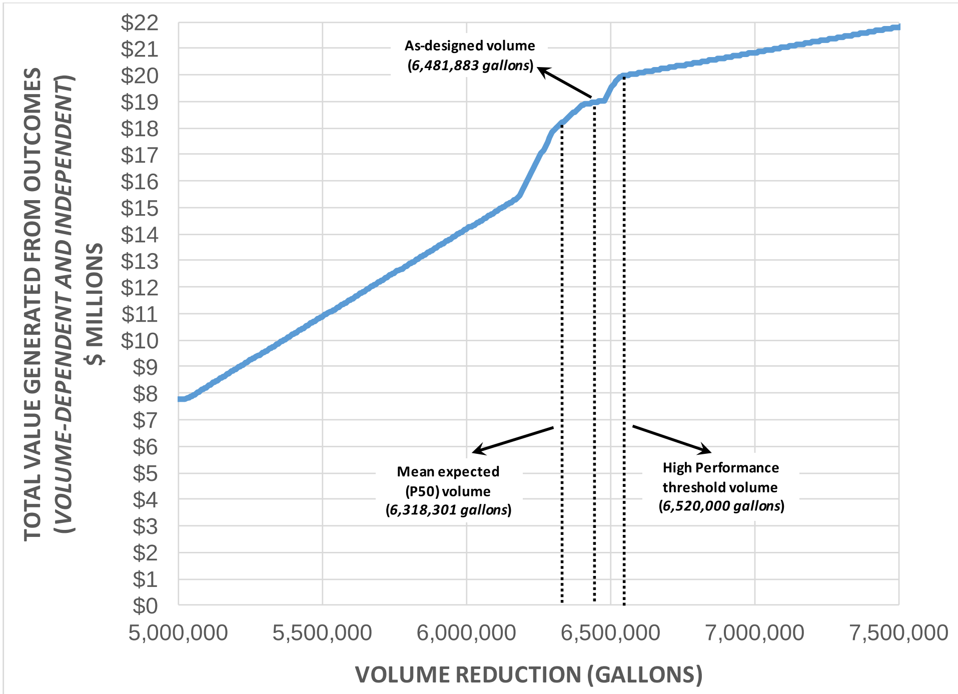

Figure 4. Economic Valuation Based on Volume Capture for EIB Projects

Atlanta's EIB Innovations

Compared to the DC Water EIB, the Atlanta EIB featured several new innovations that may continue to improve the broader appeal and marketability of this kind of financing and serve as another example to issuers of different ways and contexts in which it could be structured.

First, the Atlanta EIB was sold publicly rather than through a private placement like DC Water's EIB and other previous outcome-based impact bonds. Quantified Ventures and the DWM worked with Neighborly Securities and underwriting partners KeyBanc and Siebert Cisneros Shank to place the bond in a public offering. In doing so, this approach represented a departure from "business as usual" in the traditional municipal bond market and opened the door to a broader mainstream market for outcomes-based financing. As a public offering, the Atlanta EIB was rated by credit rating agencies Moody's (Aa3) and S&P (A+) and was successfully sold to a mix of impact and institutional investors.

A second innovation was the two-tiered rate structure the Atlanta EIB used, as opposed to a three-tiered structure like DC Water's EIB. The three-tiered structure has a base interest rate near market levels and a downside "clawback" from investors in the case of low performance that is mirrored by an additional performance payment in the case of high performance. The Atlanta EIB defines only base and high performance. Instead of incorporating the third downside clawback option, a lower base case interest rate compensates the City in exchange for the possibility of making the additional $1 million high-performance payment if the projects perform better than expected. This simpler, two-tiered structure is more intuitive, as it reflects performance in the actual rates of the bond, and is logistically easier, without the need to secure a payment from multiple investors in the case of lower performance.

Third, the selection of a single outcome metric – volumetric capacity for stormwater capture measured in gallons aggregated across the six projects – both simplified the offering leading up to the public issuance and provided a consistent, straightforward, and cost-efficient method for measuring outcomes. This metric, which served as a proxy for flood risk reduction and water quality improvements, the two major drivers of performance in mitigating the localized impacts of stormwater, could be applied to the different types and scales of GI practices to be implemented and would be easy for investors to understand and related to their environmental interests. Further, central to any impact bond is a third-party evaluation of the outcome metric(s), which drives how "performance" is defined and thus how repayments are made. Evaluating stormwater capture from the projects as a capacity, rather than a flow, allows a one-time validation of storage capacity from the completed projects through as-built surveys and aerial imagery, rather than installing sensor equipment and requiring continuous monitoring.

Finally, the Atlanta EIB offers more meaningful risk transfer. The probability of achieving low or high performance in DC Water's EIB is expected to be only 2.5 percent each, with a 95.0 percent likelihood of base performance. In contrast, the high-performance payment in Atlanta will be triggered by the top 27.7 percent of outcomes, corresponding to a volumetric capacity of stormwater capture of 6,520,000 gallons from across the six projects. That level of volume capture is associated with an additional economic value from the project outcomes of at least $1,815,668 over the expected level of volume capture, well over the additional $1-million payment, and an overall value, including environmental, social, and economic benefits, of $19.8 million.

Conclusions

With these new innovations, Atlanta has demonstrated a novel approach to financing high-impact, innovative resilience projects that lacked funding and a path to implementation through traditional channels. The data gained through the EIB evaluation on the impact of GI to vulnerable neighborhoods will help the City better understand how it can best mitigate growing stormwater challenges while meeting the needs of local communities. Further, the ability to tie the financing to these outcomes has made its spending for these projects more efficient and allowed it to access a different and growing set of investors seeking to align their financial returns with environmental and social ones. The public bond issuance represents a major step forward in making this innovative form of financing more accessible, and bringing it to the broader capital markets, and should serve as an example of how resilience may be financed in Atlanta and elsewhere.

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Innovative Design Turning Parks into Green Stormwater Infrastructure Community Attractions

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Executive Summary
This paper provides an overview of key partnerships, design strategies, and co-benefits provided by multi-objective green stormwater infrastructure, showcasing the steps involved in the creation of a park in Atlanta's Old Fourth Ward. In the early 2000s, the project site was plagued with frequent combined sewer overflows, isolation from the community, and environmental problems. Rather than construct a costly and invasive relief tunnel, a unique idea was devised to capture stormwater on the surface and make it the centerpiece of a destination park that would reconnect the neighborhood, remediate contamination, and transform the area. Today, as a result of multiple agencies working collaboratively with local residents, Historic Fourth Ward Park is a signature greenspace that attracts thousands of visitors annually. This innovative project has captured numerous awards, including an Envision Gold Rating from the Institute for Sustainable Infrastructure.

Project Description
A barren expanse of cracked concrete, weeds, and towering trees surviving against a background of neglect was the unfortunate description of a 5-acre parcel within Atlanta's Old Fourth Ward before a remarkable transformation reshaped the area (Figure 1). This stunning new park in one of Atlanta's oldest neighborhoods grew out of a need to address the unglamorous problem of combined sewer overflows (CSOs). The idea came from the people who lived in the community—rather than adding costly, traditional sewer tunnels to address the problem, the blighted industrial lowland area was transformed into a captivating public space that includes a functional stormwater retention pond. The stormwater pond serves as the centerpiece for the new park, bounded by walking trails, paved plazas, scenic overlooks, and native plantings (Figure 2).

Background
The setting for this multi-functional park is the Old Fourth Ward neighborhood, a former industrial area east of downtown Atlanta that is now a popular destination for visitors and residents. A current focal point in the city for redevelopment and resurgence, this neighborhood had long been the home of a concerned citizenry. Residents had been vocal to city officials about the racial, economic, and physical barriers that cut them off from other neighborhoods, infrastructure, and amenities.

Atlanta BeltLine, Inc. (ABI) provided opportunities to change this starting in the early 2000s. The organization was put in place to manage the implementation of the Atlanta BeltLine program. ABI's functions include specifically defining the Atlanta BeltLine plan; leading efforts to secure federal, state and local funding; spearheading all design and engineering; constructing trails, parks, transit, streetscapes, affordable housing, and art; and continuing the community engagement process.

Figure 1. In 2008, the project site was plagued with isolation, CSOs, and environmental contamination.

Figure 2. Historic Fourth Ward Park has remediated a brownfield site and helped to transform the community by providing a place for recreation, relaxation, wildlife habitat, and stormwater management.

At the same time, the city entered into two consent decrees with the U.S. EPA to address operation of its wastewater facilities and combined and sanitary sewer overflows. On October 16, 2002, Mayor Shirley Franklin announced a new Clean Water Atlanta initiative with a plan to improve the city's wastewater system. The Clear Creek Basin watershed was targeted by Atlanta's Department of Watershed Management (DWM) because of its size, volume of CSOs, and frequency of surface flooding during rain events. An underground tunnel, estimated between $50 and 70 million, was proposed to address capacity issues in the city's sewer system. The sewer relief tunnel would have been constructed in Old Fourth Ward, and if traditional cut-and-cover methods were used, the project would have disrupted the historic neighborhood for years during construction. It was further noted that, while the tunnel would serve to drain the 350-acre watershed upstream of the project site, no other noticeable benefit would accrue to the neighborhood. This proposed approach met resistance from the community.

