Bioswale Landscape Resilience in San Mateo County, CA

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ABSTRACT

Vegetation is one of the key landscape components that allows a bioswale to function at full capacity. Bioswales are low investment and low maintenance element used to control flooding and treat water quality in urban areas. Through field research and semi-instructed interviews, I addressed vegetation choice by planners. I quantified changes in the landscape over a 3 to 5 year time period and associated declines with maintenance approaches. Species richness and evenness of vegetated bioswales San Mateo County uncovered a decline in vegetation over time. Interviews with managers reflected perceptions that bioswales support drought tolerant and native plant species, both deciduous and evergreen. On multiple accounts, city planners attributed poor maintenance habits to lack of monetary resources and public knowledge of bioswales. Without proper maintenance, vegetation likely did not establish properly. Revegetation, a practice taken on by cities, occurs when bioswales are incapable of functioning at maximum capacity due to lack of adequate vegetation. Revegetating bioswales defeats the purpose of being a low-investment solution as it costs more than maintenance. To establish and maintain healthy bioswales, the public needs to become aware of how a bioswale functions and the care it requires to be successful. Establishing guidelines and protocols on how to care for bioswales specific to San Mateo County will increase the prosperity and benefits that a bioswale can provide. City planners must incorporate their landscape workers and city residence in a movement to care for landscape elements that provide many benefits to the environment and the people that surround them.

KEYWORDS

bioswale, bioretention system, vegetation, urban landscape element, vegetation maintenance

INTRODUCTION

Stormwater can be very dangerous to the infrastructure of a city, as well as unsanitary. Most sewage systems are limited in the amount of water they can transfer and often sewage systems can become backed up and flood streets. The water damages property, is unsanitary, and is dangerous to animals and humans (Brown and Peake 2006). Heavy rains wash chemical contaminates from motor vehicle emissions, oil, tire wear, corroding roofing material and asphalt road surfaces into sewage systems and waterways (Brown and Peake 2006).

Metals are of the greatest concern among the chemical contaminates, their prevalence and persistence and their ability to change pH and anaerobic and aerobic conditions while in stormwater systems are why they are a major concern (Makepeace et al. 1995). Heavy metals enter our waterways via domestic fire emissions, deliberate dumping of waste, pesticide usage, and specific point sources such as construction zones and workshops (Brown and Peake 2005). Copper, zinc, lead, cadmium, nickel, arsenic and beryllium are the heavy metals that have the largest impact on an urban environment. Heavy metal ions are typically toxic to aquatic life (Makepeace, 2009), and can contaminate drinking water.

Landscape elements such as a bioswales can be used as a stormwater management approach as a means to reduce flooding potential and to treat water quality (Scharenbroch et al. 2016). Bioswales are often used in parking lots, residential roadsides and as landscape buffers (University of Florida 2008). They increase the function of a conveyance system to move stormwater away from critical infrastructure by holding it for infiltration, while simultaneously removing pollutants from the stormwater runoff. A bioswale uses a gradual slope to mimic waterways, allowing for the soil to absorb the excess water at a rate that will prevent the water from stagnating (Scharenbroch et al. 2016). The top layer of the soil in the bioswale absorbs the water, which then seeps down to the roots of the plants. Many pollutants are filtered out through plant roots. Bioswales act as a filter before stormwater has the chance to enter sewage systems and waterways. They are intended to remove heavy metal, soaps and other contaminates from stormwater, as well as prevents trash and other solids from entering bioswales.

Vegetation helps increase the amount of water being filtered through the bioswale, while simultaneously increasing the amount of pollutants they remove from stormwater. Greater plant diversity allows for a greater resource uptake and a lowered nutrient loss for the bioswale (Hooper and Vitousek 1997). The dense, low growing plants are the best at removing solid particles above ground via sedimentation (Nevue Ngan Associates and Sherwood Design Engineers 2009). Below ground, their root system helps stabilize the deposits while preventing sediment from suspension. Trees are also known to provide extended benefits due to their canopies and root systems. They help increase infiltration rates by intercepting water through their leafs while also creating more space in the soil with their root systems (Bartens et al. 2008).

Establishing a healthy and functioning bioswale can have many positive effects in the urban environment. Bioswales help improve urban air quality while simultaneously reduce the effects of an urban heat island (Xiao and McPherson 2011). They are also capable of reducing minerals, metals, organic carbons and solids that come from water runoff (Xiao and McPherson 2011). Vegetation also takes up the readily available Nitrogen and Phosphorus from the storm water, reducing its capacity to create eutrophication in urban waterways (Read et al. 2008). Scharenbroch et. al emphasize how important vegetation is for a bioswale to function at its maximum capacity, and like most other studies, fail to provide information on how the vegetation is selected. Determining how vegetation is chosen and how maintenance influences vegetation health can help improve the planning of future bioswales.

In order to address how successful bioswales are as a landscape element for vegetation resilience, I asked the following questions. 1) How is vegetation selected? 2) How has vegetation changed over time? and 3) How does maintenance play a role in vegetation health? Addressing these questions will have the ability to provide meaningful and helpful guidance on how to improve the future health of bioswales. This information is essential for cities to have functioning green space alternatives to control flooding and treat water quality

METHODS

Study Site

San Mateo County

San Mateo County is on the San Francisco Bay Area peninsula in Northern California. It comprises sixteen cities and four towns, from Daly City to Portola Valley. The majority of the residential county is characterized by urban and suburban landscaping. The county consists of 744 square miles with an estimated population of 764,797 people (United States Census Bureau 2016). San Mateo County experiences a Mediterranean climate with warm, dry summers and cool, wet winters.

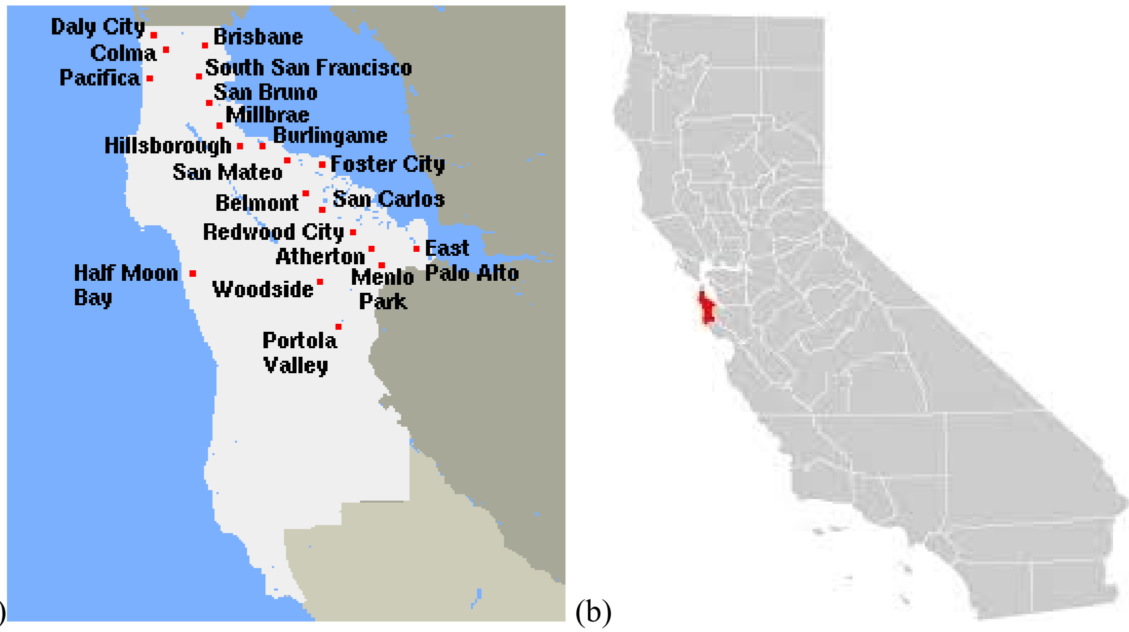
(a)  (b)

Figure 1: Study Area. (a) Map of city locations within San Mateo County; (b) Map of San Mateo County relative to California.

Old County Road Bioswale

Old County Road, located in San Carlos, runs parallel with the CalTrans railway. The Old County Road Bioswales (Figure 2) are a series of curb extensions that run from Quarry Road to Commercial Street. My study focuses on the curbside extension located on the corner of Old County Road and Cherry Street.

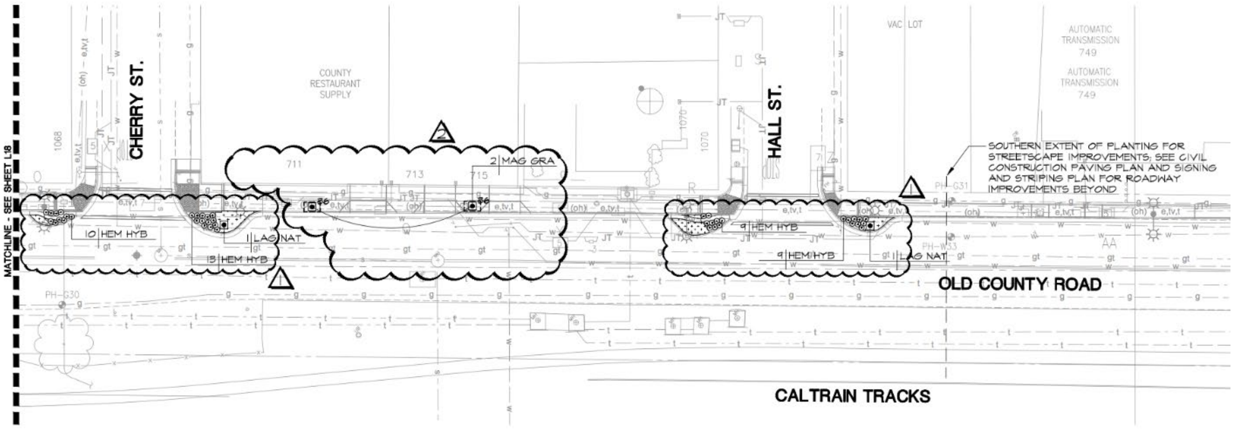


Figure 2. Layout of Old County Road (Cherry Street crossection) bioswale.

