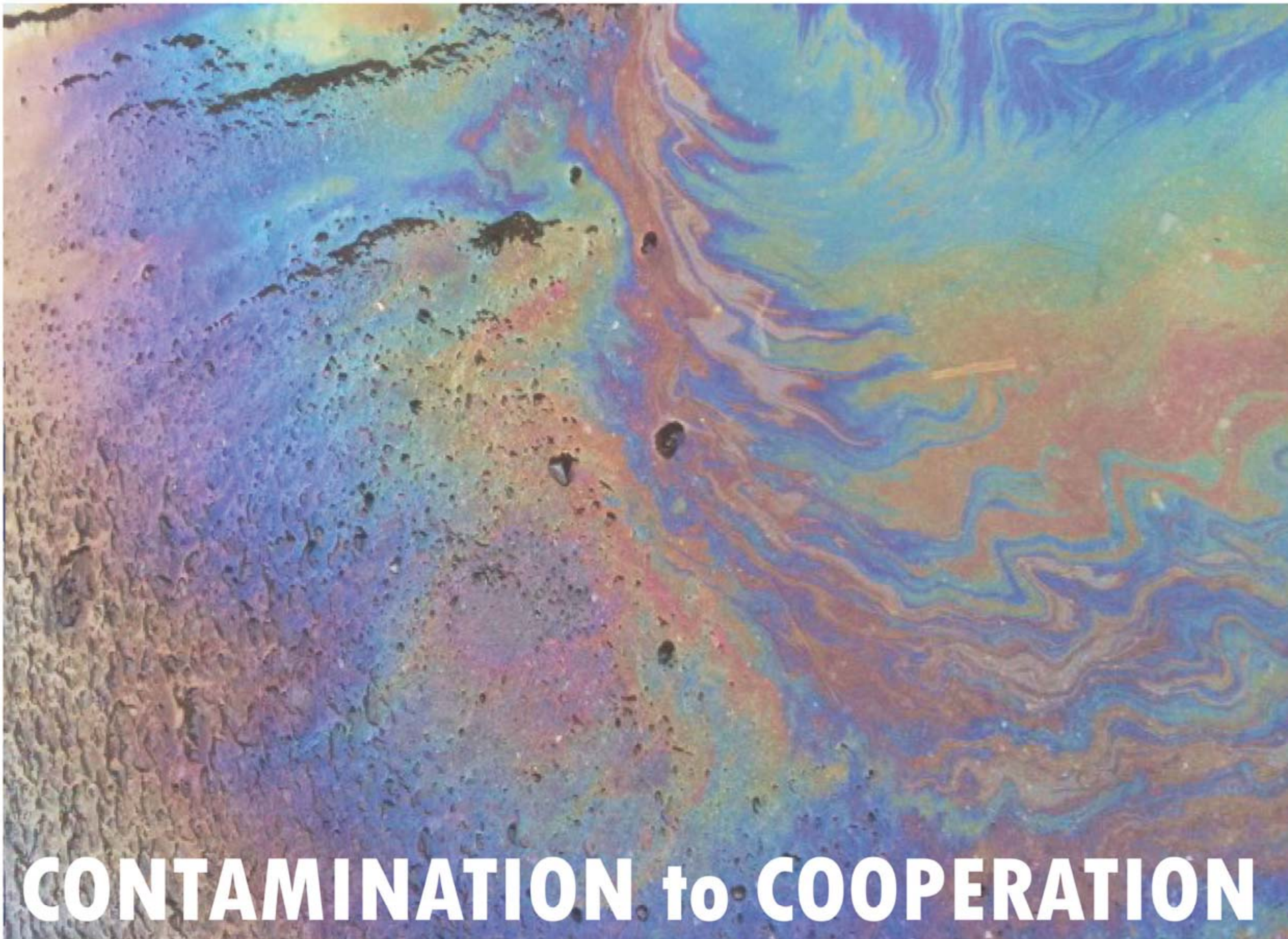

CONTAMINATION to COOPERATION

How Green Stormwater Infrastructure can Foster Collaboration in San Jose

CAROLYN NEER
San Jose State University
May 2019

CONTAMINATION to COOPERATION

How green stormwater infrastructure can foster community and collaboration in San Jose

A Planning Report Presented to

The Faculty of the

Department of Urban and Regional Planning

San Jose State University

In Partial Fulfillment

of the Requirements for the Degree

Master of Urban Planning

By

Carolyn Neer

May 2019

Acknowledgements

The author would like to extend gratitude to the following people for their guidance, constructive feedback, and continued support through the preparation of this report.

Professor Serena Alexander, Katherine Green, Margie Forman, and Courtney Nguyen for providing guidance, constructive feedback, and support throughout this year and to Scott Burroughs for lending his expertise in GIS.

My family and friends for their support of my education and their understanding during the many times I have been absent in the last two years.

TABLE OF CONTENTS

LIST OF TABLES

TABLE OF FIGURES

EXECUTIVE SUMMARY

i. Goals and Purpose of Research

Over the past century, increasing development and careless mishandling of hazardous chemicals have contaminated the groundwater, rivers, and creeks of San Jose leading regulators at the Regional Water Quality Control Board (RWQCB) to mandate the development of a plan to install Green Stormwater Infrastructure (GSI) throughout the city and improve water quality. However, infiltration of stormwater caused by GSI facilities could contaminate underground aquifers with pollutants in stormwater. This report seeks to fill the gap in scholarship on collaborative watershed management by examining challenges and opportunities associated with GSI planning in San Jose. In order to achieve this goal, this report asks the question: How can a collaborative governance model improve the effectiveness of San Jose's GSI plan? Initial hypotheses presume that a collaborative governance model will facilitate greater information sharing among agencies involved in water quality monitoring and land use decision making in San Jose, reducing the chances that new GSI facilities will be developed to a density and in locations which would threaten vulnerable groundwater aquifers.

ii. Research Methods

This report represents a case study of GSI facilities planning in San Jose. Methodology used in the preparation of this report include a comparative case study analysis on three Bay Area cities (San Francisco, Berkeley, and Palo Alto) as well as literature and document review of relevant materials on land use, hazardous materials contamination, hydrology, bioremediation, collaborative governance, and watershed management. Designed to identify best practices for the expansion of GSI facilities in San Jose, the comparative case study analysis included in-depth interviews with planning and engineering professionals as well as a document review of relevant policies, plans, and web content from these jurisdictions. Findings from these interviews were then reviewed for accuracy and confirmed by professionals involved in water quality monitoring and stormwater compliance. Finally, findings from this comparative case study analysis were compared to theoretical models for collaborative watershed management derived from the literature to produce a suggested framework for collaborative stormwater

management in San Jose. This framework was then reviewed by scholars of watershed management to ensure the efficacy of these policies at achieving their intended results.

iii. Findings and Policy Recommendations

GSI is an effective method of absorbing stormwater runoff and remediating pollutants. In the Bay Area where stormwater pollution contributes to widespread water quality violations, the RWQCB has mandated that municipalities draft plans to install GSI facilities citywide on public property in order to achieve regional water quality standards. The required framework for citywide GSI plans adheres to educational models for collaborative watershed management containing identifiable stages such as antecedents, problem identification, direction setting, monitoring, and evaluation. However, collaboration between local municipalities and community organizations is noticeably absent among Bay Area cities including San Jose.

Interviews with professionals involved in stormwater management in San Francisco, Berkeley, and Palo Alto revealed that GSI facilities have been used to address localized flooding on a small scale throughout the Bay Area for nearly a decade. However, a lack of designated funding for installation of these facilities and a shortage of skilled labor for maintenance and monitoring activities has could severely impede implementation of RWQCB mandated GSI plans in the future.

Data from the literature and from a comparative case study analysis suggest that adopting a collaborative framework for GSI facilities planning could solve the dual problems of funding and maintenance in San Jose. Increased public understanding of GSI facilities through informal hands-on interaction would increase support for these facilities, potentially creating a new population of willing and able maintenance and monitoring workers. Depending on the adopted framework, maintenance and monitoring activities could be assumed by community groups or individual volunteers at a significantly reduced cost to the City. However, literature suggests that when adopting such a community focused collaborative governance framework, expectations of public engagement efforts must be tailored to the specific organizational capacity and interests of community groups in order to achieve the established goals.

Thus, this report proposes a framework for collaborative stormwater management in San Jose which takes into consideration the educational background and language demographics of the community as well as the organizational capacity of existing community groups. The following list includes four actionable recommendations which could be implemented to improve collaboration on GSI planning in San Jose.

- Establish a Vocational Training Program for GSI Maintenance and Monitoring
- Install Interpretive Signs in new GSI facilities written in English, Spanish, and Vietnamese
- Host Community Charrettes to increase awareness of GSI function and plan new facilities
- Provide Grant Funding for community groups to maintain and monitor GSI facilities

CHAPTER 1 CREATING CONTAMINATION IN SAN JOSE

1.1 Introduction

Climate change and the increasing severity of extreme weather events are challenging cities across the globe to think critically about the adequacy of their stormwater infrastructure and their overall resilience to extreme weather.[1] In San Jose, extreme drought from 2011 to 2016[2] was followed closely in 2017 by severe flooding, bringing increasing attention to the potential benefits of GSI as an alternative to traditional hard engineered stormwater systems.[3] GSI is generally defined as a patchwork of natural areas that use vegetation, soils, and other elements to restore the natural processes required to manage water while providing habitat, flood protection, cleaner air, and cleaner water to urban environments.[4] GSI is being rapidly installed in cities across the United States and around the world.

While some progressive cities have been experimenting with small GSI projects since the mid-2000s as a means of flood reduction, the water crisis in 2015 renewed interest in GSI technology among California cities looking to recapture as much rainwater as possible.[5] Southern California cities were among the first to install GSI on a larger scale, with Los Angeles implementing a Green Street Program

---

[1] Daniel Albritton, et. al., "Climate Change 2001: Synthesis Report" (Intergovernmental Panel on Climate Change, Cambridge, UK, 2001); C40 Cities, "C40 Fact Sheet," (C40 Cities Climate Leadership Group, London, UK, 2015); U.S. Global Change Research Program, "Climate Change in the United States," (United States National Climate Assessment, Washington, D.C., 2014).

[2] Jay Lund, Josue Medellin-Azuara, Joghn Durand and Kathleen Stone, "Lessons from California's 2012-2016 Drought," *Journal of Water Resources Planning and Management*, 144, No. 10 (2018).

[3] Sang-Soo Baek, Dong-Ho Choi, Jae-Woon Jung, Hyung-Jin Lee, Hyuk Lee, Kwang-Sik Yoon, Kyung Hwa Cho, "Optimizing low impact development (LID) for stormwater runoff treatment in urban area, Korea: Experimental and modeling approach." Water Research 86(2015): 122-131; Sara Perales-Momparle, Ignacio Andres-Domenech, Carmen Hernandez-Crespo, Francisco Valles-Moran, Miguel Martin, Ignacio Escuder-Bueno, Joaquin Andreu, "The role of monitoring sustainable drainage systems for promoting transition toward regenerative urban built environments: a case study in the Valencian region, Spain." Journal of Cleaner Production 163 (2017): S113-S124; Aikaterini Basdeki, Lysandros Katsifarakis, Konstantinos Katsifarakis, "Rain gardens as integral parts of urban sewage systems-A case study in Thessaloniki, Greece," Procedia Engineering 162 (2016) 426-432; Suripin, Raith Pujiastuti, Widjonarko, "The initial step for developing sustainable urban drainage systems in Semarang city-Indonesia," Procedia Engineering 171 (2017): 1486-1494; DC Water, "Green Infrastructure," dcwater.com, April 22, 2018, https://www.dcwater.com/green-infrastructure; City of Portland, "Green Streets Policy," (City of Portland, Portland, OR, (2007).

[4] United States Environmental Protection Agency, "What is Green Infrastructure" www.epa.gov, April 22, 2018, https://www.epa.gov/green-infrastructure/what-green-infrastructure.

[5] Interviewee #4, "Stormwater Green Infrastructure Interview," Interview by Carolyn Neer. January 24, 2019; Interviewee #1, "Stormwater Green Infrastructure Interview," Interview by Carolyn Neer. January15, 2019; Interviewee #2, "Stormwater Green Infrastructure Interview," Interview by Carolyn Neer. February 1, 2019, Interviewee #3, "Stormwater Green Infrastructure Interview," Interview by Carolyn Neer. February 8, 2019.

that facilitated installation of GSI on streets throughout the city.[6] This was followed closely by other cities, such as El Cerrito and San Jose, which in 2017 completed similar green streets projects in their downtown districts.[7]

This recent uptick in GSI installations, combined with a growing body of research to support claims about its effectiveness at reducing water pollution and reconnecting the hydrologic cycles of urban areas, prompted the Regional Water Quality Control Board (RWCQB) for the San Francisco Bay region to issue an order in 2017 calling for 76 of the 77 jurisdictions under its authority to develop comprehensive GSI plans to facilitate large-scale installation of GSI throughout these cities. This bold move on the part of the RWQCB marked a decisive shift for local agencies in the Bay Area toward a more integrated and resilient approach to water management.

Despite the benefits that GSI may have over traditional hard-engineered stormwater systems, little remains known about the impacts of large-scale GSI installations across a city and still less about the long-term impacts of GSI facilities on water quality. Moreover, the growing popularity of collaborative governance models among water management agencies poses a unique opportunity for further study into the best methods for maintaining and monitoring GSI facilities across municipalities.

1.2 LOOKING FORWARD

The primary objective of this paper is to identify methods which the City of San Jose can implement to facilitate an expansion of its GSI facilities on public property while also preventing the spread of groundwater contamination. In order to fulfill this objective, this paper will explore scientific literature on GSI facilities; examine the methods used by other Bay Area jurisdictions to install GSI facilities on and near sites with known contamination and review literature on collaborative watershed management to identify the best methods to facilitate implementation of a collaborative governance model for GSI planning in San Jose. The purpose of this paper is to inform decision makers and agency staff in the City of

---

6 Haan-Fawn Chau, "Green Infrastructure for Los Angeles: Addressing Urban Runoff and Water Supply Through Low Impact Development," (City of Los Angeles, Los Angeles, CA 2009): 48-54.

7 City of San Jose, "Green Infrastructure," sanjoseca.gov, accessed April 22, 2018, http://www.sanjoseca.gov/index.aspx?NID=5722; U.S. EPA, "Clean Water State Revolving Fund Green Project Reserve, Case Study: El Cerrito Green Street Project Integrating Green Infrastructure with Community Needs," (government report, Washington, DC, 2018).

San Jose, Santa Clara Valley Water District, and RWQCB so that they can develop a more effective GSI plan.

This report will take an interdisciplinary approach, reviewing the literature on GSI technology, contaminant remediation, hydrology, water resource management, and collaborative governance to answer the research question:

- How can a collaborative governance model be used to improve the effectiveness of the City's GSI plan?

Finally, this report will be structured as follows: the definition of GSI will be reiterated in Chapter 2 followed by brief descriptions and illustrations of the various types of GSI facilities. In addition, a review of current literature will be used to explain the impacts of GSI on water quality and groundwater recharge. Chapter 3 provides an overview of the agencies, goals, and policies governing GSI and groundwater in San Jose followed by a literature review of the Watershed Approach to collaborative governance and an overview of the City of San Jose's Green Infrastructure planning efforts. Chapter 4 reviews best practices used by three Bay Area cities in the installation of existing GSI facilities and analyzes these findings using methods described in the literature on collaborative watershed management. Policy recommendations for the City of San Jose are made based on this analysis and presented in Chapter 5. Finally, Chapter 6 summarizes this report and offers suggestions for further research.

2.3 BACKGROUND/ SETTING

The City of San Jose sits at the mouth of the Santa Clara Valley on the southern shores of the San Francisco Bay, approximately 50 miles south of San Francisco. Occupying 108 square miles, San Jose boasts a population of over 1 million people, making it the fourth largest city in California by land space and the 10th largest city in the United States by population size.[8] Although San Jose is highly urbanized, for much of the City's history it has been an agricultural town and shipping center serving the farms and orchards that lined the Santa Clara Valley and drove its regional economy for decades.

---

[8] United States Census. "American Fact Finder – Results," United States Census Bureau, May 2017, accessed December 2, 2018, https://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?src=CF; Wikipedia, "List of largest California cities by land area," Wikipedia, 2012, accessed December 2, 2018, https://en.wikipedia.org/wiki/List_of_largest_California_cities_by_land_area .

Like many communities in the western United States, land and water use in San Jose intensified with increasing development in the region through the 20th century.[9] By the 1930s, agricultural production in San Jose was at its peak and groundwater remained the primary water source for residents. At this time, the growth of the agricultural industry began to strain regional groundwater supplies, with groundwater levels reaching historic lows of approximately 100 feet below the ground surface.

By the 1960s, the suburbanization of the Santa Clara Valley and the increased population (from 21,500 in 1900 to 204,196 in 1960) that accompanied such growth resulted in yet another historic low in groundwater levels and significant land subsidence. At that time, groundwater dropped 200 feet below ground surface and the land subsided nearly 13 feet.[10] Since that time, groundwater levels have continued to fluctuate with periods of extreme drought despite modern groundwater monitoring technology and the importation of supplemental surface water supplies from elsewhere in the state.[11] Figure 1 below shows the changing groundwater levels in the Santa Clara Valley between 1900 and 2016.

[9] Santa Clara Valley Water District, "Groundwater Management Plan 2016" (government policy, San Jose, CA, 2016).
[10] Santa Clara Valley Water District, "Groundwater Management Plan 2016" (government policy, San Jose, CA, 2016); Bay Area Census, "City of San Jose Santa Clara County" Bay Area Census , accessed December 2, 2018, www.bayareacensus.ca.gov/cities/SanJose50.htm.
[11] R. T. Hanson, "Hydrologic framework of the Santa Clara Valley, California. United States Geologic Survey. 2015; Santa Clara Valley Water District. "Groundwater Management Plan 2016" (government policy, San Jose, CA, 2016).

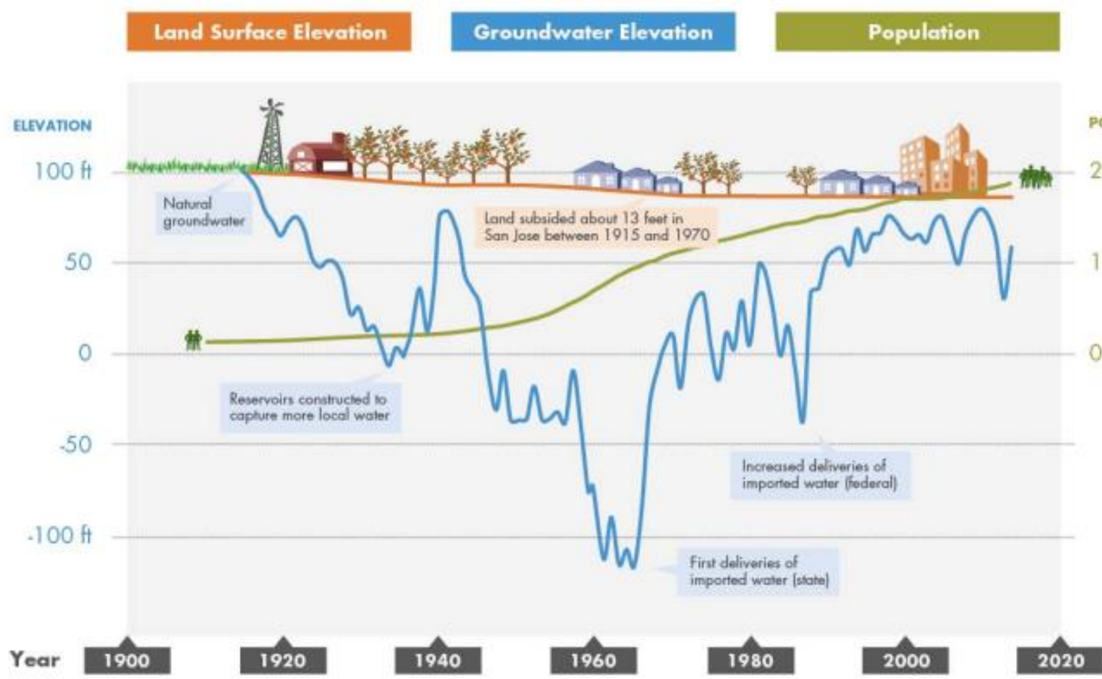

FIGURE 1 HISTORIC GROUNDWATER LEVELS IN THE SANTA CLARA VALLEY
Note: As shown in the graph above, groundwater levels in Santa Clara Valley have fluctuated greatly since the 1920s.
Source: Santa Clara Valley Water District, "Groundwater Management Plan 2016," (government policy, San Jose, CA, 2016).

In addition to groundwater impacts, population growth, coupled with a rapid expansion of the defense and technology industries in Santa Clara County during the second half of the 20th-century, also facilitated major changes to San Jose's land use patterns. Development in San Jose was characteristic of the post-war era with mass suburbanization, sprawling development and segregated land uses.[12] As a result, residential neighborhoods were constructed farther and farther away from employment centers necessitating the use of automobiles and the construction of extensive surface parking lots.[13] A consequence of this development pattern, concrete and asphalt soon replaced grass and other natural groundcover as the dominant feature within the city.

While San Jose transformed from a regional agricultural market city into a global technology center, the water quality in area surface and groundwater bodies declined. Extensive hard surfaces, such

[12] City of San Jose. "Envision San Jose 2040 General Plan" (government policy, San Jose, CA 2011).
[13] Santa Clara Valley Transportation Authority (VTA). "Valley Transportation Plan" (government policy, San Jose, CA 2015).

as parking lots and multi-lane freeways disrupted the natural hydrologic cycles and increased the transport of pollutants from the ground into waterways.