Through master planning and community input meetings, ABI led the effort to develop a vision for a park that appealed to the community and also accommodated DWM's stormwater storage requirements. Working together, DWM and ABI partnered to design a regional stormwater detention facility within a destination park that addressed both social and environmental issues at a cost of less than half that of the proposed tunnel. The end result is an example of how strategic partnerships can bring multiple benefits to the community (Figure 3).

For the project to adequately address the storage needs of the Clear Creek basin, the pond had to capture and store a calculated amount of stormwater runoff (22 acre-feet) up to the 100-year storm event from a 350-acre watershed. Hydrologic and hydraulic (H&H) modeling completed during design demonstrated that the pond installation caused an offsetting of the surface hydrographs from the subsurface flow regime, and this offsetting benefits the sewer system. For maintenance and safety purposes, the park was designed to manage frequent storms (5 year or less) away from pedestrian access areas. Pathways meander throughout the park and lead visitors to a number of plaza spaces and scenic overlooks outside the inundation zones. An elevated walkway "floats" above the storage pond creating unique viewing opportunities within the park (Figure 4).

Summary

Those who visit Historic Fourth Ward Park once, often, or even daily, may never realize that the pond is a key component of the City's drainage infrastructure. While this low-engineering profile was the intent of design, the 2-acre pond was also designed to be the focal point of the park and a celebration of water. Throughout the park, design details and artistic sculptural elements disguise the engineered solutions (Figure 5). The pond is surrounded by a natural landscape, which includes southern heritage plants, native species, and littoral shelf to create a wetland habitat. A number of paved plazas are located around the park for visitors to rest and enjoy the unique views of the pond; a performance stage with terraced seating provides a venue for educational field trips, concerts, and other special events.

Since its opening in 2011, Historic Fourth Ward Park has become a popular destination for residents and visitors. Today, the stormwater park is surrounded by redevelopment and revitalization, including a mix of residential, commercial, and office space that did not exist prior to its construction (Figure 6). Historic Fourth Ward Park is an example of a sustainable design solution that has brought broader, high-quality urban transformations to a community.

Figure 3. The stormwater pond at Historic Fourth Ward Park is surrounded by native plantings and walking trails.

Figure 4. Throughout the park, drainage features are disguised as artistic sculptural elements. This ephemeral channel is lined with river stone and granite to represent Clear Creek, which flowed through the site nearly 100 years ago.

Figure 5. An elevated walkway "floats" above the storage pond creating unique viewing opportunities within the basin.

Figure 6. Historic Fourth Ward Park has helped revitalize a once-neglected portion of the city. The graphic above shows new development since the park opened in 2011.

The design and construction of Historic Fourth Ward Park aligns with the values and intent of the Institute for Sustainable Infrastructure (ISI) Envision Rating System. Following construction, the project was registered with ISI to measure the stormwater park's actual sustainability benefits. The project scored high in the "Quality of Life" and "Leadership" credit categories as a result of the amenities incorporated into the design and the collaborative process used throughout.

The project remediated a previous brownfield site by transforming it into a community-focused open space. In addition to managing runoff from a large upstream drainage area, the pond captures and detains all onsite runoff. The detained water is circulated through aeration features disguised as waterfalls and fountains and is further treated by the wetland plantings. In 2016, Historic Fourth Ward Park received an Envision Gold Award.

Lessons Learned
Historic Fourth Ward Park's success would not have been possible without extensive collaboration and patience from multiple departments within the City of Atlanta, including the Urban Design Commission, Planning Department, Permitting, and Maintenance Staff from DWM and Department of Parks and Recreation (DPR). The process was unique and required thoughtful discussions during the design phase with each group involved. Weekly design meetings with the key stakeholders were necessary to help maintain open communication throughout the project. Without an ongoing commitment from each group to understand these unique aspects, the project would have been extremely difficult or impossible execute.

Perhaps the most notable strengths of the project are the social, environmental, and economic benefits it has brought to the neighborhood and City. These benefits are easily recognized when visiting the site. On a nice day, the park is filled with families, residents, and visitors enjoying the public space or visiting one of many adjacent businesses. During a storm, the site transforms to a carefully engineered stormwater facility, providing the necessary relief for the sewer system. Despite these positive attributes, maintaining the diverse planting palette, dealing with complexities of the pond and wetland shelf, and managing the geese population have been learning experiences for everyone involved.

Prior to the development of Historic Fourth Ward Park, an interdepartmental partnership was established to delegate operation and maintenance responsibilities. It was determined that DWM would maintain all stormwater infrastructure components (e.g., pipes, drainage structures, and outlets) and DPR would maintain the park features (e.g., landscape, walkways, walls, and fountains). Fortunately, a multi-year maintenance agreement was outsourced so that all plant materials were well established before being turned over to the city.

As demonstrated with Historic Fourth Ward Park, green infrastructure projects bring numerous benefits to a community but they also require more intensive, long-term maintenance considerations. To assist with simple routine maintenance items, a volunteer-led conservancy has been established for the park. The conservancy's tasks include fundraising, native plant installation, spreading of mulch, removal of debris, and routine inspections of the park. These requirements, in combination with outsourcing technical tasks, may be the most important considerations for the long-term success and functionality of green infrastructure projects.

Multi-agency Collaboration: Carriage Crest Park

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Executive Summary:
The Project is a collaboration between the City of Carson (Carson), County of Los Angeles, Caltrans, and the Sanitation Districts of Los Angeles County. The Project, which is led by the City of Carson, will divert urban and stormwater runoff into a detention basin underneath park fields. The runoff will then be released for sanitary sewer treatment as capacity at the treatment plant becomes available.

Project Description
The Carson Stormwater and Runoff Capture Project at Carriage Crest Park (Project) was identified as a priority project within the Enhanced Watershed Management Program (EWMP) for the Dominguez Channel Watershed Management Group. The goals of the project are to improve the water quality of stormwater and urban runoff within the Machado Lake Watershed, improve the quality of life for citizens, and provide opportunities to increase local water supply.

Figure 1: Installation of subsurface stormwater storage chambers (facing east)

The Project was initially identified as an infiltration project in the EWMP but due to the poor percolating soils, an alternative project was pursued. The Project site was ideally located across the street from the Joint Water Pollution Control Plant, which is operated by the Sanitation Districts of Los Angeles County (LACSD). A collaborative project was pursued where stormwater is temporarily detained at the park then released to the treatment plant. Since the sewer trunk line near the proposed detention basin and the treatment facility had significant available capacity, Carson was able to expand the Project and include the County of Los Angeles' drainage area. Carson was able to secure Caltrans funding through the Caltrans Cooperative Implementation Agreement (CIA) program and fund the initial portion of the project.

The Project includes a diversion system to redirect dry and wet-weather urban runoff from an existing Los Angeles County Flood Control District box culvert through a pretreatment system to remove trash, debris, and sediment. A drainage pipeline will convey the pre-treated stormwater into an underground storage facility. The Project will discharge the captured stormwater and urban runoff to an existing 60-inch sanitary sewer trunk line for treatment at the Joint Water Pollution Control Plant under the Industrial Waster Permit. The Project will address the nutrients and toxics total maximum daily loads for the Machado Lake watershed and improve the water quality at Machado Lake, which will provide recreational and aesthetic benefits. In addition, the diverted stormwater has the potential to supplement recycled water supply at the Joint Water Pollution Control Plant.

Figure 2: Installation of subsurface stormwater storage chambers (facing north)

The Project was designed to provide capture of stormwater and urban runoff from 455 acres within Carson and 319 acres within the County of Los Angeles and will have the capacity to manage the 85th percentile, 24-hour storm event runoff volume of 27 acre-feet. The total cost for design and construction of the project is $18,720,000. Carson entered into a CIA with Caltrans through which

Caltrans will provide $13,000,000 in funding for the Project. Additionally, Carson contracted with LACSD under Senate Bill 485 to develop a project proposal, provide project management, and coordinate funding.

The County of Los Angeles provided an additional not-to-exceed amount of $5,720,000 to account for planning, engineering design, and construction costs associated with upsizing of the previously planned project to capture the 85th percentile, 24-hour storm event runoff volume from the County's 319 acres tributary to the project. Carson and the County of Los Angeles will jointly fund the operation and maintenance of the water quality improvements of the Project, whereas Carson will solely fund the operation and maintenance of the recreational facilities within Carriage Crest Park.

Project construction began in the summer of 2018 and is anticipated to be complete by June 2020.

Lessons Learned

A portion of the funding from Caltrans through the CIA needed to be spent within 3 years of receipt, which is a very short amount of time to plan, design, and construct the project. To spend the funding, Carson procured the concrete detention chambers from the manufacturer, StormTrap. The detention chambers were temporarily stored by StormTrap until the construction contractor was ready to receive and place them. Project lead agencies should note that when accepting funding from Caltrans' CIAs, they need to ensure that their schedules can accommodate Caltrans' rigid scheduling requirements and short deadlines.

This Project also demonstrates that additional partnership opportunities should be explored in early planning phases and can bring agencies, not typically involved in stormwater quality, to the table. Working with LACSD to divert stormwater runoff was also a new experience for agencies responsible for improving stormwater quality (i.e., Carson, Los Angeles County, and Caltrans). Through Senate Bill 485, LACSD was able to provide the oversight, project management, and modeling analysis to assist with the design of the Project. It was a mutually beneficial relationship for all agencies.