Bransten Road Bioswale

Bransten Road, located in San Carlos, is perpendicular between two main roads, Old County Road and Industrial. It is located in the industrial part of the city. The Bransten Street Bioswales (Figure 3) are a series of nine curbside extension bioswales. Three of the curbside extensions are located on the northwest side and six are located on the southwest side. My study focuses on the Bioretention Areas 8 and 9 located on the southeast side.

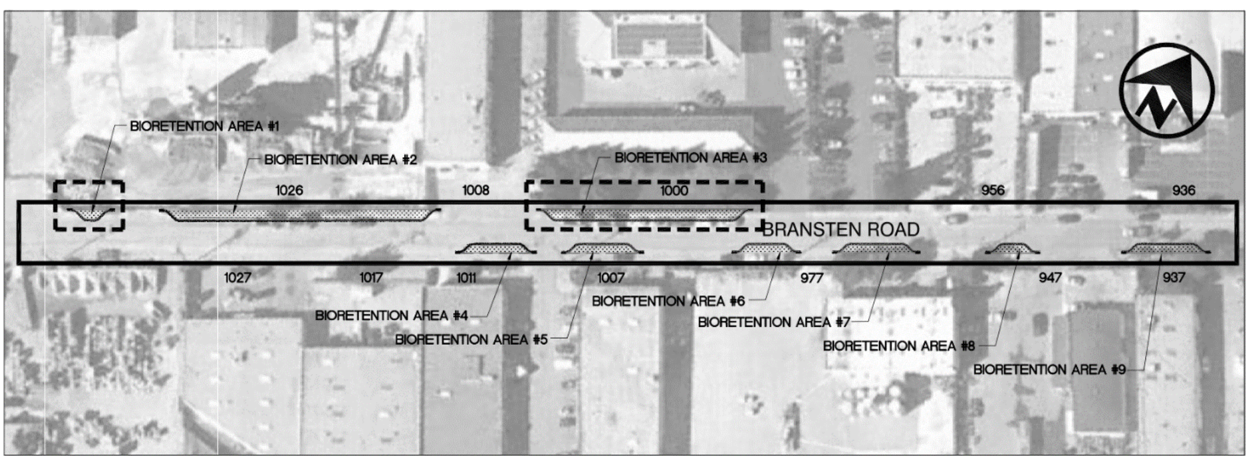


Figure 3. Layout of Bransten Road bioswales.

Donnelly Ave Bioswale

Donnelly Avenue, located in Burlingame, consists of both a curb side extension and an addition to a parking lot. The Donnelly Ave Bioswale (Figure 4) is located across the street from a parking garage and behind a main shopping strip. It consists of one curb side extension, and its parking lot addition is separated into three different section.

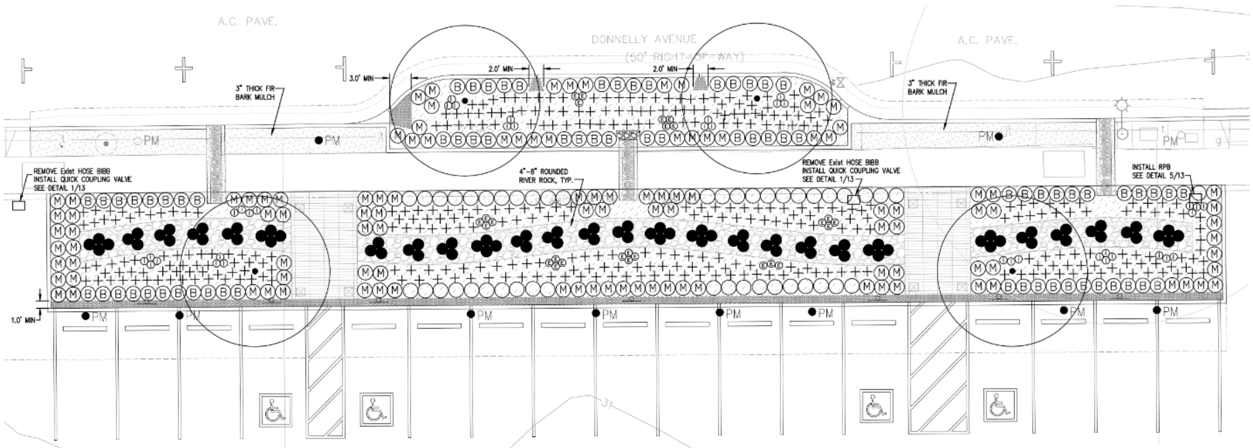


Figure 4. Layout of Donnelly Avenue bioswale curbside extension and parking lot addition.

Data Collection

To understand how vegetation was chosen by designers and managers and how maintenance influences vegetation health, I conducted a series of semi-structured interviews with city planners throughout San Mateo county. The interviews were conducted via email or over the phone, depending on the preference of the Interviewee. Each interviewee answered nine questions (Table 1). Those that were interviewed over the phone were asked follow up questions based on their answers or experience. Occasionally, individuals who responded via email would provide more explanation or background on their personal experience working with bioswales and other green spaces. Each over the phone interview lasted on average 30 minutes, and each email response was answered within a week of sending out the questions.

To record the change in bioswale vegetation over time, I also measured and calculated species richness and species evenness. Richness and evenness were calculated to compare the bioswales current condition to their original condition when they were first installed. Depending on the bioswale, the time comparisons range from three to five years. I identified, counted and measured all vegetation types within the bioswales in their current conditions. To quantify change since the bioswale was constructed, I counted and identified vegetation types through past photographs and original landscape plans.

Table 1. Corresponding interview question chosen to explore each topic of interest

Focal Topic Area	Corresponding Interview Questions
Vegetation Characteristics	• What factors influence your decision-making process when choosing vegetation for the bioswales?
Vegetation Change	• Does the vegetation planted differ from what was originally chosen?
	• If yes, how was the replacement vegetation chosen?
	• What are some of the reasons for the vegetation change?
Planning	• How long does it typically take to plan a bioswale? What are some of the steps?
	• Do people collaborate with each other during planning, or is it typically one individual? Are the choices made reviewed or looked over by other peers?
Maintenance	• How is vegetation cost and maintenance taken into account?
	• What does the maintenance entail, if there is any? And who is responsible for physically maintaining them?
	• What happens if any vegetation dies?

RESULTS

Species richness declined very little across all bioswales. Richness decreased the most in the Bransten Road #8 bioswale from eight plant species to six, decreasing very slightly in Donnelly Avenue and Bransten Road #9 from eight plant species to seven. Richness did not change overtime in the Old County Road bioswale, staying at four plant species (Figure 5). The number of each plant species, indicated in "count" graphs decreased in certain species over time. Old County Road had fewer *Hemerocallis* mixture, reduced from twenty-three to twelve (Figure 6), Bransten Road #8 decreased in *Cistus* from one to zero*, Carex Tumulicola* from nine to five and *Deschampsia cespitosa* from eleven to zero (Figure 8). Bransten Road #9 decreased in *Arctostaphylos densiflora* from three to one*, Carex tumulicola* from nineteen to fifteen*, Deschampsia cespitosa* from twenty-five to zero and *Jucas patens* from twenty-one to nineteen (Figure 10). Donnelly Avenue decreased in all vegetative species (Figure 12). *Quercus lobata* decreased from four to two, *Carex tumulicola* decreased from three-hundred and forty-eight to ninety-one, JuncusPatens decreased from eighty-nine to twenty-nine, *Ceanothus griseus* decreased from seventy to seventeen, *Ceanothus cunneatus* *prostrate* decreased from forty-one to nine, *Berberis repens* decreased from one hundred sixteen to thirty-two, *Iris douglasiana* decresed from thirty-seven to zero and *Eriogonum grande v. rubescens* decreased from twenty-six to fourteen. Evenness generally increased in every bioswale for every plant species with the exception of plant species not existing in current conditions (Figure 7, 9, 11 and 13).

Manager Interview Responses

Table 2 summarizes key findings for each interview question. Vegetation chosen is often native, drought tolerant, and capable of being inundated. Vegetation planted often does not deviate from original plans, but if deviation occurs, no more than two plant species are different. There is a ready-made list of native and drought tolerant plant species that both city managers and landscape architects chose from. One restricting factor to this list, however, is plant availability. During certain times of the year, typically the winter, some plants are not readily available. If this occurs, the person in charge of vegetation either choses another plant from the list or increases the amount of an already chosen plant species. Vegetation change can occur due to weather conditions, bioswale size differing from original plans and plants dying.

Bioswales can take up to 3 to 6 months to plan, depending on the quantity of city workers collaborating or if a landscape architect is doing the planning. Cost is all inclusive in the budget, and as bioswales are meant to be a low maintenance solution, city planners do not expect great amounts of money to be need for upkeep after installation. Bioswales are low maintenance systems, requiring basic irrigation fix, litter removal, pest damage control, and vegetation replacement. Landscape architect are responsible for vegetation health during their contracting period, which then falls to city workers once it ends.