By the 1970s and 1980s, the misuse and careless disposal of hazardous chemicals at computer chip manufacturing facilities throughout the city led to storage tank leaks that contaminated water and soil, threatening the health of the environment for residents and wildlife in the region.[14] In 1979, leaks in the chemical storage tanks at IBM's south San Jose facility were detected, marking the beginning of an era of contamination and clean up for the South Bay.[15] Two years later, a major chemical spill of over 60,000 gallons of waste solvents into the groundwater beneath the Fairchild Semiconductors facility brought heightened concern for the safety of local groundwater supplies and attracted national attention as regulators on federal, state and local levels were brought in to address the issue.[16]

In the decades since these original leaks, dozens of other leaks have been detected throughout Santa Clara County. Millions of dollars and years of remedial action have been invested into the area to address environmental health concerns.[17] Today, portions of San Jose's groundwater supply remains contaminated. The County holds the record for the most federally-designated Superfund sites in the United States and all of the surface water bodies in the City are designated "impaired" by the US EPA.[18] The most common contaminants of concern in San Jose are MTBE (an additive formerly used in gasoline), volatile organic compounds (VOCs), heavy metals, polychlorinated biphenyls (PCBs), and pesticides.[19]

---

[14] David N. Pellow and Lisa Sun-Hee Park, *Silicon Valley of Dreams: Environmental Injustice, Immigrant Workers, and the Global Technology Industry* (New York, NY: NYU Press, 2002) 70-84.
[15] United State Environmental Protection Agency. "Groundwater Contamination Cleanups at South Bay Superfund Sites, Progress Report" (government report, Washington, D.C. 1989).
[16] Eseau and Chesterman, Groundwater Contamination in the Santa Clara Valley; United State Environmental Protection Agency. "Groundwater Contamination Cleanups at South Bay Superfund Sites, Progress Report" (government report, Washington, D.C. 1989).
[17] Ibid. 1989
[18] Evelyn Nieves, "The Superfund Sites of Silicon Valley," New York Times, March 26, 2018. https://www.nytimes.com/2018/03/26/lens/the-superfund-sites-of-silicon-valley.html;United States Environmental Protection Agency. "Water Quality Assessment and TMDL Information" www.epa.gov, December 2, 2018. https://ofmpub.epa.gov/waters10/attains_index.home.
[19] United State Environmental Protection Agency. "Groundwater Contamination Cleanups at South Bay Superfund Sites, Progress Report" (government report, Washington, D.C. 1989).

Current efforts by the RWQCB and the City of San Jose to reduce future contaminant loading in San Jose's soils and groundwater are explored in Chapter 2.

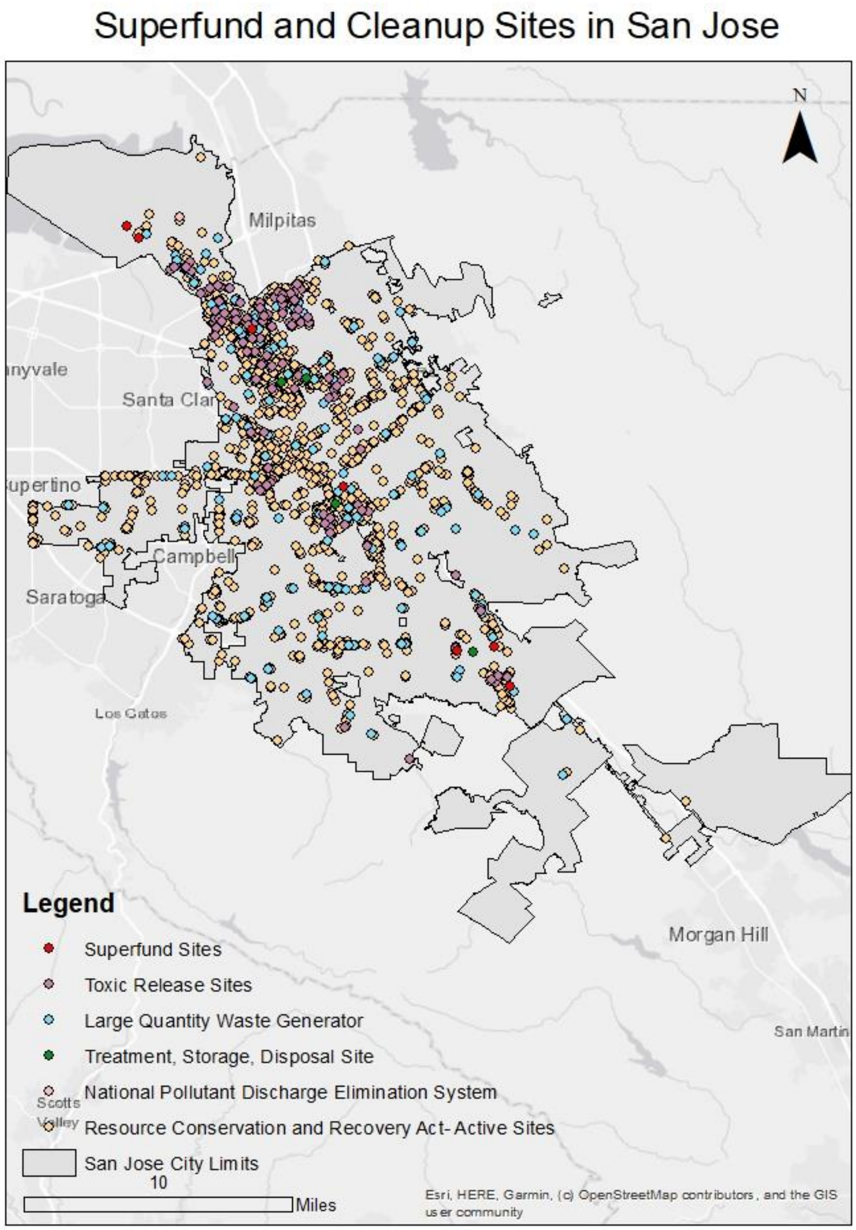

FIGURE 2 EXISTING HAZARDOUS MATERIALS CLEAN UP SITES IN SAN JOSE

Source: Author's map, created using data from California Department of Toxic Substances Control, EnviroStor Database Search: "San Jose, CA," April 24, 2019, https://www.envirostor.dtsc.ca.gov/public/map/?myaddress=san+jose+ca.

CHAPTER 2 THE SCIENCE BEHIND GSI

This chapter examines available literature on GSI in the US and across the globe to understand the use and effects of GSI on water quality, and groundwater recharge. Information included in this chapter will provide background and context for future discussion of San Jose's GSI policy found in Chapter 3.

2.1 WHAT IS GSI AND HOW DOES IT WORK?

GSI, also commonly referred to as Low Impact Development technology or simply Green Infrastructure, is defined by the US EPA as "a patchwork of natural areas that use vegetation, soils and other elements to restore the natural processes required to manage water while providing habitat, flood protection, cleaner air, and cleaner water to the urban environments".[20] There are many different types of GSI facilities, each with a unique design and slightly different purpose and function. The most commonly used GSI facilities in urban environments include bioretention basins, bioswales, rain gardens, stormwater trees, permeable pavement, and green roofs. The following section includes a brief description of each type of GSI facility followed by images of these facilities.

Bioretention Facilities

Bioretention facilities are shallow landscaped depressions that capture and manage sediment and stormwater runoff. Commonly designed with a soil mix and plants adapted to the local climate, bioretention facilities receive stormwater from a contributing area, such as the street. Bioretention facilities can be designed to reduce overall stormwater runoff quantity,optimizing surface flow rates and removing or reducing sediment and pollutants from stormwater runoff. [21]

Bioswales

Bioswales are shallow bioretention facilities with sloped sides on all sides designed to capture, treat and manage stormwater runoff from a contributing area. Bioswales are also commonly referred to as rain gardens.[22]

---

[20] United States Environmental Protection Agency, "What is Green Infrastructure" www.epa.gov, April 22, 2018, https://www.epa.gov/green-infrastructure/what-green-infrastructure.

[21] National Association of City Transportation Officials. *Urban Street Stormwater Guide.* Washington DC: Island Press, 2017.

[22] Ibid. 2017

Stormwater Trees

Stormwater Trees are a type of bioretention facility that feature a tree planted in a tree well or tree pit and is designed to maximize stormwater retention. The system can be designed to have walled sides, subsurface cells, structural soil, or be depressed below grade to retain stormwater. The soil media is designed to easily infiltrate stormwater and is typically sited below the street's gutter elevation allowing the tree to manage stormwater runoff from the street or sidewalk. [23]

FIGURE 3 BIORETENTION FACILIES IN THE BAY AREA
Sources: (left) Institute for Local Government. "El Cerrito Transforms Urban Highway into Main Street with Pedestrian and Environmental Amenities," Institute for Local Government, (accessed December 3, 2018, http:/www.ca-ilg.org/case-story/el-cerrito=transforms-urban-highway-main-street-pedestrian-and-environment, -friendly;(right) City of Lancaster, "Streets and Alleys, Mulberry Street," City of Lancastr, (accessed April 3, 2019). http://www.saveitlancaster.com/rain-gardens-along-w-james-st/

[23] National Association of City Transportation Officials. *Urban Street Stormwater Guide*. Washington DC: Island Press, 2017.

Permeable Pavement

Permeable Pavement refers to pervious concrete, porous asphalt, permeable interlocking concrete pavers, or other form of pervious or porous paving material intended to allow passage of water through the pavement section.[24]

FIGURE 4 PERMEABLE PAVEMENT
Source: Interstate Commission on the Potomac River Basin. "Watershed Connections," 2019. Https://www.potomacriver.org/

[24] Ibid. 2017

Green Roofs

Green Roofs are building roofs that include a layer of vegetation planted over a waterproofing system that is installed on top of a flat or slightly-sloped roof.[25]

FIGURE 5 GREEN ROOF AT ACADEMY OF SCIENCE, SAN FRANCISCO
Souce: California Academy of Sciences. "Museum Map," 2019. https://www.calacademy.org/museum-map/

[25] National Parks Service. "What is a Green Roof?" United States Department of the Interior, December 2, 2018, https://www.nps.gov/tps/sustainability/new-technology/green-roofs/define.htm.

Bio-retention

- Landscaped depression capures and manages stormwate
- Examples:
  - bio retention basin
  - bioswales
  - street trees

Permeable pavement

- Porous paving material that alows water to pass through
- Examples:
  - concrete
  - stones
  - pavers

Green roofs

- Vegetative and water resistent materials applied over flat or lightly sloped roof
- Examples:
  - San Francisco Academy of Sciences

2.2 IMPACTS OF GSI ON RUNOFF AND WATER QUALITY

As noted in Chapter 1 above, GSI provides many benefits to the environment in urban areas; it reconnects the hydrologic cycle of urban areas contributing to greater absorption of stormwater back into the soil, and filters pollutants from stormwater that would otherwise be deposited into surface bodies via stormwater sewer outflows. The following section provides a summary of recent literature confirming the benefits of GSI installations.

Numerous studies across the world attest to the effectiveness of GSI facilities at reducing stormwater runoff. In China and South Korea, computer modeling technology was used to study the change in urban runoff volumes before and after the installation of GSI facilities. The results revealed that the installation of GSI in Bazhong City, Sichuan province, reduced stormwater runoff by 33 percent, while similar installations in Cheongju, South Korea resulted in an average reduction of 48 percent.[26]

[26] Fanhua Kong, Yulong Ban, Haiwei Yin, Philip James, and Iryna Dronova, Modeling stormwater management at the city district level in response to chanes in land use and low impact development. Environmental Modeling & Software, 95, (2017):132-142; Junho Kim, Jungho Lee, Yangho Song, Heechan Han, and Jingul Joo, " Modeling the Runoff Reduction Effect of Low Impact Development Installations in an Industrial Area, South Korea," *Water,* (2018).

In the United States, similar modeling studies were conducted in Normal, Illinois revealing stormwater reduction rates of up to 47 percent.[27] However these conclusions were not limited to mathematical projections; in Missouri and Utah, green roofs and rain gardens were installed and tested for their efficacy at reducing runoff. Green roofs in Missouri were found capable of reducing runoff by 60 percent, while similar green roofs and rain gardens in Utah demonstrated runoff reductions of between 35 percent and 45 percent annually, depending on the amount of rainfall received.[28] Finally, in a qualitative study of flooding in Thessaloniki, Greece rain gardens installed in a residential neighborhood resulted in visibly less flooding over a two- year period.[29]

The second major benefit and function of GSI is their ability to filter contaminants from stormwater runoff. Plant transpiration is the physiological function in plants that makes green infrastructure effective at filtering pollutants from stormwater. Transpiration occurs within all plants and involves the uptake of water from the roots and the transportation of that water throughout the body of the plant where it is held temporarily before being released back into the air.[30] Nutrient accumulation goes hand in hand with transpiration as nutrients in the water are distributed throughout the plant and stored in the plant tissue (leaves, stem and flowers), delivering essential nutrients for plants to grow.[31] When the soil and water around a plant's root system are contaminated, those contaminants are extracted from the soil and groundwater and redistributed into the plant's tissue where they are held and processed.[32] A study of this natural remediation function of plants conducted by Negri and Hinchman in 1995, revealed that the higher

---

[27] Laurent Ahiablame and Ranish Shakya, "Modeling flood reduction effects of low impact development at a watershed scale." *Journal of Environmental Management,* 171, (2016): 81-91.

[28] Grace Harper, "Green roof water quality impacts and physiochemical stability," Master's Thesis Missouri University of Science and Technology, 2013; Youcan Feng, Steven Burian, Christine Pomeroy, "Potential of green infrastructure to restore predevelopment water budget of semiarid urban catchment," *Journal of Hydrology 542* (2016), 744-755.

[29] Aikaterini Basdeki, Lysandros Katsifarakis, Konstantinos Katsifarakis, Rain gardens as integral parts of urban sewage systems-A case study in Thessaloniki, Greece, Procedia Engineering, 62 (2016): 426-432.

[30]Howard Perlman, "Transpiration – The Water Cycle," United States Geologic Service (USGS), December 2, 2016, https://water.usgs.gov/edu/watercycletranspiration.html.

[31] Cristina Negri, Ray Hinchman, "Plants that Remove Contaminants From the Environment," *Laboratory Medicine 27*, no. 1 (1995).

[32] Sarka Petrova, Jan Rezek, Petr Soudek, and Tomas Vanek, "Preliminary study of phytoremediation of brownfield soil contaminated by PAHs," *Science of the Total Environment 599-600* (2017), 572-580.

the evapotranspiration rate and salt tolerance of a plant species, the more effective it can be at remediating contaminants from groundwater and soil.[33]

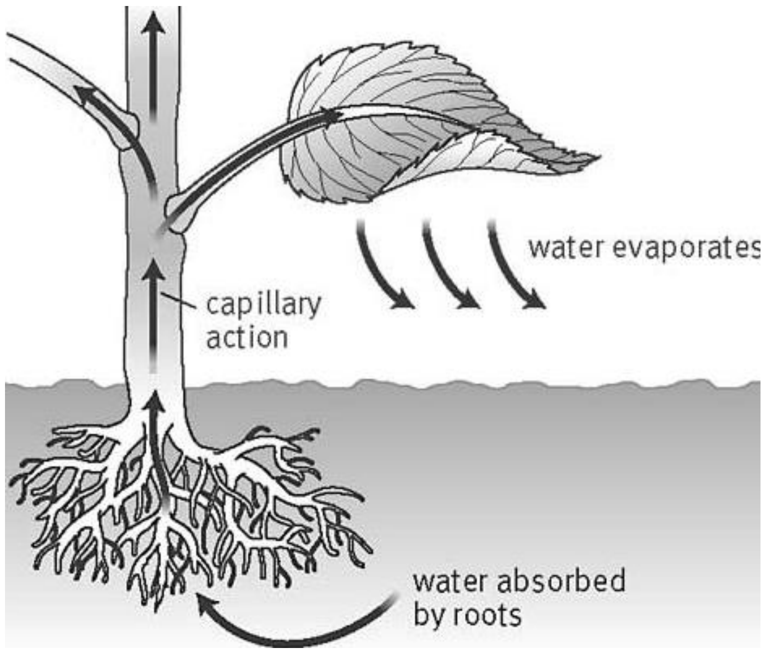

FIGURE 6 EVAPOTRANSPIRATION
Source: Sunny Datko, "What is Plant Transpiration," (website, 2018), http://sdhydroponics.com/2012/05/30/what-is-plant-transpiration/.

Numerous studies of green infrastructure installations across the United States support this fundamental understanding of remediation with plants. In 2016, Pavlowsky conducted a study of the water quality benefits of installing GSI facilities on a downstream lake in central Missouri. Bioretention facilities and pervious pavement were installed in Rolla, Missouroi upstream from Frisco Lake, an urban surface water bodywhere water quality was monitored over the course of one year. Together, biorentention facilities and pervious pavement reduced nutrient loading in Frisco Lake by 19 – 31 percent.[34] Similar studies of bioswales in Maryland and constructed wetlands in Onondaga, New York found these GSI

[33] Cristina Negri, Ray Hinchman, "Plants that Remove Contaminants From the Environment," *Laboratory Medicine 27*, no. 1 (1995).
[34] Johanna Pavlowsky, Assessing Downstream Stormwater Impacts for Urban Watershed Planning, Master's Thesis, Missouri University of Science and Technology, (2016).

facilities capable of removing between 33 percent and 40 percent of pollutants from stormwater runoff.[35] Similarly in Bejing, China a study of permeable pavement installations on a corporate campus demonstrated an average contaminant removal rate of 47 percent.[36]

However effective the natural nutrient accumulation and transpiration processes of plants can be, Tedoldi, et al.'s long-term study of contaminant accumulation in soil and groundwater near GSI facilities suggests that there is a limit to the effectiveness of these natural processes. Tedoldi, et al.'s investigation of soil and groundwater quality near five types of GSI facilities over a 20-year period suggests that there is a limit to the effectiveness of these natural processes.[37] The study revealed that the longer GSI facility operates, the higher the contaminant concentrations in surrounding soil and groundwater.[38]

Although this study does not present enough evidence to nullify the prior findings regarding the beneficial properties of GSI on contaminated groundwater and soil, it does suggest that widespread and long-term use of GSI facilities could potentially have a negative impact on local soil and groundwater quality. Thus, as GSI facilities are installed on public property with increasing frequency, the ability of water management agencies to monitor water quality at these sites could provide a critical source for new data and fuels future research into the long-term impacts of GSI facilities on water quality and soil contamination.

[35] Charles Driscoll, David Chandler, Caitlin Eger, and Babak Kassaee Roodsari, "Green Infrastructure Lessons from Science and Practice" *Research Gate*, (2015); James Stagge, Allen Davis, Eliea Jamil, Hunho Kim, "Performance of grass swales for improving water quality from highway runoff." *Water Research,* 46. (2012): 6731-6742.
[36] Shuhan Zhang, Yingying Meng, Jiao Pan, and Jiangang Chen, "Pollutant reduction effectiveness of low-impact development drainage system in a campus," Frontiers of Environmetnal Science and Engineering, 11, (2017).
[37] Damien Tedoldi, Ghassan Chebbo, Daniel Pierlot, Yves Kovacs, and Marie-Christine Gromaire, "Impact of runoff infiltration on contaminant accumulation and transport in the soil/ filter media of Sustainable Urban Drainage Systems: A literature review," *Science of the Total Environment 569-57* (2016), 904-926.
[38] Damien Tedoldi, Ghassan Chebbo, Daniel Pierlot, Yves Kovacs, and Marie-Christine Gromaire, "Impact of runoff infiltration on contaminant accumulation and transport in the soil/ filter media of Sustainable Urban Drainage Systems: A literature review," *Science of the Total Environment 569-57* (2016), 904-926.

CHAPTER 3 A WEB OF WATER AGENCIES

Stormwater and groundwater in the City of San Jose are governed by a complex web of regulatory agencies on state, regional and local levels. To clarify the roles and responsibilities of each agency and their respective policies, the following chapter is broken up into three sections. The first section provides a brief description of each agency and their role in regulating stormwater and groundwater in San Jose. The second section explores the current literature on watershed management and collaborative governance to determine methods for the City to unify the efforts of these various agencies and capitalize on the institutional knowledge and professional expertise they possess. Lastly, this chapter includes a detailed description of the City of San Jose's Green Infrastructure Plan in an effort to establish baseline understanding of the City's recent GSI planning efforts.

3.1 REGULATORY SETTING

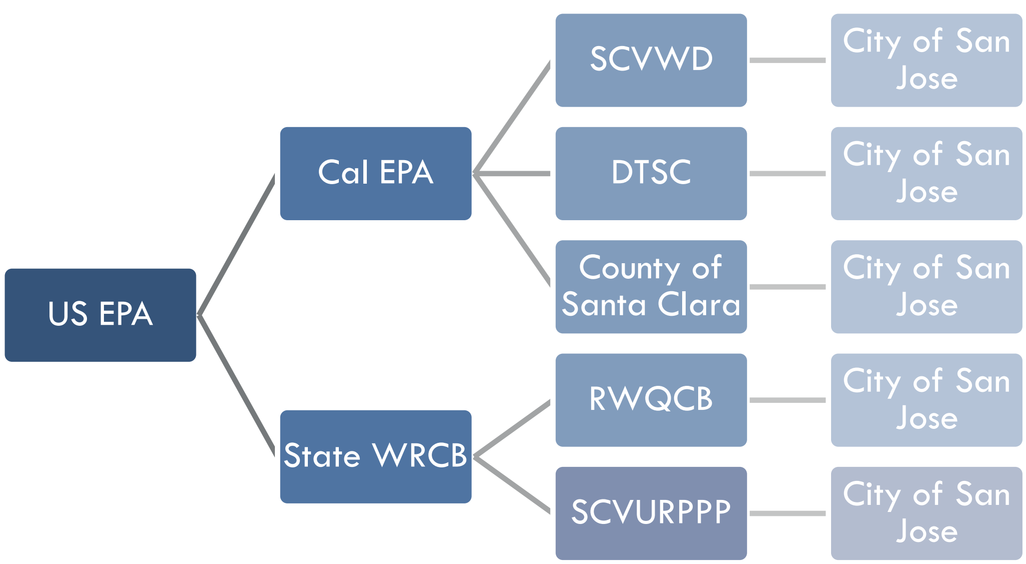

FIGURE 7 REGULATOY AGENCIES INVOLVED IN STORMWATER MANAGEMENT
Note: From left to right federal, state, regional, and local agencies involved in regulating stormwater and groundwater quality in San Jose.