Conclusions and Recommendation

The Project was funded by many different agencies including the State Department of Transportation, a local city, the County, and a regional sanitation district. Carriage Crest demonstrates that funding can come from various sources to provide a successful project that benefits all parties. Additionally, the Project demonstrates that surface water diversions to sanitary treatment facilities can make effective use of excess capacity at these treatment facilities to achieve stormwater quality and water conservation benefits.

Figure 3. Site map: Carson Stormwater and Runoff Capture Project at Carriage Crest Park

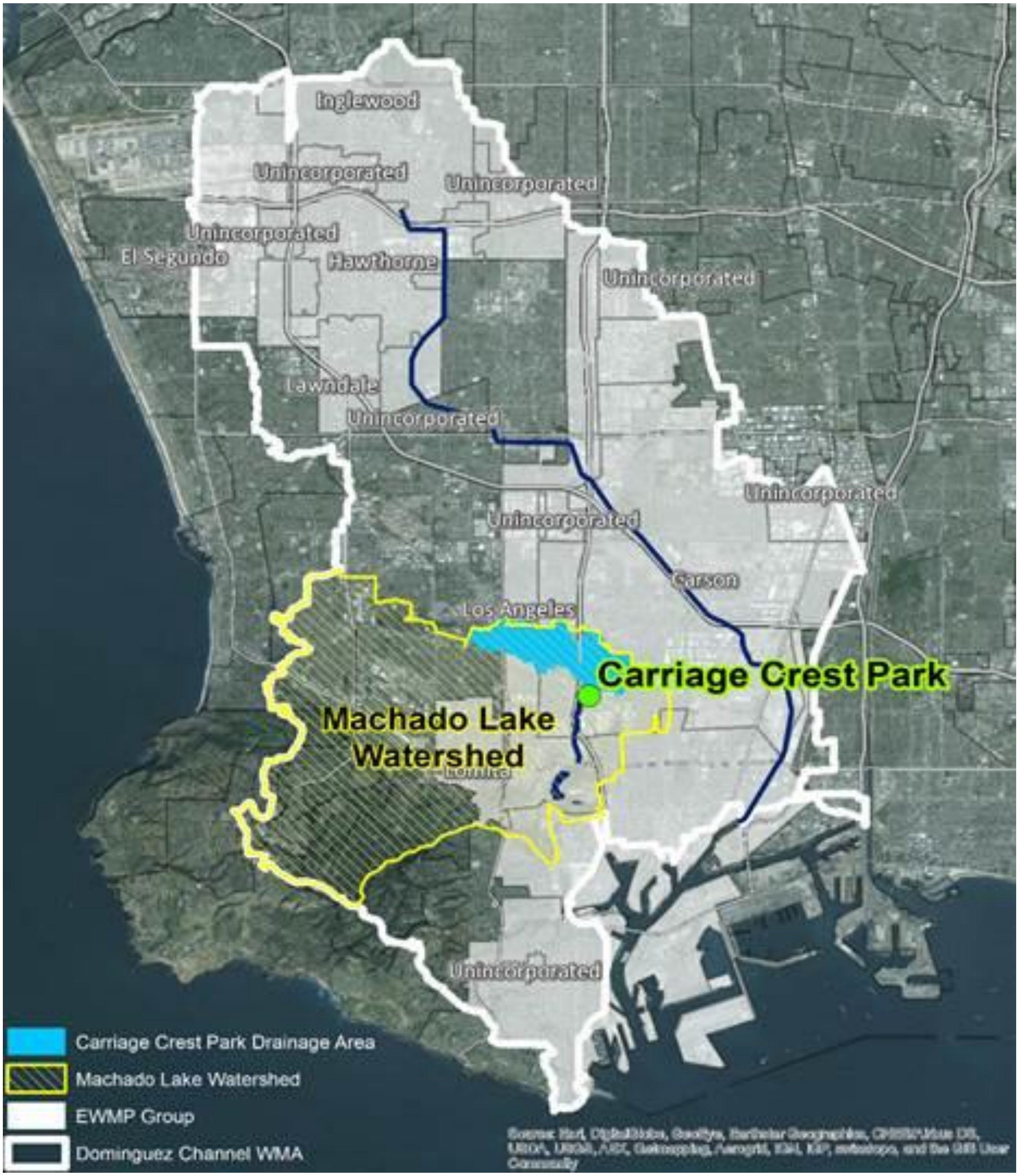

Figure 4. Tributary Area Map: Carson Stormwater and Runoff Capture Project at Carriage Crest Park

O&M Scenarios and Best Management Practices

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Introduction

Green infrastructure (GI) is being implemented with increased frequency throughout the country to meet water quality goals, improve communities, and even reduce costs. As communities implement individual GI projects or large-scale programs with multiple GI projects, they face numerous challenges. One of the most significant of these challenges is how to integrate new and presumably different maintenance protocols into their existing maintenance programs and operating budgets. This is a question that municipal governments, other public entities, and even private organizations are facing as they make decisions about long-term stormwater management. Fortunately, both large and small communities throughout the United States are proving that GI maintenance programs can succeed through proper planning, effective integration with existing programs, and the creation of new partnerships through education and outreach.

Operations And maintenance (O&M) is important to maintain performance of all stormwater control measures, and consideration of O&M is critical for GI due to the visible nature of facilities, and particularly important when GI facilities are located in parkways, recreational facilities, and other places accessible to the public. While this paper focuses on GI O&M, many of the same principles can be applied to conventional stormwater control measures.

Based on the success of the programmatic approaches employed by public agencies across the country from Syracuse, New York, to Seattle, Washington, and Honolulu, Hawaii, this paper presents and recommends a programmatic approach to GI O&M. A number of specific best practices and lessons learned are then presented for consideration during future program development.

Success Stories: Onondaga County, New York, and Lancaster, Pennsylvania

In Onondaga County, New York, the implementation of an ambitious GI program ("Save the Rain") has also meant rapid deployment of an equally ambitious GI maintenance program. To date, the Save the Rain program has successfully implemented approximately 170 GI projects in streets, parks, schools, libraries, parking lots, and numerous other settings. Building on the program's momentum, Onondaga County's maintenance program has been funded through a combination of strategies, including integration of GI maintenance into the existing infrastructure maintenance regime and computerized maintenance management system (CMMS), use of large-scale maintenance contracts to create jobs and healthy market competition, community partnerships to provide low-cost maintenance while providing entry-level jobs and job training, and establishment of incentive programs to offset costs through private implementation of GI and its associated maintenance. Since 2010, Onondaga County's GI program has been both an environmental and political success story due in large part to its effective maintenance efforts. For more information on this program, please visit: savetherain.us/greenprograms/greeninfrastructure/maintenance/.

The City of Lancaster, Pennsylvania, has embarked on an award-winning, multi-million-dollar GI program, Save It! (http://saveitlancaster.com/). The City has successfully completed over 57 city-led GI projects from 2010–2018, comprising hundreds of individual GI systems. As part of the GI program, the City has employed programmatic strategies to monitor system performance and successfully maintain GI assets.

The City has assembled a team of staff members to support GI implementation (design and construction), monitoring, and maintenance, including training of existing Parks Department staff to serve as a dedicated maintenance crew for vegetated surface GI facilities. In addition to staff training and development, the City produced a GI Maintenance Manual that is complemented by a GI Design Manual and a GI Monitoring Manual to guide designers in low-maintenance design strategies and to inform future design and construction through routine field inspection and monitoring. The O&M operating procedures developed for the Maintenance Manual are customized to integrate into the City's existing CMMS to facilitate maintenance scheduling and tracking, cost, and performance monitoring, while allowing for long-term adaptive management. Stormwater managers can use collected information to provide future level-of-service recommendations, guide future designs, view and predict program costs, and guide future program management decision making.

The City of Lancaster staff use routine performance monitoring and GI asset inspections to identify maintenance needs and inform future design and construction considerations.

Programmatic Elements

Consider the following programmatic elements that have been successfully implemented throughout the country:

Design Basis

Public agencies should establish acceptable O&M activities, levels of service, and burden on a programmatic level, creating guidelines that can be incorporated into the design basis for individual projects. Instead of creating O&M procedures during or after design, acceptable O&M scenarios and practices should be developed before detailed design is performed.

Standard Materials and Specifications for GI

With similar BMPs and facilities located in the same geography, public agencies in Seattle have partnered to create shared O&M guidelines and standard operating procedures (SOPs). Creating common maintenance requirements for standard BMPs, such as bioretention, can make the design process more efficient and lead to consistency and efficiency in facility maintenance.

Multiple public agencies within the Puget Sound region have also worked together to develop regional standard bioretention and porous asphalt specifications. Common specifications benefit the design community, help inspectors become acquainted with typical materials and procedures, and allow suppliers to limit the number of different material and construction specifications they must meet. These common specifications could be particularly helpful during O&M, as obtaining a small quantity of a common regionally used material may be significantly quicker and more cost effective than having a small batch of custom material produced.