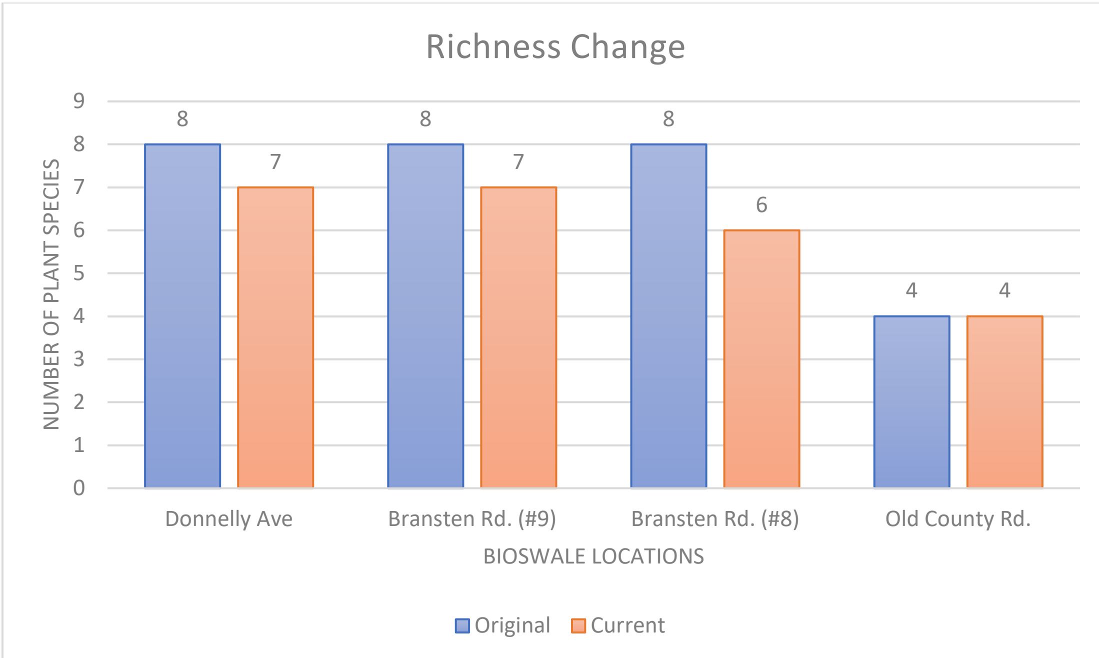


Figure 5. Vegetation Richness. Richness change between the original and current states of each bioswales.

Old County Road

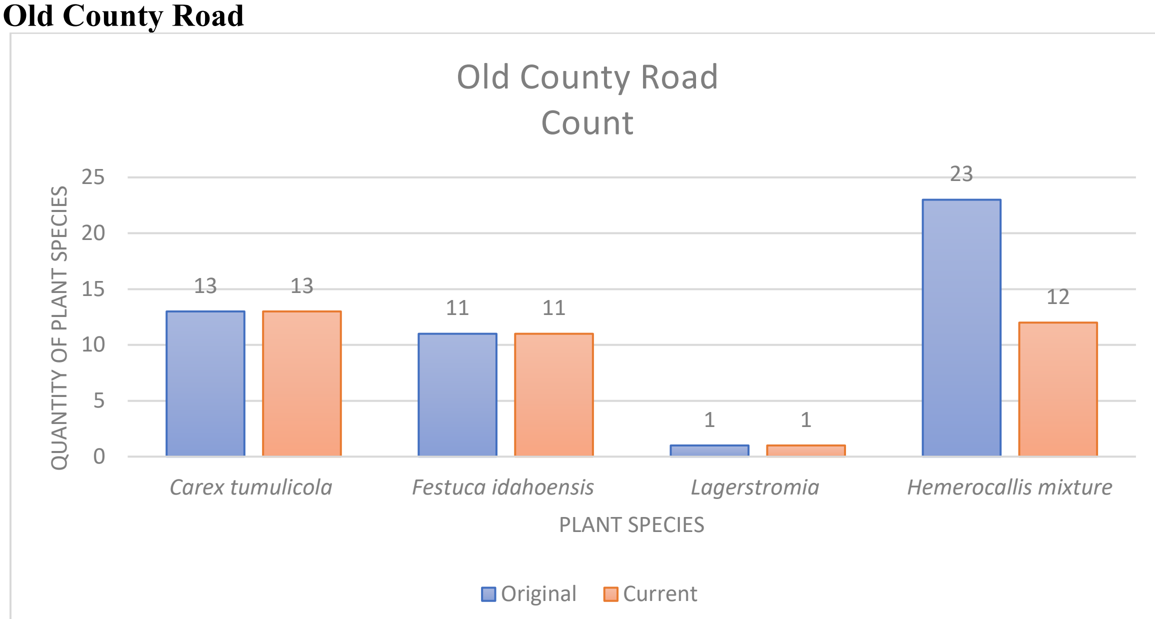


Figure 6. Vegetation Count. Quantity of each plant species between its original and current state of Old County Road bioswales.

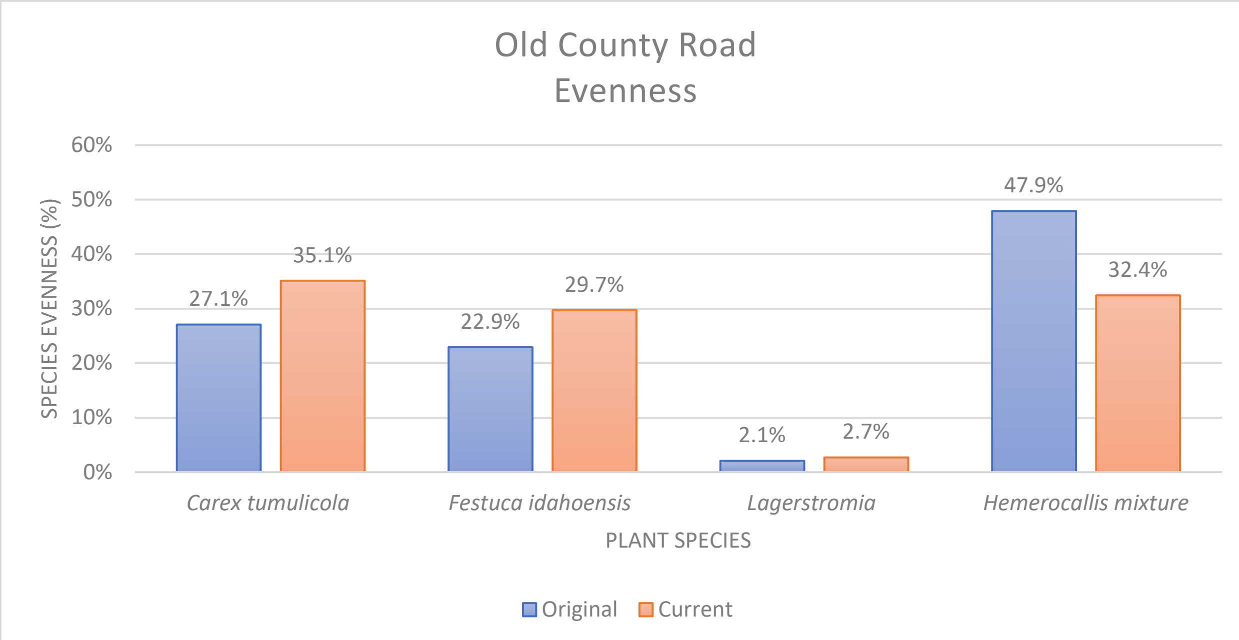


Figure 7. Evenness Change. Evenness change, in percentage, between its original and current state of Old County Road.