California Environmental Protection Agency

The California Environmental Protection Agency (CalEPA) is the state's regulatory agency for enforcing pollution control laws such as the Clean Water Act. In addition, CalEPA oversees the State Water Resources Control Board and by extension the Regional Water Quality Control Board for the San Francisco Bay Region (RWQCB), which are tasked with implementing and enforcing the provisions of the Federal Clean Water Act in California. All water-related activities that occur in San Jose are required to comply with the Clean Water Act and are subject to CalEPA oversight.

CalEPA is also responsible for overseeing cleanup activities on federally designated Superfund sites in California. Superfund sites are properties where hazardous waste has been dumped, left out in the open, or otherwise improperly managed. Enabled by the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) of 1980, the CalEPA cleans up contaminated sites and forces parties responsible for the contamination to either perform clean ups or reimburse the government for EPA-led cleanup efforts.[39] There are currently two active federally designed Superfund sites in the City of San Jose.[40]

State Water Resources Control Board

The State Water Resources Control Board (SWRCB) is responsible for implementing federally mandated water quality regulations in the state of California. Authority over enforcement of these regulations is then delegated to the state's nine Regional Water Quality Control Boards. In addition to federal requirements, the State of California has set additional standards for water quality to which all residents and businesses must adhere. One such regulation is the Nonpoint Source Pollution Program (1988), which controls stormwater drainage in an effort to improve water quality and prevent stormwater

[39] United States Environmental Protection Agency, "What is Superfund?," https://www.epa.gov/superfund/what-superfund December 4, 2018.
[40] United States Environmental Protection Agency, "Cleanups in My Community Map," https://ofmpub.epa.gov/apex/cimc/f?p=CIMC:MAP:0:::71:P71_WELSEARCH:NULL|Cleanup||||false|false|true|false|false|false|||sites|Y, December 4, 2018.

pollution. Under this program, qualifying projects are required to take additional actions to prevent the transport of debris, sediments, and other potentially harmful material in water during construction.[41]

Additionally, the SWRCB oversees local agencies, such as the Santa Clara Valley Water District, in the management of groundwater supplies under the provisions of the Sustainable Groundwater Management Act (SGMA). Adopted in 2016, the SGMA was created to halt overdraft of the state's groundwater resources and facilitate efforts to balance groundwater levels through recharge. SGMA requires local agencies to adopt a sustainability plan to restore groundwater supplies to sustainable levels within 20 years of implementing these plans.[42]

State Department of Toxic Substance Control

The State Department of Toxic Substances Control (DTSC) serves three primary purposes: to manage the storage, transportation and disposal of hazardous materials; protect consumers from potentially hazardous materials in products, and oversee cleanup of sites with contaminated soils and groundwater.

In partnership with the Regional Water Quality Control Boards, the DTSC oversees the cleanup of hazardous materials release sites across the state and publishes two publicly available lists of active, inactive, and closed cleanup sites throughout the state called the EnviroStor and GeoTracker databases. All projects, activities and sites involving hazardous or potentially hazardous materials within the City of San Jose must comply with DTSC rules and regulations. There are currently 215 contaminated sites in the City of San Jose listed on the EnviroStor database.[43]

Regional Water Quality Control Board – San Francisco Bay Region

There are nine RWQCBs in California. The San Francisco Bay RWQCB is responsible for enforcing water quality regulations within all 77 Bay Area municipalities. The San Francisco Bay RWQCB issues a

[41] State Water Resources Control Board. "National Pollutant Discharge Elimination System (NPDES) – Wastewater." https://www.waterboards.ca.gov/water_issues/programs/npdes/. December 2, 2018.
[42] State Water Resources Control Board. "Groundwater Management Program," https://www.waterboards.ca.gov/water_issues/programs/gmp/. December 2, 2018.
[43] California Department of Toxix Substances Control. "Envirostor database search: San Jose, CA," https://www.envirostor.dtsc.ca.gov/public/, retrieved on December 2, 2018.

Municipal Regional Stormwater National Pollution Discharge Elimination System permit that covers development activities in all Bay Area jurisdictions. Under the provisions of the permit, qualifying projects are required to design and construct stormwater treatment controls to treat post-construction stormwater runoff and prevent increase in stormwater pollution. Common methods of treating post-construction runoff include installation of GSI facilities.

Recently, the RWQCB efforts to reduce stormwater runoff pollution have been enhanced with the issuance of Order No R2-2015-0049. Under this order, all Bay Area municipalities (except for the City and County of San Francisco, which is regulated under a separate permit and subject to other requirements) are required to prepare and submit a formal city-wide Green Infrastructure Plan to the RWQCB for approval by September 30, 2019.[44] These plans are intended to facilitate widespread installation of GSI facilities on city-owned property to further reduce stormwater pollution and further improve water quality in the region.

Additionally, under its Site Cleanup Program, the RWQCB is responsible for overseeing the cleanup of contaminated groundwater in the region. The RWQCB regulates and oversees the investigation and cleanup of sites where recent or historical unauthorized release of pollutants to has occurred.[45] All cleanup efforts on sites in the City of San Jose are overseen by the RWQCB and DTSC.

Santa Clara Valley Water District

Formed in 1951, the Santa Clara Valley Water District (SCVWD) is the flood control district for Santa Clara County. SCVWD provides flood control services to the county and protects water courses, watersheds, public highways, life, and property from damage or destruction during floods. In addition, SCVWD facilitates the conservation and distribution of water for beneficial use in the Santa Clara County.[46] One of the District's objectives identified in its *Urban Water Management Plan* states that the

---

[44] California Regional Water Quality Control Board - San Francisco Bay Region, "Municipal Regional Stormwater NPDES Permit: Order No. R2-2015-0049, NPDES Permit No. CA5612008" (Public document, San Francisco, 2015).
[45] California Water Resources Control Board. "Site Cleanup Program (SCP)," https://www.waterboards.ca.gov/water_issues/programs/site_cleanup_program/. December 2, 2018.
[46] California State Assembly. Assembly Bill-466 Santa Clara Valley Water District. (Assembly bill, Sacramento, CA, 2009).

district will "aggressively protect groundwater from the threat of contamination and maintain and develop groundwater to optimize reliability and to minimize land subsidence and salt water intrusion."[47]

SCVWD adopted the 2016 *Groundwater Management Plan* for the Santa Clara and Llagas subbasins in November 2016. The plan outlines the district's groundwater sustainability goals, strategies, and actions to achieve those goals.

County of Santa Clara, Department of Environmental Health

The Hazardous Materials Compliance Division (HMCD) of the Santa Clara County Department of Environmental Health was established in 1983 with the adoption of the local Hazardous Materials Storage Ordinance (HSMO), which regulates the storage of hazardous materials above and below the ground. This ordinance was the first of its kind in the state and was developed in direct response to the area's many large hazardous material leaks. The ordinance seeks to protect public health and the environment by regulating the storage of hazardous materials throughout the County. The HMCD also works in collaboration with the RWQCB to enforce its Non-Point Source Pollution Ordinance.

Santa Clara County Urban Runoff Pollution Prevention Program (SCVURPPP)

All cities in Santa Clara County participate in the Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPP). Established in 1980, SCVURPPP was developed to facilitate collaboration and information sharing between public agencies in Santa Clara County regulated under a shared stormwater discharge permit. SCVURPPP is composed of two dedicated program staff, representatives from each of the County's 15 cities, and representatives from the Santa Clara County Water District.

Since its inception, the primary goal of SCVURPPP has been to assist member agencies in understanding and meeting the requirements of the County's municipal stormwater discharge permit through education, outreach and developing sample plans, and ordinance language for member agencies to adopt in their own jurisdictions.

[47] Santa Clara Valley Water District, 2015 Urban Water Management Plan, (San Jose, CA, 2016).

SCVURPP's effort to educate member agencies about GSI facilities began in 2010, when the municipal discharge permit first included provisions requiring incorporation of GSI facilities into the design of new developments totaling 10,000 square feet or greater. In December 2018, SCVURPPP published a Stormwater Resources Plan which is used to facilitate rapid development of citywide green infrastructure plans. The Stormwater Resources Plan identifies potential locations for GSI installations across the 15 jurisdictions in the county, provides design guidelines, tips for implementation of citywide green infrastructure plans, and model language to be added to existing planning documents such as general plans or specific plans to make these agencies' GSI planning efforts more effective and legally defensible.

In order to identify priority sites for potential GSI installations, SCVURPPP worked closely with the SCVWD and member jurisdictions to develop a Geographic Information Systems (GIS) application with soil, hydrology, and groundwater contamination data to identify the locations in the county best suited for GSI installations and groundwater recharge. This tool were then used by planners to screen potential sites based on criteria such as: physical characteristics, proximity to existing storm drains, flood prone areas or streams, PCB interest areas, priority to development areas, co-located planned projects, and multiple benefits.[48]

Sites with known contamination in groundwater or soils were largely avoided, along with areas with clayey soils such as those near the San Francisco Bay where stormwater infiltration is inhibited. Based on this GIS application, the Stormwater Resources Plan identified prime locations for future GSI installations in the central part of the Santa Clara Valley as well as in areas near the base of the Diablo Range and Santa Cruz Mountains where soil conditions are conducive to infiltration. Once identified, these potential sites are eligible to receive state grant funding for construction.[49]

---

[48] Santa Clara Valley Urban Runoff Pollution Prevention Program, "Stormwater Resources Plan," scvurppp.org, December 2018, https://scvurppp.org/swrp/

[49] Santa Clara Valley Urban Runoff Pollution Prevention Program, "Stormwater Resources Plan," scvurppp.org, December 2018, https://scvurppp.org/swrp/; Interviewee #7, "Stormwater Green Infrastructure Interview," Interview by Carolyn Neer. February 6, 2019; Interviewee # 6 "Stormwater Green Infrastructure Interview," Interview by Carolyn Neer. January 25, 2019.

While installation of the GSI facilities identified in SCVURPPP's Stormwater Resources Plan is not required by law, prioritization criteria, methodology, and sample language included in the plan act as a useful example for individual cities (such as San Jose) as they develop their citywide GSI plans.

City of San Jose

Authority over stormwater drainage systems in the City of San Jose is shared between three City departments: the Public Works Department, Environmental Services Department and the Planning, Building and Code Enforcement Department. While the Planning, Building and Code Enforcement Department's responsibilities (in regards to stormwater management) are limited to goal setting and ensuring that projects comply with Federal and State laws that regulate stormwater, the Public Works Department plays a more active role in the design and implementation of the City's stormwater drainage system. For example, the Public Works Department was responsible for the City's recent Green Streets Pilot Project which installed pervious pavement in Martha's Garden Alley and bioretention facilities along Park Avenue in Downtown San Jose.[50]

FIGURE 8 RAIN GARDENS INSTALLED ALONG PARK AVENUE
Source: City of San Jose. "Green Stormwater Infrastructure," sanjoseca.gov, http://www.sanjoseca.gov/index.aspx?NID=5722 (accessed April 7, 2019).

[50] City of San Jose, "Green Infrastructure," sanjoseca.gov, accessed April 22, 2018, http://www.sanjoseca.gov/index.aspx?NID=5722.

There are a range of City plans and policies pertaining to GSI, including the *Envision San Jose 2040* General Plan, the *Climate Smart San Jose* Climate Action Plan, the SCVURPPP (1990), the Urban Runoff Management Policy (1998, revised 2006), the Hydromodification Management Policy (2005, revised 2010), and finally, the Draft Green Infrastructure Plan Policy Framework (2017).

While the General Plan and Climate Action Plan set general goals for the City to promote groundwater capture, reduce stormwater pollution, and achieve sustainable groundwater supplies,[51] the SCVURPPP, Urban Runoff Management Policy, Hydromodification Management Policy and Green Infrastructure Plan (in process, expected completion June 2019) provide more concrete requirements and guidelines for reducing stormwater runoff and installing GSI throughout the city.

3.2 STRATEGIES FOR FACILITATING COLLABORATION

As demonstrated in the list of agencies above, water resource management commonly involves a wide range of agencies and organizations with authority over separate sources of contamination or geographic regions within a watershed. Historically, these agencies have operated in relative isolation from one another, limiting interaction and comment on policies to formal comment letters.[52] However, as Sabatier, et. al. state in their book, *Swimming Up Stream*, agencies frustrated by the inefficiency of this traditional management style, began in the 1990s to adopt a different approach to water resource management that sought to address all issues affecting the entire watershed, regardless of political boundaries.

[51] City of San Jose, *Climate Smart San Jose: A People-Centered Plan for a Low-Carbon City*, sanjoseca.gov, accessed May 15, 2018. http://www.sanjoseca.gov/DocumentCenter/View/75035; City of San Jose, *Envision San Jose General Plan,* sanjoseca.gov, accessed May 15, 2018. http://www.sanjoseca.gov/DocumentCenter/View/474.
[52] Paul Sabatier, Will Focht, Mark Lubell, Zev Trachtenberg, Arnold Vedlitz, Marty Matlock, Michael Kraft, and Sheldon Kamieniecki, *Swimming Up Stream: Collaborative Approaches to Watershed Management,* (MIT Press: Cambridge, MA, 2005).

Emphasizing a holistic approach to planning and pollution prevention, this new collaborative management style has required agencies to negotiate face-to-face with a variety of stakeholder groups and consider the social, economic, and environmental issues confronting the entire watershed.[53]

Since this time, collaborative watershed management has been so widely adopted that collaboration techniques are now a mainstay in resource management curricula at universities[54] and scholars have developed a theoretical models for successful collaborative governance programs.[55] According to Selin and Chavez, the five-steps for successful collaborative governance include:

1. **Antecedents.** It takes a catalyst such as financial incentives or an environmental or political crisis to jumpstart a collaborative planning program.
2. **Problem Identification.** Organizations must identify the problem in order to implement policy solutions.
3. **Direction Setting.** Once the problem is identified, it is important to establish goals and clear path of action.
4. **Monitoring.** Monitoring of the program must be conducted in order to assess its success and redirect actions if failures arise.
5. **Program Evaluation.** In the final stage, it is important for all agencies to come together and evaluate the successes and failures of the program.[56]

Using this five step-model as an analytical tool, the following discussion includes an analysis of literature on collaborative watershed management programs and identification of additional factors involved in the success of collaborative water management programs.

---

[53] Paul Sabatier, Will Focht, Mark Lubell, Zev Trachtenberg, Arnold Vedlitz, Marty Matlock, *Swimming Upstream: Collaborative Approaches to Watershed Management,* (MIT Press: Cambridge, MA, 2005).
[54] Hans Hummel, Jasper van Houcke, Rob Nadolski, Tony van der Hiele, Hub Kurvers, and Anshe Lohr, "Scripted collaboration in serious gaming for complex learning: Effects of multiple perspectives when acquiring water management skills," British Journal of Education Technology, Vol. 42, 6, (2011), 1029 -1041.
[55] Gary Bentrup, "Evaluation of a Collaborative Model: A Case Study Analysis of Watershed Planning in the Intermountain West." *Environmental Management* Vol. 27, 5. (2001), 739-748; Sarah Michaels, "Making Collaborative Watershed Management Work: The Confluence of State and Regional Initiatives," Environmental Management Vol. 27, 1. (2001), 27-35; Mark Lubell, "Collaborative Watershed Management: A view from the Grassroots," Policy Studies Journal, Vol. 32, 3. (2004).
[56] Gary Bentrup (2001).

The Upper San Pedro Partnership, studied by Saliba and Jacobs in 2008, strictly adheres to Selin and Chavez's model and suggests that establishing a common "language" is essential to creating a successful collaborative program. The Upper San Pedro Partnership was born out of a time of crisis when depleted groundwater supplies left the San Pedro River (a perennial stream spanning the Arizona-Mexico border) dry, thus threatening the viability of the River as a habitat for threatened and endangered species.[57] The program involved a wide variety of resource management organizations from the US and Mexico in charge of land and resources on federal, state, and local levels as well as non-profit advocacy organizations, and community groups.

Based on surveys taken by Saliba and Jacobs of program participants in 2008, the use of science as a common "language" was repeatedly referenced as the most important factor in the success of the program. Political and ideological differences among stakeholder groups had been a constant challenge inhibiting successful stewardship of the River until all groups came to an agreement on a scientific definition of the problem.[58]

Collaborative watershed management programs in Ohio, California and Ontario, Canada also adhered to Selin and Chavez' model and all shared a voluntary, state-supported structure favored by program participants. Koontz and Newig's study of three collaborative watershed management programs in Ohio found local agencies were motivated to collaborate and achieve state water quality goals when incentives and guidance were provided by the state but agencies were otherwise free to develop programs tailored to their local needs.[59] A similar study of collaborative watershed management programs in Ontario, Canada conducted by Beukins in 2013 supports Koontz and Newig's findings.[60] Furthermore, in the Lake Tahoe basin where agencies experimented with both mandatory and voluntary collaboration programs, the voluntary structure received higher ratings from participants than the

---

[57] George Saliba and Katherine Jacobs. "Saving the San Pedro River: Science, Collaboration, and Water Sustainability in Arizona. *Environment,* Vol 50, 6. (2008), 30-42.
[58] George Saliba and Katherine Jacobs (2008).
[59] Thomas Koontz and Jens Newig, "From Planning to Implementation: Top-Down and Bottom-Up Approaches for Collaborative Watershed Management. *Policy Studies Journal*. 42:3 (2014), 416- 442.
[60] Robin Beukins, "Connecting Watershed and Land Use Planning in Manitoba: Exploring the Potential of Collaboration as a Form of Integration." (master's thesis, University of Manitoba, Winnipeg, 2013).

mandatory program. In their study of the Tahoe Regional Planning Agency, Imperial and Kauneckis, (2003) concluded that the less structured voluntary program satisfied participating agencies' desire for greater individual autonomy in local land use decision-making but continued to encourage collaboration on issues of regional importance such as water quality.[61]

On the other hand, Lawrence 2011's study of watershed and coastal planning in Ontario, Canada and Ohio advocates for the creation of separate umbrella agencies charged with facilitating policies that would otherwise be carried out piecemeal by many different resource management agencies.[62] Lawrence argues that creating a new entirely separate umbrella agency capable of carrying out technical functions in a variety of specialized areas is necessary for efficiency in policy development and implementation.[63] While all of the previous cases discussed emphasized collaboration between different agencies and organizations, Lawrence (2011) was the only study reviewed to suggest consolidation of watershed planning efforts under one roof. Although such consolidation could certainly maximize program efficiency and foster strong collaboration, it is unlikely to be implemented in reality due to the significant administrative effort and funding required to create a new government agency.

In contrast to the agency-heavy collaborative water programs discussed above, Portland's Community Watershed Stewardship Program offers a perspective on the potential benefits and challenges of implementing a community-oriented collaborative management program. In this program, collaboration occurs not only between staff within different city departments, but also among university professors, students, neighborhood groups, and non-profit organizations. City staff and university participants developed a policy framework and identified locations for the installation of GSI facilities based on their technical expertise, while neighborhood groups and nonprofits were assigned the responsibility of installation and maintenance of GSI facilities throughout the city.

---

[61] Mark Imperial and Derek Kauneckis. "Moving from Conflict to Collaboration: Watershed Governance in Lake Tahoe," *Natural Resources Journal*, Vol. 43. (2003), 1010.
[62] Patrick Lawrence, "Achieving Teamwork: Linking Watershed Planning and Coastal Zone Management in the Great Lakes," *Coastal Management,* 39, 1. (2011), 57-71.
[63] Patrick Lawrence (2011)

Multiple studies have sought to better understand the public engagement component of Portland's successful stormwater management program. One of the earliest studies was conducted by Shandas and Messer in 2008. Using data collected in surveys, interviews and participant reports, Sandas and Messer concluded that the program was successful at building public awareness of the city's water quality issues and that an essential component of this success was the early and continued engagement with various stakeholder groups throughout program development and implementation.[64] Additionally, because responsibility for implementation (installation and maintenance of GSI facilities) was assigned to neighborhood groups and non-profit organizations, the incorporation of grant funding for participating neighborhood groups was crucial in catching the attention of the public and fostering a sense of responsibility among these organizations.[65]

Nearly eight years into program implementation, Church (2014) conducted interviews with 42 Portland residents to determine if the Watershed Stewardship Program had truly served to educate the public about water quality issues.[66] Through Church's interviews, GSI facilities had indeed caught the attention of residents, with 38 out of 42 people having noticed the GSI facilities during their daily activities.[67] However, recognition of GSI facilities in their neighborhoods did not necessarily result in greater understanding of the function of GSI, as only 24 of the 48 residents interviewed demonstrated an understanding of their function in restoring the hydrologic cycle in the city.[68] Although Church's study seemed to reveal that most residents did not have a firm understanding of the function and importance of GSI facilities, her study did identify community centers and schools as being the most likely locations for residents to connect with GSI facilities and learn something about their function.[69]

---

[64] Vivek Shandas and Barry Messer, "Fostering Green Communities Through Civic Engagement: Community-Based Environmental Stewardship in the Portland Area," Journal of American Planning Association, Vol. 74, No 4. (2008), 408-418.
[65] Vivek Shandas and Barry Messer (2008).
[66] Sarah Church, "Exploring Green Streets and rain gardens as instances of small scale nature and environmental learning tools," Landscape and Urban Planning 134 (2015), 229-240.
[67] Ibid.
[68] Sarah Church (2015)
[69] Ibid.

The contradictory conclusions of Shandas and Messer and Church's studies are likely the result of passage of time. Findings from Shandas' 2015 study of the program support the assumption that during program development and implementation, residents' awareness of GSI was at its peak and over the course of eight years, the awareness and knowledge of residents faded. Returning to the Watershed Stewardship program once again in 2015, Shandas conducted a study to understand whether or not neighborhood groups were still participating in the program by maintaining their local GSI facilities. The results of this study showed that public participation in GSI maintenance and general watershed stewardship had greatly diminished but those people who continued to participate were more likely to possess higher income and education levels.[70] However, Shandas did not provide additional information regarding why this trend existed or propose solutions to incentivize lower income groups to continue to participate.

