CITY OF SAN CARLOS

Pulgas Creek Watershed Management Plan

FINAL | ADOPTED MARCH 24, 2025
RESOLUTION NO. 2025-20

CITY of GOOD LIVING
SAN CARLOS

Acknowledgments

Land Acknowledgement

Pulgas Creek flows through the ancestral homeland of the Ramaytush Ohlone people, and that, as the original stewards of this land, the Ramaytush Ohlone people understood the interconnectedness of all things and maintained harmony with nature.

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Table of Contents

Table of Contents

01.
Introduction

Chapter 1: Introduction

The City of San Carlos (City), California, is located south of the City of Belmont and north of the City of Redwood City in the San Francisco mid-Peninsula. Stormwater from the City drains from the hills on the west side and runs off towards the east to San Francisco Bay. Runoff is collected through open channels (streams) and pipelines from the City's four primary creeks: Brittan, Belmont, Cordilleras, and Pulgas. Pulgas Creek has two forks upper Pulgas Creek and lower Pulgas Creek.

The Pulgas Creek watershed drains approximately 3.5 square miles located within the City as well as portions of Belmont and unincorporated San Mateo County. Pulgas Creek watershed includes upper Pulgas Creek and Brittan Creek, that originate east of the open space preserve near Highway 280 and flow through the City's downtown.

Figure 1.1 Regional Map

A substantial portion of the Pulgas Creek channel has been modified through multiple culverts upstream of Arroyo Avenue before being combined into a single culvert upstream of the El Camino Real crossing.

The creek is channelized east of Old County Road, passes through a culvert under Highway 101, and is lined with levees east of Highway 101 to protect adjacent areas from tidal flooding. The creek flows into Smith Slough (a tributary to San Francisco Bay) near the Bair Island National Wildlife Refuge.

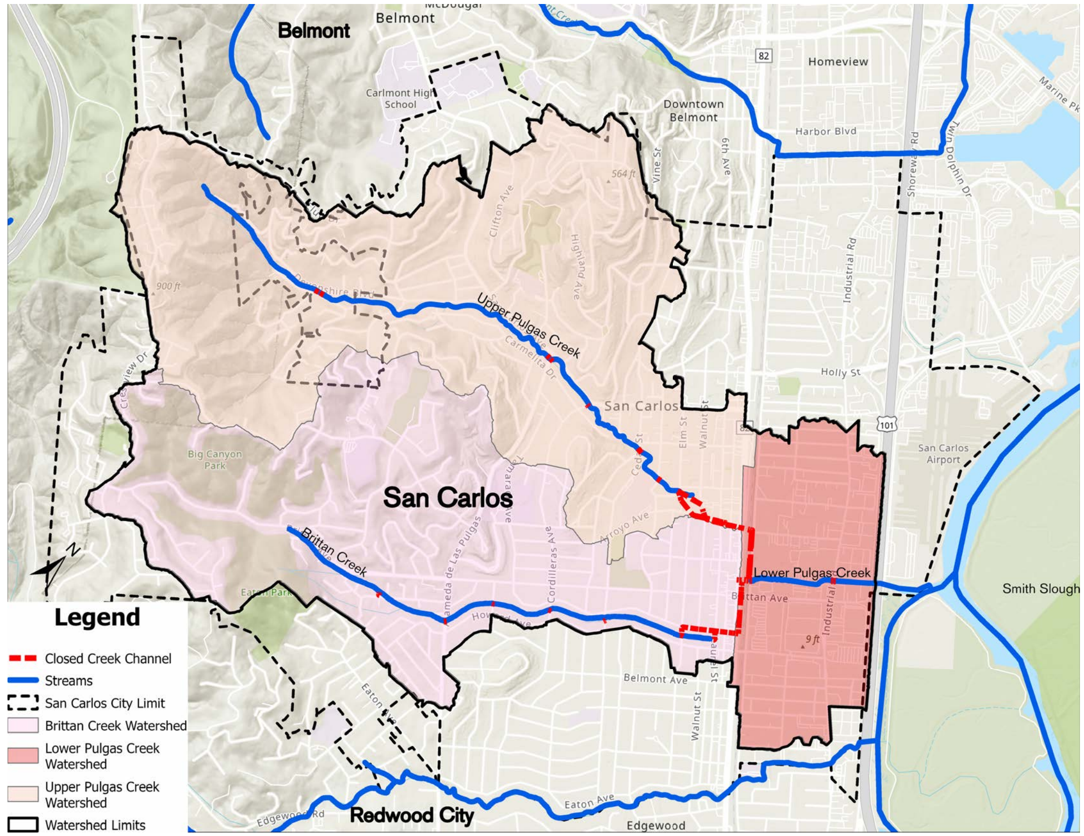


Figure 1.2 Pulgas Creek Watershed Overview

The Pulgas Creek Watershed is highly urbanized, with issues related to storm drain inlet blockages, stormwater capacity, and overtopping creeks. Key features include:

- The existing storm drain network primarily consists of roadside concrete drain inlets that often become blocked during storms causing flooding.
- There are 56 miles of pipelines and channels in the City with various capacity and maintenance issues.
- Various junctions of pipelines and channels are overwhelmed during storm events, causing flood inundation on roads, trails, and infrastructure.

Access along the tributaries of upper Pulgas and Brittan Creek is limited since the creeks are within residential properties. The County and the City own a substantial portion of the upper Pulgas Creek watershed but have limited opportunities for improvement. The upper watershed includes city parks, public and private open spaces with steep terrain, and a mixture of vegetated and unvegetated areas.

1.1 Purpose of Plan

The Pulgas Creek Watershed currently experiences varying levels of flood and other storm related issues including portions of the lower watershed that are within the Federal Emergency Management Agency (FEMA) designated special flood hazard areas. The Pulgas Creek Watershed Management Plan (Watershed Plan) identifies different projects, policies, and programs that can be utilized to create the best opportunity to begin addressing some level of storm related issues and prepare the San Carlos community for the future. Through flow monitoring of the creeks, technical studies, stakeholder feedback, and leveraging existing City efforts, the Watershed Plan provides a comprehensive strategy to advance improvements and enhancements that deliver multi-beneficial projects to reduce potential storm related risks, improve stormwater runoff water quality, enhance public access when feasible, and align with regional planning efforts for addressing climate change.

The Watershed Plan includes several recommendations for all stakeholders to consider for implementation.

Figure 1.3 Flow Monitor Installation at Smith Slough

1.2 Importance of the Pulgas Creek Watershed

A watershed is an area that captures and conveys rainfall and other water to local creeks and eventually out to reservoirs, bays, and the ocean. Rainfall and runoff from private properties and public rights-of-way in the Pulgas Creek Watershed enter the storm drain system or directly into local creeks to be conveyed to the San Francisco Bay without treatment. Since there is no treatment, it can be contaminated by pollutants that can be toxic to fish and wildlife. Example pollutants include but are not limited to debris, trash, sediment, pesticides, oils, chemicals, and solvents.

Efforts to maintain and protect healthy watersheds can have several benefits[1].

- **Economic Benefits** include reduced flood mitigation costs and increased property values.
- **Ecosystem Benefits** include improved water quality, additional carbon storage opportunities, increased climate change resiliency, and reduced risk for invasive species colonization
- **Physical and Mental Health Benefits** include lower rates of illness, decreased stress, improved cognitive development, and a higher likelihood to exercise.

Many times, people do not know how their actions, properties, or businesses impact the health of a watershed. This Watershed Plan will help guide the City, community, businesses, and residents to collectively work towards preserving, protecting, and enhancing the watershed into the future.

1.3 Property Owner Benefits & Opportunities

The Watershed Plan is not only for the City of San Carlos to utilize, but also a guide for property owners, especially those adjacent to creeks. Many residents and business with open creeks on their property are unaware of how important the creeks are for a healthy watershed and the property owners' responsibility for maintaining the portion of the creek on private property.

Who Owns the Land?

Pulgas Creek Watershed is comprised of private and public land. Brittan Creek and Pulgas Creek flow through or underneath all types of areas including residential, commercial, industrial, parks, open spaces, and public rights-of-way. The City and property owners share in the responsibility to maintain Brittan Creek and Pulgas Creek.

How will my property benefit?

The Watershed Plan will highlight areas of opportunity in the watershed, possible policies for consideration, and include a toolbox of information for the City, homeowners and developers. The vision of this Plan cannot happen without participation from private property owners and the San Carlos community.

The watershed benefits surrounding properties and the San Carlos community, by:

- Protecting open space, wildlife habitat, and creeks
- Providing access and community connection to creeks; and
- Reducing flood risk and improving water quality.

1.4 Public Meeting Outcomes

The Watershed Plan was presented and reviewed during the following public meetings noted below.

- Virtual Community Meeting: October 1, 2024
- Parks, Recreation and Culture Commission: October 2, 2024
- Planning and Transportation Commission: February 18, 2025
- City Council Meeting: March 24, 2025

City Council adopted the Pulgas Creek Watershed Management Plan at the March 24, 2025 meeting through Resolution 2025-20.

1.5 Plan Organization

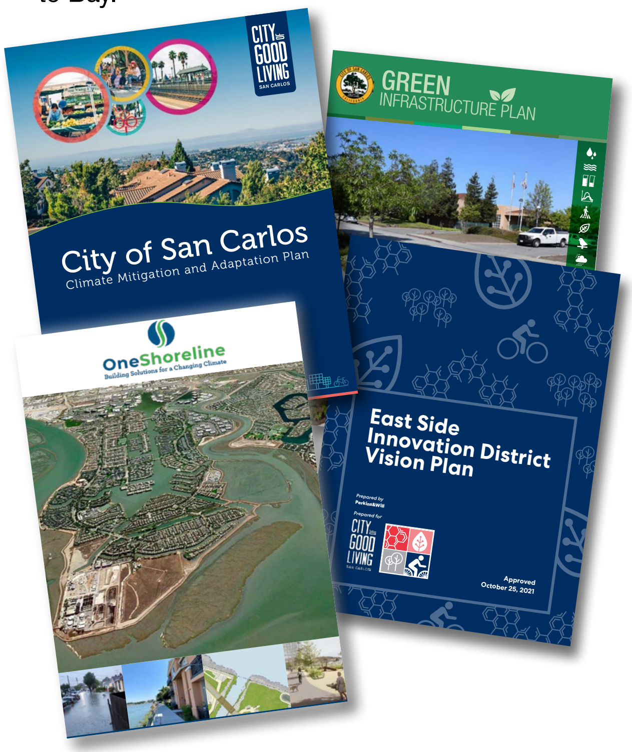
CHAPTER	DESCRIPTION
Chapter 1	**Introduction** summarizes the Plan's purpose and provides an overview of the Plan's Structure.
Chapter 2	**Goals** highlights the vision and goals of the Pulgas Creek Watershed Management Plan.
Chapter 3	**Pulgas Creek Watershed Present and Future** provides historical information of the Pulgas Creek Watershed and current and future obstacles.
Chapter 4	**Watershed Management Strategies** describes conceptual projects, policy changes and programs to best enhance, preserve and protect the watershed.
Chapter 5	**Recommendations - City** discusses actions that the City can take to implement watershed management strategies.
Chapter 6	**Recommendations - Developer** discusses actions that developers can take to implement watershed management strategies.
Chapter 7	**Recommendations - Resident** discusses actions that the residential community can take to implement watershed management strategies.
Chapter 8	**Permitting Requirements** notes different permits that may be required for projects that are implemented by the City, developers, or residents.

1.5 Plan Organization (Cont.)

CHAPTER	DESCRIPTION
Chapter 9	**Funding Sources** lists different funding sources that the City should consider.
Appendix A	**Existing Conditions Hydraulics and Hydrology Memorandum** identifies the existing flood risks and model calibration.
Appendix B	**Climate Change Memorandum** reviews impacts of climate change on the Pulgas Creek Watershed and provides recommendations of how to reduce risk.
Appendix C	**Flood Mitigation Evaluation Memorandum** assesses potential options to re-naturalize the hydrograph and reduce existing flood risk.
Appendix D	**Public Access Opportunities Memorandum** identifies potential public access and recreation improvements that can be paired with recommended watershed strategies.
Appendix E	**Revegetation Benefits and Planting Palettes** provides additional information about revegetation benefits and recommended planting palettes for planting in the upper watershed, riparian areas, street trees, and bioretention areas.
Appendix F	**Cost Estimate Memorandum** provides conceptual projects that the City could implement.

1.6 Previous Studies & Reference Documents

The Watershed Plan references several City documents such as the Climate Mitigation and Adaptation Plan, Stormwater Master Plan, East Side Innovation District Vision Plan, and Green Infrastructure Plan. The Watershed Plan also references San Mateo Countywide documents and information from OneShoreline and Flows to Bay.



REFERENCE DOCUMENTS	KEY INFORMATION
City of San Carlos Stormwater Master Plan (2017)	Provided starting point for existing conditions study and history of flood events.
City of San Carlos Green Infrastructure Plan (2019)	Review of the City's existing green infrastructure plans.
San Carlos' Climate Mitigation and Adaption Plan (2021)	Guidance and recommendations on how the City of San Carlos is preparing for climate change.
East Side Innovation District Vision Plan (2021)	Feedback from the community on what types of amenities are desired for creek adjacent developments.
OneShoreline Planning Policy Guidance (2023)	Guidance and recommendations on how to incorporate sea level rise into proposed solutions and policies.
Flows to Bay	Multiple documents were reviewed on flowstobay.org for guidance and resources on complying with the Municipal Regional Stormwater Permit (MRP 3.0)

02.
Goals

Chapter 2: Goals

The Watershed Plan was developed around four overall goals to develop flood management and climate change resiliency strategies that will prepare the San Carlos community for the future while enhancing, protecting, and preserving the watershed.

2.1 Vision Planning Process

The vision planning process involved a review of previous community outreach efforts by the East Side Innovation District Plan and engaging multiple City departments to identify the initial information needs to be incporporated into the Watershed Plan. Key takeaways were identified:

- Defining the creek setback by zoning, including process for requesting waiver
- Fostering partnerships with the development and residential communities
- Creating public access, circulation, and amenities along Brittan Creek and Pulgas Creek
- Encouraging public involvement including public art and education
- Building climate change and sea level rise resiliency
- Integrating stormwater policies and improvements into other City of San Carlos Plans
- Shaping multi-beneficial projects
- Defining what infrastructure is maintained by the City versus private property owners

Key takeaways were grouped into six major concepts: (1) Community, (2) Enhancement, (3) Multi-beneficial, (4) Maintenance, (5) Resiliency, and (6) Policy. To capture the major concepts four goal statements were established to encompass one or more of the major concepts.

2.2 Project Goals

Goal: Develop a plan through engagement of the San Carlos Community by providing accessible information, and opportunities for partnership, review, and feedback

As acknowledged earlier, the vision of this plan cannot be accomplished without the participation of the San Carlos community, residents and developers alike. The Watershed Plan is meant to be a living document that is updated and utilized based on the needs of the San Carlos community.

The Watershed Plan aims to:

- Provide educational information about the watershed
- Identify private property owners' responsibilities
- Highlight existing programs and policies that the community can benefit from
- Give opportunities for community feedback and participation

Goal: Create design guidelines and preliminary concepts that optimize the ease and accessibility for operations and maintenance, while meeting established performance levels.

To continue preparing for potential impacts from climate change, proposed solutions not only need to meet performance levels, but also need to consider short- and long-term maintenance needs. The City, developers, and residents need to understand how to properly maintain stormwater management solutions, creek setbacks, and landscapes to ensure that they are operating at the optimum level. Developers and residents also need to recognize the private property owner's responsibility to implement property enchancements to reduce stormwater impacts to individual properties, creeks, and storm drain infrastructure and perform ongoing maintenance.

The Watershed Plan aims to:

- Provide project solutions that maintain accessibility for maintenance and operations
- Define what is maintained by the City or by private property owners
- Integrate green infrastructure and native plantings into site improvements
- Build climate change resiliency solutions

Goal: Provide guidance on policy refinement and standard development to integrate climate change and flood resiliency into existing processes to create the best opportunity to prepare the San Carlos community for the future.

Implementing and refining policies can help prepare the San Carlos community for the future by ensuring that new developments and projects are constructed to benefit the watershed and community.

The Watershed Plan aims to:

- Enhance existing policies
- Recommend policies and programs that could benefit the watershed
- Identify regional strategies that may benefit the watershed

Resiliency

Policy

Goal: Identify opportunities for multi-beneficial projects that enhance, protect, and preserve the watershed while also increasing recreational opportunities for the public.

It is evident that the City and the community desire publicly accessible recreational opportunities adjacent to the creek and throughout the watershed. There are opportunities to increase and enhance recreational amenities, while also ensuring that the design can continue to protect and preserve the watershed.

The Watershed Plan aims to:

- Identify projects with parks that enhance stormwater management features
- Incentivize developers to provide publicly accessible spaces
- Require developments to enhance, protect and preserve the watershed

Multi-Beneficial

Enhancement

Community

03.

Pulgas Watershed Present & Future

Chapter 3: Pulgas Creek Watershed Present & Future

This chapter includes the following sections:

- **Flooding History** describes past flooding events in San Carlos including potential causes.
- **Hazards** note different risk factors that cause flooding.
- **Future Climate Change** discusses anticipated changes to precipitation and sea level rise.

Figure 3.1 Pulgas Creek

3.1 Flooding History

Historically, flooding has occurred in the more heavily urbanized reaches of the Pulgas Creek watershed east of Alameda de las Pulgas, especially along El Camino Real. More recently, flooding effects have been observed in the less urbanized reaches of the watershed west of Alameda de las Pulgas, particularly at properties abutting existing parks and less developed areas.

The Federal Emergency Management Association (FEMA) designates Special Flood Hazard Areas (SFHA). SFHA are land areas that face a 1.0-percent (100-year flood) or 0.2-percent (500-year flood) chance of flooding each year. The SFHA is also where the National Flood Insurance Program's (NFIP's) floodplain management regulations are enforced and where flood insurance purchase is mandatory. Portions of the Pulgas Creek Watershed in San Carlos are within the FEMA SFHA, mainly adjacent to the creeks or within the lower watershed adjacent to the bay.