Bransten Street Bioswale #8

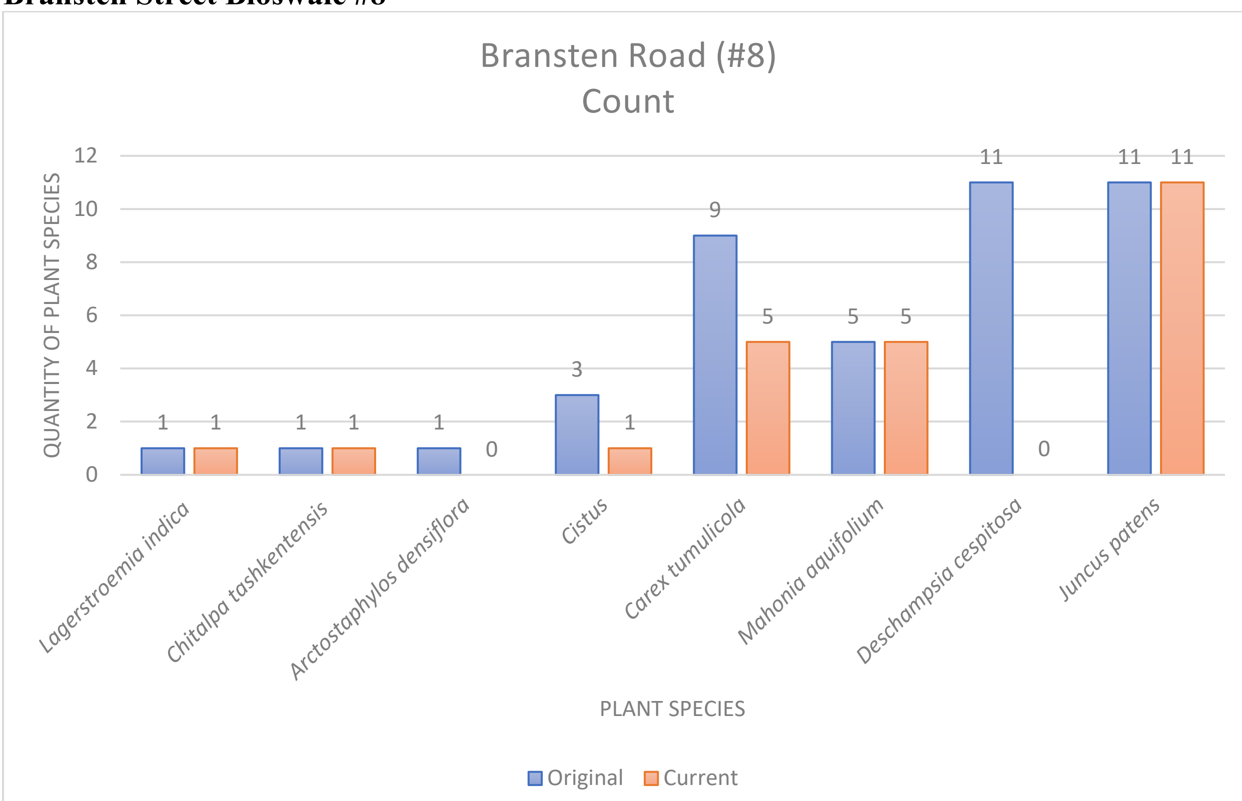


Figure 8. Vegetation Count. Quantity of each plant species between its original and current state of Bransten Road #8 bioswale.

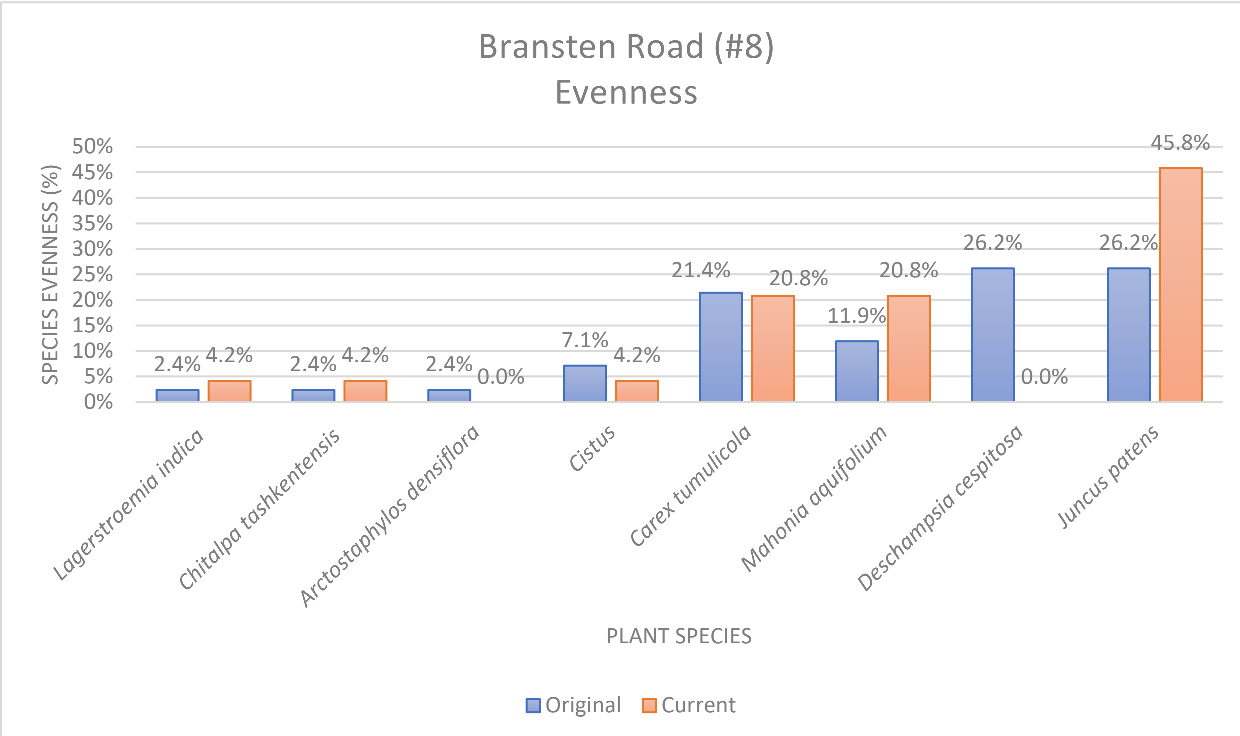


Figure 9. Evenness Change. Evenness change, in percentage, between its original and current state of Bransten Street #8.

Bransten Street Bioswale #9

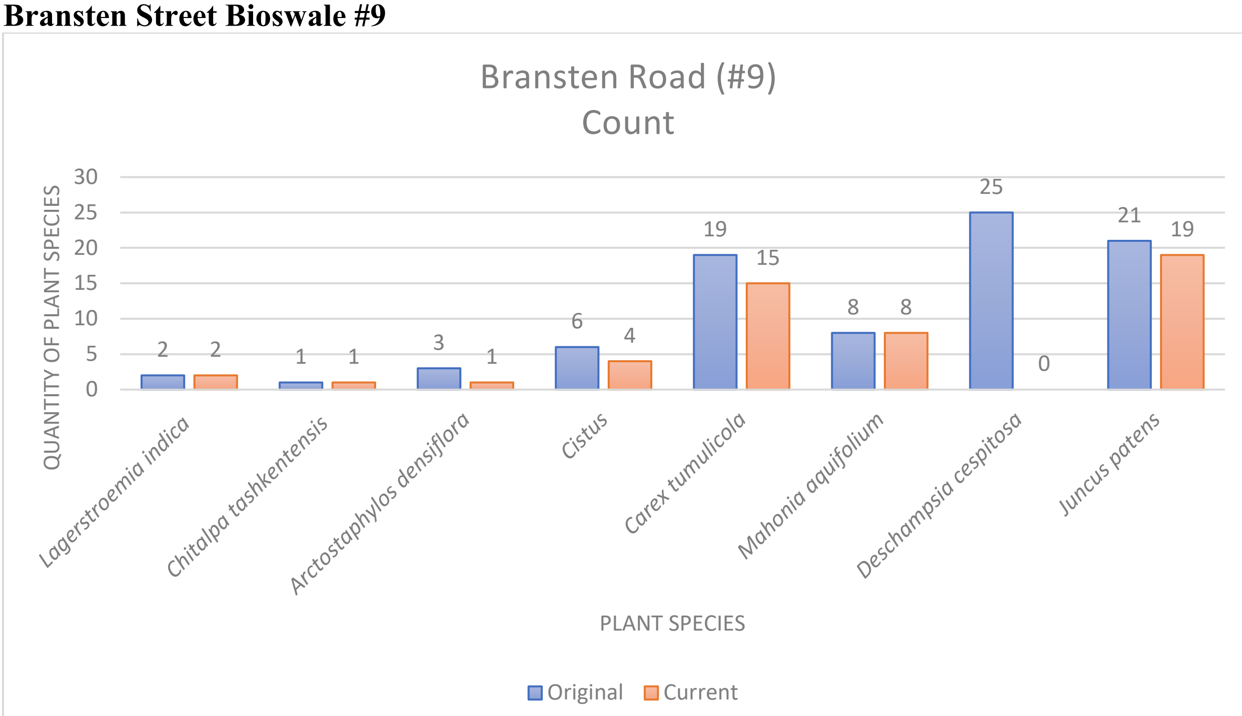


Figure 10. Vegetation Count. Quantity of each plant species between its original and current state of Bransten Road #9 bioswale.

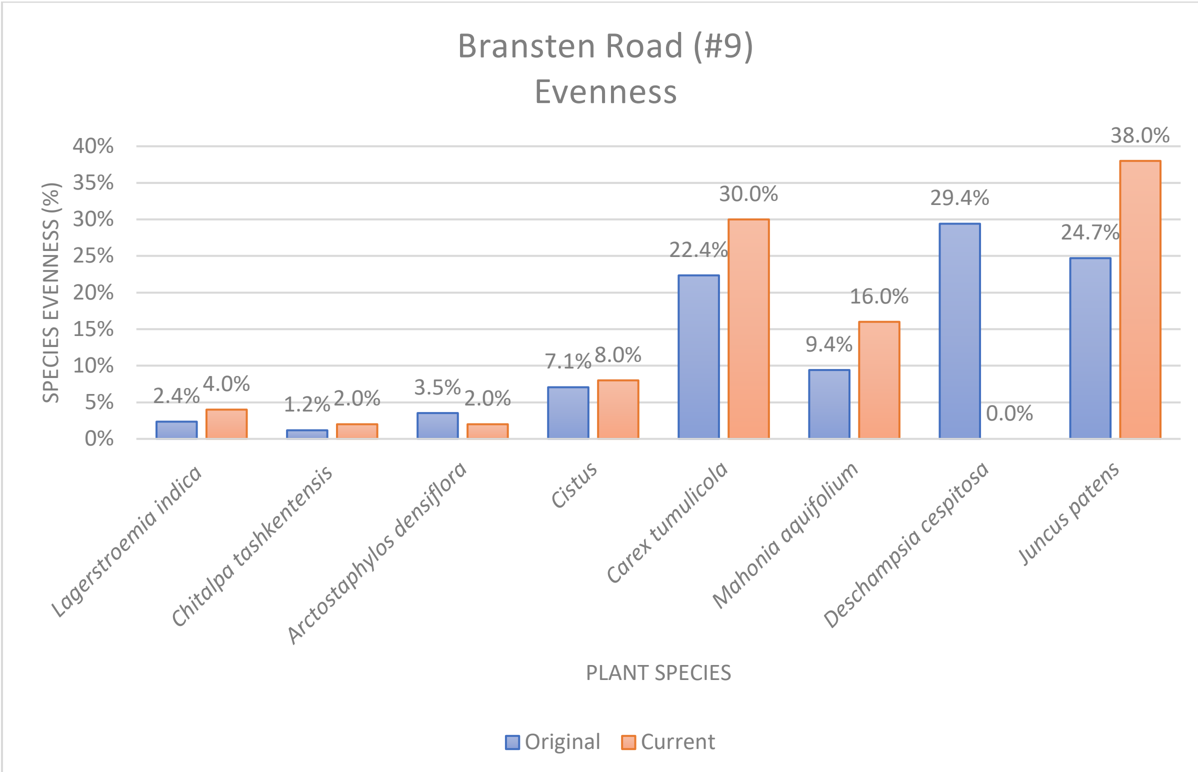


Figure 11. Evenness Change. Evenness change, in percentage, between its original and current state of Bransten Street #9.