In addition to the long-term availability and willingness of members of the public to maintain continued participation in collaborative management programs, studies by Buekins (2013) and Lubell (2004) suggest that during the long-term, data sharing is equally as important in maintaining support and participation. For Buekins, data sharing is an essential component of successful collaboration between regional agencies. According to her study, when agencies establish convenient and mutually agreed upon methods for sharing needed information, collaboration comes more easily and is maintained over the long-term.[71] Similarly, in Florida, where farmers voluntarily reduce pesticide use to protect the health of the Swanee River, continued and long-term feedback on the effectiveness of their efforts creates a positive feedback loop incentivizing continued support and participation in stewardship efforts over the long-term.[72]

[70] Vivek Shandas, "Neighborhood change and the role of environmental stewardship: a case study of green infrastructure for stormwater in the City of Portland, Oregon, USA." *Ecology and Society* Vol. 20, 3 (2015).
[71] Robin Beukins, "Connecting Watershed and Land Use Planning in Manitoba: Exploring the Potential of Collaboration as a Form of Integration." (master's thesis, University of Manitoba, Winnipeg, 2013).
[72] Mark Lubell, "Collaborative Watershed Management: A View from the Grassroots," Policy Studies Journal, Vol. 32, 3. (2004).

Literature on collaborative watershed management programs supports Selin and Chavez's five-step model and provided four additional factors to consider in the creation of a collaborative Stormwater Green Infrastructure plan in San Jose.

1. **Common Language.** When collaborating with stakeholders with varied backgrounds and expertise, it is necessary to establish a common language for defining and addressing problems.
2. **Voluntary Participation.** Collaboration functions best when all agencies and organizations involved are willing and enthusiastic about their participation.
3. **Incentives.** Financial incentives such as grant funding provide motivation for teams to achieve established goals.
4. **Public Engagement.** Engaging the public early and often throughout the program lifecycle can foster greater community support and stewardship. However, before assigning responsibility for important program functions to members of the public, consider who has the desire *and* ability to carry out these functions, as social and economic limitations may impact the ability for some groups to fulfil their obligations.

3.3 SAN JOSE GREEN INFRASTRUCTURE PLAN

Despite the compelling arguments for collaboration on watershed management and the widespread support for this collaborative governance models at universities, in practice administrative, technical, and economic constraints often impede full adoption of this collaborative governance models when it comes to water resource management.

In recent years, the City of San Jose has struggled to achieve regulatory standards set by the many federal, state, and regional agencies responsible for administering the Clean Water Act.[73] Limited funding, staffing shortages, and the mounting crisis of homelessness in San Jose have made it difficult for

[73] Paul Rogers, State files water Pollution complaint against San Jose for failing to clean up homeless encampments," *Mercury News*, March 20, 2014, https://www.mercurynews.com/2014/03/20/state-files-water-pollution-complaint-against-san-jose-for-failing-to-clean-up-homeless-encampments/; Terry McSweeny, "Pollution Problem: Water District Pulls in San Jose, County to Help Clear Homeless Camps from Creeks," NBC Bay Area, February 6, 2016, https://www.nbcbayarea.com/news/local/Pollution-Problem-Water-District-Pulls-In-San-Jose-County-to-Help-Clear-Homeless-Camps-From-Creeks-368277541.html; Robin Meadows, "Urban Jungle Inspires Unique Regulatory Tack," San Francisco Estuary Partnership, December, 2016, https://www.sfestuary.org/estuary-news-urban-jungle/.

the City to properly address water pollution issues. As a result, San Jose's efforts to comply with NPDES Order No. R02-2015-0049 are strictly limited to the minimum level required by the RWQCB and legal settlements, and collaboration efforts have been limited to interdepartmental coordination.

In April 2019, the City of San Jose published a draft of the *City of San Jose Green Stormwater Infrastructure Plan*, which is designed to build off of the six existing GSI facilities already installed on San Jose streets (see Figure 9 below) and SCVURPPP's *Stormwater Resources Plan*. The plan establishes methods which the City will use to identify and prioritize new GSI projects aimed at reducing mercury, PCBs, trash, and bacteria in local water ways.[74] In order to achieve this goal, the City will implement three types of GSI projects including Green Streets projects (designed to manage runoff from roadways), LID retrofits (designed to manage runoff on parcels), and regional projects (designed to capture large drainage areas including streets and parcels). A final version of this plan will be presented for review and approval by City Council and RWQCB in September 2019.[75]

[74] City of San Jose, "*City of San Jose Green Stormwater Infrastructure Plan Draft*," (San Jose, CA) April, 2019. http://www.sanjoseca.gov/DocumentCenter/View/84047
[75] City of San Jose, "Green Stormwater Infrastructure," sanjose.gov, accessed December 4, 2018. http://www.sanjoseca.gov/index.aspx?NID=5722.

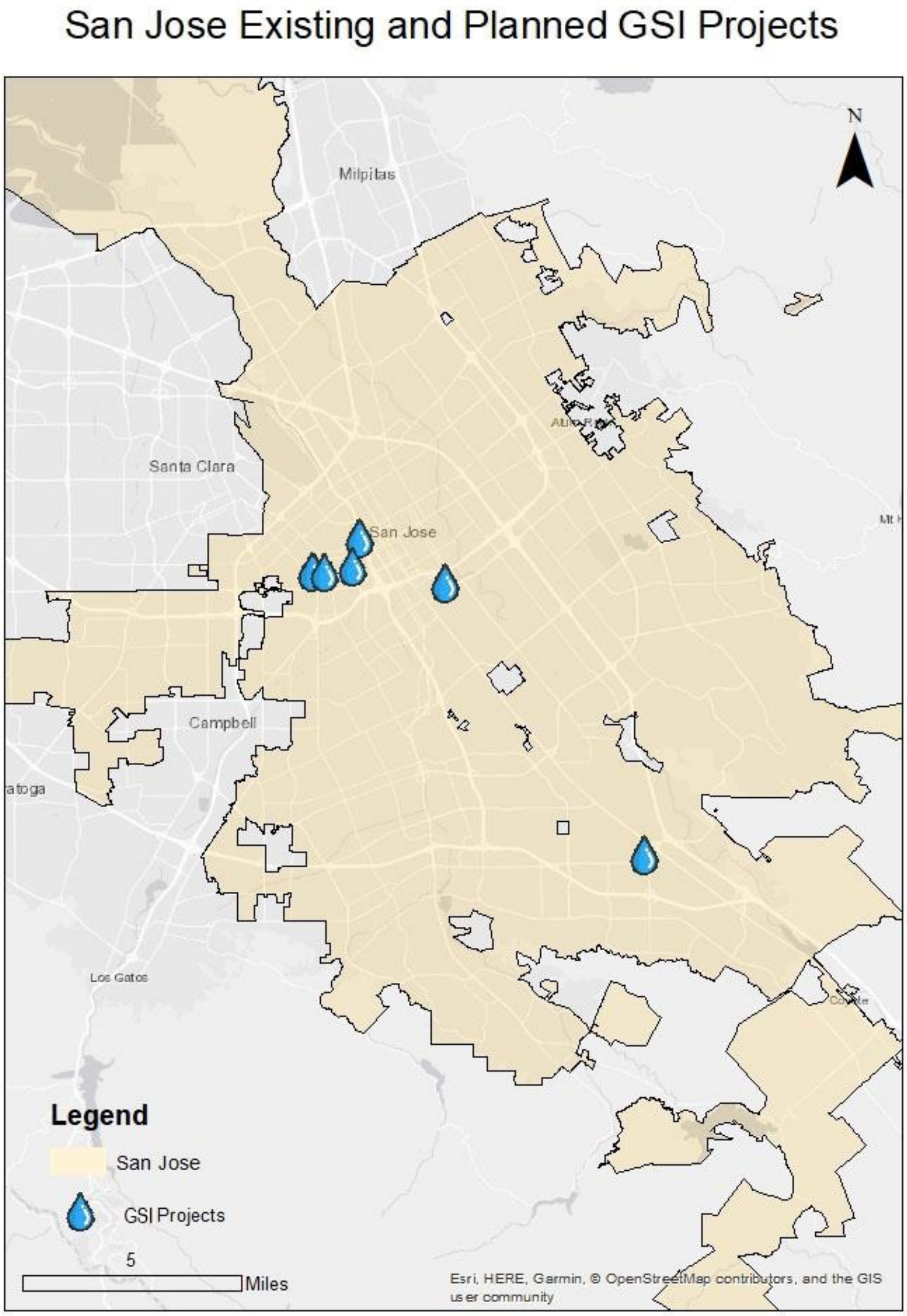

FIGURE 9 EXISTING GSI FACILITIES IN SAN JOSE
Note: Existing GSI projects in San Jose are primarily located in the Downtown area with one outlying bio retention facility in South San Jose along Chynoweth Avenue.
Source: Author's map, Created using data from City of San Jose. "Green Stormwater Infrastructure," sanjoseca.gov, http://www.sanjoseca.gov/index.aspx?NID=5722 (accessed April 7, 2019).

Site selection and prioritization methodology used by the City and outlined in the Plan differs slightly from plans developed by other Bay Area jurisdictions. In addition to the requirements of NPDES Order No. R2-2015-0049, as a result of a recent lawsuit filed by San Francisco Baykeeper against the City, San Jose must also prove planned GSI facilities will reduce fecal indicator bacteria from local waterways. [76] Therefore, in addition to using standard GIS applications (such as that previously used in SCVURPPP's Stormwater Resources Plan), the City will also use Reasonable Assurance Analysis (RAA) modeling in the site identification and prioritization process to quantitatively demonstrate the amount of GSI facilities planned will reduce bacteria in local waterways to the level required by the consent decree.[77] Furthermore, due to the extent of contaminated groundwater plumes in San Jose, the City has included additional location and prioritization criteria such as the proximity of a potential GSI facility to contaminated plumes, the depth of groundwater, and the slope to ensure new GSI facilities do not infiltrate stormwater such that contaminated plumes expand or migrate in underground aquifers.[78]

Finally, whenever possible, the Plan calls for new GSI facilities to be incorporated into planned bikeway and infrastructure improvement projects as well as in applicable all planning documents to maximize efficiency in funding allocation and construction activities. Planning documents which will be revised to include specific policies and actions related to implementing GSI projects include: Envision San Jose General Plan, Urban Village Plans, Climate Smart San Jose Climate Action Plan, San Jose Complete Streets Standards & Design Guidelines, and the Storm Sewer Master Plan.

In order to judge the adequacy of this plan and identify potential measures to improve collaboration during implementation of San Jose's Green Stormwater Infrastructure plan, Chapter 4

---

[76] Paul Rodgers. "San Jose agrees to $100 million pollution clean-up program to reduce trash, sewage spills." *Mercury News*, (San Jose, CA) June 14, 2016. https://www.mercurynews.com/2016/06/14/san-jose-agrees-to-100-million-pollution-cleanup-program-to-reduce-trash-sewage-spills/

[77] [77] City of San Jose, "City of San Jose Green Stormwater Infrastructure Plan Draft," (San Jose, CA) April, 2019. http://www.sanjoseca.gov/DocumentCenter/View/84047

[77] Paul Rodgers. "San Jose agrees to $100 million pollution clean-up program to reduce trash, sewage spills." *Mercury News*, (San Jose, CA) June 14, 2016. https://www.mercurynews.com/2016/06/14/san-jose-agrees-to-100-million-pollution-cleanup-program-to-reduce-trash-sewage-spills/; City of San Jose, *City of San Jose Green Stormwater Infrastructure Plan Draft*, (San Jose, CA) April, 2019. http://www.sanjoseca.gov/DocumentCenter/View/84047.

[78] Ibid.

explores the plans and processes used by three other Bay Area cities to install early GSI projects and draft citywide GSI plans.

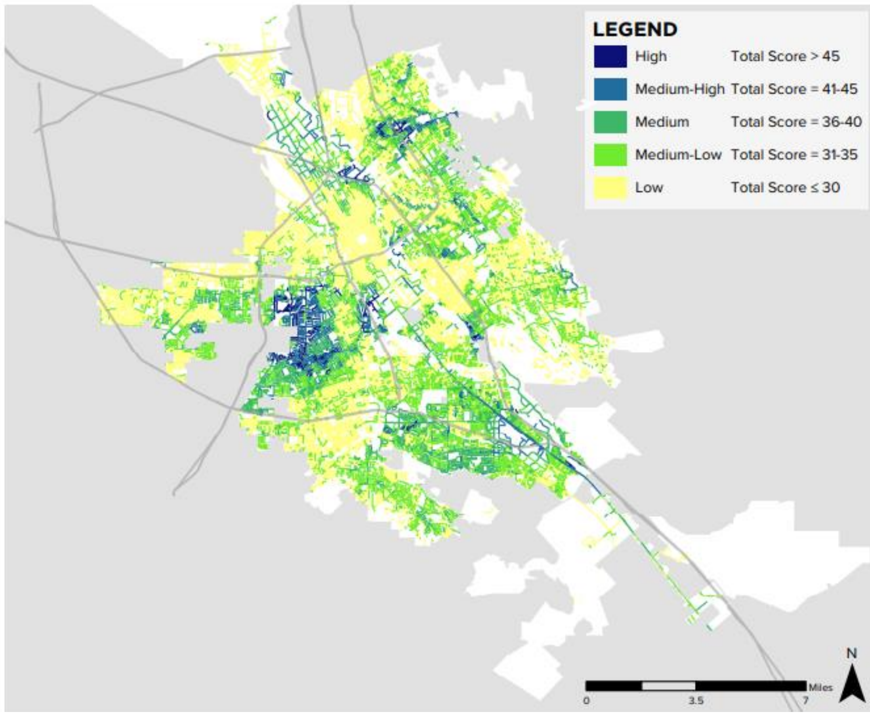

FIGURE 10 PRIORITIZED LOCATIONS FOR GREEN STREETS IN SAN JOSE
Source: City of San Jose, *City of San Jose Green Stormwater Infrastructure Plan Draft*, (San Jose, CA) April, 2019. http://www.sanjoseca.gov/DocumentCenter/View/84047.

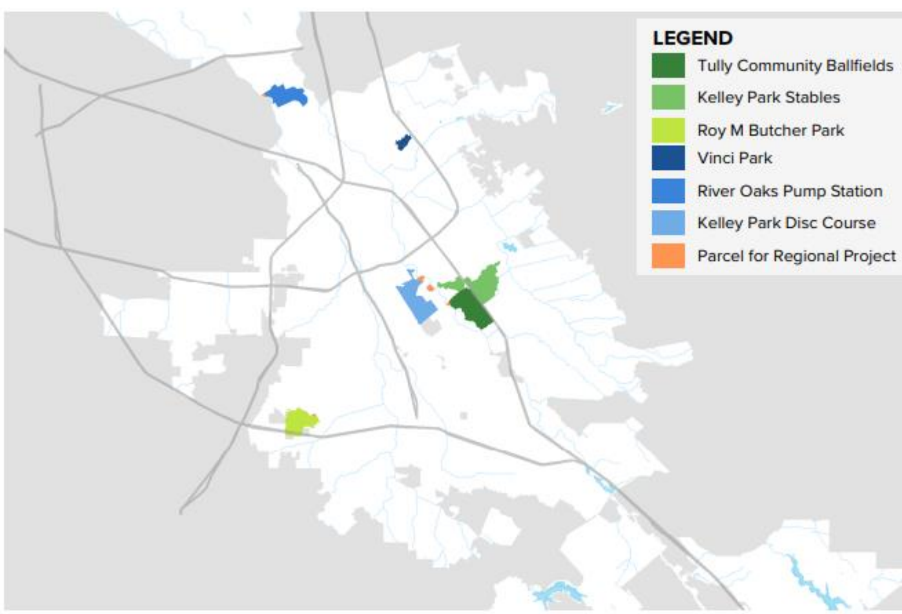

FIGURE 11 PRIORITIZED REGIONAL GSI PROJECTS IN SAN JOSE
Source: City of San Jose, *City of San Jose Green Stormwater Infrastructure Plan Draft*, (San Jose, CA) April, 2019. http://www.sanjoseca.gov/DocumentCenter/View/84047.

CHAPTER 4 WHAT HAVE OTHER CITIES LEARNED?

This section includes a description of the existing GSI plans and projects completed in three Bay Area cities followed by an analysis of these plans and projects which is informed by theories derived from relevant literature on collaborative watershed management. Cities examined in this section include: San Francisco, Berkeley, and Palo Alto, California. The purpose of this section is to explore the methods used by other jurisdictions in the Bay Area to install GSI facilities in their communities, to identify potential challenges and opportunities with implementation of a citywide GSI Plan in San Jose and to inform a proposed collaborative stormwater management program for the City of San Jose, as described in Chapter 5.

4.1 METHODOLOGY

A comparative case study of three Bay Area cities was completed to identify the best practices that would improve San Jose's citywide GSI plan. Data collection methods used in this case study analysis include document review of relevant program documents, memos, web content as well as interviews with professionals at case study cities involved in the development and implementation of GSI projects and plans. Data gathered during document review and interviews was then organized into a summary matrix and coded to reveal common themes. Appendix A to this report includes a sample interview script and interview summary matrix. A draft summary of these findings was prepared and sent to all interview subjects for review and fact-checking prior to publication. Additionally, interviews with professionals at SCVWD and SCVURPPP were conducted to verify the accuracy of case study findings.

Selection of these case study cities was based on three factors: 1) the geographic location of each city within the Bay Area, 2) its history of contamination, and 3) the quantity of existing GSI installations on public property. Although the causes are different from city to city, San Francisco, Berkeley, and Palo Alto all share a history of soil and groundwater contamination. For San Francisco, its prime location at the center of the bay with access to deep water ports made it the ideal location for business and industrial operations over the centuries. Additionally, as populations expanded, rubble from earthquake-damaged buildings was used to infill wetland areas and expand the land area of the city, leading to contamination of soils and groundwater. In Berkeley, the historic development of industrial businesses along the railroad near the bayshore have resulted in soil and groundwater contamination as stormwater runoff infiltrated the soil and contaminated local waterways with trash and vehicle fluids. Finally, in Palo Alto, the rapid growth of biomedical and communications technology industries resulted in mishandling of hazardous materials as environmental regulations struggled to keep up with the rapid pace of advances in these industries. Thus, despite the differences in the type and geographic extent of soil and groundwater contamination across these three cities, all share the common challenge of hazardous materials contamination similar to San Jose. Figure 12 below shows the geographic location of case study cities in relation to San Jose.

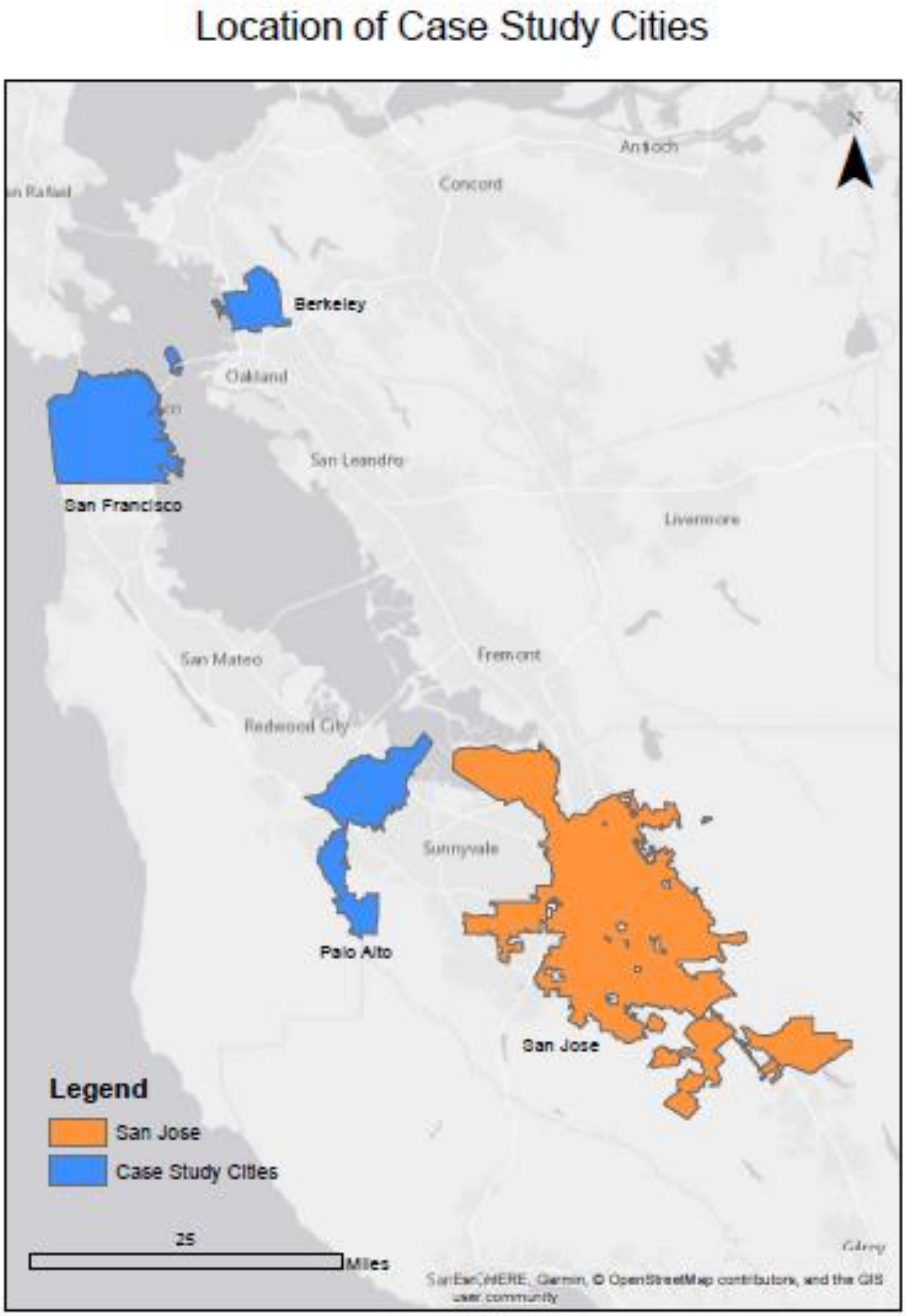

FIGURE 12 LOCATION OF CASE STUDY CITIES
Note: Case study cities were selected based on their location in the Bay Area.
Source: Author’s map, created using ESRI shape files

As mentioned briefly in Chapter 3, *A Web of Water Agencies*, all municipalities in the Bay Area are subject to the same water quality control requirements for development projects on private property. In addition, all jurisdictions in the Bay Area except for the City and County of San Francisco are subject to Order No. R2-2015-0049 requiring the preparation of citywide green infrastructure plans aimed at reducing mercury, PCBs and trash found in stormwater. Due to the common requirements of Order No. R2-2015-0049, professionals interviewed from the City of Berkeley and the City of Palo Alto cited similar criteria for measuring success of their GSI plans. Differences in the respective approaches used in prior GSI projects, as well as GSI site selection criteria and prioritization methodology utilized in current GSI planning processes are thus emphasized in the summary and analysis below.