Standard Operating Procedures

The most basic elements of a GI O&M plan are the SOPs, which are the specific maintenance instructions that must be followed to ensure long-term performance. Such procedures can take various forms, but are typically developed for each GI technology, or component, to establish who is responsible for maintenance, what specific procedures must be followed, and the frequency of those procedures. Effective SOPs should also define the key performance indicators or triggers for certain maintenance actions (e.g., storm events greater than a certain rainfall depth), as well as any seasonal considerations (e.g., clean all inlets prior to winter rains). SOPs should be clear, specific, and readily accessible to their users, especially for less frequent tasks. They are often also enhanced by the use of visuals tools, such as photographs of weeds versus bioretention plants.

Using consistent SOPs for planning, design, and during the post-construction phase will produce multiple facilities that can be maintained by interchangeable crews, will limit the number of different crew types required, and will limit the amount of specialty that each crew must carry or must obtain for a specific task. Sharing SOPs across agencies could allow for public agency crews to be shared or for private contractors to more efficiently maintain facilities from multiple agencies.

SOPs should also include guidelines for inspection and trouble-shooting. Using common terminology and standard elements in facility design and construction will again allow common resources for inspection and trouble-shooting to be shared across agencies.

Training staff

Current staff members who are skilled in the inspection and maintenance of conventional infrastructure may need additional training to manage GI. The City and County of Honolulu trained inspection staff regarding unique aspects of GI and key items to observe during field inspection, and created a field manual for staff to use in real time to identify GI and assess key performance indicators. The City has also updated annual trainings to include relevant aspects of GI.

LASAN and LA Trade Tech College have partnered to create a curriculum to recruit and train potential maintenance staff. Designing and building facilities with common BMPs and common SOPs would create even more synergy for shared educational resources.

The National Green Infrastructure Certification Program has set national certification standards for GI construction, inspection, and maintenance workers and offers training courses and certification that train participants to demonstrate competency in GI technology fundamentals, methods and materials, functionality, and appearance (https://ngicp.org/).

Partnerships

Public agencies have reduced their cost and produced a valuable product for their areas by developing regional materials, specifications, and common SOPs. Other agencies have solved potential resource challenges with obtaining seldom-used specialty equipment by developing mechanisms to share the cost of crews and equipment.

Lessons Learned
The ultimate success of GI facilities may hinge on how easily and efficiently the facilities can be operated and maintained at an acceptable level of service. Consider the following issues when developing O&M SOPs:

- Vegetation: the presence of plants and living things in GI represent a great opportunity for public benefit, but can present several O&M challenges. Current agency staff may be skilled at inspection and O&M of pipes and inlets but may be unprepared to identify invasive species or maintain plants. Consider what training, field resources, or other strategies may be necessary to help current staff successfully maintain vegetated facilities. Helpful resources may include seasonal photos of desirable and undesirable plant species, or simple schematic diagrams of how facilities should operate.
- Set Community Expectations: while conventional stormwater facilities are buried, fenced, or otherwise separated from the public, green street and other GI distributed within the public realm may reside in parkways or areas previously maintained by residents or other community members. Consider both the resources and ability of the community to perform O&M activities, such as vegetation maintenance, and set expectations regarding what O&M activities must be provided by the community and what O&M activities will be provided by the public agency, and at what level of service.
    - Also clarify if the plant palette and layout selected for a particularly site will be maintained (the original plants specified will be installed in the original location), or whether maintenance crews will have the flexibility to use similar available plant species and to use adaptive management to adjust plant type and layouts to changing site conditions.
- Specialty Skills and Equipment:
    - Consider if proposed GI requires specialty equipment, particularly for porous pavement cleaning. Can existing crews maintain the proposed facilities with existing equipment, or will additional staff, new staff skillsets, or new equipment be required? Clarify if and when the implantation of GI facilities requiring new skills or equipment is acceptable.

Photo: example of specialty equipment for green infrastructure maintenance

- If new equipment is required that would not be needed on a full-time basis, consider partnering with nearby public agencies to develop an agreement to share specialty equipment or crews.
- Note that street sweeping of permeable/pervious surfaces should be performed with regenerative air or vacuum sweepers, not with more traditional brushed sweepers. Coordination with other agencies or departments may be required to upgrade sweeping equipment and/or confirm the correct equipment operates on porous facilities.

- Access:
  - Due to the vegetated nature of many GI facilities, consideration for access to items such as cleanouts, overflow catch basins, and other structures is critical. Work boots and delicate plants do not mix; consider where staff will walk and where structure covers will be placed during access to avoid damage to vegetation and to avoid the need to enter standing water.
  - Identify which type(s) of equipment, such as eductor trucks, landscape crew vehicles, or vacuum sweepers, may be required to clean components of GI facilities, such as inlets, overflow structures, and cleanouts. Also confirm the equipment available can fit within the space available and can reach the extents of the facility. For example, can an eductor truck, parked in a curb lane, reach a cleanout or overflow structure in an adjacent park, or would existing trees or utilities impede or prevent the required activity?
  - Also consider not only the space and access required for specialty equipment such as eductor trucks or street sweepers, but consider the space that may be required for trailers, tanks, crew transportation, traffic control, or other support equipment.

Photo: Example of large footprint of vehicles accompanying pavement cleaning equipment

- Precision: staff who operate heavy equipment and clean conveyance elements may be highly skilled at cleaning conventional infrastructure but less experienced at maintaining vegetation or carefully replacing soil and mulch, and may be less accustomed to performing detailed measurements and engineering calculations. Attempt to limit the amount of detailed measurements, documentation, and precise material replacement that will be requested from crews operating heavy equipment.
- Standard versus Custom Materials: consider the balance between providing designers and contractors with the flexibility to choose the best product for each project versus using standardized materials to simplify maintenance. Using standard and readily available materials will limit the planning and logistics required to repair or replace infrastructure if a cap, lid, grate, or other structure is missing or damaged.
- Maintenance Frequency: the frequency with which a certain maintenance crew can visit a project site and/or perform certain maintenance functions may dictate the design of that facility. Increased sediment storage or other capacity may be required to accommodate less frequent maintenance.
    - Certain activities that impact pedestrian traffic or create noise may be unacceptable during certain seasons or periods of high tourism or other community events. Consider these limitations when determining how frequency a facility may be maintained.
- Asset Management: institute a new or (preferably) adapt an existing CMMS for GI assets. By defining such assets with respect to their type, location, quantity, etc. and linking them to their respective SOPs by work orders, which establish the "who, what, where, and when," the CMMS has the potential to significantly streamline preventative GI maintenance and can also streamline maintenance reporting and documentation, providing an invaluable tool for tracking labor hours, costs, and problems.

Conclusions and Recommendations

All stormwater control measures, and GI facilities in particular, require ongoing monitoring and O&M to ensure performance, meet regulatory drivers, avoid negative impacts to the community, and achieve the multiple benefits desired from infrastructure investment.

Considerations for O&M throughout the entire project life cycle are critical for project success. The details presented in this paper offer elements to be considered in a programmatic approach to GI design and O&M. Feedback from the post-construction phase of the project should be used to validate or update initial planning estimates for capital cost, O&M cost, facility lifespan, and workforce requirements.

To improve life-cycle cost efficiency and increase performance, long-term O&M should be considered during planning and design. Bid results and asset management data should be used to update life-cycle cost estimates, and feedback and lessons learned from both construction and operations should be incorporated to improve design standards, design process, and standard details.

Programmatic approaches to O&M can improve consistency and reduce maintenance burden. Adjacent jurisdictions should consider regional standards for materials, O&M practices, and other project details that have little physical reason for varying across political boundaries.

Improving the cost efficiency and maintaining the safety, aesthetic appeal, and physical function of GI and other storm water facilities will ensure stormwater control measures are truly sustainable community assets.

Stormwater Biofiltration System Promotes O&M Efficiencies, Innovative BMP Design, and Environmental Stewardship of San Diego Bay

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Executive Summary
This paper will spotlight operations and maintenance (O&M) and best management practices (BMPs) for maximizing stormwater capture on a space-constrained, industrialized port site to achieve project goals such as mandatory priority pollutant removal efficiencies and easily completed maintenance activities. Constraints such as tidal influence, flat terrain, high groundwater, and heavy equipment loading requirements brought on by terminal operations can serve as engineering challenges. Alternatives for projects that feature these constraints can include infiltration vaults, high-rate media filters, and biofiltration units.

Recently, an innovative, modular wetland stormwater capture solution was completed at the Port of San Diego, California. Priority pollutants of concern at the Tenth Avenue Marine Terminal (TAMT) included metals and total suspended sediments; these pollutants were determined based on years of water quality monitoring at TAMT and a knowledge of terminal operations. The modular wetlands installed at TAMT specifically target these priority pollutants of concern and were designed with O&M input to efficiently maintain the units without disrupting active terminal operations. This project involved over 3 years of planning and 14 months of construction, culminating in a solution that treats more than 40 acres of Port tidelands along the urban/water interface. This project was designed and constructed to maximize treatment while maintaining efficient, cost-effective implementation and redirecting stormwater flows away from San Diego Bay. The project was awarded the 2019 California Stormwater Quality Association Outstanding Stormwater BMP Implementation Project and is also competing for the American Public Works Association Project of the Year.