Based on flood reports provided from the 2014/2015 and 2022/2023 floods, the 2014/2015 flood events were generally located in the mid to lower watershed. Potential causes were mostly attributed to insufficient downstream capacity where excess runoff combined with the high tides limited the storm drain capacity and resulted in flows popping out of manholes and overwhelming catch basins. Catch basins adjacent to flooding sites were also reported to be covered by trash and debris, potentially escalating the flooding.

The 2022/2023 reported flood events were in the upper watershed. The potential causes were nearly all attributed to landslides and erosion overwhelming storm drains and diverting flood flows to homes and streets.

Based on storm drain infrastructure and creek capacity, flooding is predicted to occur at several locations adjacent to the creek and within the lower watershed area. The predicted flooding is based on a 100-year flood and consistent with the FEMA SFHA. But, as reported in the 2022/2023 storms, the upper watershed is susceptible to flooding caused by landslides and erosions. In summary, the flood reports indicate that the watershed is at risk of flooding due to multiple mechanisms, and only one mechanism is needed to cause flooding.

Additional information can be found in **Appendix A Existing Conditions Hydraulics and Hydrology Memorandum**.

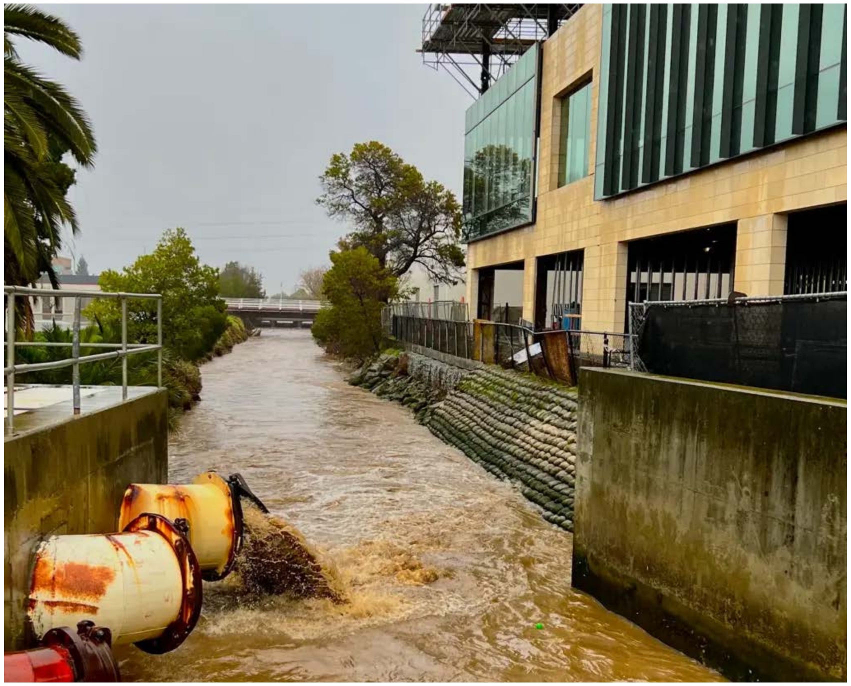


Figure 3.2 Industrial Road Pump Station Outfall

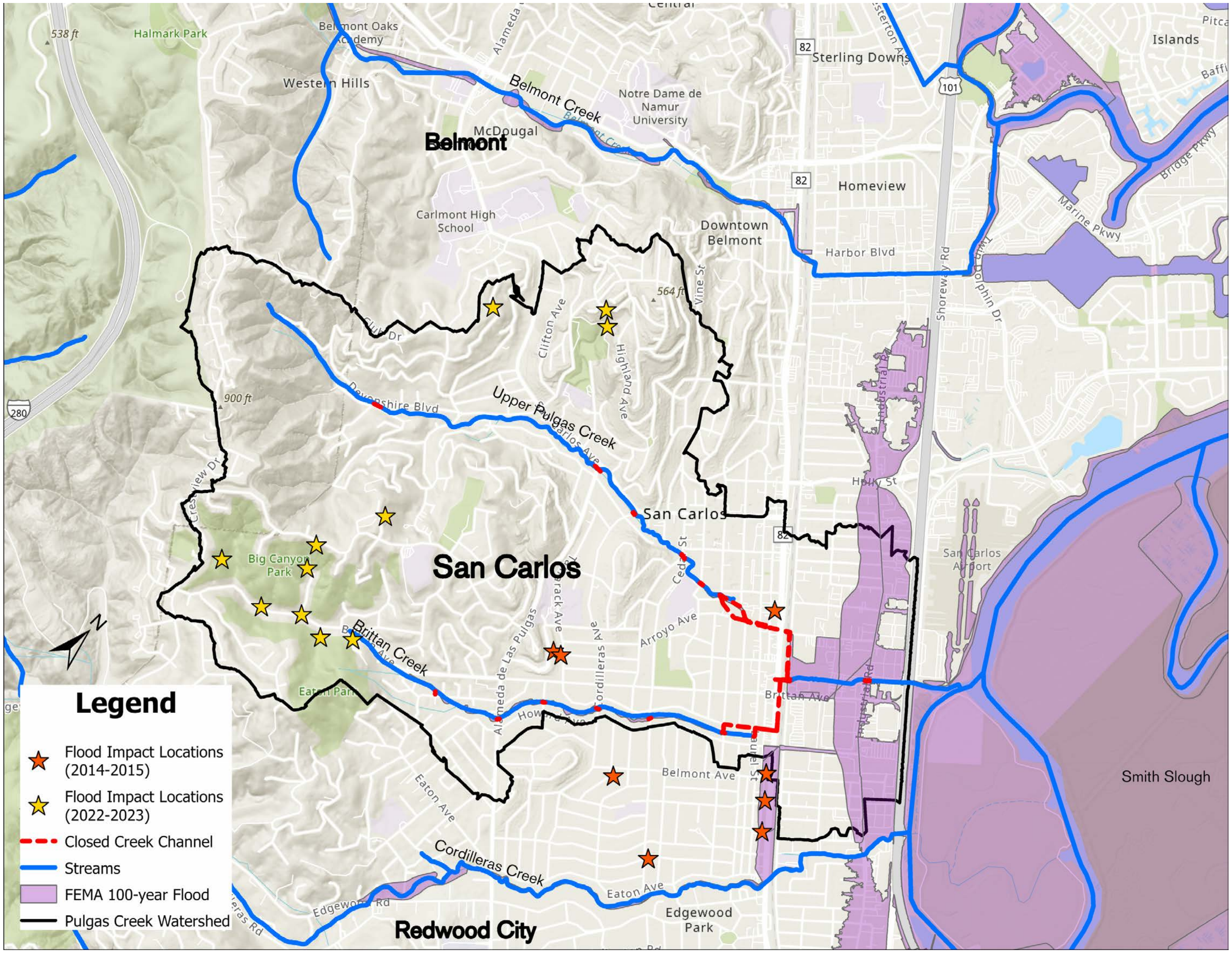


Figure 3.3 Pulgas Watershed Regions Impacted by Flooding (100-year flood)

3.2 Hazards

Flooding in the Pulgas Creek watershed can be associated with a variety of risk factors including:

- Sedimentation,
- Trash and debris,
- Insufficient storm drain capacity,
- Groundwater, and
- High tides.

The most prevalent flooding risk factors in the Pulgas Creek Watershed are sedimentation, insufficient storm drain capacity, groundwater, and high tides.

3.2.1 Sedimentation

Urbanization and development of the watershed also increases flood risk through replacement of previously permeable surfaces with impermeable developments. While municipal design standards require storm drain systems to accommodate the change in runoff, the analysis performed is typically under the assumption wherethat there is no significant presence of debris or sediment flowing with the water. Debris and sediment can drastically change the flow dynamics of a system, especially around constrictions and expansions, grade changes, and around erodible surfaces.

Sedimentation is the result of rock fragments, soil, or organic material that has been eroded and transported by water, wind or gravity. Sediment is introduced to the waterway through erosion or landslides and can exist anywhere water flows, such as where precipitation impacts the ground, on roads, inside storm water infrastructure, and within the creeks. Erosion

Figure 3.4 Landslide at Appian Way

occurs anywhere throughout the watershed where there is exposed soil experiencing heavy water flow. Sediment sources can include uncovered earth disruption activities, such as construction or landscaping, and creek bank erosion.

Landslides typically involve large volumes of soil moving either immediately into the waterway if they occur along the creek banks, or over a longer period if they occur on upper hillslopes, farther from the waterway. Landslides typically occur where steep and geological topography, morphological, and hydrological conditions result in a weak landscape region. The majority of landslides within San Carlos occur in the upper Pulgas Creek watershed, west of Alameda de las Pulgas[2].

3.2.2 Trash and Debris

Trash and debris from private property, parks, open space, and public rights of way can make its way into Brittan Creek, Pulgas Creek, and the storm drain system as rainstorms wash it into gutters and catch basins. Types of trash and debris that frequently pollute waterways include cigarette butts, paper, fast food containers, plastic grocery bags, cans and bottles, used diapers, pet waste, construction site debris, industrial preproduction plastic pellets, old tires, appliances, and more. Trash is a significant pollutant of the San Francisco Bay that adversely affects beneficial uses, including but not limited to uses that support aquatic life, wildlife, and public health.

Trash and debris also contribute to reducing the performance of critical storm drain infrastructure. Trash and debris can accumulate at catch basins and prevent the flow of water resulting in ponding. It can also enter into the storm drain system and can accumulate within the pipe reducing the overall capacity of the infrastructure. Regular maintenance activities by the City and private property owners are necessary to reduce the overall trash and debris volumes that are conveyed to Brittan Creek and Pulgas Creek.

3.2.3 Storm Drain System

Sediment, trash, and debris conveyed during a storm event can clog the intended stormwater conveyance route, resulting in flood water accumulation and potential for overtopping the channel, popping out of manholes and catch basins, or prevention of stormwater from entering stormwater infrastructure.

Man-made debris can include plastic items, metal objects, construction waste, and other synthetic materials, while natural debris can include branches, leaves, dead trees, and other plant materials. The dynamic nature of a storm can result in larger debris forming obstructions during high flows, with recessional flows causing flooding prior to the debris being removed. Sediment can also be conveyed into stormwater infrastructure and clog in lower slope pipes prior to reaching the San Francisco Bay, reducing conveyance and storage capacity for the next storm. The City of San Carlos and San Mateo County standards dictate overland flow paths to convey, at a minimum, the 100-year event within the FEMA mapped floodplain. Overland flow paths outside the FEMA floodplain require a 10-year minimum conveyance capacity. Below grade conveyances, such as pipes, shall be sized for the minimum 10-year conveyance capacity[3].

Sediment, trash, and debris can limit the actual conveyance and storage capacity resulting in a higher risk of flooding during smaller storm events. Anticipated flood volumes from a 10- and 100-year event can change over time as development continues. Increased areas of concrete, asphalt, and other impermeable surfaces can hasten the conveyance of stormwater into the drainage system and result in an increase in the peak flow for the watershed, resulting in flooding at the same 10- or 100-year precipitation event despite sizing the original infrastructure for the same event.

3.2.4 Groundwater and High Tides

Sources of inflow of water to the storm drain system include precipitation runoff and potential groundwater springs, while outflow sources include discharge into the San Francisco Bay, infiltration into the soil, evaporation, and transpiration. Groundwater levels during the winter can be as shallow as three feet below the ground surface east of El Camino Real, severely limiting infiltration potential and channel conveyance capacity[4]. As storm flows reach the lower watershed, water surface elevations are altered by tidal and groundwater elevations, causing storm flows to overtop channel banks and pop out from manholes.

This issue will be exacerbated by climate change through higher intensity storms and rising sea levels.

3.3 Future Climate Change

San Carlos is also expected to experience many impacts of climate changes such as sea level rise, droughts, extreme heat, inland flooding, landslide and debris flow, severe storms, wildfires, and groundwater level rise. Although all the climate changes will impact the watershed, some of the key climate changes that will impact the watershed are sea level rise, severe storms, and groundwater level rise. The impacts of climate change can cause more frequent landslides, flooding, and even impact water quality. Additional information on future climate change can be found in **Appendix B Climate Change Memorandum**.

3.3.1 Sea Level Rise

According to the 2021 San Carlos' Climate Mitigation and Adaption Plan, as global temperatures heat up, San Carlos Bay shoreline sea levels are projected to rise approximately 24 inches by 2050 and 84 inches by 2100. The rise in sea levels can result in larger flooding events and would make the shoreline more susceptible to flooding even during normal rain conditions.

3.3.2 Precipitation Intensity and Frequency

In the past years, flooding was mostly observed in the lower portion of San Carlos. In the most recent flooding years, the City has experienced floods in the upper portion towards the western hills comprising of parks and less developed spaces. Based on a comparison of flood events to hourly precipitation intensity data from the California Data Exchange Center (CDEC) station, the Pulgas Creek Watershed appears to be at risk of flooding at a rainfall rate of 0.75 inches per hour. Climate change can affect the intensity and frequency of precipitation. The potential impacts of more severe and more frequent storms include soil erosion leading to more frequent landslides and an increase in sedimentation due to heavy precipitation.

3.3.3 Groundwater Level Rise

Shallow groundwater levels are predicted to rise creating numerous potential impacts on the community, including buoyancy, seepage, infiltration, liquefaction, corrosion, and contaminant mobilization hazards. Initial studies identify shallow groundwater rise is one of the most consequential impacts of sea level rise and the best available science indicates that low-lying communities located inland from the Bay could experience flooding impacts from rising shallow groundwater long before sea level rise overtops the Bay shoreline.

04.

Watershed Management Strategies

Chapter 4: Watershed Management Strategies

4.1 Introduction

As discussed in Chapter 3, flooding throughout the City is due to several factors and, therefore, a combination of strategies will need to be implemented to begin addressing the flood issues. By addressing flood issues, there are opportunities to reduce sedimentation, improve water quality and provide new or improved recreational amenities. This section includes recommendations of projects, policy changes, and community partnerships that can be utilized to create the best opportunity to prepare the San Carlos community for the future.

This chapter will include the following sections:

- **Improvement Strategies** describe improvements that should be pursued throughout San Carlos and integrated into other City planning documents.
- **Policy Changes** include changes to municipal code, operating procedures, and other policies that will continue to enhance, protect, and preserve the watershed.
- **Community Partnership** highlights existing programs, proposed programs, and educational documents that provide opportunities to engage and partner with the San Carlos community.

4.2 Improvement Strategies

4.2.1 Introduction

The potential improvement strategies presented in this section were developed to reduce flooding, improve water quality, reduce sedimentation, and increase storm drain capacity. Table 4.1 summarizes how each improvement strategy can resolve and improve key issues. Most strategies identified can be implemented by the City and by the development community with select strategies that can be potentially implemented by residents. Additional information on the potential impacts of the proposed strategies can be found in **Appendix C Flood Mitigation Evaluation Memorandum** and **Appendix D Public Access Opportunities Memorandum**.

Table 4.1

IMPROVEMENT STRATEGIES	REDUCE FLOODING	IMPROVE WATER QUALITY	REDUCE SEDIMENTATION	INCREASE STORM DRAIN CAPACITY
Revegetation	■	■	■	■
Floodplain Detention Basin	■		■	■
Underground Detention Basin	■			■
Low Impact Design (LID)		■	■	■
Targeted Inspection & Maintenance	■		■	■

4.2.2 Revegetation

As storm intensity increases, more stormwater runoff is generated that can elevate the potential for more sediment to be washed away and introduced into the storm drain system, clogging storm conveyance structures. The upper watershed includes city parks, public and private open spaces with steep terrain, and a mixture of vegetated and unvegetated areas, which could add to sediment in the storm drain system during storms.

The upper watershed parks and residential properties with creeks can benefit from native planting revegetation to reduce sediment clogging the storm drain system. Vegetation efforts are primarily concentrated on a large scale where land is available to be more densely vegetated, such as in the upland reaches of the Pulgas Creek watershed and around existing public parks, especially where landslide risk is prevalent.

There are several locations primarily concentrated around existing parks where vegetation cover is dominated by non-native annual grasses that provide poor stability in the key wet months of October to December. The non-native annual grasses will yellow and only begin to re-establish in December when comprehensive vegetation coverage is needed to prevent landslides and capture precipitation. The establishment of native shrubbery and trees, which are persistent and deeply rooted, will likely decrease landslide risk, and provide precipitation absorption and abstraction throughout the year[5]. Attaining native establishment may involve a concerted annual effort to achieve success as establishment may be contingent upon a variety of factors such as soil suitability, existing soil microbial communities, nutrient availability, water availability, competition, and microclimate.

The Watershed Plan recommends that revegetation of native plants should be considered as part of any City project in parks, open space areas, properties adjacent to creeks, and street tree replacements. Native plant revegetation should also be considered for any residential or commercial properties adjacent to creeks. For detailed information about revegetation benefits and planting palettes for different areas around the watershed, please see **Appendix E Revegetation Benefits & Planting Palettes**.

Figure 4.2 Big Canyon Park

4.2.2.1 Importance of the Urban Tree Canopy

Not only can trees help reduce stormwater runoff, but it can also reduce urban temperatures, improve air quality, isolate carbon, enhance property values, provide wildlife habitat and strengthen social connections in neighborhoods. Trees can contribute to the watershed health by reducing sedimentation and erosion by holding soils in place in the upper watershed. Trees prevent soil erosion in several ways:

- Intercept rainfall which prevents splash erosion
- Reduce amount of water in soil through transpiration
- Improve soil health and nurture seedlings
- Roots bind soil to sloping ground, preventing erosion and protecting topsoil
- Provide a wind break and prevent surface soil from blowing away

California Buckeye

Coastal Live Oak

Blueblossom Ceanothus

Toyon

Figure 4.3 Examples of Native Revegetation Planting

As the conservation nonprofit American Forests reminds us, "healthy forests are our most efficient, inexpensive, and natural systems to combat climate change." Both natural and urban forests play an essential role in reducing CO2, the main contributor to climate change. There are two direct ways that trees help[6].

Trees act as a CO2 sink:

- Trees sequester and store CO2, decreasing the concentration of CO2 in the atmosphere.
- Trees use CO2 during photosynthesis to produce sugars, which provide energy for trees as well as emitting oxygen as a by-product of the process.
- Planting more trees absorbs more CO2, reducing the overall concentration of CO2 in the atmosphere.
- An average-size tree can store hundreds of pounds of CO2 over its lifetime.