Donnelly Avenue

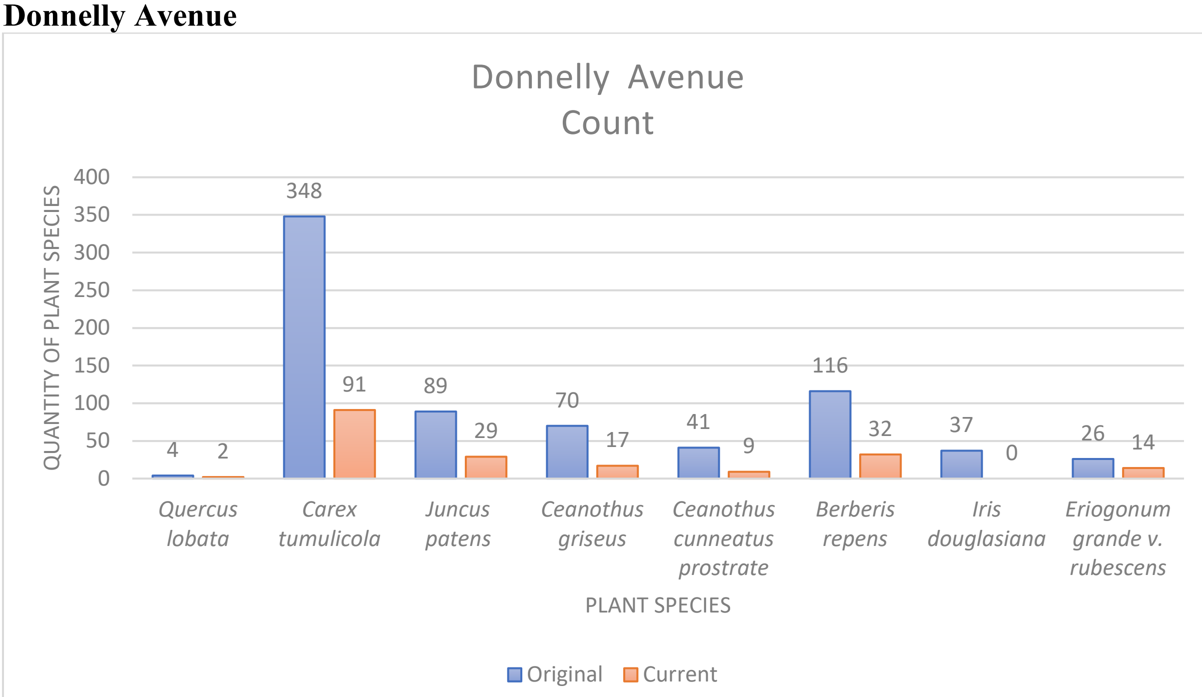


Figure 12. Vegetation Count. Quantity of each plant species between its original and current state of Donnelly Avenue bioswale.

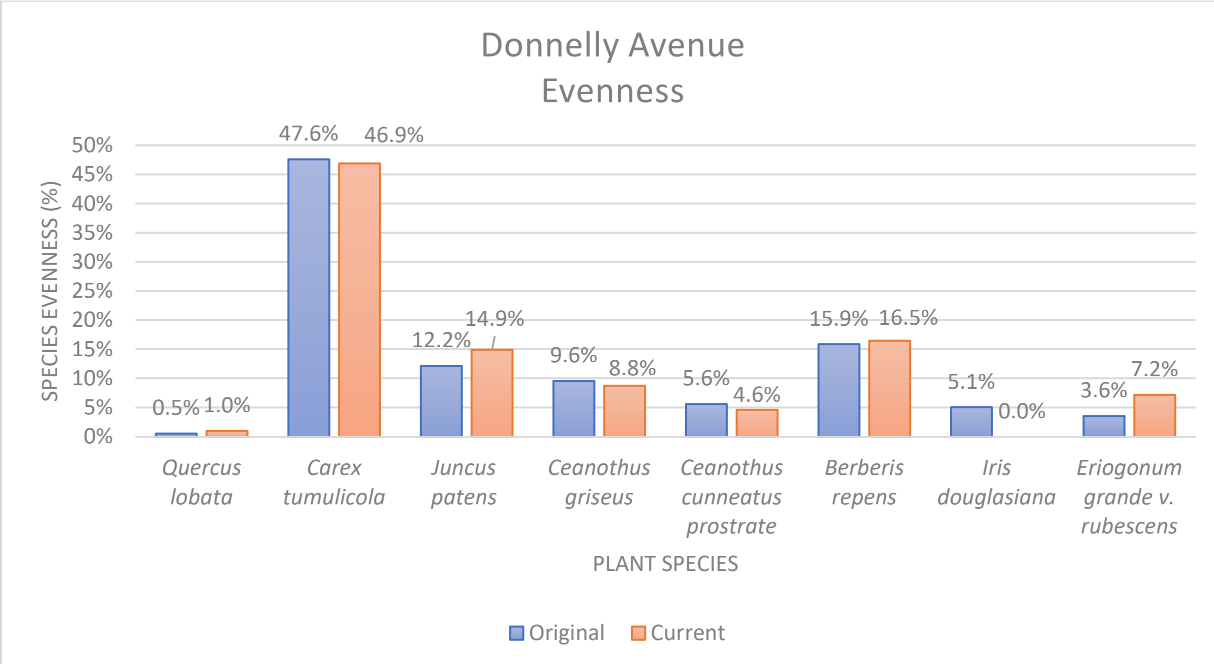


Figure 13. Evenness Change. Evenness change, in percentage, between its original and current state of Donnelly Avenue.

Table 2. Interview Question Responses

Corresponding Interview Questions	Responses
• What factors influence your decision-making process when choosing vegetation for the bioswales?	Native Species Drought Tolerant Capable of being inundated Location within bioswale Size of bioswale
• Does the vegetation planted differ from what was originally chosen?	Typically does not, but if vegetation change occurs, only a few plant species differ from original plans.
• If yes, how was the replacement vegetation chosen?	Look at a ready-made list and find a species that has similar characteristics and readily available
• What are some of the reasons for the vegetation change?	Time of year effects availability of plants Bioswale size differs from original plans Plants die Retention system becomes revegetated
• How long does it typically take to plan a bioswale? What are some of the steps?	Dependent on if city staff creates the plans or a landscape architect, 3-6 months to create plans

• Do people collaborate with each other during planning, or is it typically one individual? Are the choices made reviewed or looked over by other peers?	Dependent on city and size of the bioswale. If the swale is small, then it can often be created by one or two persons. If it's bigger in size, collaboration with a landscape architect and engineer typically occur.
• How is vegetation cost and maintenance taken into account?	Cost is included within the original budget, nothing set specifically aside for after installation. They're a low maintenance landscape, city does not expect to need great amounts of money for upkeep.
• What does the maintenance entail, if there is any? And who is responsible for physically maintaining them?	Requires low maintenance, irrigation fix, litter removal, pest damage control, replacing vegetation. Landscape Architects are responsible for vegetation health during the contract period, city workers are then responsible for the upkeep of them
• What happens if any vegetation dies?	Landscape Architects are responsible for vegetation health during the contract period. City workers are then responsible for the upkeep of bioswales.

DISCUSSION

Through field research I was able to establish a decreasing pattern in richness and evenness in bioswale vegetation. Through semi-conducted interviews, I was able to connect the cause of these patterns to the current maintenance conditions and protocols taken on by the cities of San Mateo County. The information and knowledge accumulated by these semi-conducted interviews could bridge gaps and create new opportunities for maintenance protocols of bioretention systems. Improving maintenance protocol and up keeping healthy vegetation is key to clean storm water and reduced flooding.