Project Description
The San Diego Unified Port District (Port) is currently implementing its TAMT Redevelopment Plan. The implementation includes a variety of infrastructure investments that will be undertaken over several years to accommodate an increase of the terminal's capabilities and capacity while minimizing the environmental impacts from terminal operations. The purpose of the overall modernization concept is to increase terminal capacity, create jobs, provide expanded stormwater treatment, and provide greater flexibility to meet current and future market conditions. Furthermore, by implementing project-specific technology improvements and factoring in regulations, environmental impacts from maritime activity at the terminal are minimized.

The Project is in Region 9 of the State Water Quality Control Board. The Project site is in the Pueblo San Diego Hydrologic Unit (HU; 908), in the San Diego Mesa Hydrologic Area (HA; 908.20), and in the Chollas Hydrologic Subarea (908.22). The drainage area leading to the Project site is 40.3 acres, made up of paved areas from within the terminal and accounts for almost half of the 96-acre terminal.

The area surrounding the Project is heavily industrialized and is found in the Port's "working waterfront," comprising shipyards, a marine terminal, and various other industries. The Project itself is found at the western edge of TAMT, at the downstream end of a 36-inch storm drain.

Benefits of the Project

The initial phase of the TAMT Redevelopment Plan is called the TAMT Modernization Project – TIGER Phase 1 – Stormwater Biofiltration System (Project). This phase consisted of demolishing two large transit shed structures, relocating maritime staff offices, installing permanent stormwater BMPs, and replacing asphalt along the southern berths of TAMT. The improvements of this initial phase required that 8.8 acres of disturbed area comply with the Port's BMP Design Manual, following San Diego Regional MS4 Permit (Permit) requirements to capture and treat the Project's runoff. The finished grade would be a full replacement of concrete and asphalt pavement to expand the terminal's staging and layout areas.

The Port saw this as an opportunity to integrate additional stormwater capture and treatment into the Project and treat a much greater drainage area than the 8.8 acres obligated under Port BMP Design Manual requirements. The Project team assembled workshops to understand how to strategically capture a larger drainage area and treat stormwater before it is discharged into San Diego Bay. A compact biofiltration concept using modular wetlands by Bio Clean was implemented to treat 41.4 acres of the 96-acre TAMT. Approximately 40.3 acres drain to the specific Project site, and 1.1 acres drain to another modular wetland system that treats runoff from new office structures on site. The BMP achieves the intended results by providing water quality treatment on a space-constrained site with high groundwater and tidal influence.

Construction Efficiencies: BMP construction was integrated into demolition of the transit sheds, thereby limiting impact to terminal operations and maximizing construction efficiency. Because of the size of this BMP, combining its construction with the transit shed demolition was the only opportunity to implement this ambitious and extensive water quality improvement on such a busy facility. In addition, storm drain inlet filters are installed across the drainage area to limit trash and debris entering the modular wetlands, minimizing the need for maintenance of the units.

Removal of Priority Pollutants: Priority pollutants of concern at TAMT include metals and total suspended sediments. These priority pollutants of concern were determined based on years of water quality monitoring at TAMT and a knowledge of terminal operations. The modular wetlands installed at TAMT specifically target these priority pollutants of concern. During laboratory and field testing, the modular wetlands systems were found to have removal efficiencies that meet the criteria for compact biofiltration laid out in the Port's BMP Design Manual.

Strategic Funding: In 2015, the Port competed for and was awarded a $10-million Transportation Investment Generating Economic Recovery (TIGER) grant from the U.S. Department of Transportation to help fund the Project. The Port has matched the grant with a $14-million contribution. This strategic funding approach allowed the Port to leverage the grant opportunity for innovative stormwater treatment as part of terminal modernization.

Alternatives Analysis: Site conditions provided constraints that led the team to evaluate several alternatives. Constraints included tidal influence, flat terrain, high groundwater, and heavy equipment loading requirements brought on by terminal operations. To find the best solution, the Port assembled a BMP design team to perform an alternatives analysis of the Project. The stormwater BMP facility alternatives that were analyzed and found to best address the known site constraints included infiltration vaults, high-rate media filters, and biofiltration units. Initially, nine alternatives were assessed, but the BMP design team performed further analysis on the top three alternatives, with biofiltration units identified as the best choice. The biofiltration units ranked higher during alternative evaluation due to ease of maintenance and capacity to provide the treatment levels that the Port required.

Design Specifics of the Project

The type of biofiltration units selected for the Project were modular wetlands; however, they required a custom design and modification to the operational filtration methods to overcome specific site constraints. As a result, the modular wetlands were designed with a flow-based approach as opposed to volume-based to remove the requirement for a cistern, which would have been cost prohibitive. Also, with high groundwater at the site, buoyancy of the modular wetlands was a concern, so larger structures were used acting as their own buoyancy collars.

The Project installed 11 large biofiltration units in series (Figure 1 and Figure 2). Flows from the existing 36-inch reinforced concrete pipe (RCP) storm drain line are diverted by way of a broad-crested weir into a new 18-inch PVC pipe storm drain system parallel to the 36-inch RCP storm drain line. The new 18-inch PVC storm drain system routes flows into the alignment of 11 biofiltration units using 8-inch PVC laterals to each. The biofiltration units have outlet limiting manifold structures to throttle the flows through the units and to allow for enhanced treatment of pollutants within the biofiltration media mix.

Figure 1. Setting biofiltration units in place

The outflow at each biofiltration unit is collected into 24-inch PVC pipe segments connected to the downstream side of the biofiltration units. The flows are then routed to a cleanout box that confluences back to the existing 36-inch RCP storm drain line. Since tidal influences were a major constraint with the operation of the existing 36-inch RCP storm drain line and the biofiltration units, a tidal check valve was placed to prevent tidal flows from entering the existing and proposed system.

A continuous simulation model was developed to account for tidal inundation of the BMPs. This continuous simulation indicated that 27.3 acres of full treatment could be expected over the life of the BMP, but partial treatment would be seen even during storm events that occur at tides below 5.15 feet mean low low water (MLLW) and full capacity treatment for storms that occur at tides below 1.7 feel MLLW. The simulation was run for a period of almost 14 years (July 1, 2003, through June 10, 2017). The model results indicated that for tidally influenced BMPs proposed at lower elevations, the capacities of these BMPs must be increased to capture and treat 80 percent of the average annual runoff.

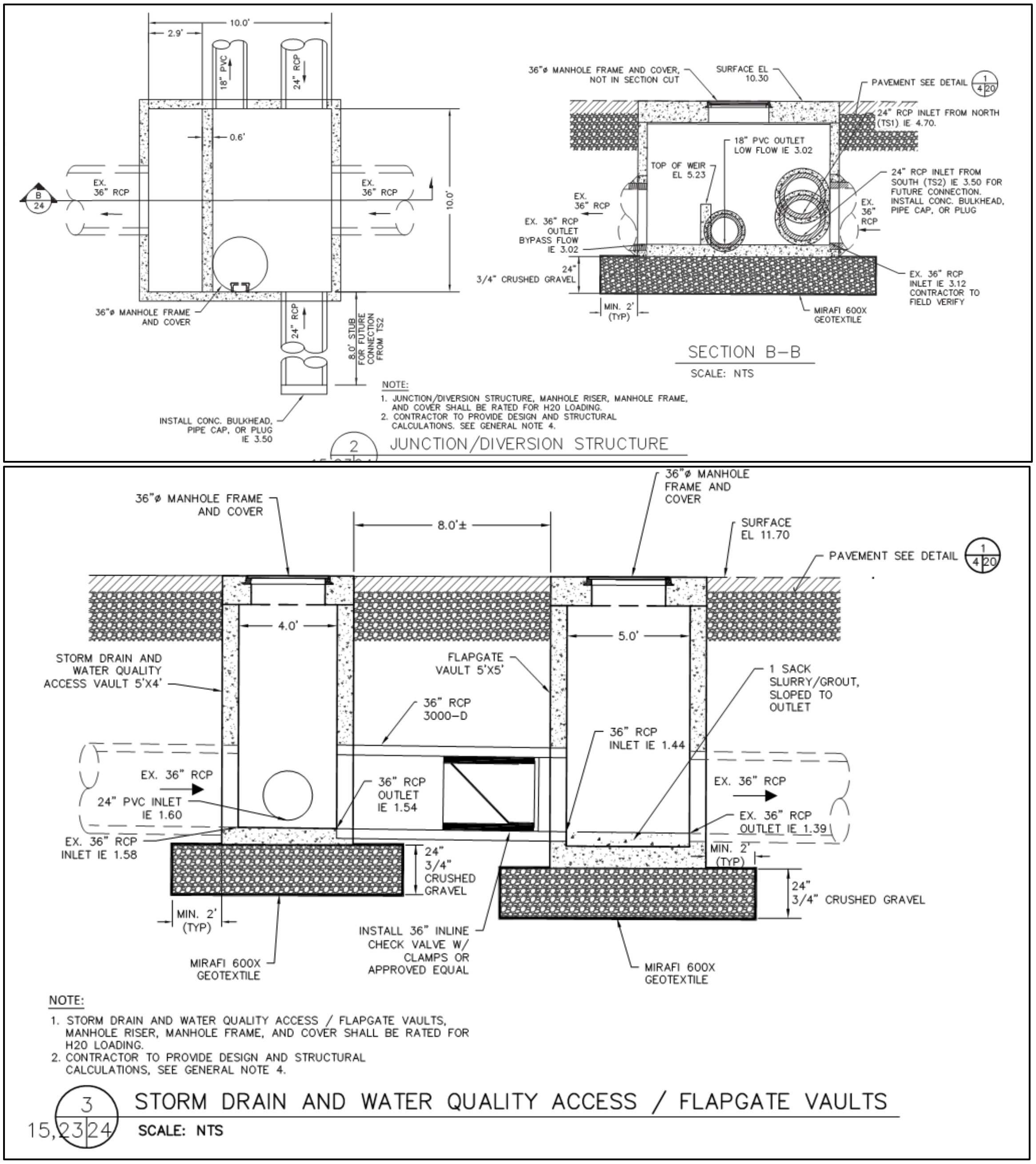

Figure 2. Junction structure with diversion weir wall (top) and flap gate section (bottom)