Trees reduce energy use:

- Neighborhoods well-shaded with street trees can be up to 6-10 degrees cooler than neighborhoods without, thereby reducing overall energy needs.
- Three trees properly placed around a house can save up to 30% of energy use.

Analysis of the existing forest reveals that almost all of the trees are non-native, most lack drought resistance, and several are invasive species that increase fire risk. To maximize the ecosystem services that trees provide in the upper watershed, it is important to plant large, native trees and shrubs, uniquely adapted to local site conditions, to increase climate resilience. A healthy forest ecosystem is self-sustaining; with adaptive management it will require minimal maintenance, expense, and energy inputs from the city while providing multiple benefits.

4.2.3 Floodplain Detention Basins

Detention basins help collect stormwater runoff from surrounding areas and slowly release runoff into the surface. Floodplains naturally provide a variety of ecosystem benefits while calming high-flow energies to retain water within the floodplain, accumulate sediment, and minimize erosion compared to a more typical engineered conveyance channel. While natural floodplains can have a large footprint, combining the morphology of a floodplain with a more typical detention basin design can provide increased ecological benefits with the intended sediment, peak flow, lowered footprint, and maintenance controls of a normal detention basin. These devices are intended to be placed in a tributary's natural flow path as it drains into the urban storm system and where there is sufficient lateral and longitudinal space, such as in San Carlos' existing parks.

In addition to San Carlos' parks and open spaces, floodplain detention should be considered by developers to reduce the impacts to offsite areas. Not only will it help reduce impacts to offsite areas, but developments next to creeks can utilize a floodplain detention basin to aid in protection from flooding.

Figure 4.4 Floodplain Detention System Concept

4.2.4 Underground Detention Basins

Similar to an above-ground detention basins, underground detention basins help collect stormwater runoff from surrounding areas and slowly release runoff into the stormdrain infrastrucuture. The underground detention basins typically consists of tanks or a network pipes that store water by filling duirng the peak flow of a storm event, allowing there to be more capacity in the storm drain infrastructure downstream. Underground detention basins are best utilizied in an urbanized area and potential locations were noted in the lower Pulgas Creek Watershed.

Figure 4.5 Detention Basin Facility Concept. Stormwater Sydney

4.2.5 Low Impact Development Design (LID)

Low impact development designs (LID) are features that can be integrated with natural and urbanized environments, while also being beneficial to stormwater management. LIDs include rain gardens, bioretention gardens, bioswales, pervious pavement, and green roofs. It is required to design and construct LIDs once certain square footage thresholds are reached through the Municipal Regional Stormwater Permit (MRP). These projects are typically found in new development, redevelopment, and public projects, but can also be utilized in residential areas.

Example of LID features includes; rain gardens, bioretention, bioswales, pervious pavement and green roof as outlined in the following section.

Rain Gardens

Rain Gardens reduce runoff by capturing rainwater and allowing it to infiltrate back into the ground. This helps reduce flooding, remove pollutants, and enhance the natural and built environment. Rain gardens can be implemented on developments and residential lots.

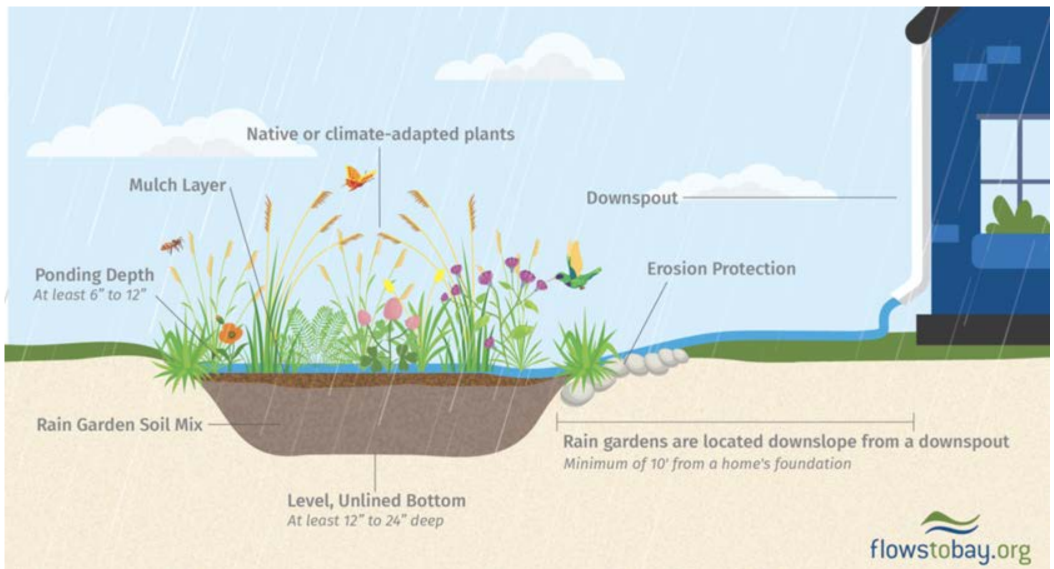


Figure 4.6 Rain Garden Example, Flows to Bay

Bioretention

Bioretentions remove pollutants through infiltration and retain sedimentation before the water is released. Water will sit in the bioretention at a designed ponding depth and is slowly released into the stormwater system.

4.7 Bioswale & Biorentention, Mission Creek Stormwater Park, San Francisco

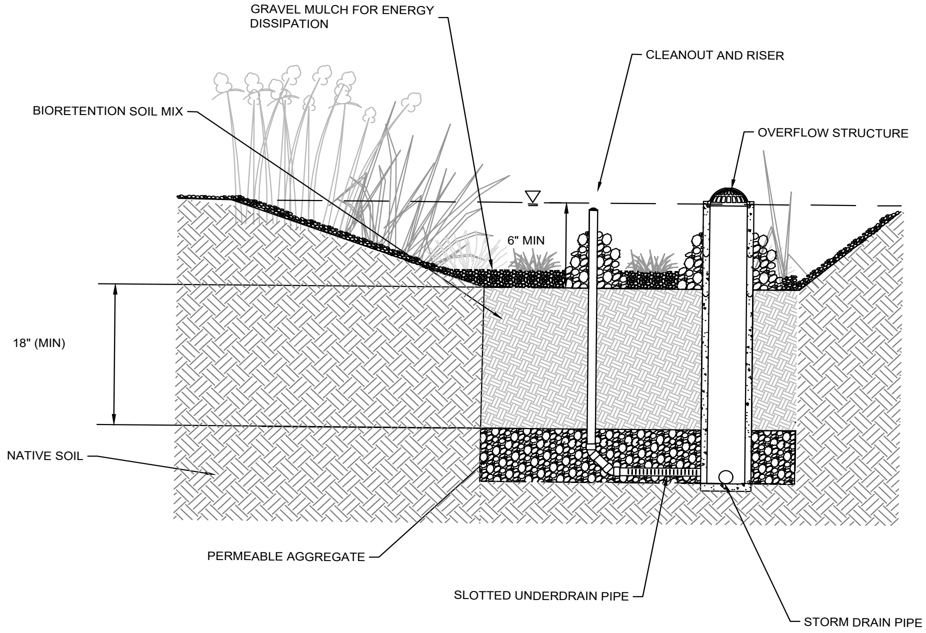


Figure 4.8 Bioretention Section

Bioswales

Bioswales remove pollutants through vegetation and soil. Water flowing into the bioswales is retained and pollutants are settled by the plants. Once on the soil, the pollutants are broken down by the bacteria in the healthy soil.

Bioswales can be used to convey stormwater to other treatment areas, but do not count as a C3 regulated treatement facility.

Plants Suitable for Bioretention & Bioswales

Bioretention and bioswales are designed to catch and treat rainwater and reduce its flow off site. A specific planting palette is recommended for these LIDs and is further discussed in **Appendix E Revegetation Benefits & Palettes for San Carlos**. The plants are mostly California native species that promote infiltration of rainwater into the soil and help filter and breakdown pollutants in the stormwater runoff.

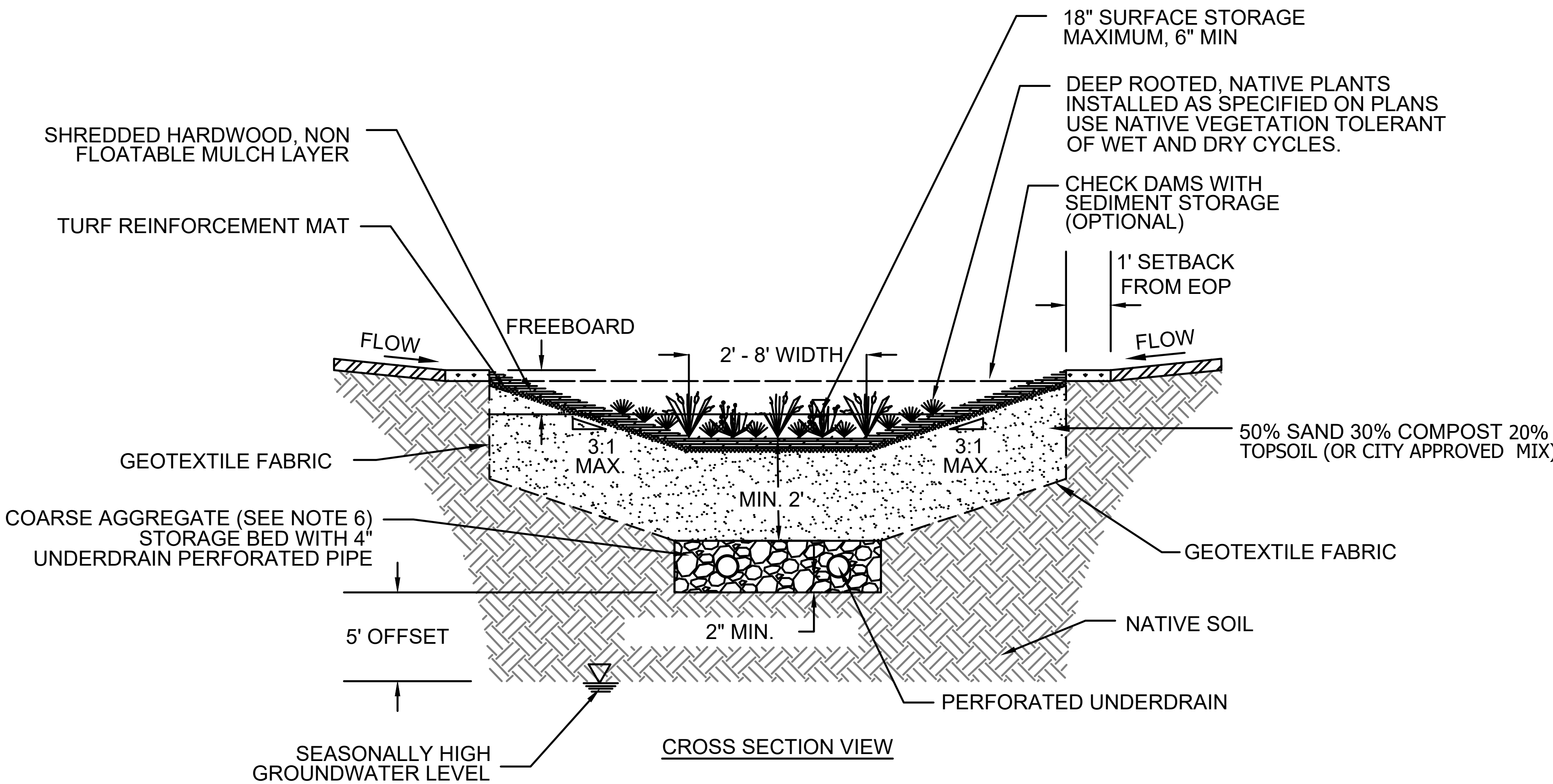


Figure 4.9 Bioswale Section

Pervious Pavement

Pervious pavement, also known as permeable pavement, can consist of porous asphalt, open joint pavers, or permeable pavers. The porous nature, whether through separated joints or type of material, allow for water to flow through and infiltration of pollutants that are absorbed and released into the ground. These systems reduce runoff and the amount of pollutants that enter creeks and the bay. Pervious pavement is best suited for parking lots, walkways, and areas that don't have heavy vehicular traffic.

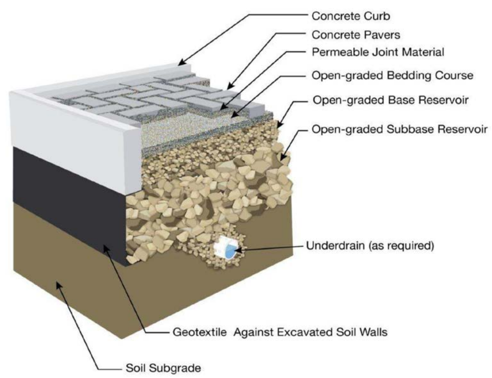
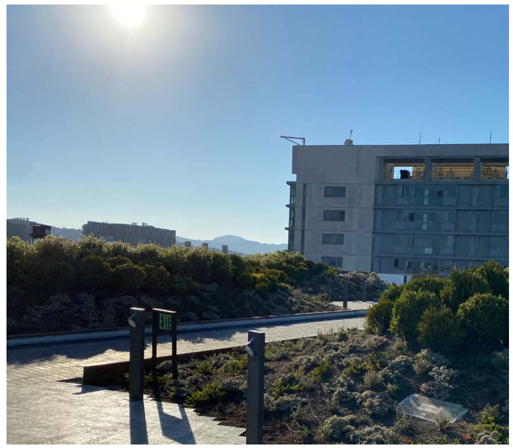


Figure 4.10 Pervious pavement, ASCE

Green Roofs

Green roofs allow roofs to capture water though vegetation and soil. Green roofs are typically composed of layers like waterproof membranes, roots barriers, and others. These additional layers help support plant life, manage stormwater, and improve air quality.



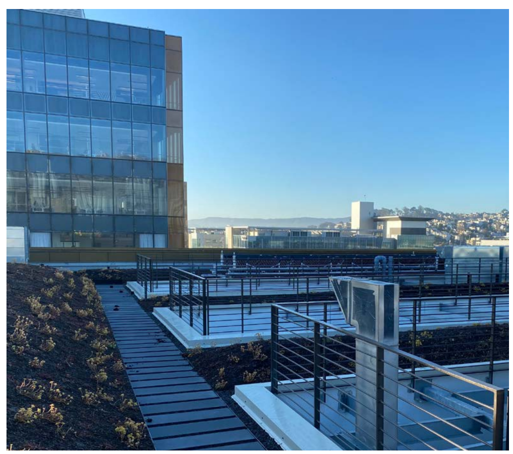


Figure 4.11 Green Roof Examples from Uber World Headquarters, San Francisco

Additional LID Considerations

As the City, residents or developers implement LIDs, in addition to the MRP requirements, the projects should consider incorporating the following:

- LID maintenance schedule should include standard operating procedures to clearly define how to maintain specific LID. City staff, contractors, and volunteers who are involved in maintenance should refer to Flows to Bay for maintenance information.
- Providing educational signage to increase public awareness
- When projects are extending pavement surface edge without adding lanes (paving shoulder or paving edge), the project should consider or require an LID measure for the new edge to drain to adjacent landscape or roadside bioretention treatment.
- Consider planting palette specific for biotreatment areas

4.2.7 Targeted Inspection and Maintenance

Targeted inspection and maintenance activities are intended to proactively investigate historic flood locations where opportunities for improvement are limited. These can include regions where the cause of the flooding is entirely within private property, is limited in available space, or where flood mitigation options are likely to yield low to no benefit.

Inspection and mainteance schedules are important to establish, not only for storm drain infrastrucutre, but also for stormwater treatment measures. Depending on the type of stormwater treatment measure, the inspections and maintenance activies may vary. Typical inspections of stormwater treatment measures include:

- Inspecting that storm drain infrastructure is properly functioning prior to storms
- Monitoring vegetation to ensure successful root establishement, semi-annually
- Inspect for erosion, clogging and vegetation damage, semi-annually
- Inspect for signs of mosquito breeding, semi-annually

Typical maintenance of stormwater treatment measures include:

- Regularly water vegetation during root establishment
- Trim vegetaion as needed to prevent overgrowth, monthly or as needed
- Remove visible contaminants, debris, and trash from inlets, semi-annually
- Add mulch to bare area and remove any mulch that has been contaminated with oil, grease or other hazardous material, semi-annually
- Replace dead, damaged, or diseased plants and provide weed control, annually or as needed
- Regrade soil surface if erosion or scouring has occured, annually or as needed
- Till or aerate soil and replant if basin does not drain within 24 hours after a storm event, as needed
- Utilize integrated pest management strategies to safely and effectively minimize pest damage and hazard, as needed

By creating plans to inspect and maintain, the community can take necessary steps to ensure that the creek, storm drain infrastructure, and stormwater management features are operating at the optimal ability.

4.3 Policy Changes

The following recommended changes include policies and municipal code revisions that support the goals of this Watershed Plan.

- Modifications to Creek Setback Requirements
- Adoption of a Sea Level Rise Overlay District
- Adoption of a Shallow Groundwater Rise Overlay District

The policy changes and recommendations are further discussed in Chapter 5 - Recommendations - City.

4.4 Community Partnerships

Existing Programs

Maintaining the watershed is a community effort. There are multiple existing programs that the community can participate including:

- San Carlos Annual Creek Clean Up Day
- San Carlos Day of Service
- Cal Water Lawn-to-Garden Program
- Bay Area Water Supply and Conservation Agency Lawn Be Gone! Program
- County Wide Rain Barrel Rebate & Program

To learn more about each of these programs, additional information is detailed in Chapter 7 Recommendations - Residential.

Proposed Programs

In addition to existing programs, there are opportunities to provide more awareness and education on how to maintain the watershed. Proposed programs include:

- Property Owners Education Program
- Interpretive Signage and Programs
- Adopt a Drain
- Artwork

To learn more about each of the proposed programs, additional information is detailed in Chapter 5 Recommendations - City.

05.