Although the City and County of San Francisco is not subject to the same requirements as the other Bay Area jurisdictions in terms of citywide green infrastructure planning, San Francisco was selected as a case study in this report because of its extensive GSI planning, public engagement efforts, and numerous existing GSI projects on public lands. Thus, San Francisco offers a useful comparison in this report, demonstrating how a jurisdiction might develop, implement and monitor a citywide network of GSI facilities even if it were not required to do so by the RWQCB.

4.2 SAN FRANCISCO

The City and County of San Francisco occupies the tip of the San Francisco Peninsula, bordered by the San Francisco Bay to the north and east, the Pacific Ocean to the west and the County of San Mateo to the south. With a total population of 884,363 people, San Francisco is the most urbanized city in the greater Bay Area.[79]

Land use in San Francisco is generally organized into quadrants with the highest concentration of commercial and mixed-uses located in the central and eastern portions of the city, residential land uses dominate the north, west, and southern portions of the city while a small and dwindling stock of industrial

---

79 "U.S. Census Bureau QuickFacts: San Jose City, California; UNITED STATES." *Census Bureau QuickFacts*, United States Census Bureau, 2019, www.census.gov/quickfacts/fact/table/sanjosecitycalifornia,US/PST045217; City of San Francisco, San Francisco Stormwater Management Requirements and Design Guidelines, Chapter 3: Low Impact Design in San Francisco. July 1, 2018. San Francisco, CA. https://sfwater.org/modules/showdocument.aspx?documentid=9020

lands occupies the southeastern shoreline near the San Mateo County border.[80] Development in San Francisco has historically followed these land use trends. However, increasing demand for additional commercial and residential space during the last two decades has resulted in conversion of previously industrial properties in the Mission District, South of Market, Mission Bay, Dog Patch, and Hunters Point-Bayview neighborhoods into new commercial and mixed-uses.[81]

With the majority of land in San Francisco already developed, infiltration of stormwater into the soil presents a challenge for planners and public works officials. In addition, stormwater and sewage in San Francisco is transported through a combined sewer system (the only one on the coast of California), which means that both stormwater and sewage flow through the same wastewater pipeline before being processed at the San Francisco's wastewater treatment facility, after which it will ultimately flow into the San Francisco Bay or Pacific Ocean. This combined sewer system presents unique challenges during the rainy season when the quantity of stormwater entering these pipelines exceeds capacity, resulting in combined sewer discharge to the bay and ocean. However, despite the challenges associated with development patterns and wastewater collection in San Francisco, as of January 2019, San Francisco was in full compliance with the Clean Water Act and was not required by law to produce a stormwater green infrastructure plan or implement other measures to reduce stormwater pollution within its boundaries.[82]

Wastewater collection, transportation and treatment in San Francisco is managed by the San Francisco Public Utilities Commission (SFPUC), an arm of the City and County of San Francisco. As the primary agency responsible for managing water and wastewater in San Francisco, the SFPUC is also charged with overseeing GSI facilities on both public and private property through a number of plans and policies including the Stormwater Management Ordinance and the Sewer System Improvements Program.

The San Francisco's first official GSI planning efforts began in 2007 with the adoption of the City's Sewer System Improvements Program, which included projects and programs aimed at developing GSI

---

[80] City of San Francisco, San Francisco Zoning Map, October 2018, San Francisco, CA. https://sfplanning.org/sites/default/files/resources/2019-02/zoning_use_districts.pdf

[81] J. K. Dineen, "Offices Intruding on SF Space Zond for Industrial Use." *San Francisco Chronicle,* March 14, 2016. https://www.sfchronicle.com/bayarea/article/Offices-intruding-on-SF-space-zoned-for-6889809.php

[82] Interviewee #1, "Stormwater Green Infrastructure Interview," Interview by Carolyn Neer. January15, 2019.

facilities on public property throughout the city. Due to the city's compliance with the Clean Water Act, and constant struggle with overflows of its combined sewer system, the primary goal of the GSI installed as a part of the Sewer System Improvements Program was to achieve volume and flow rate reduction within the City's wastewater system. To achieve this goal, the city initiated a pilot project to install eight GSI facilities, one in each watershed of San Francisco. To date, six of the eight GSI project identified in the Sewer System Improvement Program have been installed.[83] Figure 13 shows an example of a newly completed GSI project in San Francisco.

FIGURE 13 EXISTING GSI PROJECT HIGHLIGHTS
Note: This project installed bio retention facilities, rain gardens and a subsurface infiltration gallery. Co-benefits of the project include improving sidewalks to comply with ADA, improved and expanded community gathering space.
Source: San Francisco Public Utilities Commission, Green Infrastructure Stormwater Management Projects Overview, December 2018. https://sfwater.org/modules/showdocument.aspx?documentid=13249

The locations of these facilities were selected based on flow rate reduction potential, soil, subsurface hydrologic conditions and based on community input collected during a series of public meetings held by the SFPUC over the course of two years (2007 – 2009). GSI facilities installed include

[83] San Francisco Public Utilities Commission, "Green Infrastructure Projects," San Francisco Water Power Sewer, https://sfwater.org/index.aspx?page=614 (accessed March 6, 2019).

rain gardens, permeable paving and green bulbouts on city streets. Figure 14 shows the location of existing GSI facilities in San Francisco.

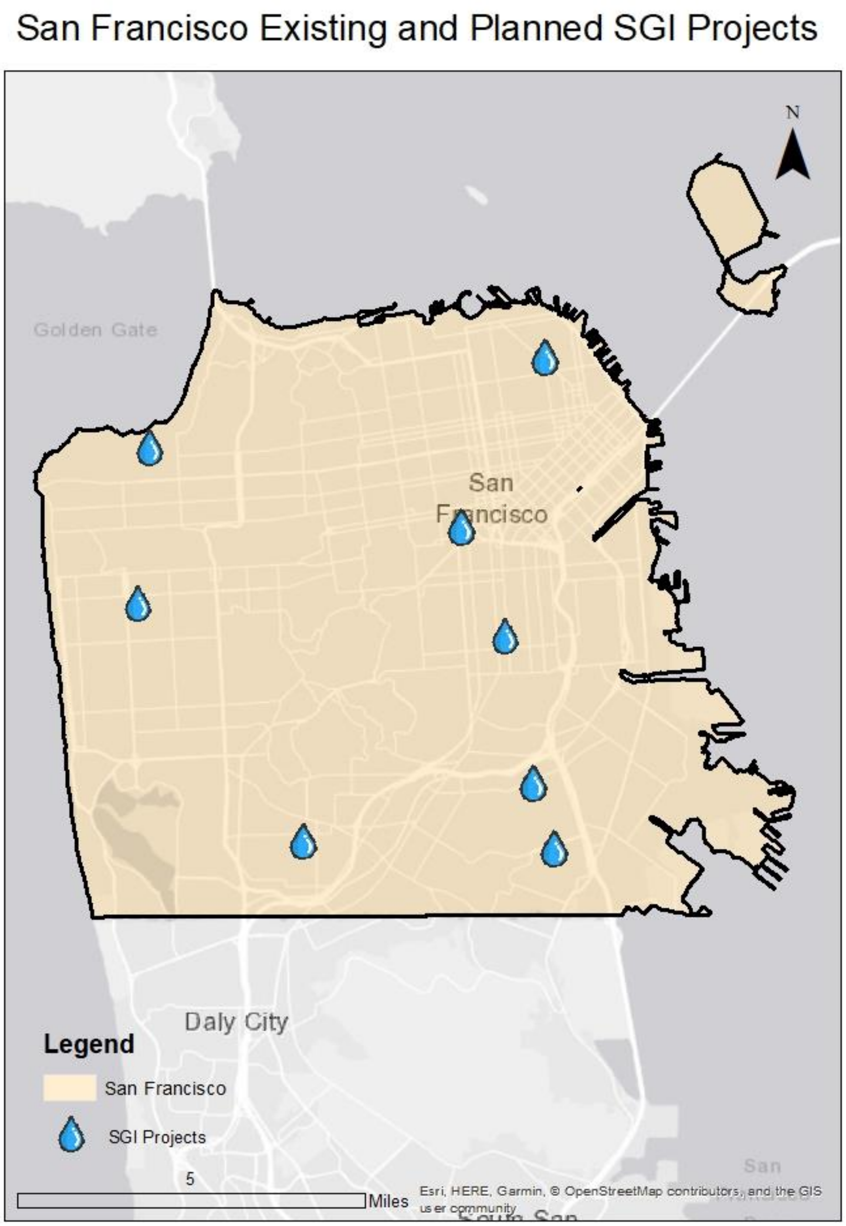

FIGURE 14 LOCATION OF EXISTING AND PLANNED GSI FACILITIES IN SAN FRANCISCO
Source: Author's map, Created using data from San Francisco Public Utilities Commission, https://sfwater.org/Modules/ShowDocument.aspx?documentid=9507, March 2019.

Meanwhile, as a part of an alternative settlement agreement for a water quality violation at the San Francisco's wastewater treatment facility, the SFPUC launched its Watershed Stewardship Grant Program.[84] The Watershed Stewardship Grant Program provides watershed education to students in the San Francisco Unified School District and assists the School District in design and installation of rainwater capture and GSI facilities on school sites. Since its inception, the Watershed Stewardship Grant Program has evolved to meet the changing needs of City staff and community members with recent additions to the existing educational program including training seminars for construction personnel, maintenance workers, and members of the public interested in learning more about how to design, install, and maintain GSI facilities.[85]

By 2010, in response to regulatory mandates from the Regional Water Quality Control Board, and with political support from SFPUC leadership and Mayor Gavin Newsom, the SFPUC successfully passed the Stormwater Management Ordinance (2010) which requires all new developments and redevelopments on private properties with over 5,000 square feet of disturbed area to install GSI facilities in response to regulatory mandates from the Regional Water Quality Control Board. This mandate mobilized the reduction of post construction stormwater pollution.[86]

In an effort to prevent conflicts between new GSI facilities on public and private property and existing groundwater and soil contamination, staff at the SFPUC and Planning Department assess the location of a proposed GSI facility using maps such as GeoTracker, EnviroStor and the San Francisco's own Maher Ordinance map which identifies properties with known groundwater and soil contamination as a result of seepage from improper fill materials after the 1906 earthquake.[87] Generally speaking, the City has a policy of avoiding infiltrative GSI installations on sites with known contamination. Sites identified in the Maher Ordinance map are eligible for the San Francisco's Stormwater Management Ordinance

---

84 Interviewee # 1, "Stormwater Green Infrastructure Interview," Interview by Carolyn Neer. January15, 2019.
85 Interviewee #1, "Stormwater Green Infrastructure Interview," Interview by Carolyn Neer. January15, 2019
86 Ibid. 2019; City of San Francisco, Stormwater Management Ordinance, May 2010, http://www.sfbos.org/ftp/uploadedfiles/bdsupvrs/ordinances10/o0083-10.pdf
87 San Francisco Public Health Department, "Maher Ordinance (San Francisco Public Health Code Article 22A) Program Description and Process," Revised January 2015. https://www.sfdph.org/dph/files/EHSdocs/Maher/Maher_Process_Procedure.pdf

Modified Compliance program and when necessary, GSI facilities are designed to include an impervious liner to prevent infiltration of stormwater into the soils and groundwater on or near a contaminated site.[88] Thus, it would seem that the hypothesis which assumes strict avoidance of contaminated sites is the only method of ensuring that GSI facilities do not exacerbate existing contamination issues may be false. Figure 15 below, features the most recent version of San Francisco's Maher Ordinance Map.

[88] Interviewee #1 , "Stormwater Green Infrastructure Interview," Interview by Carolyn Neer. January15, 2019.,

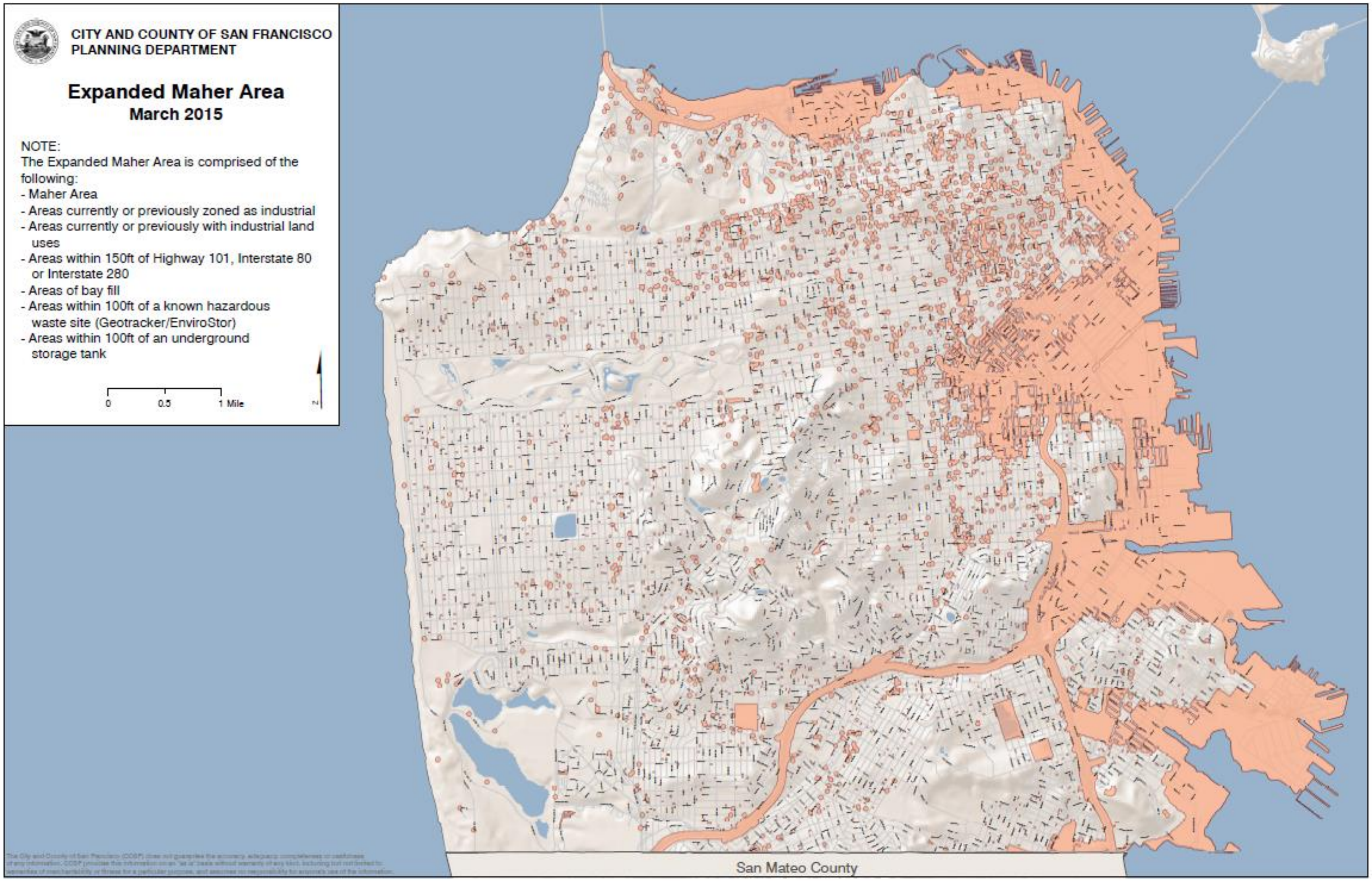

FIGURE 15 CITY AND COUNTY OF SAN FRANCISCO MAHER ORDINANCE AREA MAP

Source: City and County of San Francisco, “Maher Ordinance Map,” March, 2015. http://adeptconstruction.solutions/wp-content/uploads/2016/04/Maher-Ordinance-Map-SF.png

4.3 BERKELEY

The city of Berkeley is located on the eastern shores of the San Francisco Bay. Situated between the bayshore and the East Bay hills, Berkeley is bordered by Albany and Kensington to the north, the San Francisco Bay to the west, Emeryville and Oakland to the south, and unincorporated Alameda County to the east. Land use patterns in Berkeley are urban with higher density commercial and residential development concentrated in the central portion of the city near the University of California campus, Downtown, and along major transportation corridors. Lower density residential development can be found in North Berkeley and in the residential neighborhoods in the East Bay Hills. Industrial land uses in the city are primarily concentrated in a narrow strip along the western border, bounded by I-880 to the west and 5th Street to the east. This distribution of land uses within Berkeley has persisted for several decades. However, beginning in the 1970s there was a significant loss of industrial properties to new commercial development in West Berkeley as many large industrial employers left the central city for alternate suburban locations.[89]

Wastewater collection and treatment in Berkeley is managed by the City's Public Works Department. Berkeley's wastewater (stormwater and sewage) is conveyed through separate pipelines and is treated at the East Bay Municipal Utilities District treatment plant in Oakland before being released into the San Francisco Bay.

GSI planning efforts in Berkeley began in 2011 with the publication of the Berkeley's *Watershed Management Plan*. The plan was initiated in response to public health and safety concerns related to physically deteriorated sewer infrastructure that allowed stormwater to seep into old damaged sewage pipes and resulted in sewage overflows during the rainy season, the *Watershed Management Plan* was the Berkeley's first attempt at identifying locations for GSI installations on public property.[90] The *Watershed Management Plan* relied on hydrologic modeling data from two of the Berkeley's watersheds, the

---

[89] City of Berkeley, City of Berkeley General Plan: A Guide for Public Decision-Makers, Land Use Element, February 18, 2001. https://www.cityofberkeley.info/Planning_and_Development/Home/General_Plan__A_Guide_for_Public_Decision-Making.aspx; Barry Bluestone and Harrison Bennett. *The Deindustrialization of America: Plant Closings, Community Abandonment, and the Dismantling of Basic Industry*. New York: Basic Books, 1982.

[90] Interviewee #4, "Stormwater Green Infrastructure Interview," Interview by Carolyn Neer. January 24, 2019.

Cordonices and the Potter Watersheds, to identify and prioritize sites for new GSI facilities designed to reduce flooding. During this process, 30 sites were identified across the two watersheds.[91] Since this time, 22 GSI facilities have been installed, nine of which are located in public right-of-way, five in parks, and eight within other City-owned properties such as libraries and the City animal shelter.[92]

In 2017, in response to the NPDES Order R2-2015-0049, Berkeley began the developing its citywide *Green Infrastructure Plan*. The methods used to identify potential locations for new GSI facilities on public property differed from that used in the prior *Watershed Management Plan* due to the requirements of the NPDES Order. This plan is aimed at reducing mercury, PCBs, and trash levels in Berkeley's stormwater.

In order to identify priority sites on public property for installation of GSI facilities, Berkeleydeveloped two GIS applications. The first application was developed based on analog microwatershed data used to prepare the 2011 *Watershed Management Plan*. Once digitized, this data was used to generate a map of the drainage areas for each stormdrain in the city. In addition, a second layer was created that includes data on contaminant contributions of different areas of the city based on current and historic land uses. Data for this layer was obtained from the Toxics Management Division's Environmental Management Area map (shown in Figure 16 below), as well as from the Envirostor and GeoTracker databases. Sites with known current or historic groundwater or soil contamination were generally avoided to reduce the risk of spreading hazardous materials.

---

[91] Ibid; City of Berkeley, *Watershed Management Plan*, October 2011, https://www.cityofberkeley.info/uploadedFiles/Public_Works/Level_3_-_Sewers_-_Storm/WatershedMgtPlan_2011October_Version1.0.pdf

[92] Interviewee #4, email message to Carolyn Neer, February 28, 2019.