Each biofiltration unit is 21.5 feet long by 11.5 feet wide by 8.7 feet tall, for a total footprint area of 2,700 square feet. Each biofiltration unit is designed to treat up to 0.69 cubic feet per second (cfs). The combined series of the biofiltration units allows for 7.59 cfs to be treated at the site. The Port is obligated to treat for up to 8.8 acres, or 2.51 cfs, which is the total area of the Project.

The O&M challenges that were addressed included accessibility of the system due to the high-traffic nature of the Port terminal. Quick in-and-out maintenance visits were required and the area is designed and clearly delineated as to where access is not allowed. High tides were also considered in the design so a specially created tide gate (Figure 3) was constructed that allows access to a special clean-out area on both sides (downstream and upstream face). Other features that maximized functionality and O&M efficiency included construction of a diversion structure with adjustable weir wall (Figure 4) that can be adjusted and dropped from an easy access manhole and a hydrodynamic separator (Figure 5) to prevent debris from clogging the stormwater biofiltration system.

Assessment of Effectiveness

Bio Clean has attained the Technology Assessment Protocol – Ecology certification from the State of Washington Department of Ecology for plantless modular wetland systems and therefore meets Port BMP Design Manual requirements. Based upon laboratory testing of this system, the modular wetland stormwater-linear modular wetland will achieve significant pollution reduction efficiencies for total suspended solids, copper, and zinc and with appropriate O&M protocols will be in service for the next 40–50 years.

Figure 3. Downstream side of tide gate

Figure 4. Diversion weir structure

Figure 5. Rocking and grouting of hydrodynamic separator (see inset)

Summary

The TAMT Modernization Project – TIGER Phase 1 - Stormwater Biofiltration System (Project) was developed with a team approach to maximize stormwater capture on the marine terminal. The goal was to divert the 85th percentile storm design capture volume from the existing storm drain and into a stormwater BMP facility for the entire drainage area (40.3 acres) rather than only the Project footprint, while assuring ease-of-maintenance in the future. The completed Project (Figure 6) is distinguished from others for the following reasons:

- It was designed with unique O&M processes in mind because of its location at a busy port.
- The BMP system addresses 40.3 acres of a large, busy marine terminal when only 8.8 acres of treatment were required at this location, providing opportunities to use the additional treated acreage for other projects once an alternative compliance program is implemented on tidelands.
- The system considers and addresses high groundwater and tidal inundation issues.
- The Project redirected stormwater flows from approximately 0.4 acres of pavement along the southern edge of the terminal to the biofiltration system. Stormwater previously sheet flowed into San Diego Bay at this location.
- This is the largest modular wetland system of its kind in the country.
- An innovative piping system puts the units in parallel, which saves money and space.
- The project is gravity fed and uses no pumps, controlling stormwater flows through orifices and weirs with design geometries determined using hydraulic modeling software.

Figure 6. Installed biofiltration units in place with finished pavement

Stormwater Capture Parks Program

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Executive Summary: Guided by the strategies in Los Angeles Mayor Eric Garcetti's 2019 Green New Deal, the Los Angeles Department of Water and Power (LADWP) is committed to developing new local supplies to improve long term supply reliability. These strategies consist of planning and collaboration with various agencies to implement regional and neighborhood-scale stormwater capture projects. The Stormwater Capture Parks Program (Program) is LADWP's latest multi-beneficial efforts that will help replenish the San Fernando Groundwater Basin, improve the water quality in the Los Angeles River, reduce localized flooding, and enhance open space recreation.

Project Description

LADWP is the largest municipal utility in the nation and serves water and electricity to nearly 4 million residents and businesses in the City of Los Angeles (City). Historically, over 85 percent of the City's water supply comes primarily from imported sources, such as the Los Angeles Aqueduct, and purchased imported water from the State Water Project, and Colorado River Aqueduct. These imported supplies have been significantly impacted by environmental regulations and the effects of climate change, such as prolonged droughts and extreme weather events.

LADWP is actively improving its long-term supply reliability by reducing reliance on purchased imported supplies and enhancing local supplies through the implementation of strategies guided by the Mayor's 2019 Green New Deal (update to the Mayor's 2015 Sustainable City pLAn). These strategies consist of the expansion of water conservation, enhancement of stormwater capture, and development of recycled water supplies by 2035. When completed, local water is estimated to make up 70 percent of the City's total supplies.

LADWP is collaborating with multiple City departments to implement the Parks Program; these departments include the Los Angeles Department of Recreation and Parks (RAP), Los Angeles Department of Public Works Bureau of Engineering (BOE), and Bureau of Sanitation (LASAN). The Program consists of implementing multi-beneficial stormwater capture projects at nine city-owned park locations, which are David M. Gonzales Recreation Center, Fernangeles Park, Strathern Park North, Whitsett Fields Park, Valley Plaza Parks North and South, Alexandria Park, North Hollywood Park, and Valley Village Park (see **Figure 3**). These projects will capture surface flows and divert stormwater runoff from nearby storm drain pipes and the Tujunga Wash Central Branch storm drain collector line from a 5,700-acre tributary area and infiltrate into the San Fernando Groundwater Basin. The potential capture, pretreat, and infiltration volume is approximately 2,900 acre-feet annually of stormwater runoff to help improve the health of the basin.

The Program proposes to install subsurface infiltration galleries, as shown in **Figure 1**,and other best management practices, such as drywells, bioswales, bioretention, infiltration trenches, and hydrodynamic separators, which will be strategically located throughout the parks. In addition to augmenting local water supplies, the Program will also improve downstream water quality, mitigate localized flooding, and enhance park spaces. Various stakeholder engagement meetings will be conducted to ensure community input is integrated into the Program objective.

Figure 1: Infiltration Galleries at City's Garvanza Park

LADWP's program delivery method is shown in **Figure 2** for the design, funding, and implementation of projects. A Memorandum of Agreement (MOA) was executed between LADWP and BOE, for BOE to provide Program planning and design. Once funding is secured for project implementation, individual project MOAs will be executed with BOE, RAP, and LASAN for the construction and long-term operation and maintenance. While the individual projects will be implemented through the traditional design-bid-build process, the overall delivery method is at the Program level. This streamlined approach allows for securing of potential funding and in-kind services from multiple sources while providing regional benefits. Additionally, Program implementation will include long-term operation and maintenance, something often not considered with project implementation.

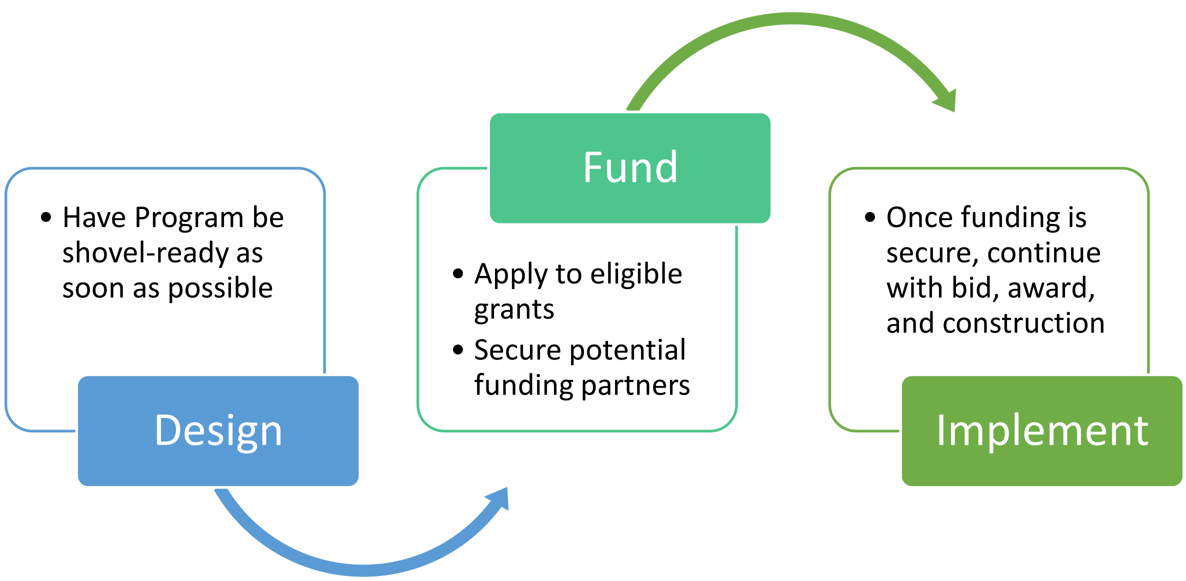


Figure 2: Program Delivery Method

The Program is currently in the design phase, with expected completion by late 2021. Implementation of the Program is anticipated to be completed by 2025. The total Program cost is estimated to be $240.1 million. LADWP's Stormwater Capture Master Plan (SCMP) was completed in 2015 and identified long term strategies for the advancement of stormwater and watershed management throughout the City. The SCMP also included an assessment on the value of water the Program can potentially capture, which considers the avoided cost of purchased water from the Metropolitan Water District of Southern California. The value of captured water typically funds the planning, design, and implementation of stormwater projects, whereas LASAN will provide funding for any operation and maintenance cost. If LADWP is unable to fund the project costs, other funding partners and grants are sought after to cover the difference.