Vegetation Decline

In each bioswale, there has been an overall decrease in vegetation richness and evenness. A decline in vegetation richness could be accounted for by plants not being readily available during the installation time period. In both Bransten Street bioswales (#8 and #9), *Deschampsia cespitosa* had a count of zero, indicating that it was most likely not available at time of construction. Given that there was no increase in quantity of any other plant species, no substitutions were made. No substitutions could be accounted for by the bioswale being smaller in size than what the plans originally called for. Through interviews, I found that this is a common occurrence among curb side extensions. In the Donnelly Avenue bioswale, *Celtis reticulata* was not available at time of construction and *Quercus lobata* was chosen as replacement. The original plans indicated four

Celtis reticulata to be planted, but only two *Quercus lobata* were used. While the reasoning behind this remains unclear, it could be due to lack of availability, increase in cost or overall size reduction. Throughout all bioswales *Carex tumulicola* was one plant species that decreased in quantity consistently, indicated in the photographs. During the period of establishment they require vast amounts of water to develop themselves. Lack of available water and competition with other pants can explain their common decline. This can be connected to low maintenance efforts put on by the city or landscape architects. Quantity and diversity are ideal to maximize the functional capacity of a bioswale. Plants are responsible for many different functions in a bioswale, including slowing horizontal flows, maximizing vertical infiltration, preventing erosion, and filtering metals and toxins out of water (Levin and Mehring, 2015). Through the complementarity hypothesis, different species of plants carry out different functions, and when performed together create a holistically functioning bioswale (Levin and Mehring, 2015). There have also been studies that show water quality improvement and productivity can be attributed to biodiversity within an ecosystem (Cardinale, 2011).

Vegetation Characteristics

Vegetation chosen for these bioswales are native species, drought tolerant, and tolerant of being inundated after storms. They include a mixture of evergreen and deciduous species for aesthetic purposes (Nevue Ngan Associates and Sherwood Design Engineers 2009). The style of bioswale also influences the type of plants that are chosen. Flat-bottom bioswales need plants that are capable of being inundated, as that is where the majority of storm water pools before infiltration. The sloped slides in a bioswale often include shrubs, groundcover, and perennials (Nevue Ngan Associates and Sherwood Design Engineers 2009). This coincides with the vegetation layout designs of the Bransten Road, Old County Road and Donnelly Ave bioswales. Common plant species that I have come across include *Carex tumulicola* and *Juncas patens* which are often placed in portions of the bioswales that are more likely to become inundated. Species such as *Berberis repens* and *Cistus* are located on sloped sides, or away from inundation spots and typically chosen for aesthetic benefits.

Vegetation Change

Even after the vegetation landscape is planned, there are still multiple hurdles that planners and landscape architects come across during the installation process. Interviewees expressed that some plant species are not readily available during certain parts of the year, causing the need to find replacement vegetation. Landscape architects often choose a species with similar function from a group of species that are readily available. Other times, they decide to plant a greater quantity of a species that they already have chosen for that retention system. Another common occurrence that can cause vegetation change is the bioswales size. It is not uncommon that many landscape architects find that the size of the bioswale is smaller in area than what was originally predicted. This, intern, causes a lesser quantity of plants to be planted. While there are many factors that can cause vegetation change during the instillation phase, maintenance has also presented itself to be a great contributor to the decline in vegetation.

Vegetation Maintenance

One of the main reasons bioretention systems have become a popular solution for flood reduction and water quality treatment is the minimal amount of maintenance and upkeep they require. However, interviewees indicated that while they require minimal attention, the first two years are the most important in establishing the vegetation. Maintenance includes adequate watering and fertilizer, rodent and pest damage treatment, litter removal and replacing vegetation. As a result California's cycles of drought, many bioswales built in the past five to eight years have included an irrigation system to ensure that vegetation and trees have an adequate amount of water to establish. Ideally, after the first two years, vegetation should be established enough and capable of surviving without the help of an irrigation system. Lack of maintenance and reduction of species richness can reduce the bioswales functional capacity (Hooper and Vitousek 1997). Vegetation has two main functions: maximizing the water holding capacity of the overall Bioretention system and removing pollutants and toxins from the storm water (Scharenbroch et al. 2016). The addition of weeds and other invasive plant species reduces the amount of nutrients native species can uptake. In turn, this causes a decrease in the quantity and size of native species (McPhearson et al. 2013) Overgrown vegetation can also become a safety hazard to both drivers and pedestrians. It can cause visual obstruction while driving in addition to obscuring the depth of a bioswale, leaving citizens vulnerable to injuries or accidents (Everett et al. 2015). Vegetation plays the primary role in removing pollutants and toxins from storm water, thus it very important for the function of the bioswale to keep the vegetation alive.

Public Knowledge

While there is a lack of monetary resources to fund maintenance, there is also a lack of resources in regards to individuals with adequate knowledge of what a bioswale is and how it functions. This leads to only a small pool of people capable of maintaining them. For example, in Portland, Oregon, residential respondents indicated that while they have noticed bioswales around their neighborhoods, they were not aware of their purpose in addition to other benefits they can provide (Everett et al. 2015). This lack of understanding is similar to those responsible for up-keeping public landscapes within San Mateo County. When weeds and other invasive species establish themselves in bioretention systems, there is confusion of what plant species actually belong in the bioswale and which do not. If a landscape architect is involved with the planning and installation of bioswales, they city has a contract that indicates a time period in which the landscape architect is held responsible for the survival of all vegetation. On average, managers stated a contract ranges from six to nine months, in which replacement vegetation is paid for and replanted by the architect. Once the city is held responsible for vegetation survival, it is less likely vegetation will be successfully replaced.

A great way to increase the amount of qualified persona to help maintain bioswales is educating the public and city workers. Ways in which communities and counties can educate their residents on bioretention systems starts with the identification of bioswales and conveying their function and purpose in a colloquial language (Shandas et al. 2010). Technical descriptions can lead residence to feel overwhelmed and to lose interest. Providing how-to guides or in-person instructions on care and maintenance can lead to an increase in human interaction and better care for bioswales (Tzoulas el al. 2007). This in turn can lead to a greater amount of bioswales being installed throughout more than just San Mateo County. Volunteer work days can be put together by cities to help implement green space maintenance. This reduces the stress of city workers while also working around budget constraints.

Challenges and Future Directions

Bioswales are designed to be a low investment and low maintenance method of storm water management (Wise et al. 2010). However, many bioswales end up being restored or revegetated when the original vegetation dies out, defeating the purpose of bioswales being used as a low investment solution. The Old County Road bioswale has already undergone revegetation once, and the Bransten Road bioswale series are scheduled to undergo revegetation within the next two years. One way to prevent revegetation from occurring would be to develop a detailed and understandable maintenance guide, not only for residents but for city workers. Seattle Public Works have developed a "Green Stormwater Operations and Maintenance Manual". The manual works by identifying the current conditions of a bioswale or green space, and providing a list of action or tasks that will lead to a healthier and better functioning bioswale (Seattle Public Utilites, 2009). Different characteristics that the maintenance manual identifies include vegetation, soil/substrate, filtration, retention, conveyance, sediment/debris accumulation, infrastructure, catch basins and debris screens. However, this manual tends to over simplify the maintenance actions due to their city workers having vast knowledge on green spaces. If San Mateo County were to develop a maintenance guide, they would need to incorporate more detailed information than Seattle Public Works. Including a list (and photos) of types of plants that belong and a list (and photos) of weeds that do not belong in a bioswale would be beneficial. Developing a protocol of how to remove and replace dead vegetation would counteract the decline in species richness and evenness. Instructions on vegetation pruning would eliminate possible injuries or accidents. Monitoring and aiding the growth of vegetation will ensure an increase in water quality and a decrease in flooding potential. In order for a manual to be created, more research needs to be done on what types of weeds establish themselves in a bioswale. Research on optimal conditions of vegetation, such as height, width and distance to same-species and different species would also be ideal.

CONCLUSION

The decline in vegetation within bioswales around San Mateo county results from a lack of resources after construction. Despite bioswales being a low maintenance landscape solutions to reduce flooding and water toxicity, only a few people have adequate knowledge and understanding to maintaining them. Lack of awareness can be easily solved by educating the public and city workers responsible for landscape maintenance. Developing a guide book that contains information and photographs of what vegetation belongs in a bioswale and a list of common invasive plant species that establish themselves will help minimize the confusion of what does and does not belong in a bioswale. Developing a standardized system on how to replace dead vegetation after the contract period with landscape architects are over will allow for the bioswale to function at its maximum capacity at all times. Encouraging city planners to require longer contracting periods with landscape architects would take pressure off of city resources during the vegetation establishing period. Putting together volunteer work days would also help educate the public, while also ensuring removal of invasive plant species and litter. Replacing vegetation would require city planners to prepare ahead of time and have replacement vegetation on hand during the volunteer worktime. Without vegetation, a bioswale is rendered useless, further proving that steps need to be taken to establish better maintenance tactics throughout San Mateo County.