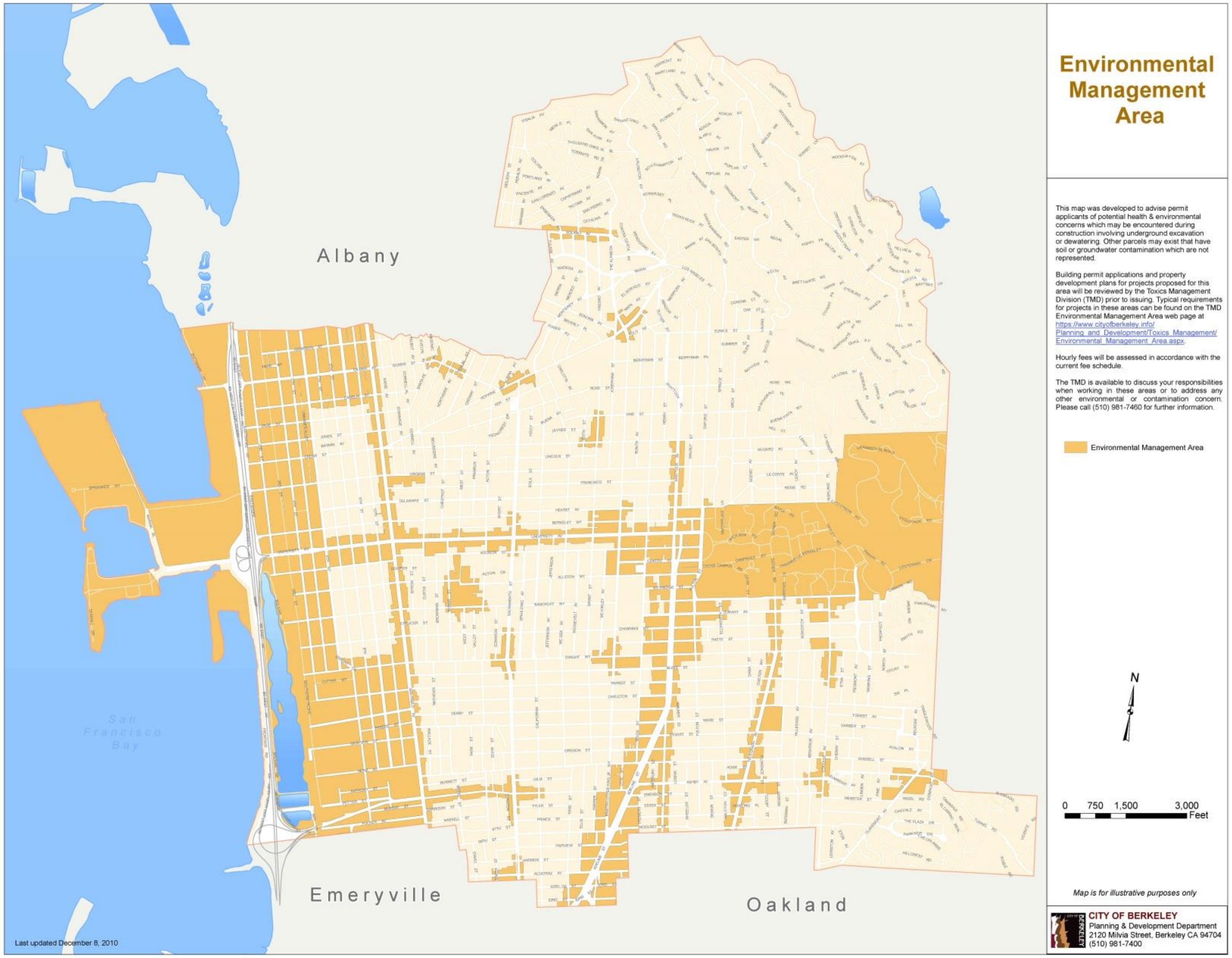

FIGURE 16 CITY OF BERKELEY ENVIRONMENTAL MANAGEMENT AREA MAP

Source: City of Berkeley. Environmental Management Area Map, December 8, 2010. https://www.cityofberkeley.info/uploadedFiles/IT/Level_3_-_General/ema.pdf

The second tool developed for Berkeley's *Green Infrastructure Plan* was a multi-benefits prioritization tool with layers containing data on soils, earthquake hazards, trash generation, and groundwater elevations. Data on these layers are then weighted based on their suitability for GSI installations, allowing the city to assign a numeric score to every block and public right of way. When combined, these two GIS tools enable Berkeley to locate and prioritize the best sites for new GSI installations and maximize the efficiency of that particular facility in regards to achieving the overarching goal of reducing mercury, PCBs, and trash from stormwater.

Although performance metrics and tracking mechanisms for Berkeley's GSI plan are still being developed, water quality monitoring is currently underway in the Allston Way Green Street Pilot Project (project highlights included in Figure 17), where the pavement on this narrow downtown street has been almost entirely replaced with permeable pavement. There, the quality of stormwater is being monitored after passing through the pavers. The data is then collected and used in a lifecycle performance analysis. Performance metrics and monitoring methods for other City GSI facilities will likely follow a similar format and be made available to the public.[93]

[93] Interviewee #4. "Stormwater Green Infrastructure Interview," Interview by Carolyn Neer. January24, 2019.

FIGURE 17 PROJECT HIGHLIGHTS OF EXISTING GSI FACILITIES
Note: This project installed pervious pavers along Allston Way to reduce flooding along this narrow downtown street. Stormwater that permeates through these pavers is collected tested and pumped to an offsite treatment plant. The City is currently using water quality monitoring data from this pilot project to conduct a lifecycle analysis.
Source: google.com/maps; Interviewee # 4, City of Berkeley

Collaboration efforts concerning Berkeley's *Green Infrastructure Plan* have primarily occurred between the City Public Works Department and Alameda County Clean Water Program personnel. Thus far, public input has been limited, with the first public engagement event occurring on February 27, 2019. Similar to SCVURPPP, the Alameda County Clean Water Program published a Stormwater Resources Plan, which identifies potential locations for GSI installations within the County's 17 jurisdictions. Priority is awarded to those sites best suited for groundwater recharge and/or pollution reduction, which enables jurisdictions to be eligible to receive state grant funding for these projects. Additionally, the Alameda County Clean Water Program also provides sample ordinance language and design resources to assist jurisdictions in the implementation of GSI plans and permit compliance.[94] However, in contrast to SCVURPPP's program, the Alameda County Clean Water Program requires each jurisdiction to share data

---

[94] Alameda County Clean Water Program, Stormwater Resources Plan, Hayward, CA, October 2018, https://www.cleanwaterprogram.org/images/2018-10_PUBLIC_DRAFT_ACCWP_SWRPApp1-4.pdf.

on planned and completed GSI facilities in an effort to track the location and water quality improvements of GSI facilities across the county.[95]

4.4 PALO ALTO

The City of Palo Alto is located at the base of the San Francisco Peninsula, situated between the Santa Cruz Mountains to the west and the San Francisco Bay to the east. Palo Alto is the northernmost city in Santa Clara County and is bordered by East Palo Alto and Menlo Park to the north, Stanford University and unincorporated Santa Clara County to the west, the San Francisco Bay to the east, and Los Altos and Mountain View to the south. Commercial and mixed-use development in Palo Alto are concentrated along major roadways such as University Avenue, El Camino Real, Alma Street, Page Mill Road, San Antonio Road, and Oregon Expressway/ Embarcadero Road, while industrial developments are primarily located near Page Mill Road, San Antonio Road, and Embarcadero Road.

According to a map of historic land uses in Palo Alto circa 1980, land use patterns in Palo Alto have mirrored existing conditions for several decades. Generally speaking, Palo Alto's larger industrial facilities such as technology and bio-medical research facilities have remained in roughly the same area as they do today. However, a number of small parcels of non-residential uses (likely a mix of commercial and industrial developments), which were previously dispersed throughout the central portion of the city between El Camino Real and Highway 101, have since been converted into residential uses.[96]

With Palo Alto's long history of industrial use near the bayshore and along Page Mill Road, at the foothills of the Santa Cruz Mountains, it is not surprising that contamination of groundwater has occurred in these locations. As shown in Figure 18 below, the city has two large contaminated groundwater plumes in these locations. As a result, Palo Alto has established control measures such as C*onstruction Dewatering Regulations* (2018) to reduce health and safety risks associated with these pollutants in the groundwater. [97]

---

[95] Interviewee #4, "Stormwater Green Infrastructure Interview," Interview by Carolyn Neer. January24, 2019.
[96] City of Palo Alto. Draft Green Stormwater Infrastructure Plan. Palo Alto, CA, February 2019. https://www.cityofpaloalto.org/civicax/filebank/blobdload.aspx?t=49281.34&BlobID=68727
[97] City of Palo Alto, Regulations for Groundwater Dewatering during Construction of Below Ground Structures, April 2008, https://www.cityofpaloalto.org/civicax/filebank/documents/64867.

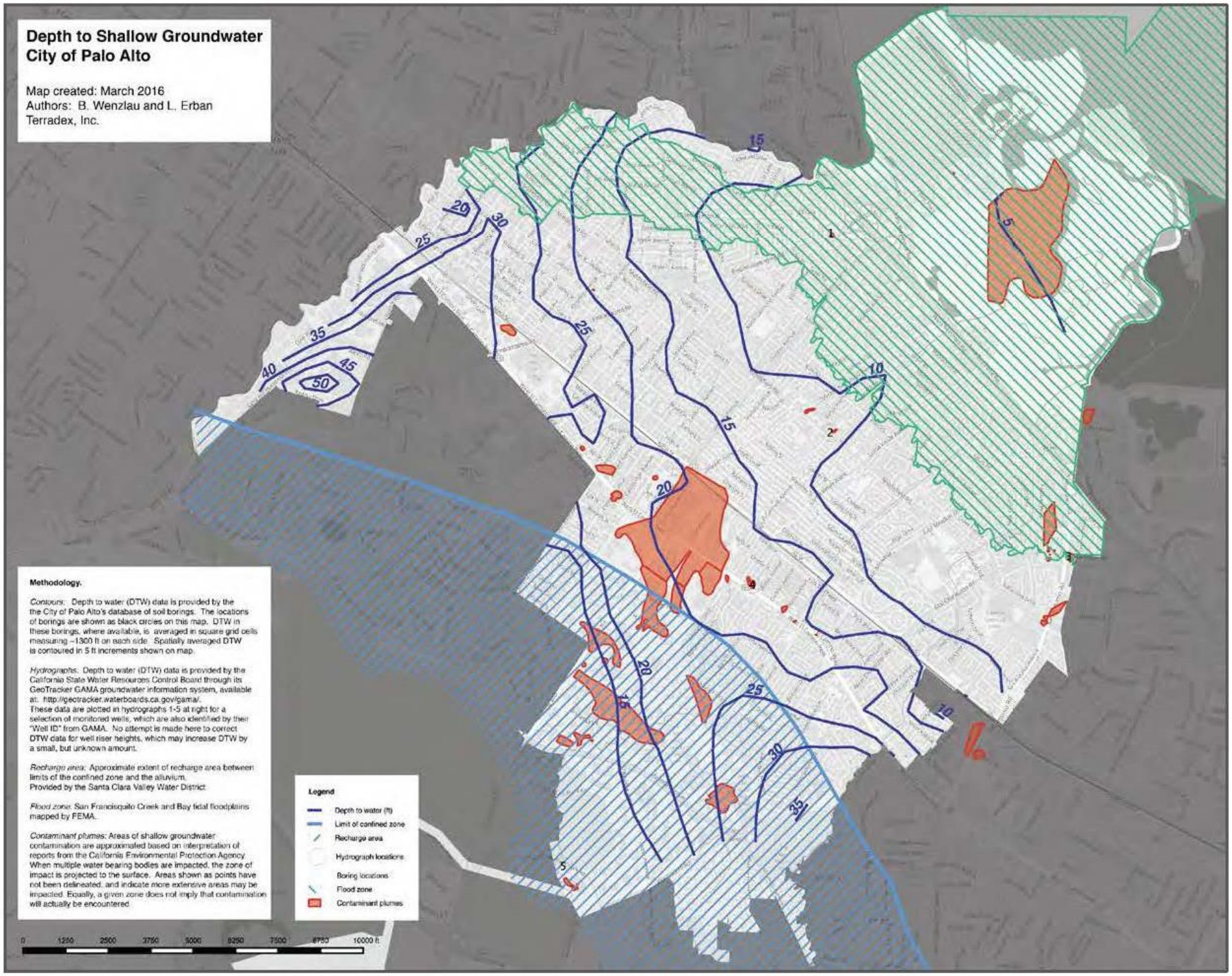

FIGURE 18 LOCATION OF CONTAMINATED GROUNDWATER PLUMES IN PALO ALTO

Source: City of Palo Alto. "Depth to Shallow Groundwater City of Palo Alto." March, 2016. https://www.cityofpaloalto.org/civicax/filebank/documents/63220

Wastewater collection and treatment in Palo Alto is managed by Palo Alto's Public Works Department. Palo Alto's wastewater (stormwater and sewage) is conveyed through separate pipelines with stormwater released directly into local creeks and the San Francisco Bay.[98] Palo Alto's first GSI project was completed in 2008 with the installation of runoff infiltration trenches along Alma Street between Loma Verde and San Antonio Streets.[99] With the success of the Alma Street Infiltration Trenches at reducing flooding along this roadway, Palo Alto began its first official GSI project in the Southgate neighborhood shortly thereafter. The Southgate Neighborhood Green Streets project consisted of installation of 16 bioretention facilities and pervious crosswalks in an historic residential neighborhood, originally constructed without traditional stormwater infrastructure. Completed in 2014, the Southgate Neighborhood Green Streets project directed the majority of stormwater collected in these GSI facilities to a nearby existing storm drain, while a small portion of stormwater collected in the bioretention facilities was allowed to infiltrate directly into the soils to facilitate groundwater recharge.[100]

Similar to the City of Berkeley and other Bay Area jurisdictions subject to NPDES Order No R-2015-0049, Palo Alto began its citywide GSI planning process in 2017. In order develop a plan that met the requirements of this order, Palo Alto formed an GSI working group composed of staff from different departments in the city, such as parks and recreation, public works, transportation, and planning. The GSI working group was an effort to facilitate collaboration and information sharing between the different departments. While initial meetings were well attended by representatives from all departments, scheduling conflicts have repeatedly decreased regular attendance and inhibited these collaboration efforts. In response to this challenge, the group has switched to holding smaller focused group meetings consisting of 3 – 10 key representatives by which specific issues or concerns are discussed and resolved more efficiently.[101]

---

[98] City of Palo Alto. City of Palo Alto *Storm Drain System Facts and Figures*. https://www.cityofpaloalto.org/civicax/filebank/documents/2806 (accessed March 7, 2019).
[99] City of Palo Alto. Draft Green Stormwater Infrastructure Plan. Palo Alto, CA, February 2019. https://www.cityofpaloalto.org/civicax/filebank/blobdload.aspx?t=49281.34&BlobID=68727
[100] Interviewee #5, "Stormwater Green Infrastructure Interview," Interview by Carolyn Neer. February 21, 2019; City of Palo Alto. Draft Green Stormwater Infrastructure Plan. 2019.
[101] Interviewee #5, "Stormwater Green Infrastructure Interview," Interview by Carolyn Neer. February 21, 2019.

Location identification and prioritization methodology used by Palo Alto in its *Green Stormwater Infrastructure Plan* were primarily adopted from SCVURPPP's *Stormwater Resources Plan* and include the use of GIS applications. Among the many factors considered in identifying the location of future GSI facilities, the City of Palo Alto has identified sites with historic industrial use, areas with clustered commercial development and land uses with particularly high trash generation rates as priority sites for new GSI facilities in order to maximize the pollutant reduction potential of these facilities. Finally, sites with no existing bikeways or safe routes to school were also prioritized for installation of GSI facilities to capitalize on other city projects such as Palo Alto's Green Streets and Better Bikeways programs, which are well suited to incorporating GSI facilities into their design.

After collaboration with SCVWD on the potential impacts of GSI facilities on contaminated groundwater, Palo Alto has ruled out sites within 500 feet of the city's existing contaminated groundwater plume as well as sites located within the groundwater recharge area managed by SCVWD.[102]

FIGURE 19 EXISTING GSI PROJECT HIGHLIGHTS – SOUTHGATE NEIGHBORHOOD GREEN STEETS
This project installed 16 bioretention facilities and pervious pavement on crosswalks in a residential neighborhood with limited existing stormwater infrastructure and a history of flooding.
Source: City of Palo Alto, 2019.

102 Interviewee #5, "Stormwater Green Infrastructure Interview," Interview by Carolyn Neer. February 21, 2019.

4.5 SUMMARY OF FINDINGS

Of the case studies discussed above, Berkeley had the most existing GSI facilities, while San Francisco had the broadest selection of existing GSI policies and programs. Additionally, while all case study cities had a history of groundwater contamination and, when asked about the challenges that this contamination posed for installing GSI facilities, each interview subject responded with confidence that this was not a major issue. Interview subjects explained that their cities had already developed a process for reviewing GSI facility designs on sites with known contamination as early as 2010 when the RWQCB began requiring installation of GSI facilities on larger private developments.[103] For these case study cities, this review process involves determining whether a site is likely to contain contaminated groundwater using existing maps of contaminated sites and ensuring that any GSI facilities installed on these properties include an impervious barrier to prevent infiltration of stormwater into the soil and groundwater. Despite the simplicity of this review process, interviews with professionals involved in water quality monitoring and GSI compliance at the SCVWD and SCVURPPP confirmed this as industry standard and largely effective at mitigating potential spread of contaminated groundwater.[104]

4.6 ANALYSIS OF BEST PRACTICES

Although this comparative case study analysis suggested that conflicts between GSI facilities and existing contaminated groundwater supplies could be addressed easily through project review and facility design measures, given the long history of severe contamination in San Jose and the large number of GSI facilities identified for installation in the City's *Green Stormwater Infrastructure Plan*, monitoring and maintenance of these facilities must be prioritized. Long-term use of these facilities could lead to localized contaminant accumulation, further exacerbating the contamination crisis in San Jose.

Recent literature suggests that a collaborative governance model may be a useful model for San Jose to follow especially as it relates to maintenance and monitoring of GSI facilities. Thus, the following

---

[103] Note: The size of development projects triggering NPDES C.3 requirements for installation of GSI facilities differs by county. In Santa Clara and Alameda Counties projects are required to comply with C. 3 if they disturb an area equal to or greater than 10,000 square feet while, in the City and County of San Francisco that threshold is 5,000 square feet or more.

[104] Interviewee #7, "Stormwater Green Infrastructure Interview," Interview by Carolyn Neer. February 6, 2019; Interviewee #6, "Stormwater Green Infrastructure Interview," Interview by Carolyn Neer. January 25, 2019.

case study analysis was developed to answer the questions: How have these case studies conformed to theoretical models of successful collaborative governance programs identified in the literature?, and in what ways can collaborative governance models be used to address the challenges of GSI planning and implementation?

All three case study cities followed Selin and Chavez's five-step model for successful collaboration as identified in the literature. All cities experienced issues with flooding (antecedent and problem identification), which they addressed through installation of GSI facilities (direction setting), which over time demonstrated effectiveness at addressing the problem (monitoring and evaluation).

Furthermore, in Berkeley and Palo Alto, current citywide green infrastructure planning efforts will by default adhere to Selin and Chavez's model due to the specific requirements of the NPDES Order No. R02-2015-0049 which defines the problem as pollution of stormwater with mercury, PCBs, and trash, sets reduction goals and requires each citywide green infrastructure plan to include well-defined methods for achieving and monitoring these reduction goals in the future.

However, despite adherence to Selin and Chavez's five step model the case studies did not strictly adhere to the four additional factors identified in the literature on collaborative watershed management- Common Language, Voluntary Participation, Incentives, and Public Engagement.

When analyzed through the lens of the first factor, Common Language, San Francisco emerged as the most successful among the three case study cities at establishing a common language to communicate with different actors. While public engagement efforts in Berkeley and Palo Alto were limited to traditional public meetings, in San Francisco, the SFPUC engaged a broader spectrum of the public through providing educational events designed for k-12 students, construction and engineering professionals, maintenance workers, and homeowners interesting in learning how GSI facilities work and the best methods for maintaining them. However, staff at the SFPUC still viewed establishing a common language for communicating with the public as a major challenge to future GSI planning and implementation efforts. In order to solve this problem, SFPUC has established the Watershed Stewardship Program to facilitate greater understanding of GSI facilities and their benefits to the community through educational programs tailored to professionals in the construction and maintenance industries, as well as the general public.

For the cities of Berkeley and Palo Alto on the other hand, the regulatory framework of NPDES Order No. R02-2015-0049 has dictated the language these cities use to communicate with the public about GSI and stormwater pollution. Interviews with staff at the City of Berkeley and the City of Palo Alto revealed that this highly scientific language lacks the context and background needed to effectively communicate with members of the public lacking a specialized education in the field. Interviewees recounted experiences where members of the public reacted negatively to this language, fearing the installation of GSI facilities near their homes due to misunderstandings about the safety risk of contaminants held in GSI facilities.[105]

The second factor, Voluntary Participation, was more widely adopted and successfully implemented by all three case study cities. For San Francisco, collaboration between educational program participants and SFPUC staff was entirely voluntary and driven in large part by the third factor, Financial Incentives. Community organizations interested in installing GSI facilities with the help of SFPUC were incentivized to participate in the educational programs in order to be eligible for grant funding. Similarly, in Berkeley and Palo Alto collaboration between the cities and their respective county stormwater pollution prevention programs was voluntary and incentivized by the availability of grant funding for projects identified through collaborative efforts in the county stormwater resource plans.

Finally, the fourth factor, Public Engagement, was once again implemented more extensively by San Francisco than Berkeley and Palo Alto. To date, San Francisco has engaged with the public on GSI planning in a more collaborative manner while Berkeley and Palo Alto have limited their public engagement efforts to formal comment periods during public meetings. Due to the highly technical nature of GSI facility designs and the lack of funding provided by the state, it is understandable why smaller cities such as Berkeley and Palo Alto have not invested heavily in developing educational programs like San Francisco. However, given the difficulty these communities have had at communicating the safety,

[105] Ibid.

importance, and function of GSI facilities to members of the public, it would seem additional educational programs are necessary to ensure continued public support for implementation of citywide GSI plans. Table 1 summarizes these findings.

TABLE 1 SUMMARY OF COMPARATIVE CASE STUDY FINDINGS

Case Study City	**Factor from Literature**	**Description of Effort**	**Achieved Goal (Y/N)**
San Francisco	Common Language	None identified	N
	Voluntary Participation	Class attendance	Y
	Financial Incentives	Grant funding	Y
	Public Participation	Educational courses	Y
Berkeley	Common Language	Scientific	N
	Voluntary Participation	Meeting attendance	N
	Financial Incentives	None	N
	Public Participation	Public meeting	N
Palo Alto	Common Language	Scientific	N
	Voluntary Participation	Meeting attendance	N
	Financial Incentives	None	N
	Public Participation	Public meeting	N

For the City of San Jose, adherence to the requirements of NPDES Order No. R02-2015-0049 will ensure San Jose follows Selin and Chavez's five-step model for successful collaboration. However, results of the case study analysis suggest that Selin and Chavez's five-step model is not enough to ensure successful collaboration with members of the public. As a result, further efforts to incorporate these four additional factors -Common Language, Voluntary Participation, Incentives, and Engaging the Public -are necessary to develop a successful citywide green infrastructure plan that prevents future contamination and engages outside agencies, nonprofits, educational institutions *and* members of the public. Specific methods of integrating these four additional factors into GSI planning in San Jose are outlined in Chapter 5.