LADWP is actively seeking regional partnerships to leverage the Program costs, as well as its multiple benefits. Various agencies have been identified as potential partners in the Program to assist in meeting their respective goals. The Program can potentially also qualify for various local, state, and federal funding sources, such as Measure W, Caltrans, Proposition 1, etc.

Lessons Learned

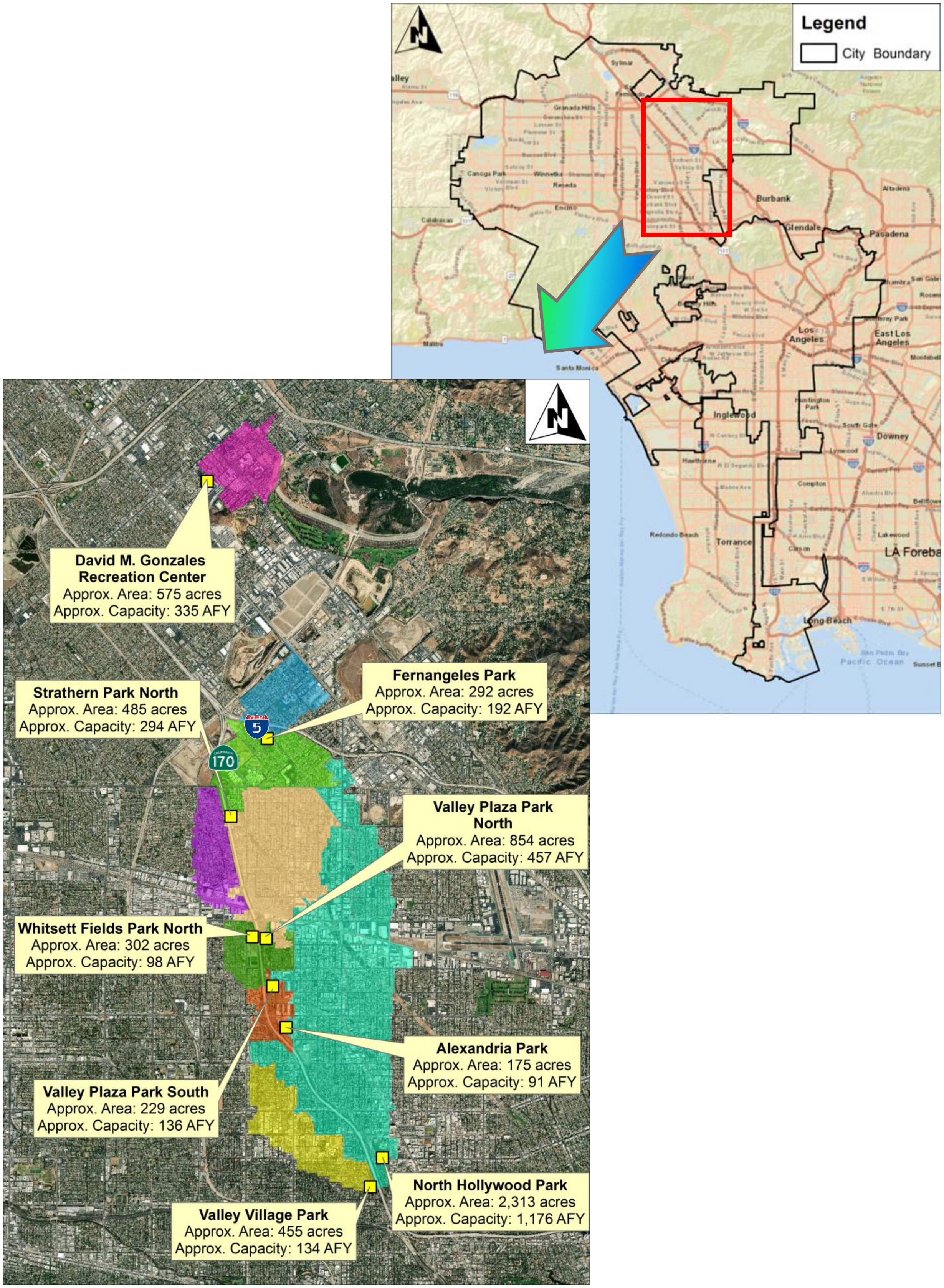
Grant funding is key for the Program's cost effectiveness and LADWP plans to pursue all eligible grants that may assist with funding this Program. Based on LADWP's previous experience, these grants are competitive and usually require projects to be "shovel ready." LADWP's approach to complete the design of multiple projects will allow the projects in the Program to be ready for consideration and be more competitive and qualified for grant funding, while also making it more probable to meet strict deadlines.

In addition to grants, securing funding from partnerships is also critical for maximizing the cost effectiveness of the Program. The multiple benefits offered by the Program not only helps LADWP, but will assist other agencies meet their goals. Currently in the early stages of design, the significance of including all partners during the scope development was realized to ensure all needs were addressed. Receiving inputs from all stakeholders as early as possible will result with fewer changes to the scope during the design. This will also allow more time for all agencies to be familiar with the necessary procedures to formally execute the partnerships in a timely manner.

Conclusions and Recommendations

The Stormwater Capture Parks Program provides a sustainable and reliable local water supply to serve customers. By transitioning to local supplies that have less energy and carbon footprints compared to purchased imported water, the Program also indirectly helps reduce emission of greenhouse gases that contribute to climate change. The Program demonstrates LADWP's strong commitment toward the environment, community, innovation, and collaborative partnerships to meet water management challenges. The Parks Program serves as an excellent example for others in the water industry to implement sustainable and multi-beneficial water supply projects.

Figure 3: Program Map Highlighting Each Project's Tributary Area and Estimated Annual Yield



Tujunga Spreading Grounds Enhancement Project

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Executive Summary: The Tujunga Spreading Grounds Enhancement Project (Project) represents a unique, multi-benefit, collaborative partnership between the Los Angeles Department of Water and Power (LADWP) and the Los Angeles County Flood Control District (District) to help increase local water supplies. The Project enhances the existing 150-acre Tujunga Spreading Grounds in the San Fernando Valley to maximize stormwater capture and infiltration for groundwater replenishment while maintaining open space and passive recreation. The improvements aim to double the average stormwater recharge to 16,000 acre-feet per year by consolidating the existing basins into larger deeper basins to increase their storage capacity and by constructing new intakes to take additional flows, including flows from a previously untapped channel. More storage means less water is lost to the ocean during sustained heavy rains. The $50.4 million Project also received multiple state grants totaling $10.2 million to help fund and further improve the cost effectiveness. The Project exemplifies sustainable and multi-beneficial local water supply project implementation through multi-agency collaboration.

Project Description

LADWP, the largest municipal water and power utility in the nation, serves water and electricity to nearly 4 million residents and businesses in the City of Los Angeles (City). Historically, over 85 percent of the City's water supply comes primarily from imported sources, including the Los Angeles Aqueduct, and purchased water from the State Water Project and Colorado River Aqueduct. These imported supplies have been significantly impacted by environmental regulations and the effects of climate change, such as prolonged droughts and extreme weather events.

LADWP is proactively improving its long term supply reliability by reducing reliance on purchased imported supplies and enhancing local supplies through the implementation of strategies guided by the Mayor's 2019 Green New Deal (update to the Mayor's Sustainable City pLAn). These strategies consist of expansion of water conservation, enhancement of stormwater capture, and development of recycled water supplies by 2035. When completed, local water is estimated to make up 70 percent of the City's total supplies, and the Project is a critical component to LADWP's long term strategy.

Due to urbanization, the majority of rainwater that historically infiltrated, now flows eventually into the Pacific Ocean. More of this undervalued resource can be captured and recharged into the groundwater basin for future use. The Project is a multi-agency collaboration between LADWP and the District to help improve local water supplies. The Tujunga Spreading Grounds is owned by LADWP and has been operated by the District since 1990. The District is the regional entity with expertise and experience in the design and construction of spreading facilities throughout the County of Los Angeles. The District operates five spreading ground facilities in the San Fernando Valley, including the Tujunga Spreading Grounds. LADWP and the District naturally partnered together for the design, construction management, and contract management for this Project. Prior to this Project, LADWP and the District have also partnered in the modernization of four other spreading ground facilities in the San Fernando Valley, including Pacoima Spreading Grounds, Lopez Spreading Grounds, Branford Spreading Basin, and Hansen Spreading Grounds. The continued multi-agency collaboration demonstrates seized opportunities for integrated planning, design, and construction to develop a multi-beneficial solution to meeting today's watershed management challenges in the region and developing local supplies.