Recommendations - City

Chapter 5: Recommendations - City

5.1 Introduction

Each community member will serve varying roles to implement the strategies identified in Chapter 4. This section is organized to present actions that could be taken by the City.

To implement the various proposed project strategies, programs and policies, permitting requirements and funding must be acknowledged. For further discussion regarding permitting requirements and funding, please see Chapter 8 and Chapter 9 respectively.

The City will be the primary stakeholder to implement a larger number of the strategies presented in Chapter 4. Potential City actions are grouped by:

- Develop Capital Improvement Projects
- Integrate with other City Planning Documents and Projects
- Implement Policy Changes
- Perform Annual Maintenance
- Implement Proposed Programs

5.2 Develop Capital Improvement Projects

The City should explore opportunities to implement a range of potential capital projects including revegetation, floodplain detention, and underground detention.

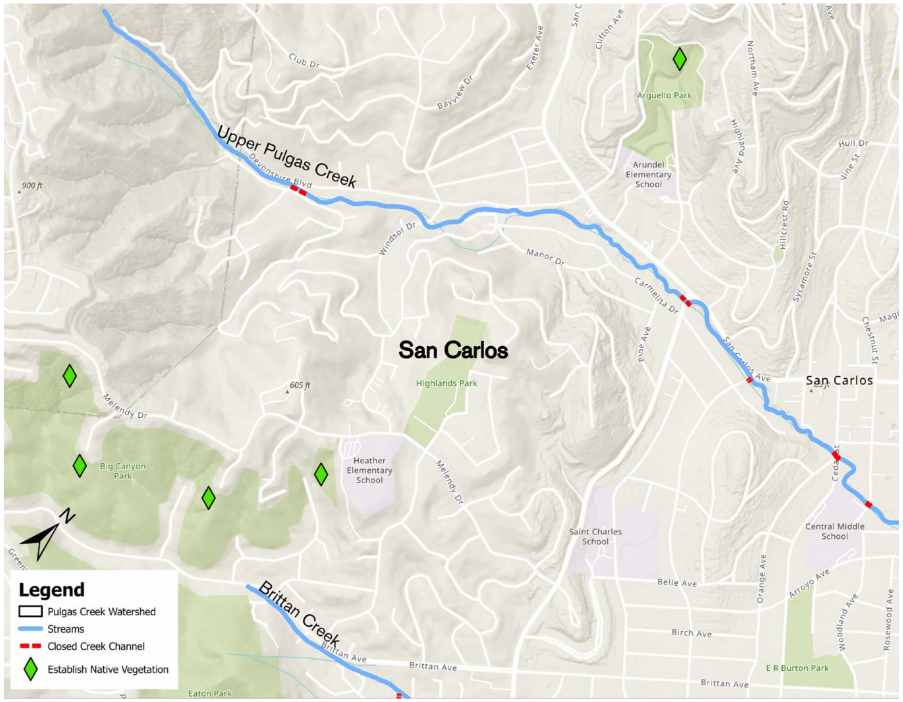


Figure 5.1 Proposed Revegetation Areas

5.2.1 Revegetation

The City can consider implementing a native planting pilot program to better quantify the water runoff improvement at the site and downstream. The pilot program would include establishing a baseline hydrology for existing (non-native) vegetation, removal of non-native vegetation, treatment of topsoil if needed, installation of native plants, seeding and irrigation. It is anticipated that the program should be conducted for a minimum of five years which include maintenance, irrigation and runoff monitoring.

The pilot program would consist of planting native plants such as trees and shrubs specific for the upper watershed (Table 5.1 and Table 5.2). The proposed plant palettes will enhance and expand the tree canopy for a sustainable forest ecosystem that will help reduce sedimentation and erosion.

Next Steps: *City to consider the feasibility of implementing a native plant pilot program as part of the Parks Master Plan.*

Native Plant Pilot Program

Location:	Big Canyon Park
Recommended Size:	Approximately 1.5 acres
Duration:	5 years
Funding:	Attract grants and PhD students to perform monitoring & analysis

Table 5.1: Native Oak Woodland Community Trees for Upland Slopes

COMMON NAME	BOTANICAL NAME	CANOPY SPREAD (FEET)	DECIDUOUS/EVERGREEN	SUN	WATER USE
California Buckeye	*Aesculus californica*	40’	Deciduous	Part (Pt) Shade (Sh), Full (F) Sun	Very Low (VL), Low (L)
Coast Live Oak	*Quercus agrifolia*	15 - 35’	Evergreen	F Sun, Pt Sh	L
Blue Oak	*Quercus douglasii*	30’	Deciduous	F Sun, Pt Sh	L
Garry’s Oak	*Quercus garryana*	30’	Deciduous	F Sun, Pt Sh	L
Valley Oak	*Quercus lobata*	50’	Deciduous	F Sun	L
Interior Live Oak	*Quercus wislizeni*	10 - 50’	Evergreen	F Sun, Pt Sh	VL, L

Table 5.2: Native Shrubs for Upland Slopes

COMMON NAME	BOTANICAL NAME	CANOPY	DECIDUOUS/EVERGREEN	SUN	WATER USE
Chamise	*Adenostoma fasciculatum*	1 - 8'	Evergreen	F Sun	Extremely Low (EL), Very Low (VL)
California Sagebrush	*Artemisia californica*	4'	Summer Deciduous	F Sun	EL, VL
Coyote Bush	*Baccharis pilularis*	12'	Evergreen	F Sun, Pt Sh	VL, L
Ceanothus	*Ceanothus cuneatus*	5 - 12'	Evergreen	F Sun	VL
Blueblossom Ceanothus	*Ceanothus thyrsiflorus*	2 - 40'	Evergreen	Pt Sh	L
Bush Monkey Flower	*Diplacus aurantiacus*	5'	Evergreen	Pt Sh, F Sun	VL, L
Coffeeberry	*Frangula californica*	5 - 15'	Evergreen	F Sun, Pt Sh	L,VL
Coast Silktassel	*Garrya elliptica*	6 - 10'	Evergreen	Pt Sh, F Sun	VL
Toyon	*Heteromeles arbutifolia*	10 - 15'	Evergreen	F Sun, Pt Sh	EL, VL
Silver Lupine	*Lupinus albifrons*	2 - 3'	Evergreen	F Sun	VL
Black Elderberry	*Sambucus nigra*	10 - 20'	Deciduous		L

5.2.2 Floodplain Detention Basins

The San Carlos Parks Master Plan is under development and should consider the integration of floodplain detention basins in the upper watershed parks. Two potential project sites are Arguello Park and Big Canyon Park. The two potential sites would require further engineering study and analysis to optimize the size and location of the floodplain detention basins.

Arguello Park

The City should consider integrating a floodplain detention basin as part of the San Carlos Parks Master Plan for Arguello Park. The floodplain detention basin would capture flow from Arguello Park and detain water during a storm event. Water would flow out of the detention basin and would be connected to the existing storm drain infrastructure on Phelps Road.

Next Steps: *City to consider the feasibility of implementing a floodplain detention basin in Arguello Park as part of the Parks Master Plan. A floodplain design example can be found in* ***Appendix F Cost Estimate Memorandum.***

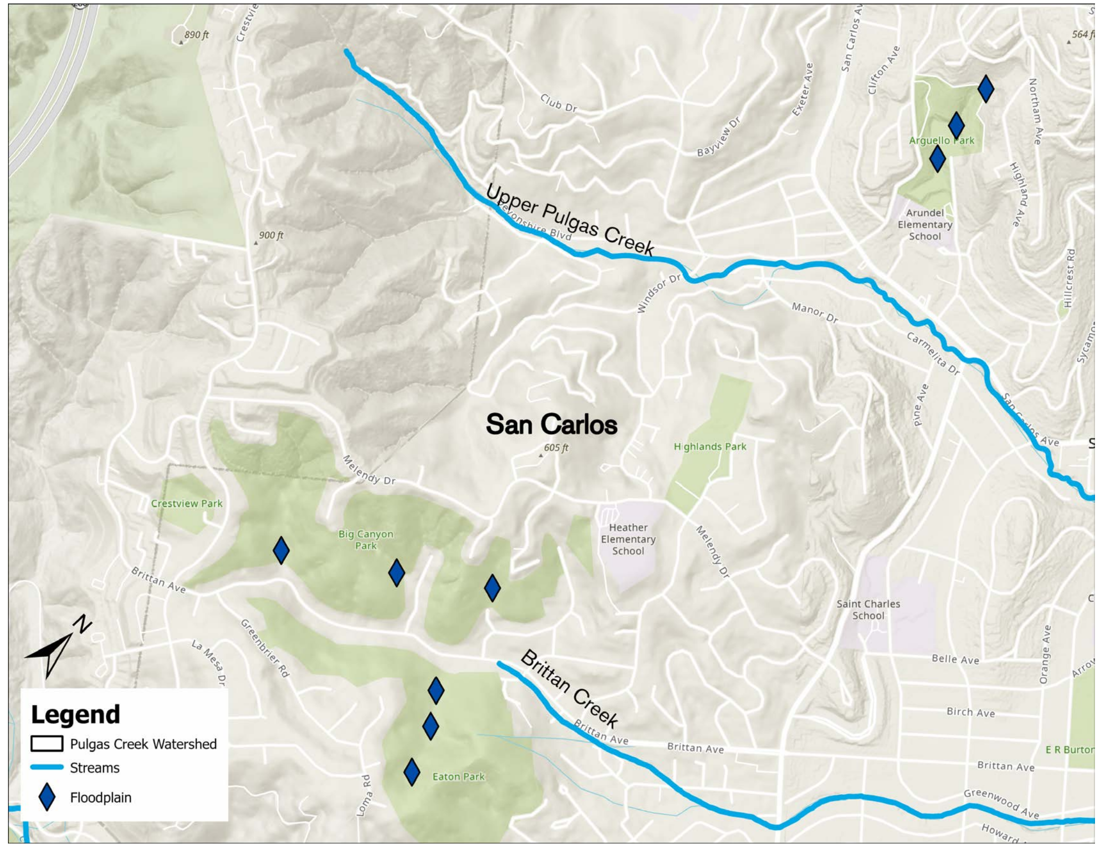


Figure 5.2 Potential Floodplain Detention Locations

Big Canyon Park

The City should consider integrating a floodplain detention basin as part of the San Carlos Parks Master Plan for Big Canyon Park. There is currently a detention area located within Big Canyon Park. This plan recommends that the existing detention area would be further studied and designed to enhance the existing detention area and ensure that the size and elevation are sufficient. The detention basin is already connected to the existing storm drain infrastructure in Brittan Avenue, so no significant change to storm drain infrastructure is anticipated.

Next Steps: *City to consider the feasibility of implementing a floodplain detention basin in Big Canyon Park as part of the Parks Master Plan. A floodplain design example can be found in* ***Appendix F Cost Estimate Memorandum.***

Figure 5.3 Proposed Floodplain Detention Basin Location at Brittan Ave.

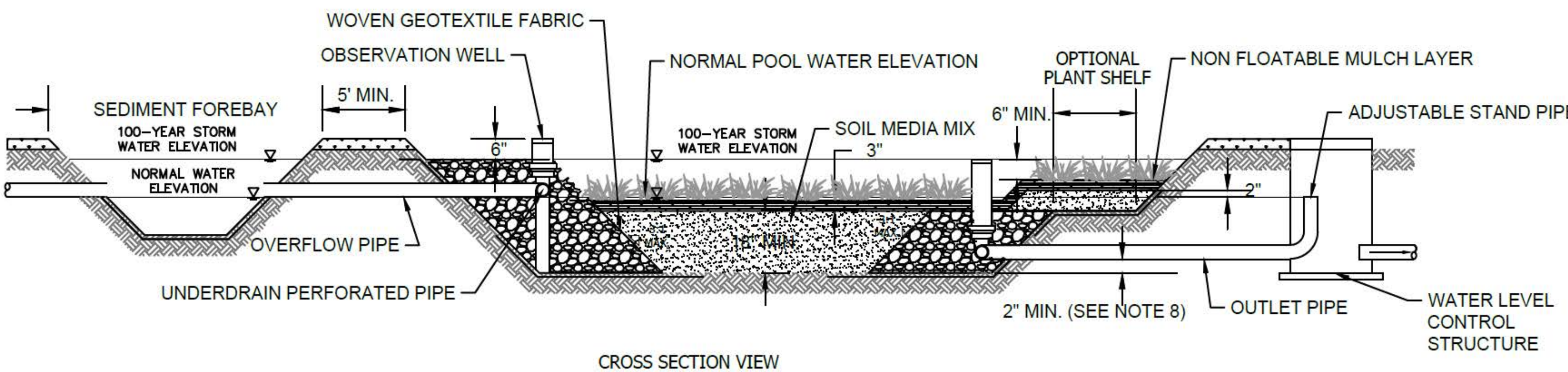


Figure 5.4 Floodplain Detention Basin Concept Design

5.2.3 Underground Detention

The City may consider implementing one or more underground detention basins. Two potential project sites have been initially identified but further engineering study and analysis would be required to optimize the capacity and effectiveness of the underground detention basins.

Burton Park

The City is beginning development of the San Carlos Parks Master Plan and integration of underground detention at Burton Park is recommended to be explored. The City should consider the use of an underground detention basin under the baseball field, tennis courts, or parking lot. Stormwater would be conveyed from Brittan Creek along Brittan Avenue in a new pipeline to the the underground detention basin. Once the storm has passed, water held in the detention basin can be pumped back to the storm drain system on Brittan Avenue.

Next Steps: *City to consider the feasibility of an underground detention basin in Burton Park as park of the Parks Master Plan. See* ***Appendix F Cost Estimate Memorandum for detailed project information.***

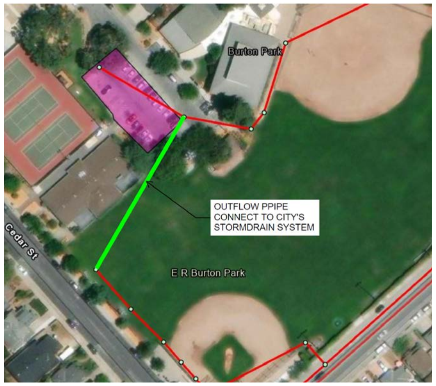


Figure 5.5 Proposed Underground Detention Basin Location at Burton Park

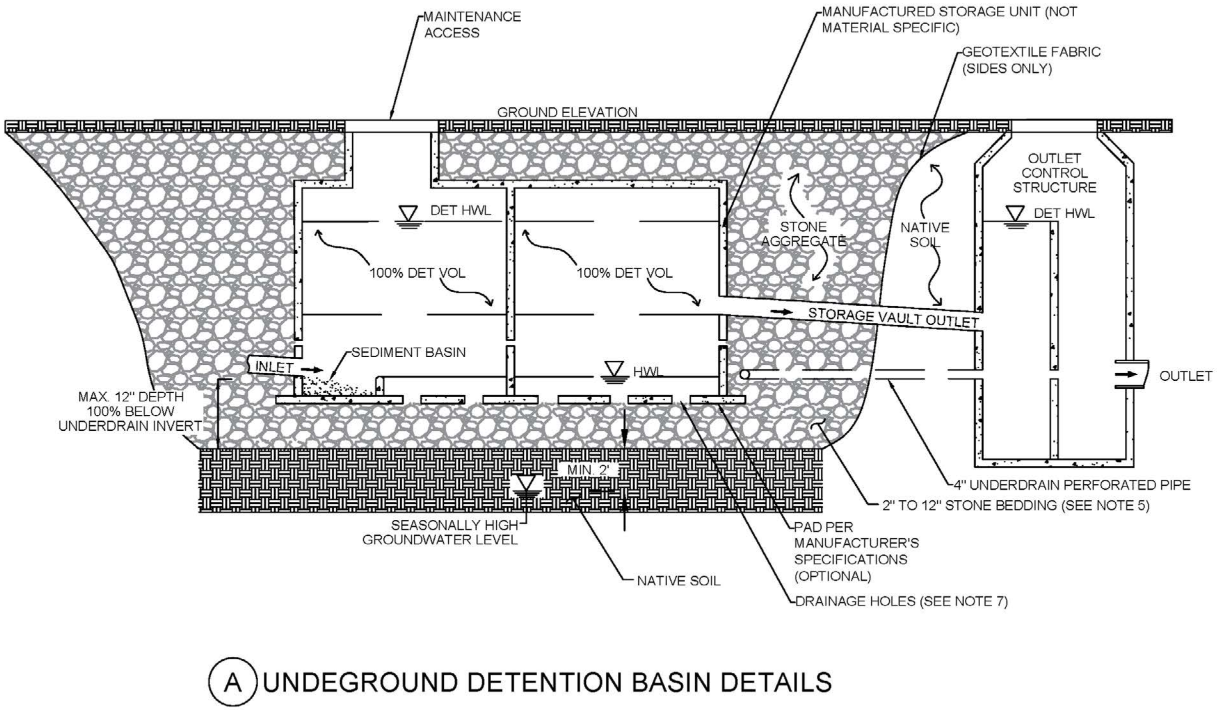


Figure 5.6 Underground Detention Basin Concept Design

El Camino Real

Adjacent to the Caltrain railway between Arroyo Avenue and Brittan Avenue is an underutilized dirt lot that appears to be a combination of private property (Sam Trans) and public right of way that could be utilized for an underground detention basin. Land acquisition may be needed in order to construct a portion of the underground detention basin. The City should consider the use of an underground detention basin within this lot. Stormwater would be conveyed from the open channels.