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_APPENDIX

A. Original Donnelly Avenue Vegetation Landscape Plans

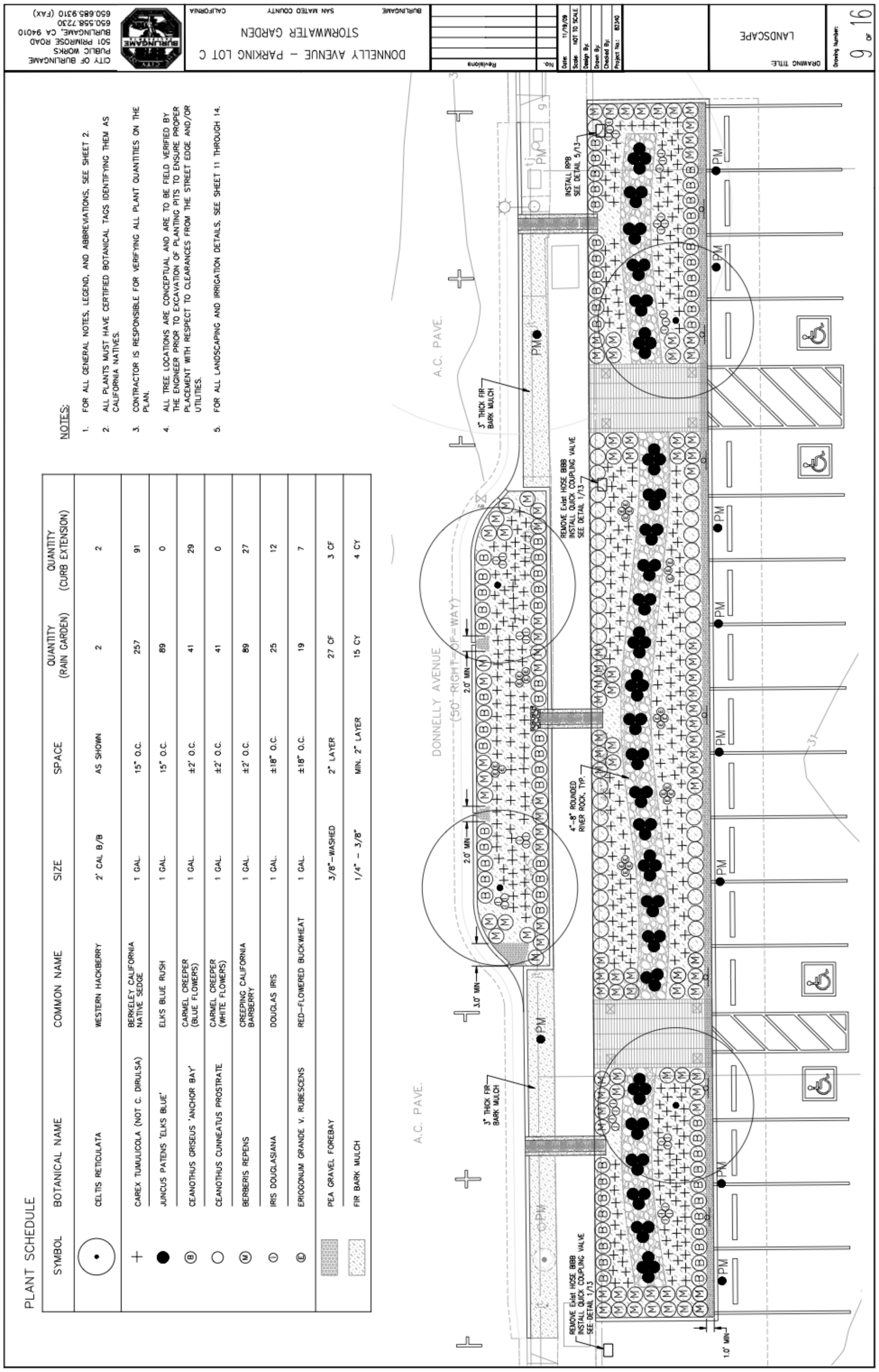
B. Original Bransten Road Vegetation Landscape Plans

C. Original Old County Road Vegetation Landscape Plans

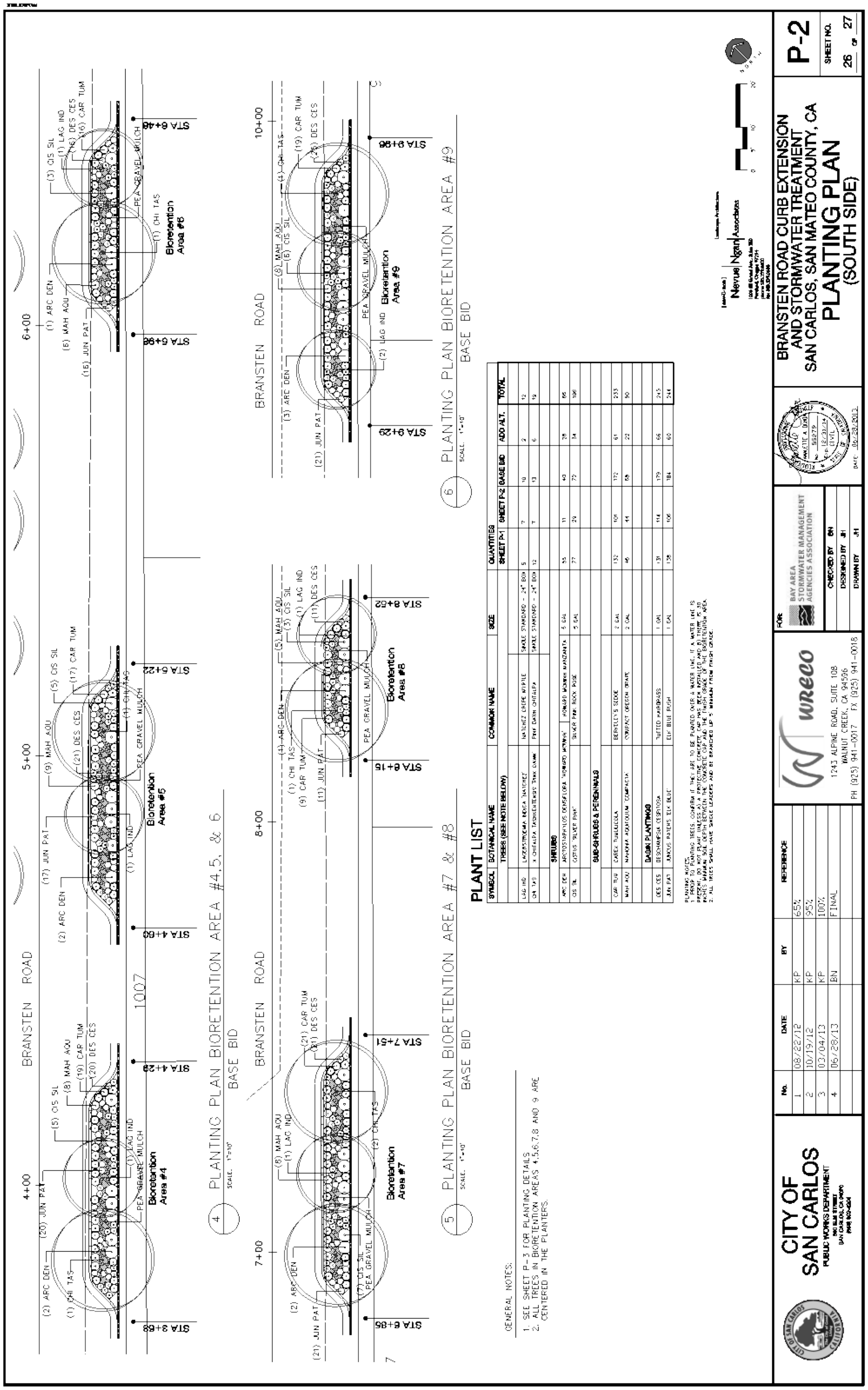
   a. Includes Vegetation Key

   b. Includes Cherry Street Cross Section

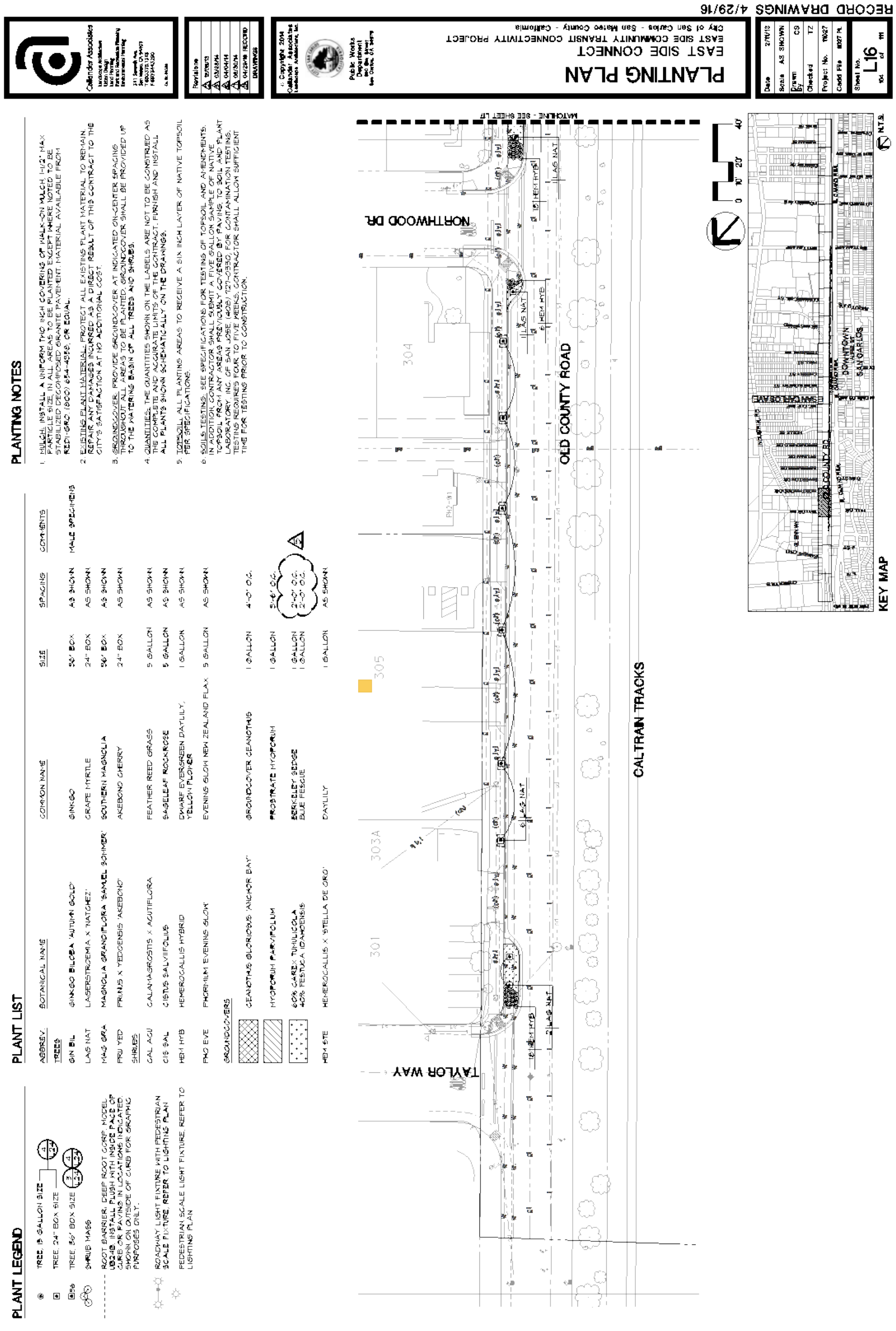
A.