Since the 1930s, LADWP's Tujunga Spreading Grounds have been used to spread excess imported water and stormwater to recharge the underlying San Fernando Groundwater Basin. No substantial modifications or improvements had been made to the spreading grounds since the original construction (Figure 1). Improvements were identified to help increase the stormwater capture and infiltration capacities to further replenish the groundwater basin. The Project implementation is separated into three phases: Phase 1 – Basin Enhancements, Phase 2 – Intake Improvements, and Phase 3 – Open Space Enhancements. Phase 1 construction was completed in April 2019. Phase 2 construction began in June 2019 and will be complete by November 2019. This will allow for increased stormwater capture from the subsequent rainy season. Phase 3 construction is anticipated to start in early 2020 and the entire Project is slated for completion in December 2020.

Figure 1. Tujunga Spreading Grounds prior to the Enhancement Project

This Project is estimated to double the Tujunga Spreading Grounds' average stormwater capture to 16,000 acre-feet per year to replenish the groundwater basin, enough to sustain 48,000 homes in Los Angeles. The scope of work includes consolidating and deepening the existing basins to increase the storage capacity from 100 to 885 acre-feet. The Project also adds two high-flow intake structures to increase diversion of stormwater from 250 to 450 cubic feet per second from the adjacent flood control channel into the basins. One of the new intakes is strategically placed downstream of the confluence of the Tujunga Wash and Pacoima Diversion Channel. This expands the watershed tributary area by 30 percent to over 200 square miles. The Project will also incorporate walking paths to promote public health, an outdoor classroom with educational signage, and habitat restoration for environment awareness (Figure 2). Compared to building a new facility with similar capabilities and amenities, modernizing the existing Tujunga Spreading Grounds brings maximum economical value with limited environmental impacts.

Figure 2. Rendering of the proposed open space enhancements during Phase 3

The construction of basin enhancements required export of over 1.6 million tons of excavated soil to a nearby recycling facility. The conventional method of using a dump truck for hauling would disrupt traffic and generate noise and air pollutants in the neighborhoods. Based on input from the community, the Project elected to use a quiet, emission-less electric conveyor belt system to transport soils (Figures 3 & 4). The conveyor belt system successfully completed the export operation within 16 months compared to an estimated 120,000 truck trips over a three-year period. The adverse impacts associated with typical grading construction were essentially eliminated with the use of the conveyor belt system.

Figure 3. The conveyor belt system used to transport soil

Figure 4. Aerial view of the conveyor belt and the excavation in progress

The total cost of the Project is approximately $50.4 million, with a $6.3 million contribution from the District. The Project also received a $3.2 million grant through the Integrated Regional Water Management Plan under Proposition 84, and a $7 million grant through the Storm Water Grant Program under Proposition 1 – Round 1. The general breakdown of the project budget consists approximately of $3 million for design, $40 million for construction, and $7 million for construction management.

The cost-benefit, in consideration of the multiple funding sources, equates the additional stormwater capture to $85 per acre-foot of recharged water to LADWP, assuming a 50-year project life. This compares very favorably to imported purchased water currently priced at $731 per acre-foot in 2019 and is expected to increase gradually to over $1,100 per acre-foot in the next 15 to 20 years. At the end of the Project's life, it is anticipated an additional 400,000 acre-feet of stormwater will be captured to recharge the Basin.

Lessons Learned

The original Memorandum of Agreement (MOA) between LADWP and the District was executed in June 2013 for implementation of the Project. Since the execution, the Project budget and schedule have increased due to higher bids from the engineer's estimate, additional design requirements imposed by regulatory agencies, construction change orders due to site conditions, and the associated increase of construction management costs.

LADWP and the District worked collaboratively to amend the MOA in March 2019 to provide additional funding contribution from both parties and extension of the contract term. Unforeseen changes occurred during design and construction, resulting in increased costs and schedule impacts. For future collaborations, there is an opportunity to improve project cost estimates in MOAs for construction implementation with terms and conditions based on full design and actual bids, as opposed to use of preliminary estimates that originated during planning.

Conclusions and Recommendations

The improvements to the Tujunga Spreading Grounds will enable the region to infiltrate higher volumes and flows of stormwater, improving the sustainability and reliability of groundwater production.

As climate change impacts the availability of imported water from hundreds of miles away, this Project provides a sustainable and reliable local water supply to serve customers. By transitioning to local supplies that have less energy and carbon footprints compared to purchased imported water, this Project also indirectly helps reduce emission of greenhouse gases that contribute to climate change. The Tujunga Spreading Grounds Enhancement Project demonstrates LADWP's and the District's strong commitment toward the environment, community, innovation, and collaborative partnerships to meet water management challenges. This Project also serves as an excellent example for others in the water industry to implement sustainable and multi-beneficial water supply projects.

Figure 5. Tujunga Spreading Grounds after Phase 1- Basin Enhancements

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Appendix B: Agenda

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SOUTHERN CALIFORNIA WATER COALITION

STORMWATER workshop

Los Angeles County Public Works
900 S. Fremont Ave., Alhambra, CA

SEPT. 27
9AM-3PM
2019

Innovative Solutions for Stormwater Capture

Sheila Kuehl
Los Angeles County Supervisor

Mark Pestrella
Director, Los Angeles County Public Works

SOUTHERN CALIFORNIA WATER COALITION

Tickets: $75 | Event Sponsorship: $2,000
(includes ten tickets)

Contact: Julie Ackman
jackman@socalwater.org

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LA DWP Los Angeles Department of Water & Power

Irvine Ranch Water District

Engineering Contractors' Association

West Basin Municipal Water District

Riverside County Flood Control and Water Conservation District

Southern California Water Coalition

2019 Stormwater Workshop

September 27, 2019 | Los Angeles County Public Works, Alhambra, CA

Innovative Solutions to Stormwater Capture

9:00 am **Welcome & Introductions**

Charley Wilson, *SCWC Executive Director*
Rich Nagel, *Jacobs Engineering, Co-Chair SCWC Stormwater Task Force*

9:10 AM **Enhancing Water Resiliency in Southern California**

Mark Pestrella, *Director, Los Angeles County Public Works*

9:25 AM **Creating the Safe, Clean Water Program from Scratch:**
Honoring the Community's Investment

Keith Lilley, *Assistant Deputy Director, Los Angeles County Public Works*

9:45 am **SCWC 2019 Stormwater Task force White Paper:**
Innovations in Stormwater Project Implementation & Enhanced O&M Strategies

Rich Nagel, *Jacobs Engineering, SCWC*

10:00 AM **White Paper Panel 1: Multi-Agency Collaboration to Achieve Co-Benefits and Cost Sharing**

Moderator:	*Panelists:*
Rich Atwater, *Metropolitan Water District, Foothill Municipal Water District*	Art Castro (LADWP): **Tujunga Spreading Grounds,** Los Angeles, CA TJ Moon (LA Public Works): **Carriage Crest Park,** Carson, CA Robby Bryant (HDR): **Fourth Ward Park**, Atlanta, GA

10:45 AM **Break**

11:00 AM **Tapping into Available Capacity in Existing Infrastructure to Create Water Supply and Water Quality Benefits**

John Zhao, *Las Virgenes Municipal Water District*
Amanda Heise, *Jacobs Engineering*

11:30 PM **Lunch Keynote Speaker ▶ Supervisor Sheila Kuehl (Los Angeles County, District 3)**

Introduction by Charley Wilson, *SCWC Executive Director*

12:30 PM **2019 White Paper Panel 2: Programmatic Innovations to Enhance Communities and Delivery Efficiency: Alternative Delivery and Financing**

Moderator:	*Panelists*
Dustin Atchison *Jacobs Engineering*	Art Castro (LADWP): **Stormwater Capture Parks Program**, Los Angeles, CA David Bell, (Jacobs): **Financing Resilience in Atlanta using an Environmental Impact Bond** Richard Watson (RWA) & Jason Fussel (Tetratech): **Bolivar Park Stormwater/ Cooperative Implementation Agreements**, Lakewood, CA

1:15 PM **2019 White Paper Panel 3: Assuring Sustainable Operations and Maintenance of Stormwater**

Moderator:	*Panelists:*
Susan Moisio *Jacobs Engineering,*	Alex Yescas (HDR): **Tenth Avenue Marine Terminal**, San Diego, CA Susan Beck (Jacobs): **O&M Scenarios and Best Management Practices** Victoria Johnson (Jacobs): **Workforce Development**

2:00 PM **Regional Panel: Stormwater Innovations**

Moderator:	*Panelists:*
Josh Svensson *LA County Public Works*	Matthew Hacker, *Metropolitan Water District* Daniel Apt, *California Stormwater Quality Association* Stephanie Gaines, *County of San Diego*

2:45 PM **Closing Remarks**

Charley Wilson, *SCWC Executive Director*