CHAPTER 5 HOW CAN SAN JOSE IMPROVE ITS GSI PLANNING?

5.1 METHODOLOGY

Utilizing data derived from the literature and case study analysis above, the following section presents a recommended framework for collaborative GSI planning in San Jose. To ensure all elements of this framework are feasible and effective at achieving their desired outcomes, a draft of this recommended framework was presented to and reviewed by scholars specializing in water resource management.

5.2 PROPOSED COLLABORATIVE FRAMEWORK

TABLE 2 PROPOSED FRAMEWORK ELEMENTS

Factor	Policy Option	Costs	Benefits
Common Language	Vocational Training Program	Staff time Maintenance materials Marketing materials	Maintained GSI facilities In expensive labor Cleaner streets Economic opportunity
Engage the Public	Interpretive Signs	Staff time to draft/ design Materials	Increased public awareness and understanding of GSI
Voluntary Participation	Host Charrettes	Staff time Materials Location fees	Increased awareness of GSI New GSI facilities
Financial Incentives	Provide Grant Funding	Staff time Capital for grant awards	Increased use of GSI Reduced installation and maintenance costs

Establish a Common Language

While science was established as the favored and most neutral common language used in the Upper San Pedro Partnership Program, data collected during case study interviews for this report suggests the contrary to be true in regards to GSI planning in the Bay Area.[106] In Arizona, collaboration partners included representatives of resource management agencies, non-profit groups

[106] George Saliba and Katherine Jacobs. "Saving the San Pedro River: Science, Collaboration, and Water Sustainability in Arizona. *Environment,* Vol 50, 6. (2008), 30-42.

and advocacy organizations who likely possessed specialized education in the topics of ecology and watershed management whereas members of the public in the Bay Area are less likely to have previous education in stormwater pollution and GSI facilities.[107]

Furthermore, new concepts or theories concerning ecology and watershed management are more readily learned through first-hand experience of ecological systems and management techniques than the design and function of GSI facilities which are partially concealed underground and impacted by stormwater pollution originating from many dispersed sources. Thus, scientific language is not a suitable common language for discussing GSI facilities planning in San Jose.

Out of all cases discussed in the literature on collaborative watershed management, Portland's Community Watershed Stewardship Program was the only program which sought to engage the public directly in the work of installing and maintaining GSI facilities on public properties.[108] The broader range of participants involved in Portland's Community Watershed Stewardship Program provides a better example for common language aimed reaching members of the public in San Jose.

While the Community Watershed Stewardship Program was not solely designed for public education, but instead to facilitate community projects to improve the health of the local watershed, City staff and university faculty and students communicated the importance and function of GSI facilities to members of the community through hands on training in the installation and maintenance of GSI facilities.[109] To date, San Francisco is the only city in the Bay Area with a model similar to this for educating the public about GSI facilities.[110]

---

[107] Ibid.

[108] Sarah Church, "Exploring Green Streets and rain gardens as instances of small scale nature and environmental learning tools," Landscape and Urban Planning 134 (2015), 229-240; Vivek Shandas and Barry Messer, "Fostering Green Communities Through Civic Engagement: Community-Based Environmental Stewardship in the Portland Area," Journal of American Planning Association, Vol. 74, No 4. (2008), 408-418; Vivek Shandas, "Neighborhood change and the role of environmental stewardship: a case study of green infrastructure for stormwater in the City of Portland, Oregon, USA." *Ecology and Society* Vol. 20, 3 (2015).

[109] Sarah Church, "Exploring Green Streets and rain gardens as instances of small scale nature and environmental learning tools," Landscape and Urban Planning 134 (2015), 229-240; Vivek Shandas and Barry Messer, "Fostering Green Communities Through Civic Engagement: Community-Based Environmental Stewardship in the Portland Area,"

The ethnic and linguistic diversity of San Jose supports the theory that communications about GSI facilities should be done through hands-on experience and not through scientific language. San Jose has an ethnically and linguistically diverse population with 33.2 percent of residents identifying as Hispanic, 32.8 percent Asian, 27.6 percent White, and 2 percent African American. This ethnic diversity is also visible in the languages that most residents speak at home with only 43 percent of residents speaking English at home, while 27 percent speak an Asian/ Pacific Island language and the remaining 24 percent speak Spanish at home.[111] Furthermore, the majority of the city's population, 83.5 percent, holds only a high school diploma.[112] Thus, it is recommended that all communications about GSI facilities in San Jose be as experiential as possible with a hands-on focus that enables members of the public to engage directly with the GSI facilities instead of through traditional lecture or presentation formats. Finally, any written or visual communications about GSI facilities in the city should be made available in multiple languages including Spanish, English, and Vietnamese to ensure all members of the community in San Jose are able to participate regardless of their native language.

One format for a hands-on training program which the City of San Jose could adopt to facilitate greater levels of community collaboration on GSI maintenance and monitoring is through expanding the City's existing partnership with the San Jose Downtown Business Association and Downtown Streets Team/Groundwerx program.[113] The current program which engages homeless and low income residents in

---

Journal of American Planning Association, Vol. 74, No 4. (2008), 408-418; Vivek Shandas, "Neighborhood change and the role of environmental stewardship: a case study of green infrastructure for stormwater in the City of Portland, Oregon, USA." *Ecology and Society* Vol. 20, 3 (2015).

[110] Interviewee # 1, "Stormwater Green Infrastructure Interview," Interview by Carolyn Neer. January15, 2019; Interviewee #4, "Stormwater Green Infrastructure Interview," Interview by Carolyn Neer. January 24, 2019; Interviewee #2. "Stormwater Green Infrastructure Interview," Interview by Carolyn Neer. February 1, 2019; Interviewee #3. "Stormwater Green Infrastructure Interview," Interview by Carolyn Neer. February 8, 2019; Interviewee #4, "Stormwater Green Infrastructure Interview," Interview by Carolyn Neer. February 21, 2019; City of Palo Alto. Draft Green Stormwater Infrastructure Plan. 2019.

[111] US. Census Bureau, "2012 American Community Survey," https://www.sanjose.org/meetings/quick-guides/san-jose-demographics-and-diversity

[112] US. Census Bureau, "2012 American Community Survey," https://www.sanjose.org/meetings/quick-guides/san-jose-demographics-and-diversity

[113] Downtown San Jose Property Based Improvement District, 10-Year Anniversary Report 2008-2017. 2017, San Jose, CA. http://sjdowntown.com/wp_2016/wp-content/uploads/2018/01/Groundwerx-Digital.pdf (accessed April 6, 2019).

street maintenance and beautification activities could be expanded to include specialized training on and maintenance/ monitoring of city-owned GSI facilities.

Under this program, low income and homeless residents would have the opportunity to receive free specialized training on how to properly clean, maintain, and monitor GSI facilities. Thus, solving the problem of a skilled labor shortage and ensuring data is collected on long-term efficacy of these facilities. Training could be provided by City staff as well as faculty and students from San Jose State University's Environmental Studies Department through CommUniverCity. Upon successful completion of the educational program, participants would be eligible for paid positions as maintenance workers for the City, charged with maintaining and monitoring GSI facilities on City-owned property.

Once hired as maintenance workers, program participants would be overseen by the City's Environmental Services and Public Works Departments and the San Jose Downtown Association Groundwerx Program team. Funding requirements for this alternative would include staff time and materials used in maintaining and repairing GSI facilities which could be obtained through grant funding or through the City's general maintenance fund.[114] Once trained, program participants would provide relatively inexpensive labor and satisfy the need for specially-trained maintenance workers.

FIGURE 20 DOWNTOWN STREETS TEAM/ GROUNDWERX CREW IN ACTION
Note: The Groundwerx, Downtown Streets Team at work at Cesar Chavez Plaza in Downtown San Jose.
Source: Downtown San Jose Property Based Improvement District, 10-Year Anniversary Report 2008-2017. 2017, San Jose, CA. http://sjdowntown.com/wp_2016/wp-content/uploads/2018/01/Groundwerx-Digital.pdf (accessed April 6, 2019).

[114] Emily Deruy, "San Jose to Pay Homeless $15 an hour to pick up trash," *Mercury News*. October 25, 2018. https://www.mercurynews.com/2018/10/25/san-jose-homeless-people-will-be-paid-15-an-hour-to-pick-up-trash/

Engage the Public Early and Often

In addition to hands on training during the installation and maintenance of GSI facilities, Church's study of GSI facilities installed under Portland's Community Watershed Stewardship Program suggests that the simple presence of GSI facilities on public streets increased public awareness of GSI facilities and for approximately half of the study population interviewed, improved their understanding of the purpose and function of those facilities.[115] While these results don't guarantee 100 percent successful education of the public about the purpose and function of GSI facilities, it does suggest that experiencing the GSI facilities first hand during daily life can increase understanding and acceptance of GSI facilities.[116]

Given the City of San Jose's current legal requirements to plan for and install 100 million dollars of infrastructure to reduce mercury, PCBs, and trash from local surface waterways, installation of GSI facilities on public streets across the city will occur perhaps even faster than in other Bay Area communities who are not required to do so as a result of the settlement of a lawsuit.[117]

If Church's findings are correct in San Jose, the mere presence of GSI facilities across the city in various neighborhoods will increase public familiarity with GSI facilities. However, without direct and conscious efforts on the part of the City to educate the public on the function of these facilities, such as through incorporation of educational signs in the GSI facility design, it is not likely that a large portion of the population will gain understanding of the function and purpose of these facilities. Thus, it is recommended that the City of San Jose incorporate educational signs into the design of their GSI facilities which explain, in several languages and using illustrations, the function and purpose of the facilities at achieving water quality standards and improving the health of local surface water bodies.

---

[115] Sarah Church, "Exploring Green Streets and rain gardens as instances of small scale nature and environmental learning tools," Landscape and Urban Planning 134 (2015), 229-240.

[116] Sarah Church, "Exploring Green Streets and rain gardens as instances of small scale nature and environmental learning tools," Landscape and Urban Planning 134 (2015), 229-240.

[117] Paul Rodgers. "San Jose agrees to $100 million pollution clean-up program to reduce trash, sewage spills." *Mercury News*, (San Jose, CA) June 14, 2016. https://www.mercurynews.com/2016/06/14/san-jose-agrees-to-100-million-pollution-cleanup-program-to-reduce-trash-sewage-spills/

FIGURE 21 EXAMPLE OF PROPOSED INTERPRETIVE SIGNS TO ACCOMPANY GSI FACILITIES
Note: Educational signs such as this multi-lingual sign connect members of the public with GSI facilities, improving their understanding of the purpose and function of these facilities as they experience them in the street environment.
Source: Sophia Weller, https://www.pinterest.com/pin/394276142360189912/?lp=true (accessed April 6, 2019).

Encourage Voluntary Participation

The third factor in this proposed framework for collaboration on GSI planning in San Jose is voluntary participation. Voluntary participation was clearly established as an important component of successful watershed management in the literature reviewed. For jurisdictions in Ohio and California, the benefits of voluntary participation were clear: community groups were free to participate when and in a manner that was right for them.[118] In Ohio, this meant that local jurisdictions were free to design programs and projects to achieve state-mandated water quality goals based on the needs and specific conditions of their local community.[119]

---

118 Mark Imperial and Derek Kauneckis. "Moving from Conflict to Collaboration: Watershed Governance in Lake Tahoe," *Natural Resources Journal*, Vol. 43. (2003), 1010; Patrick Lawrence, "Achieving Teamwork: Linking Watershed Planning and Coastal Zone Management in the Great Lakes," *Coastal Management,* 39, 1. (2011), 57-71; Thomas Koontz and Jens Newig, "From Planning to Implementation: Top-Down and Bottom-Up Approaches for Collaborative Watershed Management. *Policy Studies Journal.* 42:3 (2014), 416- 442.
119 Ibid. Koontz and Newig, (2014); Ibid. Lawrence, (2011).

Similarly, in the Tahoe Basin of California, a switch from mandatory collaboration over water quality regulations to voluntary cooperative management agreements between nonprofit organizations and local governments increased the number of habitat restoration projects by allowing individual nonprofit groups to propose and implement projects designed and supported by the local residents.[120]

However, in the Bay Area, out of the three case study cities examined in this report, none have truly implemented this technique.[121] This is likely the result of the specific requirements of the NPDES order which sets strict stormwater pollutant reduction goals for communities to achieve. In addition to the top down regulatory nature of this NPDES order, as noted above, the highly technical nature of GSI facility planning requires a level of understanding about hydrology, engineering, and bioremediation which many members of the public do not possess. Thus, it is not surprising that many communities in the Bay Area and elsewhere hold the view that the public is not well enough educated to collaborate on location identification and prioritization of GSI facilities.[122] However, despite this common sentiment, Berkeley has suggested it may adopt a variation of this method in its public meetings by providing a space for residents to identify areas within their neighborhoods where they would like an GSI facility to be installed in the future. Then, using the City's GIS applications, City staff would vet proposed GSI locations based on the local hydrology, presence of contamination, and other factors to determine the suitability of a site for GSI facilities.

In order for this method to be successful in San Jose, the public would need to be better educated on the purpose and function of GSI facilities as well as be fully supportive of their installation in the community.

---

[120] Mark Imperial and Derek Kauneckis. "Moving from Conflict to Collaboration: Watershed Governance in Lake Tahoe," *Natural Resources Journal*, Vol. 43. (2003), 1010.

[121] Interviewee #1, "Stormwater Green Infrastructure Interview," Interview by Carolyn Neer. January15, 2019; Interviewee #4, "Stormwater Green Infrastructure Interview," Interview by Carolyn Neer. January 24, 2019; Interviewee #3. "Stormwater Green Infrastructure Interview," Interview by Carolyn Neer. February 1, 2019; Interviewee #2. "Stormwater Green Infrastructure Interview," Interview by Carolyn Neer. February 8, 2019; Interviewee #5, "Stormwater Green Infrastructure Interview," Interview by Carolyn Neer. February 21, 2019; City of Palo Alto. Draft Green Stormwater Infrastructure Plan. 2019.

[122] Kweit M. G., & Kweit, R. W., *People and politics in urban America*. Belmont, CA: Wadsworth. (1990).

As noted in the case study analysis above, early feedback from public engagement efforts in Palo Alto suggest that members of the community in Santa Clara County are still wary of GSI facilities and fearful that installation of these facilities near their homes will bring health impacts.[123] Furthermore, in order to comply with NPDES Order No. R02-2015-0049, San Jose has already identified the location of future GSI facilities throughout the City which will likely be installed first before additional locations would be identified. Thus, if San Jose were to implement a similar technique allowing members of the public to propose locations for future GSI facilities, it would represent a second step in the City's GSI planning efforts likely several years, if not a decade in the future.

When San Jose determines it is appropriate and necessary to install more GSI facilities, a series of public engagement charrettes should be held to facilitate positive collaboration between city staff and members of the public. According recent research on public engagement methodology, the informal, non-hierarchical format of charrettes creates a welcoming environment for community members to share contribute ideas, feedback and ask questions of city staff without the natural feeling of intimidation which many members of the public experience in a traditional public meeting.[124] Given the highly technical nature and complex nature of GSI facility design and site identification and prioritization, a charratte format would allow members of the public to learn about GSI planning in a more accessible and hands-on manner.

[123] Interviewee #5, "Stormwater Green Infrastructure Interview," Interview by Carolyn Neer. February 21, 2019; City of Palo Alto. Draft Green Stormwater Infrastructure Plan. 2019.

[124] Porter, Douglas R. Breaking the Development Logjam: New Strategies for Building Community Support. Washington, D.C.: ULI-the Urban Land Institute, 2006; Flint, R. Warren. Practice of Sustainable Community Development: A Participatory Framework for Change. Ebooks Corporation. New York: Springer, 2013.; Walters, David, and Linda Brown. Design First: Design-based Planning for Communities. Oxford: Architectural, 2004.

FIGURE 22 ENCORAGE VOLUNTARY PARTICIPATION AT CHARRETTES
Note: Charrettes are the perfect platform to encourage voluntary participation in site identification for GSI facilities. Source: National Charrette Institute at MSU, https://www.facebook.com/nationalcharrette/ (accessed April 6, 2019).

Provide Incentives for Participation

Like Voluntary Participation, Incentives for Participation was clearly established as an important component of successful collaborative watershed management in the literature reviewed as well as in the Bay Area case studies analyzed for this report. Koontz and Newig's 2014 study of watershed management planning in Ohio found that when collaboration was incentivized through grant funding, agencies were more willing to participate.[125]

Similarly, in the Bay Area, the availability of grant funding for GSI project implementation for jurisdictions that worked collaboratively on the development of county stormwater resources plans was an effective mean of incentivizing collaboration.

The proven effectiveness of financial incentives has led San Francisco to establish a new Green Infrastructure Grant Program which provides grant awards of up to $765,000 for the design

[125] Thomas Koontz and Jens Newig, "From Planning to Implementation: Top-Down and Bottom-Up Approaches for Collaborative Watershed Management. *Policy Studies Journal*. 42:3 (2014), 416- 442.

and construction of an GSI facility in the City's identified priority regions.[126] Launched in February 2019, this program has not been implemented long enough to demonstrate effectiveness at facilitating collaboration on GSI planning.[127] However, with such high dollar grant awards, it can be expected to incentivize considerable collaboration among many groups in the city.

As noted above, due to the current level of understanding and acceptance of GSI facilities in Santa Clara County, it is unlikely that providing financial incentives for community groups to collaborate with the City on installation and maintenance of GSI facilities would be an effective method of facilitating collaboration. Once again, increased education on the function and purpose of GSI is necessary prior to provision of financial incentives for additional GSI projects. However, once the public has become more familiar with and supportive of GSI facilities in their communities, providing financial incentives such as grant funding to non-profit organizations, neighborhood associations and school districts interested in installing and maintaining GSI facilities would be a method of facilitating better collaboration between these groups and the City.

Once the City has determined that a substantial percent of the population understands and is not fearful of GSI facilities, a grant program should be established that provides funding for the construction and maintenance of GSI facilities on public property owned by the City and school districts. In order to ensure that grant funding is provided to organizations with the administrative and volunteer capacity to implement these projects, San Jose's grant program should specifically target nonprofits, neighborhood associations and school districts that can demonstrate a history of successful project implementation, and provide records showing consistent volunteer participation over the previous five years. The total amount of grant awards should be determined based on the average costs of construction and maintenance of similar GSI facilities already installed by the City in San Jose. Finally, the location and design of these facilities funded through this grant program should follow San Jose's Complete Streets Guidelines, and wherever possible, incorporate

[126] San Francisco Public Utilities Commission, "Green Infrastructure Grant Program," sfwater.org, February 20, 2019, https://sfwater.org/index.aspx?page=1269 (accessed April 4, 2019).
[127] Ibid.

educational materials and seating to facilitate greater interaction and connection between the public and the GSI facility.

FIGURE 23 GRANT-FUNDED GSI FACILITY IN SAN FRANCISCO SCHOOLYARD
Note: SFPUC has partnered with San Francisco Unified School district to install GSI facilities such as this bioswale in local schoolyards to reduce stormwater runoff pollution and improve students' understanding of the purpose and function of GSI facilities.
Source: San Francisco Public Utilities Commission, "Green Infrastructure Grant Program," sfwater.org, https://www.sfwater.org/index.aspx?page=1260 (accessed April 6, 2019).

CHAPTER 6 CONCLUSIONS AND RECOMMENDATIONS

6.1 Summary of Findings

The City of San Jose has many polluted water bodies and numerous sources of stormwater pollution. GSI facilities are increasingly being used to solve similar problems in cities across the globe despite recent findings which suggest that long-term operation of GSI facilities may contribute to localized contaminant accumulation and require continued and diligent monitoring to ensure their long-term safety. Despite the potential challenges of operating numerous GSI facilities in perpetuity, recent regulatory mandates from the RWQCB have prompted action on the part of municipalities in the Bay Area to draft citywide GSI plans, expanding the use of GSI on public property to achieve water quality standards.

The framework for citywide GSI plans as required by the RWQCB adheres to educational models for collaborative watershed management containing identifiable stages such as antecedents, problem identification, direction setting, monitoring, and evaluation. However, despite the potential benefits of collaboration across jurisdictional boundaries on water quality issues, collaboration between local municipalities and community organizations is noticeably absent among Bay Area cities including San Jose.

The unfunded reality of this regulatory mandate in the Bay Area makes the prospects for successful program implementation dim. The high cost of installation, maintenance, and monitoring of GSI facilities will strain local resources unless alternative actions are taken. However, literature suggests that collaborative governance models can be an effective means of reducing maintenance costs by engaging the public, community groups, and school districts in maintenance and monitoring activities, thereby reducing the financial burden traditionally assigned to cities. Findings from the comparative case study analysis, particularly data collected through indepth interviews with planners and engineering professionals in San Francisco, Berkeley, and Palo Alto, support the literature on the advantages of utilizing a collaborative governance model in stormwater management.

Building on prior research, this report fills the gap in literature by exploring the potential application of collaborative governance models on stormwater management in the highly contaminated city of San Jose. A framework for collaborative stormwater management is established including an easily understandable language for communications with the public, voluntary hands-on maintenance and monitoring program for new GSI facilities, and the provision of grant funding for future projects.