Next Steps: *City to consider the feasibility of an underground detention basin adjacent to El Camino Real. See* ***Appendix F Cost Estimate Memorandum*** *for detailed project information.*

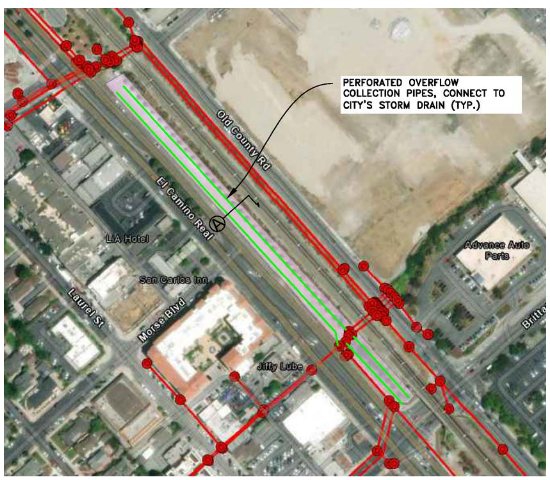


Figure 5.7 Proposed Underground Detention Basin Location at El Camino Real

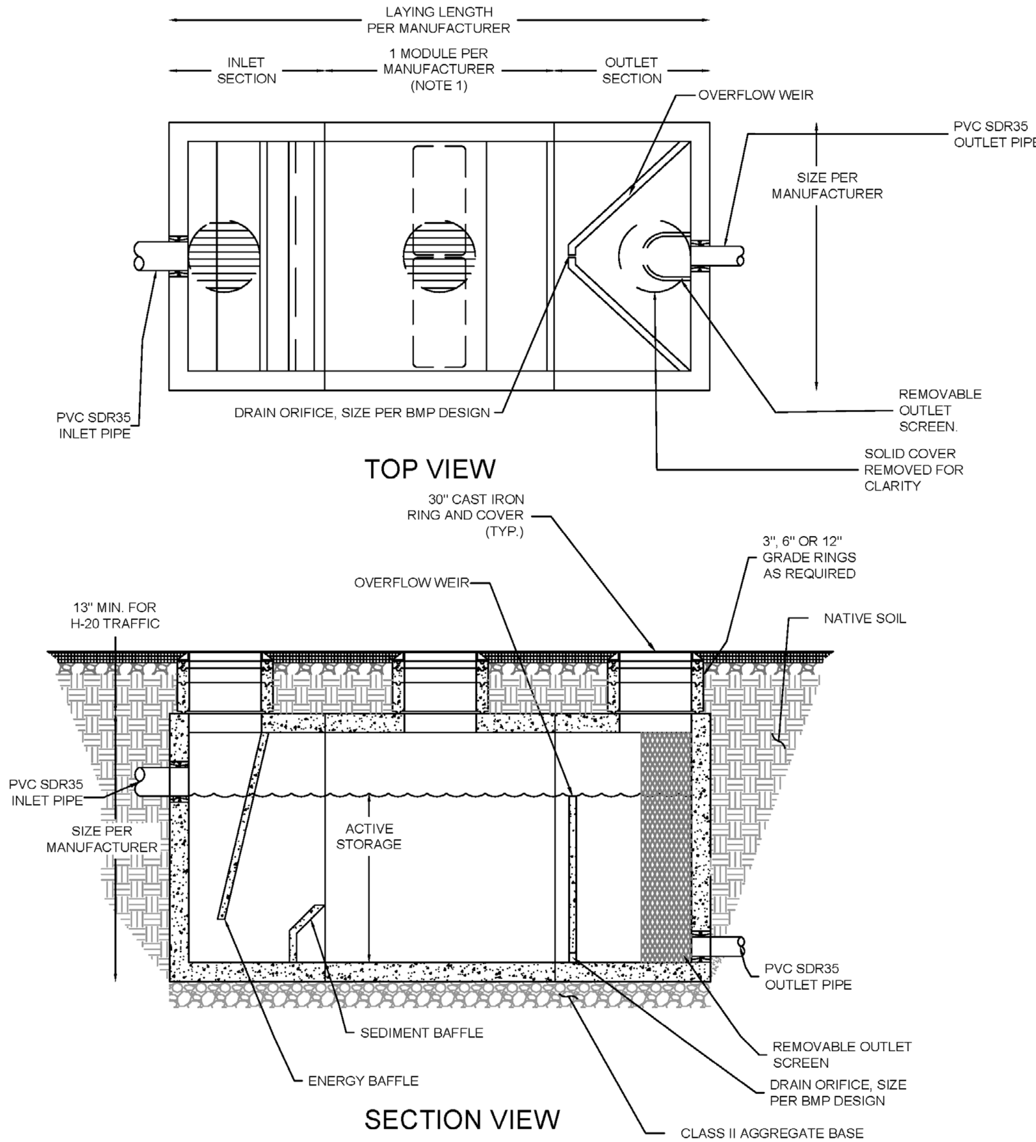


Figure 5.8 Underground Detention Basin Concept Design

5.3 Integrate with Other City Documents and Projects

It is recommended that the City consider implementing LIDs in parks, streets, and open spaces, not only as required by the MRP, but also as stand-alone projects. The City should consider integrating LIDs in City master plans, such as:

- Parks Master Plan
- Streetscape Master Plan, and;
- District-specific master plans

The City has other potential opportunities to incorporate LIDs such as:

- City paving projects
- ADA improvements, such as new or improved curb ramps
- Pedestrian improvements such as crosswalks, bulb outs, and sidewalks
- Bicycle pathway improvements
- Parking lot upgrades

Next Steps: *City to consider feasibility of implementing LIDs in all City projects, including projects considered in master plans.*

5.4 Implement Policy Changes

There are many policies that the city can implement by enhancing existing code, adopting new overlay districts, and conducting additional studies to understand what policies can provide the best benefits for the watershed and the community of San Carlos.

Creek Setbacks

Per the City's Municipal Code (Chapter 18.14 Stream Development and Maintenance (SDM) Overlay District), the existing creek setback requirement is 25-feet from the top of bank, where the top of bank is defined as substantial grade change in natural stream with defined bank or channelized creek or at the 100-year storm surface elevation adjacent to a waterway without a defined bank. It is recommended that the creek setback remain 25-feet in residential and mixed-use zoning districts due to the location of existing structures that are adjacent to the creek.

The City's Municipal Code does not differentiate between creek setback requirements for residential, mixed-use zoning districts and other zoning districts. It is recommended that the City consider creating a creek setback for new development within commercial and industrial zoning districts along the creeks. Consistent with OneShoreline's recommendation, a minimum of 35-feet is recommended for the creek setbacks in these zoning districts.

The policy for creek setbacks in commercial and industrial zoning districts should require restoration of creek for any new developments, including removing non-native plants, planting native plants, repairing any erosion, and creating publicly accessible spaces including creek trails and open space.

Next Steps: *City to consider developing potential revisions to the ordinance.*

Creek Setback Waivers

Per the City's Municipal Code, all new development shall be set back a minimum of 25-feet from the top of bank line or such other distance as specified by the Planning and Transportation Commission. Property owners can go to the Planning and Transportation Commission to ask for an alternative creek setback distance. To request an alternative creek setback distance, a biological resources technical memorandum is required to document existing site conditions, proposed site conditions and recommended construction best management practices (BMP). To aid the Planning and Transportation Commission in determining if an alternative creek setback distance is recommended, the City should create a creek setback waiver checklist. The checklist should include documents needed from the property owner and quantitative measures that would allow for a reduced creek setback.

Next Steps: *City to consider creating a creek setback waiver checklist that includes quantitative measure that allow for a reduced creek setback. For commercial and industrial zoning districts, the City should consider that all waivers require City Council approval.*

Sea Level Rise Overlay District

As climate changes and sea levels rise, San Carlos will likely experience more instances of flooding. It is crucial to identify the sea level rise area in San Carlos and ensure that the residents, businesses, and critical infrastructure are protected. This plan recommends that the City consider developing and adopting a Sea Level Rise Overlay District or Zone with associated land use regulations for site planning and minimum construction elevations that support appropriate mitigation and adaption in response to sea level rise data. Policies with the associated District or Zone could include:

- Increasing required amount of stormwater retention on site
- Requiring documentation of building elevation
- Requiring fees to fund restoration of creeks

In addition to adopting a Sea Level Rise Overlay District, it is recommended that the City continue to participate in and develop countywide strategies to update development standards and ordinances for at-risk areas.

The City should adopt a Sea Level Rise Overlay District. The City would need to develop a policy that includes:

- Sea Level Rise Overlay boundaries and map
- Development standards including floor elevation, floodproofing critical equipment, buffer zones from the San Francisco Bay Shoreline and creeks
- Additional Requirements for shoreline barriers

The policy should be consistent with OneShoreline Planning Policy Guidance and in coordination with adjacent jurisdictions.

Next Steps: *City to consider developing and adopting a Sea Level Rise Overlay District utilizing OneShoreline's Planning Policy Guidance.*

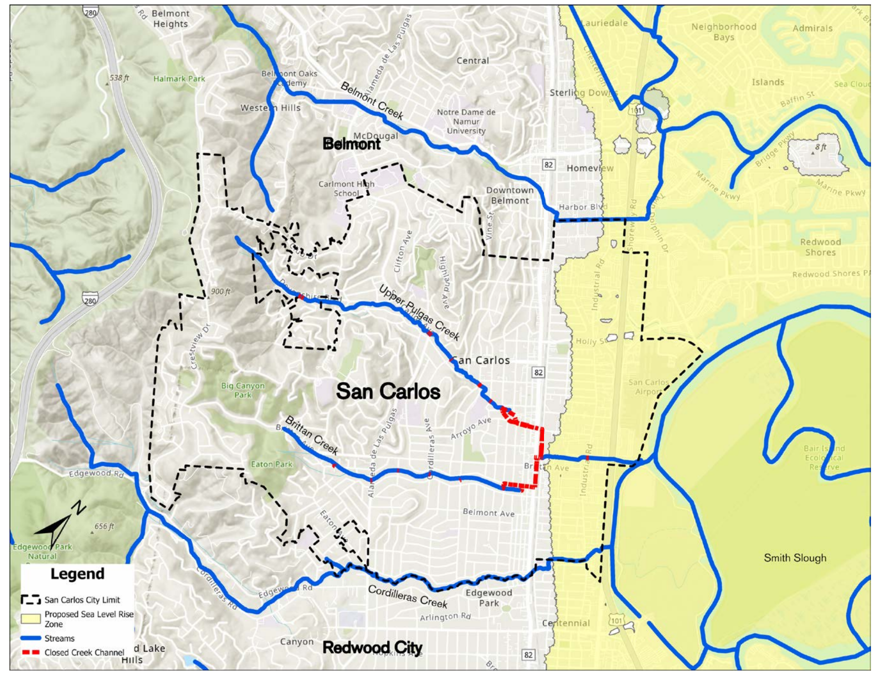


Figure 5.9 Sea Level Rise Overlay District Map Recommended by OneShoreline

Shallow Groundwater Rise Overlay District

As climate changes and sea levels rise, groundwater is also anticipated to rise. The rise of groundwater can create numerous potential impacts on the community. It is necessary to identify the groundwater rise in San Carlos and ensure that the residents, businesses, and critical infrastructure are protected. This plan recommends that the City consider developing and adopting a Shallow Groundwater Rise Overlay District or Zone (Figure 5.10) with associated land use regulations for site planning and standards that support appropriate mitigation and adaption in response to shallow groundwater. Policies with the associated District or Zone could include:

- During the planning stage a report should be submitted. Report should include assessment of project's vulnerability to future shallow groundwater rise.
- During the building permit process, compliance should be confirmed.
- Incorporation of project measures that monitor and mitigate shallow groundwater impacts

The City should adopt a Shallow Groundwater Rise Overlay District. The City would need to develop a policy that includes:

- Shallow Groundwater Overlay boundaries and map
- Development standards to address future groundwater conditions, contaminated sites, liquefaction, below grade structures and utilities, and roadway subgrades
- Requirement of additional performance standards such as, geotechnical data collection, topographic data collection, vulnerability assessment and mitigation and real estate disclosure of hazards.

The policy should be consistent with OneShoreline Planning Policy Guidance and in coordination with adjacent jurisdictions.

Next Steps: *City to consider developing and adopting a Shallow Groundwater Rise Overlay District utilizing OneShoreline Planning Policy Guidance.*

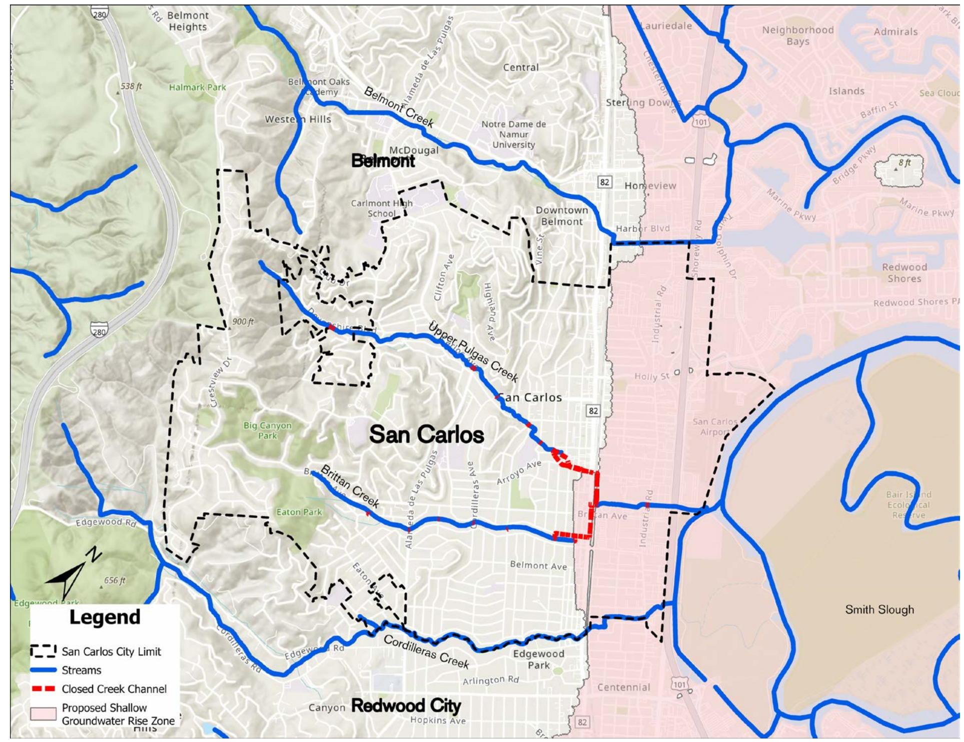


Figure 5.10 Shallow Groundwater Rise Overlay Map Recommended by OneShoreline

FEMA Community Rating System

San Carlos participates in the FEMA Community Rating System (CRS). CRS is a voluntary incentive program that recognizes and encourages community floodplain management practices that exceed the requirements of the National Flood Insurance Program (NFIP). CRS credits community efforts to surpass the minimum requirements and awards reduced flood insurance premiums for the community's property owners. San Carlos should continue to participate in CRS and study the full extent of the program's benefits, which reduce flood insurance premiums and can help save lives and property when a flood occurs.

The goals of the CRS are to (1) reduce and avoid flooding damage to insurable property, (2) strengthen and support the insurance aspects of the NFIP, and (3) foster comprehensive floodplain management. There are opportunities to continue to exceed the minimum requirements of NFIP, which could lead to further flood insurance premium rate discounts, including creating policy related to stormwater management regulations, such as:

- Size of Development (SZ): Credit is based on the minimum size of the area that is required to comply with stormwater management standards.
- Design Storms (DS): Credit is based on what design storm the community is using in the regulations.
- Low-Impact Development (LID): Credit is provided only if the community's stormwater management ordinance requires the use of LID.
- Public Maintenance (PUB): Credit is provided when the owners of all new facilities are required to allow the community to inspect stormwater management as necessary and perform the required maintenance.

San Carlos is currently a CRS Class 9 with a 5% discount for FEMA designated Special Flood Hazard Areas (SFHA) / Non-SFHA. By creating policies noted above, San Carlos could be eligible to earn CRS credits and reduce flood insurance premiums.

This plan recommends that San Carlos conduct a study to understand the cost-benefit of implementing policies that surpass NFIP to improve the CRS score resulting in reduced flood fees. The study should investigate CRS policy recommendations to understand the associated CRS credit that allow for premium discounts. In addition, the study should help guide and establish policies that will continue to help prepare the community for future flood events.

Next Steps: *City to consider further studies to understand the cost-benefit to implementing policies that improve the Community Rating System score that may allow for premium flood insurance discounts.*

5.5 Perform Annual Maintenance

The City's Public Works Department maintains the City's infrastructure, public parks, and LIDs in public right-of-way. Currently, to prepare for the rainy season, the City begins maintenance on all the storm drain structures in August through October. The storm drain infastructure is also cleaned throughout the rainy season with a final check typically at the end of the rainy season, around late March or April.

The City should consider developing standard operating procedures (SOP) for the continual maintenance of LID features within parks and right-of-ways. The SOPs should include:

- Vegetation maintenance schedule
- Inspections checklists
- Routine maintenance checklists

By developing standard operating procedures, the maintenance for the different LIDs can be properly maintained to ensure that the LID continue to function as intended.

The City should continue to take advantage of the San Mateo Countywide Water Pollution Prevention Program (SMCWPPP), which provides municipal staff with training in key areas of the MRP and also reference the Flows to Bay site for any additional training.

Next Steps: *City to consider developing standard operating procedures for maintaining the different types of city-owned LIDs.*

5.6 Implement Proposed Programs

Property Owners Education Program

As property owners adjacent to a creek, it is integral to take care of the watershed by maintaining the creek on your property to ensure it is free of debris and litter. It is recommended that the City consider developing a program to provide education and support for homeowners adjacent to the creek[7]. City should evaluate permitting process and consolidation with other agencies. City could partner with Master Gardners group and provide native planting education targeted to creek side property owners.

The City could explore providing specialized workshops and engagement for open space adjacent properties and creekside property owners. Some of the workshops can touch on improving drainage and reducing landslide risk on their own property as a way to improve overall watershed health.

As part of this program, a Creekside Property Owner's Manual can be provided. The manual is a guide that will help property owners understand how to maintain healthy creeks, how to recognize and prevent erosion on their property, and any available resources.

Access to this program can be provided online to all residents via QR code at parks and open space sites or mailed as flyers to creekside property owners.

Interpretive Signage and Programs

Signage can be around drains, ditches, LID features, and stream crossing throughout the parks, open spaces, and City wide to educate the residents about flood resiliency, stormwater management, and hydrology of the watershed and other related topics. This can help raise awareness about resilient infrastructure.