CITY OF BURLINGAME
PUBLIC WORKS
501 PRIMROSE ROAD
BURLINGAME, CA 94010
650.558.7230
650.685.9310 (FAX)
DONNELLY AVENUE – PARKING LOT C
STORMWATER GARDEN
BURLINGAME SAN MATEO COUNTY CALIFORNIA
LANDSCAPE
9 of 16
PLANT SCHEDULE
SYMBOL BOTANICAL NAME COMMON NAME SIZE SPACE QUANTITY (RAIN GARDEN) QUANTITY (CURB EXTENSION)
CELTIS RETICULATA WESTERN HACKBERRY 2" CAL B/B AS SHOWN 2 2
CAREX TUMULICOLA (NOT C. DIVULSA) BERKELEY CALIFORNIA NATIVE SEDGE 1 GAL. 15" O.C. 257 91
JUNCUS PATENS 'ELKS BLUE' ELKS BLUE RUSH 1 GAL. 15" O.C. 89 0
CEANOTHUS GRISEUS 'ANCHOR BAY' CARMEL CREEPER (BLUE FLOWERS) 1 GAL. ±2' O.C. 41 29
CEANOTHUS CUNNEATUS PROSTRATE CARMEL CREEPER (WHITE FLOWERS) 1 GAL. ±2' O.C. 41 0
BERBERIS REPENS CREEPING CALIFORNIA BARBERRY 1 GAL. ±2' O.C. 89 27
IRIS DOUGLASIANA DOUGLAS IRIS 1 GAL. ±18" O.C. 25 12
ERIOGONUM GRANDE V. RUBESCENS RED-FLOWERED BUCKWHEAT 1 GAL. ±18" O.C. 19 7
PEA GRAVEL FOREBAY 3/8"-WASHED 2" LAYER 27 CF 3 CF
FIR BARK MULCH 1/4" - 3/8" MIN. 2" LAYER 15 CY 4 CY
NOTES:
1. FOR ALL GENERAL NOTES, LEGEND, AND ABBREVIATIONS, SEE SHEET 2.
2. ALL PLANTS MUST HAVE CERTIFIED BOTANICAL TAGS IDENTIFYING THEM AS CALIFORNIA NATIVES.
3. CONTRACTOR IS RESPONSIBLE FOR VERIFYING ALL PLANT QUANTITIES ON THE PLAN.
4. ALL TREE LOCATIONS ARE CONCEPTUAL AND ARE TO BE FIELD VERIFIED BY THE ENGINEER PRIOR TO EXCAVATION OF PLANTING PITS TO ENSURE PROPER PLACEMENT WITH RESPECT TO CLEARANCES FROM THE STREET EDGE AND/OR UTILITIES.
5. FOR ALL LANDSCAPING AND IRRIGATION DETAILS, SEE SHEET 11 THROUGH 14.
DONNELLY AVENUE
A.C. PAVE.
3" THICK FIR BARK MULCH
4"-8" ROUNDED RIVER ROCK, TYP.
REMOVE Exist HOSE BIBB INSTALL QUICK COUPLING VALVE SEE DETAIL 1/13
INSTALL RPB SEE DETAIL 5/13
2.0' MIN
3.0' MIN
1.0' MIN
PM

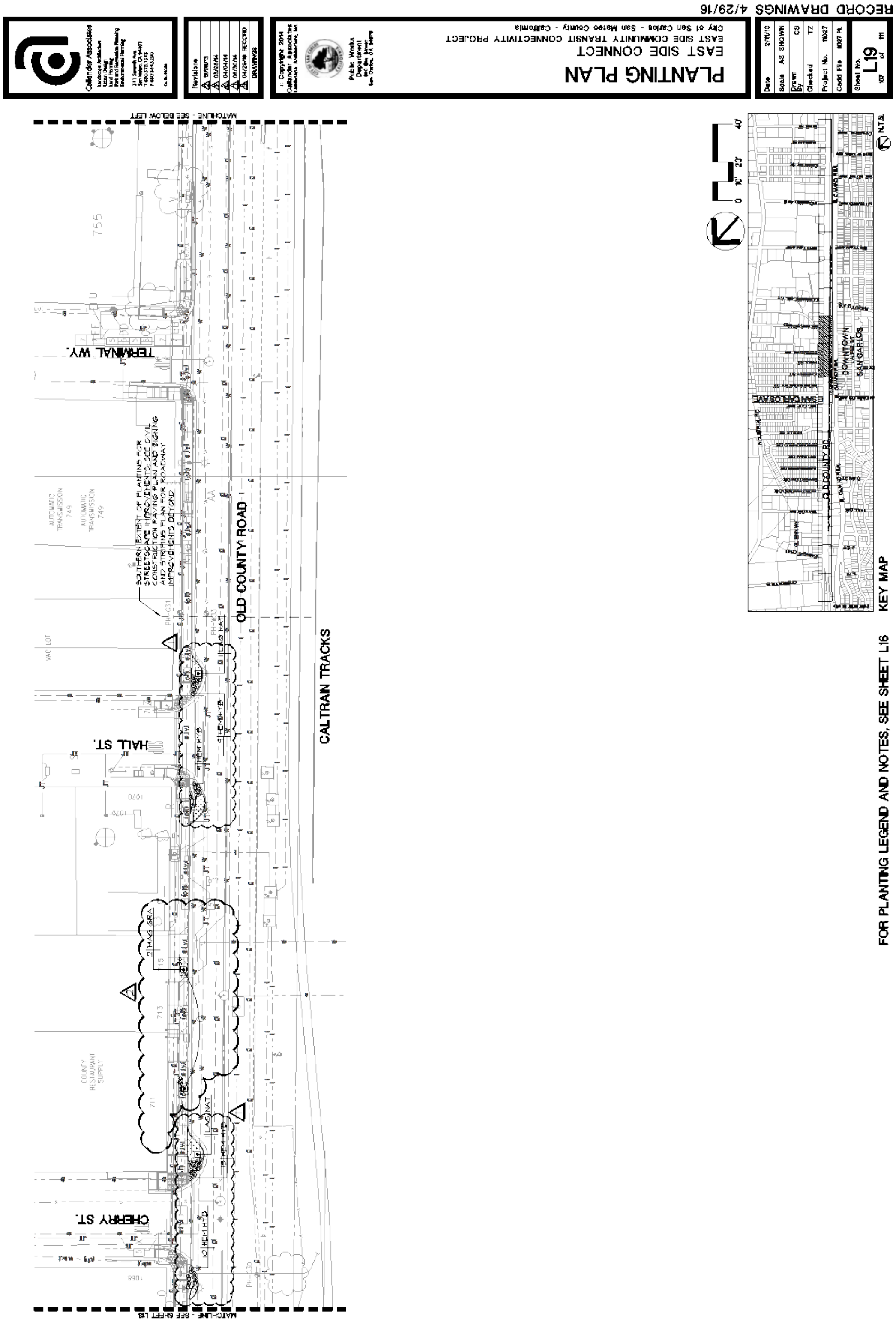
B.


BRANSTEN ROAD CURB EXTENSION
AND STORMWATER TREATMENT
SAN CARLOS, SAN MATEO COUNTY, CA
PLANTING PLAN
(SOUTH SIDE)
P-2
CITY OF
SAN CARLOS
PLANTING PLAN BIORETENTION AREA #4,5, & 6
PLANTING PLAN BIORETENTION AREA #7 & #8
PLANTING PLAN BIORETENTION AREA #9
BRANSTEN ROAD
PLANT LIST
GENERAL NOTES:

Ca.


RECORD DRAWINGS 4/29/16
PLANTING PLAN
EAST SIDE CONNECT
PLANT LEGEND
PLANT LIST
PLANTING NOTES
NORTHWOOD DR.
OLD COUNTY ROAD
TAYLOR WAY
CALTRAIN TRACKS
KEY MAP

Cb.


RECORD DRAWINGS 4/29/16
PLANTING PLAN
EAST SIDE CONNECT
EAST SIDE COMMUNITY TRANSIT CONNECTIVITY PROJECT
City of San Carlos - San Mateo County - California
L19
TERMINAL WY.
HALL ST.
CHERRY ST.
OLD COUNTY ROAD
CALTRAIN TRACKS
KEY MAP
FOR PLANTING LEGEND AND NOTES, SEE SHEET L16