6.2 Recommendations for Future Study

Despite the contributions of this report to current scholarship on collaborative watershed management, time and resource limitations have left room for future research into the following topics:

The effects of long-term operation of GSI on groundwater and soil quality: As discussed in Chapter 3, *The Science Behind GSI*, there is ample literature supporting the effectiveness of GSI facilities at reducing stormwater flow and filtering stormwater pollutants in the short-term. However, few studies have explored the long-term effects of GSI operation on soil and groundwater quality. As GSI facilities become increasingly popular as a solution to stormwater overflow and groundwater depletion in cities across the globe, it is necessary to better understand the long-term impacts of these facilities on our soil and groundwater resources. Therefore, further studies are necessary.

The effects of long-term operation of GSI on groundwater recharge rates: Due to the relatively recent adoption of GSI facilities in arid and semi arid regions of the world, research on the effectiveness of GSI facilities at facilitating groundwater recharge over the long-term is also limited. If these facilities are found to be a reliable solution to longterm groundwater sustainability, knowledge of this information may facilitate quicker approval for new GSI projects and could result in greater sources of grant funding.

APPENDIX A

INTERVIEW SAMPLE INTERVIEW QUESTIONS AND DATA MATRIX

Sample Interview Questions

Q 1: What was your involvement in the green infrastructure program?

Q 2: How is the program organized?

Q 3: How have/ are you measuring success in this program?

Q 4: Were environmental factors such as soil or groundwater contamination considered in the identification of suitable sites for GSI installations?

Q 5: Is there anything that you would do differently looking back?

Q 6: Is there anything else you would like to add?

Q 7: Is there anyone else you recommend I speak to?

TABLE 3 INTERVIEW DATA MATRIX

Name, Title, Organization	Organization Type	Measurement of Success	Contamination considered?	Challenges	Opportunities
Subject 1 Watershed Planner, SFPUC	Service Enterprises	Used Dam monitoring methods	Yes, not located on sites with contamination, or if necessary lined facilities	Maintenance and funding	Training centers for GSI education
Subject 2 CIP Planner SFPUC	Service Enterprises	Water quality improvements and flow rate reductions	Yes, same answer as above	Utility conflicts communication between agencies	Leverage private public partnerships for poled grant funding
Subject 3 Interim CIP Planner SFPUC	Service Enterprises	Unable to answer	If necessary designed to be lined so no infiltration	Durability of new materials in GSI facilities	GSI Leadership Exchange network
Subject 4 City of Berkeley Public Works	Departments	Water Quality, monitoring protocol in development	Yes, generally avoided of lined if necessary	Maintenance staff/ time	Coordinate with Groundwater Sustainability Planning
Subject 5 Stormwater Program Manager City of Palo Alto	Departments	PCB, Mercury, Trash reduction	Yes, avoid sites in or within 500 ft of plume, or with high groundwater	Scheduling - collaboration, forecasting maintenance costs and funding Communicating / public education	Regional effort to educate public on GSI purpose and function
Subject 6 Assistant Program Manager SCVURPPP	Non-profit with board	N/A specific projects, determined by jurisdictions	Yes, not located on sites with contamination	Funding Maintenance Staff knowledge	Wrap GSI into Green Streets grant projects
Subject 7 Senior Water Resources Specialist Santa Clara Valley Water District, chair of SCVURPPP	Non-profit with board	Water Quality Flood Reduction	Yes, Avoid contaminated sites No direct infiltration to groundwater	Communicating / educating public	New Natl. Certification for GSI maintenance workers

Ahiablame, Laurent; Shakya, Ranish. "Modeling flood reduction effects of low impact development at a watershed scale." *Journal of Environmental Management.* 171, (2016): 81-91.

Alameda County Clean Water Program, Stormwater Resources Plan, Hayward, CA, October 2018, https://www.cleanwaterprogram.org/images/2018-10_PUBLIC_DRAFT_ACCWP_SWRPApp1-4.pdf.

Albritton, Daniel et. al., "Climate Change 2001: Synthesis Report" (Intergovernmental Panel on Climate Change, Cambridge, UK, 2001).

Basdeki, Aikaterini; Katsifarakis, Lysandros; Katsifarakis, Konstantinos; "Rain gardens as integral parts of urban sewage systems- A case study in Thessaloniki, Greece," Procedia Engineering 162 (2016) 426-432.

Bay Area Census, "City of San Jose Santa Clara County" Bay Area Census , accessed December 2, 2018, www.bayareacensus.ca.gov/cities/SanJose50.htm.

Berkeley, City of. Environmental Management Area Map, December 8, 2010. https://www.cityofberkeley.info/uploadedFiles/IT/Level_3_-_General/ema.pdf

Berkeley, City of. City of Berkeley General Plan: A Guide for Public Decision-Makers, Land Use Element. Berkeley, CA, February 18, 2001.
https://www.cityofberkeley.info/Planning_and_Development/Home/General_Plan__A_Guide_for_Public_Decision-Making.aspx

Berkeley, City of. *Watershed Management Plan*, Berkeley, CA, October 2011, https://www.cityofberkeley.info/uploadedFiles/Public_Works/Level_3_-_Sewers_-_Storm/WatershedMgtPlan_2011October_Version1.0.pdf

Bluestone, Barry and Bennett, Harrison. *The Deindustrialization of America: Plant Closings, Community Abandonment, and the Dismantling of Basic Industry*. New York: Basic Books, 1982.

C40 Cities, "C40 Fact Sheet," (C40 Cities Climate Leadership Group, London, UK, 2015)

California Department of Toxic Substances Control. "Envirostor database search: San Jose, CA," https://www.envirostor.dtsc.ca.gov/public/, retrieved on December 2, 2018.

California Regional Water Quality Control Board - San Francisco Bay Region, "Municipal Regional Stormwater NPDES Permit: Order No. R2-2015-0049, NPDES Permit No. CA5612008" (Public document, San Francisco, 2015).

California State Assembly. Assembly Bill-466 Santa Clara Valley Water District. (Assembly bill, Sacramento, CA, 2009).

California Water Resources Control Board. "Site Cleanup Program (SCP)," https://www.waterboards.ca.gov/water_issues/programs/site_cleanup_program/. December 2, 2018.

Chau, Haan-Fawn. "Green Infrastructure for Los Angeles: Addressing Urban Runoff and Water Supply Through Low Impact Development," (City of Los Angeles, Los Angeles, CA 2009): 48-54.

DC Water. "Green Infrastructure," dcwater.com, April 22, 2018, https://www.dcwater.com/green-infrastructure

Deruy, Emily. "San Jose to Pay Homeless $15 an hour to pick up trash." *Mercury News*. October 25, 2018. https://www.mercurynews.com/2018/10/25/san-jose-homeless-people-will-be-paid-15-an-hour-to-pick-up-trash/

Dineen, J. K. "Offices Intruding on SF Space Zond for Industrial Use." *San Francisco Chronicle,* March 14, 2016. https://www.sfchronicle.com/bayarea/article/Offices-intruding-on-SF-space-zoned-for-6889809.php

Driscoll, Charles; Chandler, David; Eger, Caitlin; Kassaee Roodsari, Babak. “Green Infrastructure Lessons from Science and Practice.” *Research Gate*, (2015).

Downtown San Jose Property Based Improvement District, 10-Year Anniversary Report 2008-2017. 2017, San Jose, CA. http://sjdowntown.com/wp_2016/wp-content/uploads/2018/01/Groundwerx-Digital.pdf (accessed April 6, 2019).

Downtown Streets Team. “San Jose.” Streetsteam.com, 2019. https://www.streetsteam.org/san-jose (accessed March 13, 2019).

Eseau, Ronald; Chesterman, D.J. Groundwater Contamination in the Santa Clara Valley; United State Environmental Protection Agency. “Groundwater Contamination Cleanups at South Bay Superfund Sites, Progress Report” (government report, Washington, D.C. 1989).

Feng, Youcan; Burian, Steven; Pomeroy, Christine. “Potential of green infrastructure to restore predevelopment water budget of semiarid urban catchment.” *Journal of Hydrology 542* (2016), *744-755.*

Flint, R. Warren. Practice of Sustainable Community Development: A Participatory Framework for Change. Ebooks Corporation. New York: Springer, 2013.

Hanson, R. T. “Hydrologic framework of the Santa Clara Valley, California. United States Geologic Survey. 2015

Harper, Grace. “Green roof water quality impacts and physiochemical stability,” Master’s Thesis Missouri University of Science and Technology. 2013.

Hong, Marjorie; Farayan, Walter; Dortch, Ira; Chiang, Chen. “Phytoremediation of MTBE from a Groundwater Plume.” *Environmental Science Technology 35*, 35 (2001), 1231-1239.

Humphries, Marc; Kindness, Andrew; Ellery, William; Hughes, Jeffrey; Bond Jonathan; Barnes, Kristen. “Vegetation influences on groundwater salinity and chemical heterogeneity in a freshwater, recharge floodplain wetland, South Africa.” *Journal of Hydrology 411* (2011), 130-139.

Interviewee #1. “Stormwater Green Infrastructure Interview,” Interview by Carolyn Neer. January15, 2019

Interviewee #2. “Stormwater Green Infrastructure Interview,” Interview by Carolyn Neer. February 1, 2019.

Interviewee #3. “Stormwater Green Infrastructure Interview,” Interview by Carolyn Neer. February 8, 2019.

Interviewee #4. Email message to Carolyn Neer, February 28, 2019.

Interviewee #4. “Stormwater Green Infrastructure Interview,” Interview by Carolyn Neer. January 24, 2019.

Interviewee #5. “Stormwater Green Infrastructure Interview,” Interview by Carolyn Neer. February 21, 2019.

Interviewee # 6. “Stormwater Green Infrastructure Interview,” Interview by Carolyn Neer. January 25, 2019.

Interviewee # 7. “Stormwater Green Infrastructure Interview,” Interview by Carolyn Neer. February 6, 2019.

Kim, Junho; Lee, Jungho; Song, Yangho; Han, Heechan; Joo, Jingul. “Modeling the Runoff Reduction Effect of Low Impact Development Installations in an Industrial Area, South Korea,” *Water*. (2018).

Kong, Fanhua; Ban, Yulong; Yin, Haiwei; James, Philip; Dronova, Iryna. Modeling stormwater management at the city district level in response to changes in land use and low impact development. *Environmental Modeling & Software*. 95, (2017):132-142.

Kweit M. G., & Kweit, R. W., *People and politics in urban America*. Belmont, CA: Wadsworth. (1990).

Laffey, Anne. "A Brief History of San Jose," (Envision San Jose 2040 General Plan Meeting Agenda No. 3, San Jose, 1992).

Los Angeles and San Gabriel Rivers Watershed Council, "Los Angeles Basin Water Augmentation Study" (Los Angeles and San Gabriel Watershed Council, CA, 2005).

Lubell, Mark. "Collaborative Watershed Management: A View from the Grassroots." Policy Studies Journal, Vol. 32, 3. (2004).

Lund, Jay; Medellin-Azuara, Josue; Durand, Joghn Stone, Kathleen. "Lessons from California's 2012-2016 Drought." *Journal of Water Resources Planning and Management*. 144, No. 10 (2018).

McSweeny, Terry. "Pollution Problem: Water District Pulls in San Jose, County to Help Clear Homeless Camps from Creeks." *NBC Bay Area*, February 6, 2016, https://www.nbcbayarea.com/news/local/Pollution-Problem-Water-District-Pulls-In-San-Jose-County-to-Help-Clear-Homeless-Camps-From-Creeks-368277541.html

Meadows, Robin. "Urban Jungle Inspires Unique Regulatory Tack." *San Francisco Estuary Partnership*, December, 2016, https://www.sfestuary.org/estuary-news-urban-jungle/.

Michaels, Sarah. "Making Collaborative Watershed Management Work: The Confluence of State and Regional Initiatives." Environmental Management Vol. 27, 1. (2001), 27-35.

National Parks Service. "What is a Green Roof?" United States Department of the Interior, December 2, 2018, https://www.nps.gov/tps/sustainability/new-technology/green-roofs/define.htm.

Negri, Cristina; Hinchman, Ray. "Plants that Remove Contaminants From the Environment," *Laboratory Medicine 27*, no. 1 (1995).

Nieves, Evelyn. "The Superfund Sites of Silicon Valley," New York Times, March 26, 2018. https://www.nytimes.com/2018/03/26/lens/the-superfund-sites-of-silicon-valley.html.
Palo Alto, City of. Regulations for Groundwater Dewatering during Construction of Below Ground Structures, April 2008. https://www.cityofpaloalto.org/civicax/filebank/documents/64867.

Palo Alto, City of. City of Palo Alto *Storm Drain System Facts and Figures*. 2019. https://www.cityofpaloalto.org/civicax/filebank/documents/2806.

Palo Alto, City of. Draft Green Stormwater Infrastructure Plan. Palo Alto, CA, February 2019. https://www.cityofpaloalto.org/civicax/filebank/blobdload.aspx?t=49281.34&BlobID=68727.

Pavlowsky, Johanna. Assessing Downstream Stormwater Impacts for Urban Watershed Planning, Master's Thesis, Missouri University of Science and Technology, (2016).

Pellow, David N.; Sun-Hee Park, Lisa. *Silicon Valley of Dreams: Environmental Injustice, Immigrant Workers, and the Global Technology Industry* (New York, NY: NYU Press, 2002) 70-84.

Perales-Momparle, Sara; Andres-Domenech, Ignacio; Hernandez-Crespo, Carmen; Valles-Moran, Francisco; Martin, Miguel; Escuder-Bueno, Ignacio; Andreu, Joaquin. "The role of monitoring sustainable drainage systems for promoting transition toward regenerative urban built environments: a case study in the Valencian region, Spain." Journal of Cleaner Production 163 (2017): S113-S124

Perlman, Howard. "Transpiration – The Water Cycle," United States Geologic Service (USGS), December 2, 2016, https://water.usgs.gov/edu/watercycletranspiration.html.

Petrova, Sarka; Rezek, Jan; Soudek, Petr; Vanek, Tomas. "Preliminary study of phytoremediation of brownfield soil contaminated by PAHs." *Science of the Total Environment 599-600* (2017), 572-580.

Porter, Douglas R. Breaking the Development Logjam: New Strategies for Building Community Support. Washington, D.C.: ULI-the Urban Land Institute, 2006

Portland, City of. “Green Streets Policy,” (City of Portland, Portland, OR, (2007)

Portland, City of. “2013 Stormwater Management Facility Monitoring Report,” (City of Portland: Sustainable Stormwater Management Program, Portland, OR, 2013), 10-11

Rodgers, Paul. “San Jose agrees to $100 million pollution clean-up program to reduce trash, sewage spills.” *Mercury News*, (San Jose, CA) June 14, 2016. https://www.mercurynews.com/2016/06/14/san-jose-agrees-to-100-million-pollution-cleanup-program-to-reduce-trash-sewage-spills/.

Rodgers, Paul. “State files water Pollution complaint against San Jose for failing to clean up homeless encampments,” *Mercury News*, March 20, 2014, https://www.mercurynews.com/2014/03/20/state-files-water-pollution-complaint-against-san-jose-for-failing-to-clean-up-homeless-encampments/

Rosenzweig, Cynthia; Solecki, William. “Hurricane Sandy and adaptation pathways in New York: Lessons from a first-responder city,” Global Environmental Change 28, (2014): 395-408

Sabatier, Paul; Focht, Will; Lubell, Mark; Trachtenberg, Zev; Vedlitz, Arnold; Matlock, Marty; Kraft, Michael; Kamieniecki, Sheldon. *Swimming Up Stream: Collaborative Approaches to Watershed Management,* (MIT Press: Cambridge, MA, 2005).

San Francisco, City of. San Francisco Stormwater Management Requirements and Design Guidelines, Chapter 3: Low Impact Design in San Francisco. July 1, 2018. San Francisco, CA. https://sfwater.org/modules/showdocument.aspx?documentid=9020 .

San Francisco, City of. San Francisco Zoning Map, October 2018, San Francisco, CA. https://sfplanning.org/sites/default/files/resources/2019-02/zoning_use_districts.pdf

San Francisco, City of. Stormwater Management Ordinance, San Francisco, CA. May 2010. http://www.sfbos.org/ftp/uploadedfiles/bdsupvrs/ordinances10/o0083-10.pdf.

San Francisco, City of., Public Health Department. “Maher Ordinance (San Francisco Public Health Code Article 22A) Program Description and Process,” Revised January 2015. https://www.sfdph.org/dph/files/EHSdocs/Maher/Maher_Process_Procedure.pdf

San Francisco Public Utilities Commission, “Green Infrastructure Projects,” San Francisco Water Power Sewer, https://sfwater.org/index.aspx?page=614 (accessed March 6, 2019).

San Francisco Public Utilities Commission, “Green Infrastructure Grant Program,” sfwater.org, February 20, 2019, https://sfwater.org/index.aspx?page=1269 (accessed April 4, 2019).

San Jose, City of. *Climate Smart San Jose: A People-Centered Plan for a Low-Carbon City*, sanjoseca.gov, accessed May 15, 2018. http://www.sanjoseca.gov/DocumentCenter/View/75035

San Jose, City of. “Draft Green Infrastructure Plan Framework,” (San Jose, CA) May 1, 2017. http://sanjose.granicus.com/MetaViewer.php?meta_id=630673

San Jose, City of. *Envision San Jose General Plan,* sanjoseca.gov, accessed May 15, 2018. http://www.sanjoseca.gov/DocumentCenter/View/474.

San Jose, City of. “Green Stormwater Infrastructure,” sanjose.gov, accessed December 4, 2018. http://www.sanjoseca.gov/index.aspx?NID=5722.

Sang-Soo Baek, Dong-Ho Choi, Jae-Woon Jung, Hyung-Jin Lee, Hyuk Lee, Kwang-Sik Yoon, Kyung Hwa Cho, “Optimizing low impact development (LID) for stormwater runoff treatment in urban area, Korea: Experimental and modeling approach.” Water Research 86(2015): 122-131.

Santa Clara Valley Transportation Authority (VTA). “Valley Transportation Plan” (government policy, San Jose, CA 2015).

Santa Clara Valley Water District, 2015 Urban Water Management Plan, (San Jose, CA, 2016).

Santa Clara Valley Water District, "Groundwater Management Plan 2016" (government policy, San Jose, CA, 2016)

Stagge, James; Davis, Allen; Jamil, Eliea; Kim, Hunho. "Performance of grass swales for improving water quality from highway runoff." *Water Research.* 46, (2012): 6731-6742.

State Water Resources Control Board. "National Pollutant Discharge Elimination System (NPDES) – Wastewater." https://www.waterboards.ca.gov/water_issues/programs/npdes/. December 2, 2018.

State Water Resources Control Board. "Groundwater Management Program," https://www.waterboards.ca.gov/water_issues/programs/gmp/. December 2, 2018.

Suripin, Raith Pujiastuti, Widjonarko, "The initial step for developing sustainable urban drainage systems in Semarang city-Indonesia." Procedia Engineering 171 (2017): 1486-1494

Tedoldi, Damien; Chebbo, Ghassan; Pierlot, Daniel; Kovacs, Yves; Gromaire, Marie-Christine. "Impact of runoff infiltration on contaminant accumulation and transport in the soil/ filter media of Sustainable Urban Drainage Systems: A literature review." *Science of the Total Environment 569-57* (2016), 904-926.

United States Census Bureau. "2012 American Community Survey," https://www.sanjose.org/meetings/quick-guides/san-jose-demographics-and-diversity

United States Census Bureau. "American Fact Finder – Results," United States Census Bureau, May 2017, accessed December 2, 2018, https://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?src=CF.

United States Census Bureau. "QuickFacts: San Jose City, California; UNITED STATES." *Census Bureau QuickFacts*, United States Census Bureau, 2019, www.census.gov/quickfacts/fact/table/sanjosecitycalifornia,US/PST045217

United States Environmental Protection Agency. "Clean Water State Revolving Fund Green Project Reserve, Case Study: El Cerrito Green Street Project Integrating Green Infrastructure with Community Needs," (government report, Washington, DC, 2018).

United States Environmental Protection Agency, "Cleanups in My Community Map," https://ofmpub.epa.gov/apex/cimc/f?p=CIMC:MAP:0:::71:P71_WELSEARCH:NULL|Cleanup||||false|false|true|false|false|false|||sites|Y, December 4, 2018.

United State Environmental Protection Agency. "Groundwater Contamination Cleanups at South Bay Superfund Sites, Progress Report" (government report, Washington, D.C. 1989).

United States Environmental Protection Agency. "Water Quality Assessment and TMDL Information" www.epa.gov, December 2, 2018. https://ofmpub.epa.gov/waters10/attains_index.home.

United States Environmental Protection Agency, "What is Green Infrastructure" www.epa.gov, April 22, 2018, https://www.epa.gov/green-infrastructure/what-green-infrastructure.

United States Environmental Protection Agency, "What is Superfund?," https://www.epa.gov/superfund/what-superfund December 4, 2018.

United States Global Change Research Program, "Climate Change in the United States," (United States National Climate Assessment, Washington, D.C., 2014).

Walters, David, and Linda Brown. Design First: Design-based Planning for Communities. Oxford: Architectural, 2004.

Wikipedia, "List of largest California cities by land area," Wikipedia, 2012, accessed December 2, 2018, https://en.wikipedia.org/wiki/List_of_largest_California_cities_by_land_area .

Yin, Lihe; Zhoug, Yangxiao; Huang, Jinting; Wenninger, Jochen; Zhang, Eryong ; Hou, Guangcai; Dong, Jiaqiu. "Interaction between groundwater and trees in an arid site: Potential impacts of climate variation and groundwater abstraction on trees." *Journal of Hydrology 528* (2015), 435-448.

Zhang, Shuhan; Meng, Yingying; Pan, Jiao; Chen, Jiangang. "Pollutant reduction effectiveness of low-impact development drainage system in a campus." Frontiers of Environmental Science and Engineering. 11, (2017).

Zhang, Zhiqiang; Li, Min; Si, Bingcheng; Feng, Hao. "Deep rooted apple trees decrease groundwater recharge in the highland regions of the Loess Plateau, China." *Science of the Total Environment 622-623* (2018): 584-593.