Interpretive Signage

Galvanized steel railing and interpretive signage at Codornices Creek in Berkeley by Restoration Design Group with Leslie Stone Associates., Source: https://www.restorationdesigngroup.com/interpretation

Adopt a Drain

There are over 600 drains in the City's storm drain network. Stormwater captured in these drains eventually ends up in one of the City's creeks and ultimately in the San Francisco Bay and the Ocean. When leaves, trash, or other debris cover the drain, it reduces the efficiency of the drain and can lead to flooding. Also, any of the leaves, waste, or other debris that accumulate in the storm drains throughout the year and can be carried directly into the city's creeks.

The Adopt a Drain program will enable anyone who lives, works, or spends time in San Carlos to become environmental stewards of their neighborhood by adopting one of the 600 storm drains and pledge to keep your drain free of leaves and debris, especially prior to a storm. By adopting a drain, you are partnering with the City and your community in helping to protect the environment, help manage stormwater and minimize flooding.

SAN CARLOS
ADOPT A DRAIN

Artwork

Artwork can bring awareness to storm water infrastructure, creeks or channels that typically go unnoticed. Artwork can also be a wonderful opportunity to engage the community and promote awareness. The City should consider implementing a program similar to City of Burlingame's Storm Drain Murals Pilot Project, where digital artwork was requested from the community for murals on key storm drain locations. The murals can draw attention from the community and allow an opportunity for education on the storm drain.

Figure 5.11 Burlingame Storm Drain Mural by Angela Chen, Photo Credit: City of Burlingame

Next Steps: *City to consider implementing programs to expand awareness and education of how the community can participate in maintaining the watershed.*

06.
Recommendations - Developer

Chapter 6: Recommendations - Developer

6.1 Introduction

Each community member will serve varying roles to implement the strategies identified in Chapter 4. This section is organized to present actions that could be taken by developers.

To implement the various proposed project strategies, permitting requirements must be acknowledged. For further discussion regarding permitting requirements, please see Chapter 8.

The development community has a prominent role in maintaining, protecting and enhancing the watershed by:

- Integrating LID improvements into site development
- Complying with City policies
- Implementing Community benefit improvements
- Performing annual maintenance of private infrastructure

6.2 Integrate LID Improvements into site development

Developers are required by the MRP to integrate stormwater management infrastructure on site. LIDs should be implemented to treat stormwater and the developer should consider other opportunities to improve stormwater capture and management onsite. Developers should strive to go above the current requirements of the MRP to contribute to enhancing the watershed.

Next Steps: *Early in site development activities, developer should identify all LID strategies and collaborate with the City to expand LID and GI above minimum requirements as community benefits, see Section 6.5 Implement Community Benefit Improvements.*

6.3 Obtain LEED Certification

The U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED) certification should be encouraged for all developments, especially those adjacent to creeks, within the Stream Development and Maintenance (SDM) Overlay District. It is the world's most widely used green building rating system and new developments are always looking for ways to gain LEED certification. LEED certification provides developers with a framework to design and construct highly efficient and cost-saving green buildings. Although all LEED categories will benefit the community, there are four key LEED categories that are consistent with the Watershed Plan and should be highlighted to developers. The LEED categories and requirements summaries are listed below.

- Protect or Restore Habitat
  - » Preserve and protect 40% of the greenfield area on the site (if exists)
  - » Restore portion of site (15 - 25%) and follow LEED vegetation and soil requirements
- Open Space
  - » Provide outdoor space greater than or equal to 30% of the total site area
  - » 25% of the required outdoor space must be vegetated space
  - » Outdoor Space must be physically adjacent to one or more of the following: social areas, recreational areas, diverse green space, gardens, or habitat areas

- Rainwater Management
    - » In a manner best replicating natural site hydrology processes, retain on-site the runoff from the local rainfall events (80-90%). Must be retained using low-impact development (LID) and green infrastructure (GI) practices.
- Heat Island Reduction
    - » Provide a vegetated roof using native or adapted plant species

Next Steps: *Developer to consider implementing additional site enhancements detailed in each LEED category, which may improve marketing of the site.*

6.4 Comply with City Policies

Maintenance of the creek is required through San Carlos' code (13.14.120 Watercourse Protection), which requires owners, lessees, or tenants with creeks within the property to keep and maintain the creek reasonably free of trash and debris, excessive vegetation, and other obstacles that would pollute, contaminate or significantly impact the flow water. Developers should ensure that the creek within the property is compliant with the watercourse protection code.

Next Steps: *Creekside developers are required to maintain the creek per the Watercourse Protection ordinance.*

6.5 Implement Community Benefit Improvements

To continue to enhance and provide access to the creek, developers should consider implementing the following onsite:

- Publicly accessible open space areas, including the continuation or development of creek trails that are accessible to the community, including consideration of creek adjustments
- Rehabilitation and restoration of the creek within the project's property
- Interpretive signage to further inform and educate the public of the project's green infrastructure on site or key creek elements

Creek Alterations

Creek alterations considers opportunities to work directly in the creek by integrating multiple interests and project partners. Projects such as the bank stabilization project for privately owned streambanks should be thought of as opportunities for ecosystem restoration, flood risk mitigation, and park planning. Widening of the creek provides opportunities for improved creek access and should be considered by creekside developers. Currently, much of Pulgas Creek and Brittan Creek exists underground in man-made storm conveyance features or within private parcels. Most creek crossings through public land involve tributary flow through parks or main channel flow through street crossings. In-channel work to alleviate flooding typically involves expansion of restrictive conveyance structures, or channel widening, which all require extensive funding and real estate.

Further studies will need to be done to understand the specific political, legal, and monetary viability to widen the creek.

Next Steps: *Developers should consider implementing community benefits, including utilizing the creek setback for flood mitigation and public access.*

6.6 Perform Annual Maintenance of Private Infrastructure

As part of the MRP, maintenance is required for the constructed LID measures. The property owner is responsible for the maintenance of the stormwater treatment measures and are detailed out in an Operation and Maintenance Agreement. Inspection and maintenance of privately owned features should be site specific to ensure that the different measures can continue to work at it's optimal function.

Next Steps: *Developers are required to perform annual maintenance detailed out in the Operation and Maintenance Agreement for the site.*

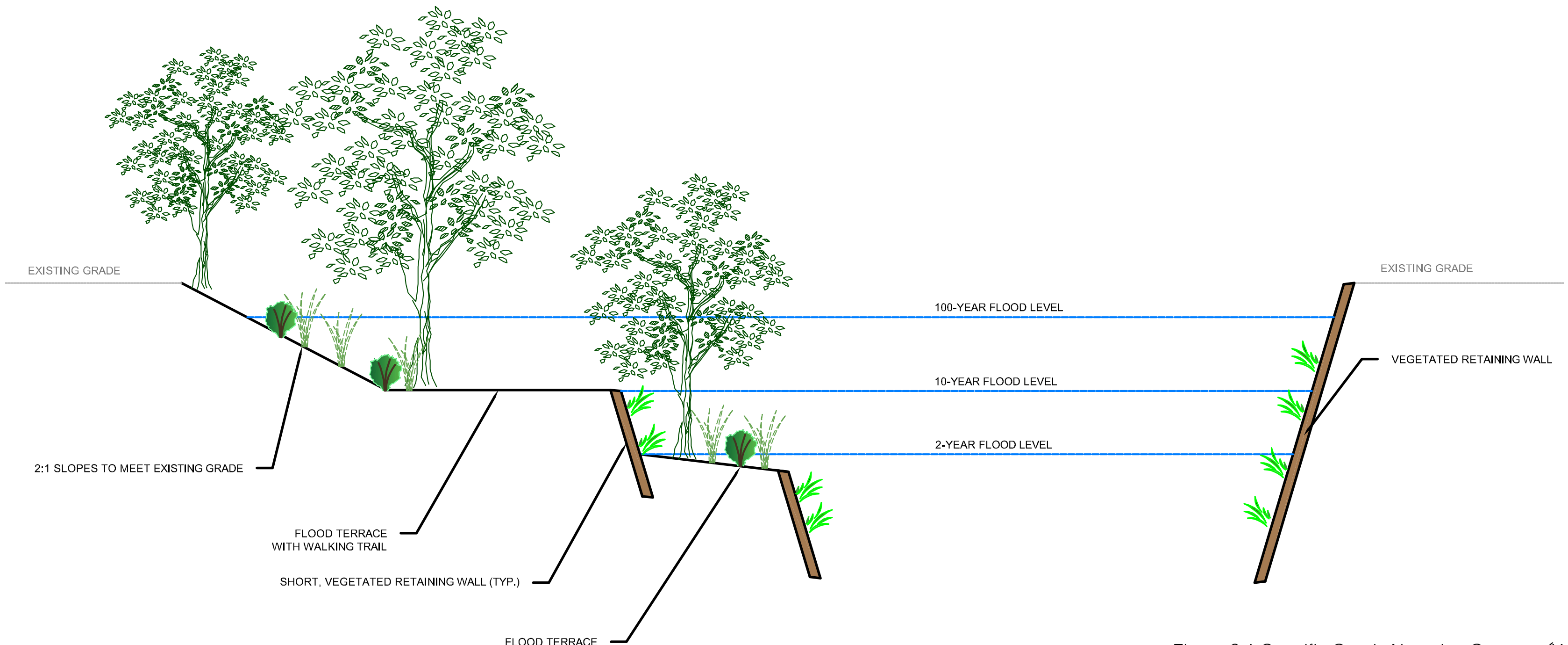


Figure 6.1 Specific Creek Alteration Concept (Widening)

07.

Recommendations - Residential

Chapter 7: Recommendations - Residential

7.1 Introduction

Each community member will serve varying roles to implement the strategies identified in Chapter 4. This section is organized to present actions that could be taken by the residential community.

To implement the various proposed project strategies, permitting requirements must be acknowledged. For further discussion regarding permitting requirements, please see Chapter 8.

The residential community has a prominent role in maintaining a healthy watershed. Some potential areas that can be led by residents are:

- Integrate LID improvements into property remodels
- Comply with City policies
- Implement revegetation improvements
- Perform annual maintenance of private infrastructure
- Participate in Community Programs

7.2 Integrate LID Improvements into Property Remodels

The residential community should consider integrating LID improvements into property remodels, such as installing rain gardens into their lawns. The rain gardens are typically in low-lying areas where stormwater runoff gathers.

Residents are eligible to receive rebates through the Bay Area Water Supply and Conservation Agency (BAWSCA) Lawn Be Gone! Program, further described in Section 7.6 Participate in Community Partnerships.

Next Steps: *Residents to consider implementing LID improvements within property.*

7.3 Comply with City Policies

Maintenance of the creek is required through San Carlos' code (13.14.120 Watercourse Protection), which requires owners, lessees, or tenants with creeks within the property to keep and maintain the creek reasonably free of trash and debris, excessive vegetation, and other obstacles that would pollute, contaminate or significantly impact the flow water.

Next Steps: *Creekside residents are encouraged to read through the Watercourse Protection ordinance to understand maintenance requirements.*

7.4 Implement Revegetation Improvements

All residents, especially creekside residents, should implement revegetation improvements within their property. This includes planting native plants within their property including areas within the creek setback. Residents can find planting palettes for creekside projects and private properties in **Appendix E: Revegetation Benefits and Palettes for San Carlos**.

Residents who implement revegetation improvements that include removing lawns and planting drought-tolerant native plants can receive rebates. Residents are eligible to receive rebates through the *Cal Water Lawn-to-Garden Program*, further described in Section 7.6 Participate in Community Partnerships.

Next Steps: *Residents to consider implementing native revegetation within property.*

7.5 Perform Annual Maintenance of Creek and Private Infrastructure

Residents should perform annual maintenance of their private property. Annual Maintenance of residents' properties, especially adjacent to the creek is required by code as noted in previous sections. Annual maintenance can contribute to the following:

- Minimizing erosion
- Preserving water quality
- Avoiding flood damage
- Contributing to the survival of fish and wildlife
- Minimizing creek contamination
- Preserving the creek in a natural state
- Keeping San Carlos beautiful

Annual maintenance should occur prior to the wet season, and can include:

- Clearing debris off any storm drains
- Clearing trash and debris out of the creek
- Monitor erosion adjacent to creek

When maintaining the creek on resident's property, residents should consider participating in San Carlos' annual Creek Clean Up Day that is described in "7.6 Participate in Community Programs."

Next Steps: *Residents to consider performing annual maintenance of property.*

7.6 Participate in Community Programs

Maintaining the watershed is a community effort. There are existing programs that the community can participate it.

Annual Creek Clean Up Days

San Carlos creeks and streams are important for conveying storm water and providing a habitat for wildlife including birds, fish, and vegetation. Because the creeks and streams are so important the City hosts an annual Creek Clean-up Day. Typically hosted on a Saturday in September, the City invites all creek-side residents and neighbors to volunteer and clean up the creek that runs adjacent to the property. Clean-up includes trash, yard clippings, or any other materials that are not natural or native to the creek.

As part of the Creek Clean-up Day, City crews will pick up items removed from the creek areas. To participate in this event please call (650) 802-4140 and leave a message to be placed on the pick-up list. The message should include your name and address in the message.

Flyers for this event are mailed to all creek property owners. The creek maintenance flyer can also be found on the City's website.

San Carlos Day of Service

San Carlos Day of Service is a one-day celebration of the City through acts of community service. The Day of Service was started in 2017 and consists of volunteers from around the community that participate in city-wide projects ranging from volunteer projects, pledges to donate items, or services that give back to the community. In the past few years, the day of service has included mulch distribution in parks and planting trees.

Additional information on dates, volunteer projects, and sign ups can also be found on the City's Day of Service website.

SAN CARLOS DAY OF SERVICE

Cal Water Lawn-to-Garden Program

Through Cal Water Conservation Rebates, the Lawn-to-Garden Program, property owners can receive up to a $3 per square foot rebate by transforming lawns with low water use, California-friendly, drought-tolerant landscaping.

Learn more information and how to receive a rebate from the Cal Water Lawn-to-Garden Program.

County Wide Rain Barrel Rebate & Program

Through Flows to Bay, the Countywide Rain Barrel Rebate Program property owners can qualify for up to $200. Rain barrels are an effortless way that homeowners can reduce the amount of pollution that enters our waterways. Some other benefits include:

- Saving money and water by cutting back potable water usage for irrigation
- Protecting local creeks, the San Francisco Bay, and the Ocean by reducing urban runoff that transports pollutants into the storm drain system
- Moderate flooding during rainy weather season and decreasing land erosion

In addition to the County Wide Rain Barrel Rebate, the County Wide Rain Barrel program opens every fall. The program allows the community to buy 50-gallon Ivy Rain Barrels at a discounted price. The program is only for a limited time and while supplies last.

Learn more information and how to receive a rebate from the Countywide Rain Barrel Rebate Program or to how to purchase a discounted rain barrel from the Countywide Rain Barrel Program.

Figure 7.1 Rain Barrels, Flows to Bay

Bay Area Water Supply and Conservation Agency (BAWSCA) Lawn Be Gone! Program

Through BAWSCA's Lawn Be Gone! Program, property owners can receive up to a $4 per square foot rebate for up to $300 by replacing traditional lawn with landscape that includes plants, flowers, and landscape elements. All eligible Lawn Be Gone! Projects that include a qualifying rain garden will be rebated an additional $300. Some benefits include:

- Redirecting moisture away from a building's foundation
- Reducing localized flooding
- Filtering out pollutants in runoff

Learn more information and how to receive a rebate from the BAWSCA's Lawn Be Gone! Program.

Next Steps: *Residents to consider participating in community events and rebate programs.*

7.1.5 Key Informational City Websites

For additional information on what residents can do, San Carlos maintains multiple informational City websites that the community can reference for key topics, including:

- Creek Maintenance
- Storm and Flood Preparation
- Water Conservation

08.
Permitting Requirements

Chapter 8: Permitting Requirements

8.1 Permitting Requirements

The City, developers, and residents are responsible for obtaining the correct permits for proposed work. Table 5.3 represents a high-level assessment of potential aquatic resource permitting that may be needed for the various watershed management activities. Since project solutions may be adjacent to or within the creek below are some key items to note:

- Any earthwork and/or maintenance of existing structures within creeks, channels, and/or along creek banks would likely trigger permitting with:
  - U.S. Army Corps of Engineers (Corps)
  - Regional Water Quality Control Board (RWQCB)
  - California Department of Fish and Wildlife (CDFW).
- Above ground aquatic areas within the project area should be reviewed to evaluate for special-status species known to occur in proximity of the project. Some common special species include:
  - California red-legged frog (Rana draytonii, CRLF; federally threatened) is the species of most concern for creeks within this region and may be potentially present within or near specific project sites, particularly creeks, ponds, and riparian areas near natural open spaces.
  - Bay checkerspot butterfly (Euphydryas editha bayensis; federally threatened), which could be located in sites that are adjacent to serpentine habitat.
- Below ground work (i.e. work contained entirely within culverts or subsurface storm drains) would not trigger the need for permits.
- The Bay Conservation and Development Commission (BCDC) jurisdiction is applicable for any projects occurring within 100-feet of San Francisco Bay.

Individual project areas and sites in stream channels and in natural areas should be evaluated for potential biological resources (including sensitive natural communities and special-status species). This should be done in advance of any design work preparation to help inform design constraints.

Table 8.1: Potential Aquatic Resource Permitting

PROJECT SOLUTIONS	ANTICIPATED AQUATIC RESOURCE REGULATORY PERMITTING	RECOMMENDATIONS
Revegetation	No aquatic resource permits required.	Site evaluation for special-status plants, wildlife, and sensitive biological communities.
Floodplain Detention Basins	Work within the creek channel, banks, and/or adjacent riparian habitat triggers permitting with the following agencies: ▪ U.S. Army Corps of Engineers ▪ Regional Water Quality Control Board ▪ California Department of Fish and Wildlife	Conduct delineation of waters and a detailed biological resources evaluation prior to detailed design work.
Underground Basin	Permits are needed if/where underground basins connect to above ground aquatic features.	Evaluate individual project sites to confirm presence/absence of waters. If/where waters are present, conduct a delineation of waters. Conduct detailed biological resources evaluation.
Low Impact Development (LID)	Aquatic resource permits are only required if activity will occur within a channel/aquatic feature or connection to stream/creek.	Evaluate individual project sites to confirm presence/absence of waters. If/where waters are present, conduct a delineation of waters. Conduct detailed biological resources evaluation for locations outside of developed land.
Creekside Public Access	Permits are required if/where public access features affect creek bank or riparian vegetation. Permits likely only needed from: ▪ Regional Water Quality Control Board ▪ The California Department of Fish and Wildlife.	Conduct delineation of waters and a detailed biological resources evaluation prior to detailed design work. Conduct tree survey if riparian trees will need to be removed.
Inspection & Maintenance	Permits are needed for operations and maintenance activities in above ground aquatic resources.	It is recommended to explore a programmatic approach for permitting of O&M activities, as opposed to getting permits for each individual O&M project.

09.
Funding Sources

Chapter 9: Funding Requirements

9.1 Funding Sources

As discussed in earlier chapters, there is a variety of proposed projects, programs, and policies that the City could choose to pursue. To fund these solutions, there are multiple potential funding sources including local, regional, state, and federal. The City should consider taking advantage of collaborating with private developers to fund specific projects.

Federal

- Flood Mitigation Assistance Program, *Federal Emergency Management Agency (FEMA)*
- Pre-Disaster Mitigation Program, *FEMA*
- Hazard Mitigation Grant Program, *FEMA*
- Cooperating Technical Partners Program, *FEMA*
- Emergency Management Performance Grant, *FEMA*
- Community Change Grants, *US Environmental Protection Agency*

State

- Addressing Climate Impacts, *California Department of Fish and Wildlife*
- Senate Bill 1 Sea Level Rise Adaptation Planning Grant Program, *Ocean Protection Council*
- Coastal Conservancy Grants, *Coastal Conservancy, State of California*
- Riverine Stewardship Program, *California Department of Water Resources*
- Watershed Coordinator Program, *California Department of Conservation*
- Urban Greening Program, *California Natural Resources Agency*
- Statewide Park Development and Community Revitalization Program, *California Department of Parks and Recreation*
- Urban and Community Forestry Program, *California Department of Forestry and Fire Protection*

State Loan

- Clean Water State Revolving Fund (CWSRF) Program – Construction, *California State Water Resources Control Board*

Private

- Better Together Nature Positive Innovation Grant Program, *Pacific Gas and Electric Company (PG&E)*
- Five Star Urban Waters Restoration Grant Program, *National Fish and Wildlife Foundation*

Table 9.1: Funding Sources Summary

	NAME	AGENCY	MINIMUM/MAXIMUM AMOUNT
FEDERAL	Flood Mitigation Assistance Program	FEMA	Dependent /$40,000,000
	Pre-Disaster Mitigation Program	FEMA	Dependent
	Hazard Mitigation Grant Program	FEMA	Dependent /$35.333 billion
	Cooperating Technical Partners Program	FEMA	Dependent
	Emergency Management Grant Program	FEMA	Dependent
	Community Change Grants	US Environmental Protection Agency	$1 Million/$20 Million
STATE	Addressing Climate impacts	California Department of Fish and Wildlife	Dependent
	Senate Bill 1 Sea Level Rise Adaptation Planning Grant Program	Ocean Protection Council	$200,000 / $1,500,000
	Coastal Conservancy Grants	Costal Conservancy, State of California	$200,000 / $8,000,000
	Riverine Stewardship Program	California Department of Water Resources	Dependent
	Watershed Coordinator Program	California Department of Conservation	Dependent
	Urban Greening Program	California Natural Resources Agency	Dependent
	Statewide Park Development and Community Revitalization Program	California Department of Parks and Recreation	$200,000/$8,500,000
	Urban and Community Forestry Program	California Department of Forestry and Fire Protection	Dependent
STATE LOAN	Clean Water State Revolving Fund Program - Construction	State Water Resources Control Board	Dependent
PRIVATE	Better Together Nature Positive Innovation Grant Program	PG&E	$100,000 for 5 projects
	Five Star Urban Waters Restoration Grant Program	National Fish and Wildlife Foundation	$30,000 / $60,000

Endnotes

Endnotes

1 U.S. Environmental Protection Agency. (2012, April). Benefits of Healthy Watersheds. Retrieved from U.S. Environmental Protection Agency: https://www.epa.gov/hwp/benefits-healthy-watersheds

2 California Department of Conservation - California Geological Survey. (2015). Landslide Inventory and Deep Landslide Susceptibility Map. San Carlos, California, USA.

3 San Mateo County. (2019). Drainage Manual.

4 California Department of Water Resources. (2024). Sustainable Groundwater Management Act (SGMA) Data Viewer. Retrieved from Well Site Code 374907N1222309W002: https://sgma.water.ca.gov/webgis/?appid=SGMADataViewer#gwlevels

5 Wilcox, B. P., Turnbull, L., Young, M. H., Williams, J. C., Ravi, S., Seyfried, M. S., . . . Wainwright, J. (2012). Invasion of shrublands by exotic grasses: ecohydrological consequences in cold versus warm deserts. ECOHYDROLOGY, 160-173.

6 Canopy. (2016). Retrieved from Urban Trees and Climate Change: https://canopy.org/tree-info/benefits-of-trees/urban-trees-and-climate-change/

7 Contra Costa Clean Water Program funds an Urban Creeks Council's Stream Management Program for Landowners (SMPL) which provides advice, services, educations about creek care to Contra Costa County property owners.

References

CSG Consultants, Inc. (2019). *City of San Carlos Green Infrastructure Plan*.

Flows to Bay. (2024). *https://www.flowstobay.org/*

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Freyer & Laureta, Inc. (2024). *Pulgas Creek Watershed Funding Sources Draft Memorandum*.

GHD (2017). *City of San Carlos Stormwater Master Plan*.

OneShoreline and Good City Company (2023). *OneShoreline Planning Policy Guidance*.

Perkins&Will (2021). *East Side Innovation District Vision Plan*.

PlaceWorks (2021). *San Carlos' Climate Mitigation and Adaption Plan*.

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WRA Environmental Consultants. (2024). *Pulgas Creek Watershed Study: Existing Conditions Hydraulics and Hydrology Memorandum*.

WRA Environmental Consultants. (2024). *Pulgas Creek Watershed Study: Flood Mitigation Evaluation Memorandum*.

Appendix A: Existing Conditions Hydraulics and Hydrology Memorandum

MEMORANDUM - DRAFT

TO:	Grace Le, PE	**FROM:**	Andrew Smith, PE Angela Hogan, PE Chris Feng, PE
CC:	Camille Bandy, PE, QSD Freyer and Laureta	Jeff Tarantino, PE Freyer and Laureta	
DATE:	December 19, 2024		
SUBJECT:	Pulgas Creek Watershed Study: Existing Conditions Hydraulics and Hydrology Memorandum Rev. 1		

BACKGROUND AND PURPOSE

The City of San Carlos, CA (City) is interested in developing a better understanding of the Pulgas Creek watershed and establishing a management plan with the aim of enabling creek restoration, increasing public access to sections of the creek, addressing existing flooding issues, and developing climate change mitigation strategies. A previous watershed study and hydraulic model was developed by GHD in 2017 as a part of the City's Storm Drain Master Plan (City of San Carlos, 2017). Traditionally, flood risk reduction efforts have focused on increasing channel capacity with large conduits which require substantial funding and have considerable impacts on traffic during implementation. More recently, guidance for managing watersheds also focus on reducing peak flow and sedimentation by re-naturalizing the watershed (Exhibit 1).

The objectives of this Existing Conditions Hydraulics and Hydrology (H&H) Memorandum are to:

- Describe the mechanisms impacting flood behavior in the Pulgas Creek watershed
- Identify and assess existing flood risks and behavior throughout the Pulgas Creek watershed
- Validate and calibrate the existing conditions model
- Provide a baseline assessment of flooding behavior

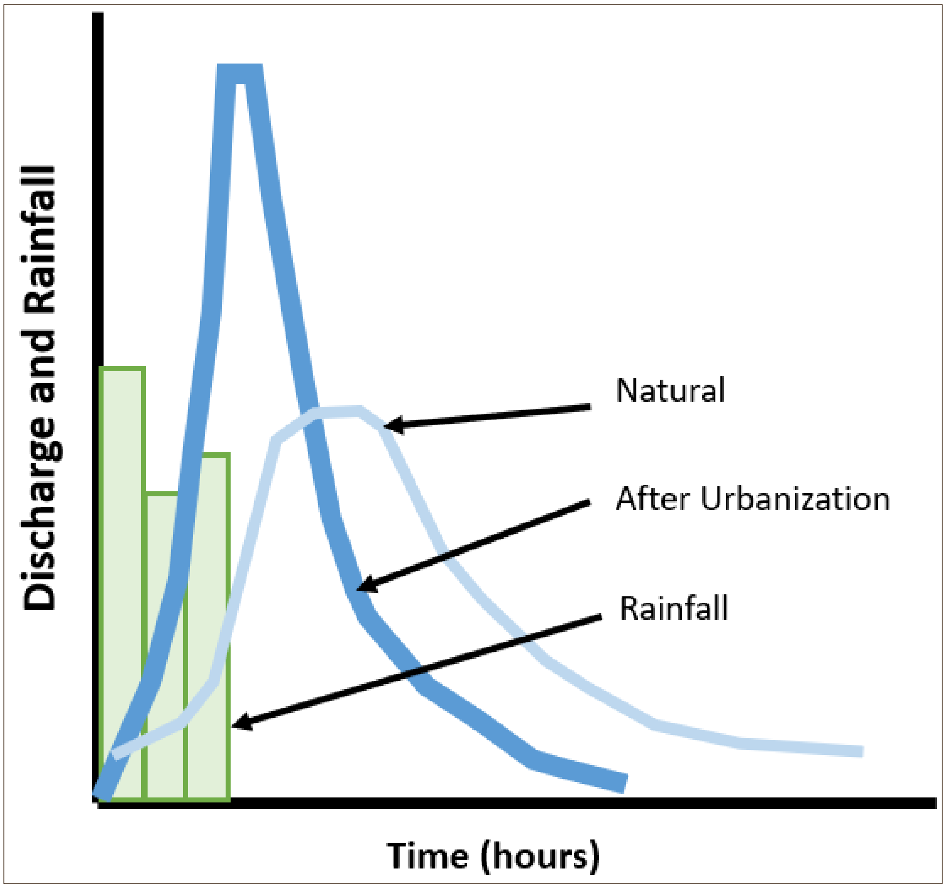

Exhibit 1. Impact of urbanization of previously undeveloped land on the flow hydrograph.

WATERSHED CHARACTERISTICS

Watershed Description

The Pulgas Creek watershed is primarily located within the City limits with portions of the watershed within unincorporated San Mateo County (Figure 1). The watershed begins in the hills around 0.5 miles east of Highway 280 and ends at Smith Slough before discharging into the San Francisco Bay. The watershed is comprised of two creeks—Pulgas Creek and Brittan Creek. Brittan Creek is tributary to Pulgas Creek, and the two converge through an underground storm drain along El Camino Real (Figure 2).

Stormwater generally flows from west to east from the City limit bordering the Santa Cruz Mountain ridgeline down to the San Francisco Bay. Local precipitation distribution within the Pulgas Creek watershed can be highly dynamic due to the variable temperature, wind, and humidity associated with the Santa Cruz Mountain range and the San Francisco Bay. Pulgas Creek and Brittan Creek are highly modified with approximately 64–87% of the creek containing bank hardening through concrete, gunnite, sackcrete, and stone. Erosion within the creek itself was low compared to other watersheds throughout San Mateo County (EOA, Inc., 2007). Hill slopes are steep in the City parks and some of the residential areas and can be highly susceptible to landslides which occur naturally due to geologic processes. Channel slopes vary depending on position in the watershed, with the upper watershed above the foothills containing slopes of 2–

15%, the mid watershed between Alameda de las Pulgas and El Camino Real around 1.5%, and the lower watershed east of El Camino Real around 0.5%. The flat slopes in the lower watershed substantially reduce stormwater capacity in Pulgas Creek and the storm drain network.

Flooding Mechanisms

Flooding in the Pulgas Creek watershed can be associated with a variety of risk factors including sedimentation, storm drain system clogging, insufficient storm-drain capacity, groundwater, and tides. Urbanization and development of the watershed also increase flood risk through replacement of previously permeable surfaces with impermeable developments. While municipal design standards require storm drain systems to accommodate the change in runoff, the analysis performed is typically under a clear water assumption where there is no significant presence of debris or sediment flowing with the water. Debris and sediment can drastically change the flow dynamics of a system, especially around constrictions and expansions, grade changes, and around erodible surfaces.

Sedimentation

Sedimentation is the result of suspended and bed-load sediment settling out of the water column where low energy conditions exist. Sediment is introduced to the waterway through erosion or landslides and can exist anywhere water flows, such as where precipitation impacts with the ground, on roads, inside storm water infrastructure, and within the creeks. Erosion can occur anywhere throughout the watershed where there is exposed soil experiencing sufficiently high local flow and can increase from small to large volumes of sediment. Sediment sources can include uncovered earth disruption activities, such as construction or landscaping, as well as creek bank erosion. Landslides typically involve large volumes of soil moving either immediately into the waterway if they occur along the creek banks, or over a longer period if they occur on upper hillslopes, farther from the waterway. They typically occur where topography is steep and geological, morphological, and hydrological conditions result in a weak region of the landscape (*Exhibit **2***). The majority of landslides within the City occur in the upper watershed, west of Alameda de las Pulgas (California Department of Conservation - California Geological Survey, 2015).

Exhibit 2. Temporarily stabilized landslide from the 2022-2023 storms along Dartmouth Ave above Arguello Park. Photo taken by WRA 4/12/24.

An in-depth analysis of erosion risk and sediment sources within the Pulgas Creek watershed has not been performed. Estimates of normal sediment load throughout the Bay Area, including the Pulgas Creek watershed have been made by the San Francisco Estuary Institute (SFEI) (SFEI, 2009). Approximately 2,186-2,791 metric tons per year (2,410-3077 tons per year) was estimated based on typical land use and flow for the watershed. It is assumed that the large grain sizes that typically cause issues with storm drain systems are delivered during the large flood events with intense flows typically occurring for a few hours. Pulses in sediment loading can constrain the existing storm drain systems, lowering capacity and resulting in flooding. Smaller storms can aid in flushing sediment out from the clogged storm drain systems such that little evidence of the underlying flooding issue remains after the wet season ends. Future City efforts to remove sediment from the storm drain network or creeks or sloughs should codify dates and estimated quantities and gradations of sediment removed. This information will aid in preparing appropriate and timely flood-risk reduction responses.

Storm Drain System Issues

Sediment and debris conveyed during a storm event can clog the intended stormwater conveyance route, resulting in flood water accumulation and potential for overtopping the channel, popping out of manholes and catch basins, or prevention of stormwater from entering stormwater infrastructure. Man-made debris can include plastic items, metal objects, construction waste, and other synthetic materials, while natural debris can include branches, leaves, dead trees, and other plant materials. The dynamic nature of a storm can result in larger debris forming obstructions during high flows, with recessional flows causing flooding prior to the debris being removed. Sediment can also be conveyed into stormwater infrastructure and clog in lower slope conduits prior to reaching the San Francisco Bay, reducing conveyance and storage capacity for the next storm. The City of San Carlos and San Mateo County standards dictate a 100-year event minimum conveyance capacity for infrastructure within the Federal Emergency Management Agency (FEMA) mapped floodplain. Infrastructure outside the FEMA floodplain require a 10-year minimum conveyance capacity (San Mateo County, 2019). Sediment and debris can limit the actual conveyance and storage capacity resulting in a higher risk of flooding during smaller storm events. Anticipated flood volumes from a 10- and 100-year event can change over time as development continues. Increased areas of concrete, asphalt, and other impermeable surfaces can hasten the conveyance of stormwater into the drainage system and result in an increase in the peak flow for the watershed, resulting in flooding at the same 10- or 100-year precipitation event despite sizing the original infrastructure for the same event.

Groundwater and High Tides

Sources of inflow of water to the system includes precipitation runoff and potential groundwater springs, while outflow includes discharge into the San Francisco Bay, infiltration into the soil, evaporation, and transpiration. Groundwater levels during the winter can be as shallow as 3 feet below the ground surface east of El Camino Real, severely limiting infiltration potential and channel conveyance capacity (California Department of Water Resources, 2024). As storm flows reach the lower watershed, water surface elevations (WSEs) are altered by tidal and groundwater elevations, causing storm flows to overtop channel banks and pop out from manholes (*Exhibit 3*). This issue will be exacerbated by climate change through higher intensity storms and rising sea levels.

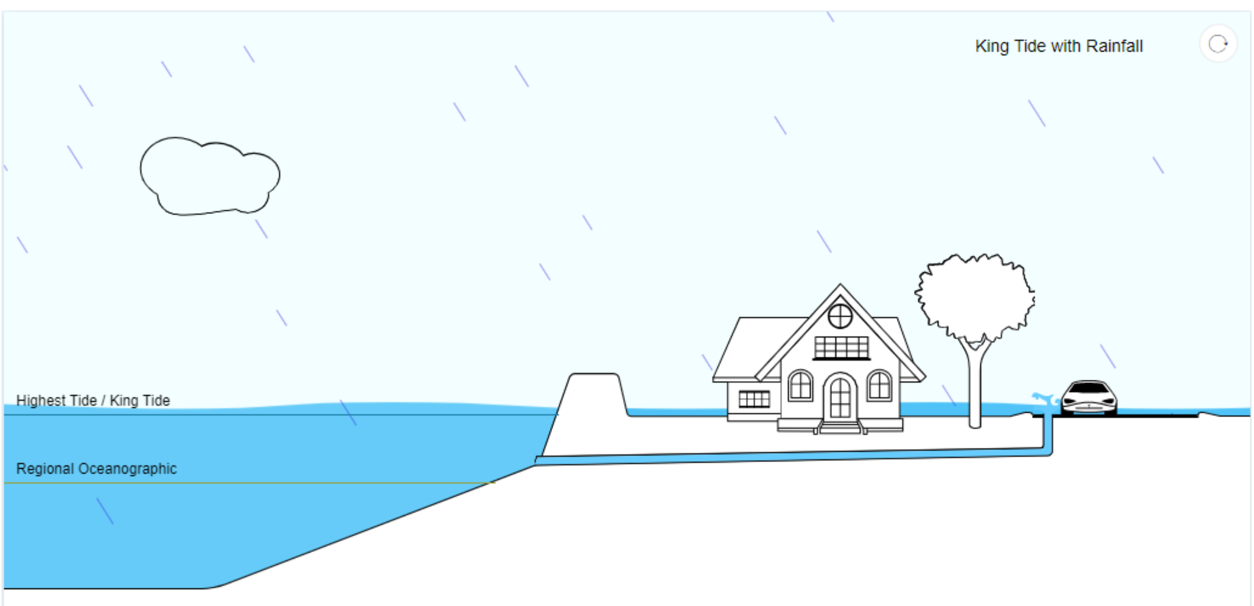

Exhibit 3. Tidal limitations on stormwater drainage and flooding. Graphic by **(NOAA, 2024)**

Flood Reports

Historically, flooding has occurred in the more heavily urbanized reaches of the Pulgas Creek watershed east of Alameda de las Pulgas, especially along El Camino Real. More recently, flooding effects have been observed in the less urbanized reaches of the watershed west of Alameda de las Pulgas, particularly at properties abutting existing parks and less developed regions. All available flood reports from those provided in the Storm Drain Master Plan and from the 2023 floods are shown in Figure 3. Based on a comparison of flood events to hourly precipitation intensity data from the CDEC station, the Pulgas watershed appears to be at risk of flooding beginning with rainfall intensity of 0.75 inch over one hour (*Exhibit* ***4***), equivalent to a 10-year precipitation event based on the National Oceanic and Atmospheric Administration's (NOAA) Atlas 14 (*Exhibit* ***5***). Flood timing data is based on the recorded time of reporting and not necessarily the exact time the flood occurred, limiting this analysis from assessing hour-scale precipitation to flooding relations.

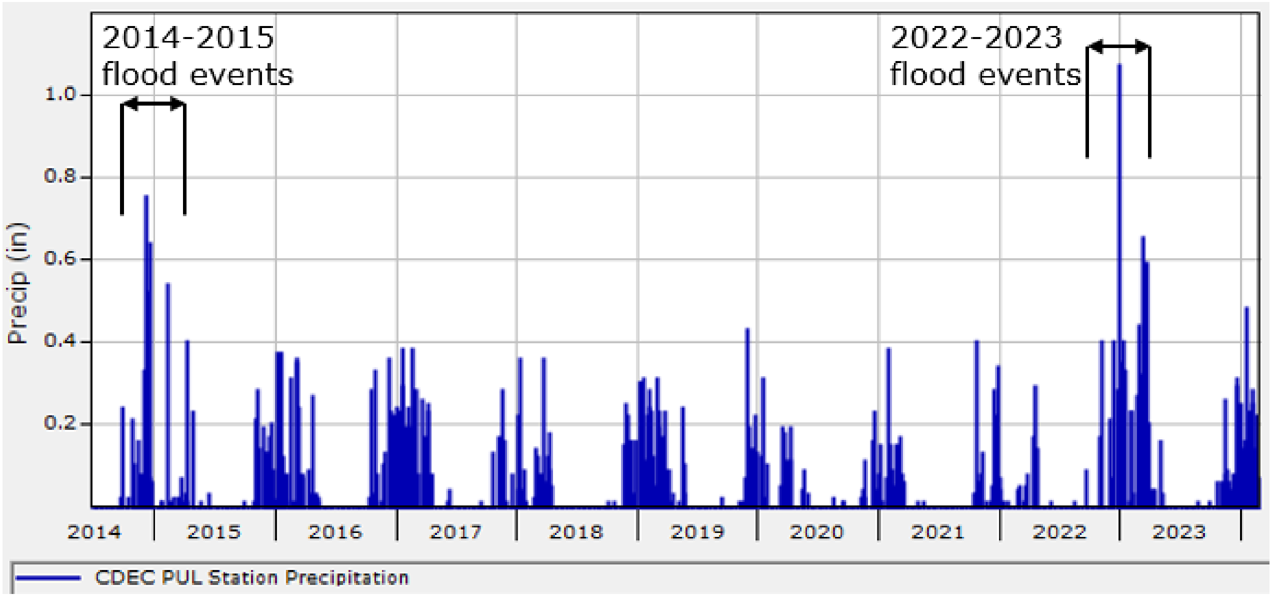

Exhibit 4. Flood impact years compared to hourly precipitation data from the CDEC PUL station

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]										
Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.123 (0.109-0.140)	0.149 (0.132-0.171)	0.186 (0.164-0.213)	0.216 (0.189-0.250)	0.259 (0.218-0.311)	0.294 (0.242-0.360)	0.330 (0.265-0.415)	0.368 (0.287-0.477)	0.422 (0.314-0.571)	0.465 (0.334-0.653)
10-min	0.176 (0.156-0.201)	0.214 (0.189-0.245)	0.266 (0.234-0.305)	0.310 (0.271-0.358)	0.372 (0.313-0.445)	0.421 (0.347-0.516)	0.473 (0.379-0.594)	0.527 (0.411-0.683)	0.604 (0.451-0.818)	0.666 (0.479-0.935)
15-min	0.213 (0.188-0.243)	0.259 (0.229-0.296)	0.322 (0.283-0.369)	0.375 (0.327-0.433)	0.449 (0.379-0.538)	0.509 (0.419-0.624)	0.571 (0.459-0.719)	0.638 (0.497-0.827)	0.731 (0.545-0.990)	0.805 (0.579-1.13)
30-min	0.295 (0.261-0.337)	0.359 (0.317-0.411)	0.446 (0.393-0.512)	0.520 (0.454-0.601)	0.624 (0.526-0.747)	0.706 (0.582-0.866)	0.793 (0.637-0.998)	0.885 (0.690-1.15)	1.01 (0.756-1.37)	1.12 (0.803-1.57)
60-min	0.417 (0.369-0.477)	0.508 (0.449-0.580)	0.631 (0.556-0.723)	0.735 (0.642-0.850)	0.881 (0.743-1.06)	0.998 (0.823-1.22)	1.12 (0.900-1.41)	1.25 (0.975-1.62)	1.43 (1.07-1.94)	1.58 (1.14-2.22)
2-hr	0.610 (0.540-0.696)	0.736 (0.651-0.842)	0.908 (0.800-1.04)	1.05 (0.918-1.22)	1.25 (1.06-1.50)	1.41 (1.16-1.73)	1.58 (1.27-1.98)	1.75 (1.37-2.27)	1.99 (1.49-2.70)	2.19 (1.57-3.07)
3-hr	0.766 (0.678-0.875)	0.926 (0.819-1.06)	1.14 (1.01-1.31)	1.32 (1.16-1.53)	1.57 (1.33-1.89)	1.77 (1.46-2.17)	1.98 (1.59-2.49)	2.20 (1.71-2.85)	2.50 (1.86-3.38)	2.74 (1.97-3.84)
6-hr	1.08 (0.959-1.24)	1.32 (1.17-1.51)	1.64 (1.44-1.88)	1.90 (1.66-2.20)	2.27 (1.91-2.72)	2.56 (2.11-3.14)	2.86 (2.30-3.60)	3.18 (2.48-4.12)	3.61 (2.70-4.89)	3.96 (2.85-5.56)
12-hr	1.41 (1.24-1.60)	1.76 (1.55-2.01)	2.22 (1.96-2.55)	2.61 (2.28-3.02)	3.16 (2.66-3.78)	3.58 (2.95-4.39)	4.02 (3.23-5.06)	4.48 (3.49-5.81)	5.12 (3.82-6.93)	5.62 (4.04-7.90)
24-hr	1.70 (1.56-1.90)	2.18 (2.00-2.44)	2.82 (2.57-3.16)	3.35 (3.04-3.78)	4.09 (3.60-4.74)	4.66 (4.03-5.50)	5.26 (4.45-6.34)	5.88 (4.85-7.26)	6.73 (5.36-8.62)	7.41 (5.73-9.78)

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

Exhibit 5. NOAA Atlas 14 precipitation frequency estimates for San Carlos, CA **(NOAA, 2014)**

In general, the 2014-2015 flood events were located in the mid to lower watershed. Potential causes were mostly attributed to insufficient downstream capacity where excess runoff combined with the tidal condition limited drainage capacity and resulted in flows popping out of manholes and overwhelming catch basins. The 2022-2023 flood events were located in the upper watershed and potential causes were nearly all attributed to landslides and erosion overwhelming storm drains and diverting flood flows to homes and streets. In summary, the flood reports indicate that the watershed is at risk of flooding due to multiple mechanisms and only one mechanism is needed to cause flooding.

FLOW MONITORING

WRA installed a total of two barologgers and 11 water level loggers on December 20, 2023 to provide site-specific water level data around the Pulgas watershed for model calibration. Each barologger unit records barometric pressure for use in compensating for local atmospheric effects on the water level loggers' measurements. Each water level logger records water depth and temperature using a pressure sensor and temperature detector, respectively. The data loggers record pressure representing the height of water above the transducer sensor elevation. Water levels below the data logger sensors are not able to be measured. Loggers were placed along the low point of the selected feature (creek bottom, culvert invert, storm drain invert) and record levels in 6-minute intervals. The logger locations installed are shown in Figure 4. Loggers are labeled from number 1 to 13, with Loggers 5 and 6 omitted as the sites did not meet expectations for yielding usable data. Descriptions of the logger location, conditions, and purpose are provided in Table 1.

Table 1. Monitoring Locations and Intent

LOGGER #	ATTACHMENT FEATURE	LOCATION	PURPOSE
1	Storm drain manhole in Pulgas Creek watershed	In manhole adjacent to 400 Devonshire Blvd	Track urbanized catchment flow
2	Pulgas Creek on tree	Adjacent to hillside trail accessible from 400 Devonshire Blvd	Track non-urbanized catchment flow
3	On culvert for tributary to Pulgas Creek	At intersection between Cyn Vista Wy and Chesham Ave	Track non-urbanized catchment flow into urban storm drain system
4	Storm drain manhole in Pulgas Creek watershed	In manhole at San Carlos Ave and Wellington Dr	Track urbanized catchment flow
7	Pulgas Creek on tree	At Cedar St adjacent to Central Middle School	Track lower reach inundation along Pulgas Creek
8	Pulgas Creek on tree	Near Brittan Ave between Industrial Rd and Old County Rd	Track inundation near storm drain and tidal interface
9	Pulgas Creek in tidal slough	Just upstream of Pulgas Creek and Smith Slough confluence	Track tidal effects
10	Brittan Creek on concrete box culvert	On Elm St between Howard Ave and Greenwood Ave	Track urbanized flow
11	Brittan Creek on concrete box culvert	At Alameda de las Pulgas between Gaylord St and Howard Ave	Track urbanized flow

LOGGER #	ATTACHMENT FEATURE	LOCATION	PURPOSE
12	Storm drain manhole in Brittan Creek watershed	On Brittan Ave between Faribanks Ave and Sunset Dr	Track urbanized storm flow at the urban and non-urban interface
13	Tributary to Brittan Creek	In Eaton Park south of 3015 and 3017 Brittan Ave	Track non-urbanized catchment flow
Baro 1	On tree near logger 8	Near Brittan Ave between Industrial Rd and Old County Rd	Collect above ground atmospheric pressure data
Baro 2	In logger 12 storm drain manhole	On Brittan Ave between Faribanks Ave and Sunset Dr	Collect below ground atmospheric pressure data

EXISTING CONDITIONS MODEL

Baseline Model

A hydrologic and hydraulic model of all watersheds within the City's jurisdiction was developed by GHD in the PC SWMM software by Computational Hydraulics International (CHI) as a part of the City's Storm Drain Master Plan in 2017. WRA revised the existing condition models from GHD and performed validation of input data, model component additions and modifications, and model calibration. Details and descriptions of the components included in the existing conditions model built by GHD can be found in the Storm Drain Master Plan Section 4 (GHD, 2017). The baseline model includes the Cordilleras Creek and West Redwood Shores watersheds; however, no changes were made at these locations because the purpose of this study is to focus on the Pulgas Creek watershed (Figure 5). Model components are shown in Figure 2 including subbasin areas, conduit structures, and node junctions.

Model Calibration

A calibration model scenario was developed by utilizing precipitation and water level logger data from January 21, 2024 to January 22, 2024. The January 21/22, 2024 storm event yielded the greatest cumulative precipitation depth where logger data was available. The relation between precipitation and flow in the upper, mid, and lower sections of the Pulgas Creek watershed represented by loggers 2, 11, and 8, respectively, can be seen in Exhibit 6. No flooding was reported during the period of recorded logger data.

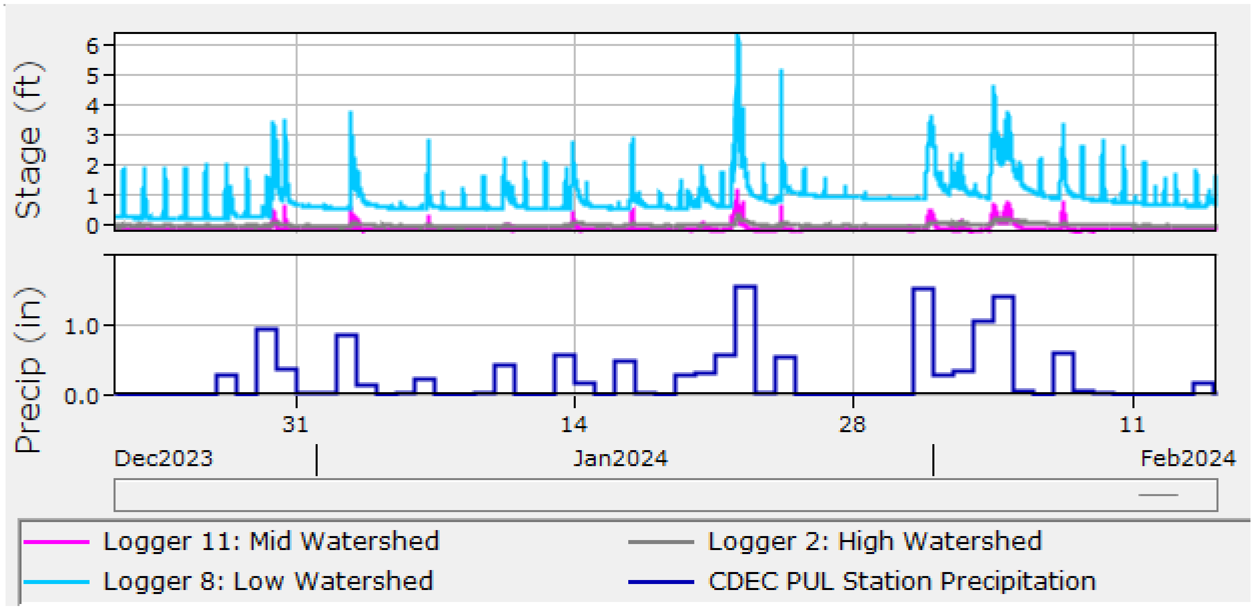

Exhibit 6. WRA Logger 2, 8, and 11 water level data and CDEC PUL station hourly precipitation

Calibration efforts involved manipulation of input parameters including slopes, curve number (CN) values, invert elevations, and impervious land percent. CN values are numbers applied based on land cover type associated with the Soil Conservation Service (SCS) method for estimating precipitation runoff. Higher CN values represent high potential for generating runoff, such as concrete and other impermeable surfaces, while low CN values represent low potential for generating runoff, such as highly porous, unsaturated, and well vegetated soils. Model calibration was expected to roughly match peak timings, peak values, and water accumulation trends. An exact match between modeled and measured values was not expected due to the inability of the model to accurately capture all physical factors that can have a significant impact in flow behavior such as sediment transport, complex storm drain geometries, debris effects, etc. Flood reports from the 2022–2023 storm events claim multiple locations of flooding at the edge of Eaton Park and Big Canyon Park. These locations require a qualitative assessment to account for sediment when comparing model outputs and observed data. It is anticipated the observed depth values will be higher than model outputs due to sediment in the system. Output from the calibration efforts can be found in the Model Output and Assessment section below.

Existing Conditions Hydraulic Model Adjustments

Model input parameters including storm drain inverts, CN values, rainfall, and land cover data such as impervious cover percent were updated based on field inspections and observed data. At loggers 2, 3, and 13, subbasin regions were split to account for existing conveyance channels not captured in the baseline model. Subbasin outlets were set upstream of the logger locations to be used for calibration purposes in comparing modeled vs. recorded water depths and timing. Transect geometries were assigned for creeks in newly split subbasins based on terrain elevations obtained from the San Mateo County 2017 1-Meter Digital Elevation Model (San Mateo County, 2017). Storm drain geometries were assumed based on existing data for nearby equivalent drainage area storm drains. Subbasin outfall locations were adjusted to better reflect real conditions.

Calibration Model Outputs

Modeled depths and timings roughly match logger data in the high watershed of Pulgas Creek based on Logger 2 observations (Exhibit 7). As expected, due to reports of landslides in Brittan Creek and substantial sediment mobilizing in the Brittan creek watershed, Logger 11 observations at the Alameda De Las Pulgas bridge demonstrate higher observed depth values than model outputs (Exhibit 8). This variance from model output to observations should be expected throughout Brittan Creek until high sediment loads are no longer expected to enter Brittan Creek or nearby storm drain conduits and sediment within the system is removed. Modeled depths downstream of Old County Road roughly match logger data in magnitude and timing. Observed values from Logger 8 show similar patterns as the model output with a slightly lower peak value and shorter time of concentration suggesting the watershed may have slightly more attenuation of the peak flow but also less detention than the model (Exhibit 9).

There are differences in the timing and higher deviations at the start and end of the model. The discrepancies at the start of the model may be described by irregularities during model warm-up such as insufficient pre-wetting, sediment mounds elevating water depths, and groundwater seepage into the system not accounted for in the modeling. The drift in timing near the end of the modeled time may be explained by the time interval of the precipitation data. Higher resolution precipitation data (1-minute) could provide model results more similar to observed data. Significant discrepancies between modeled and measured flow depths, such as that for Logger 11, can be explained by local factors such as debris/sediment pileup causing elevated water levels before being flushed through the system.

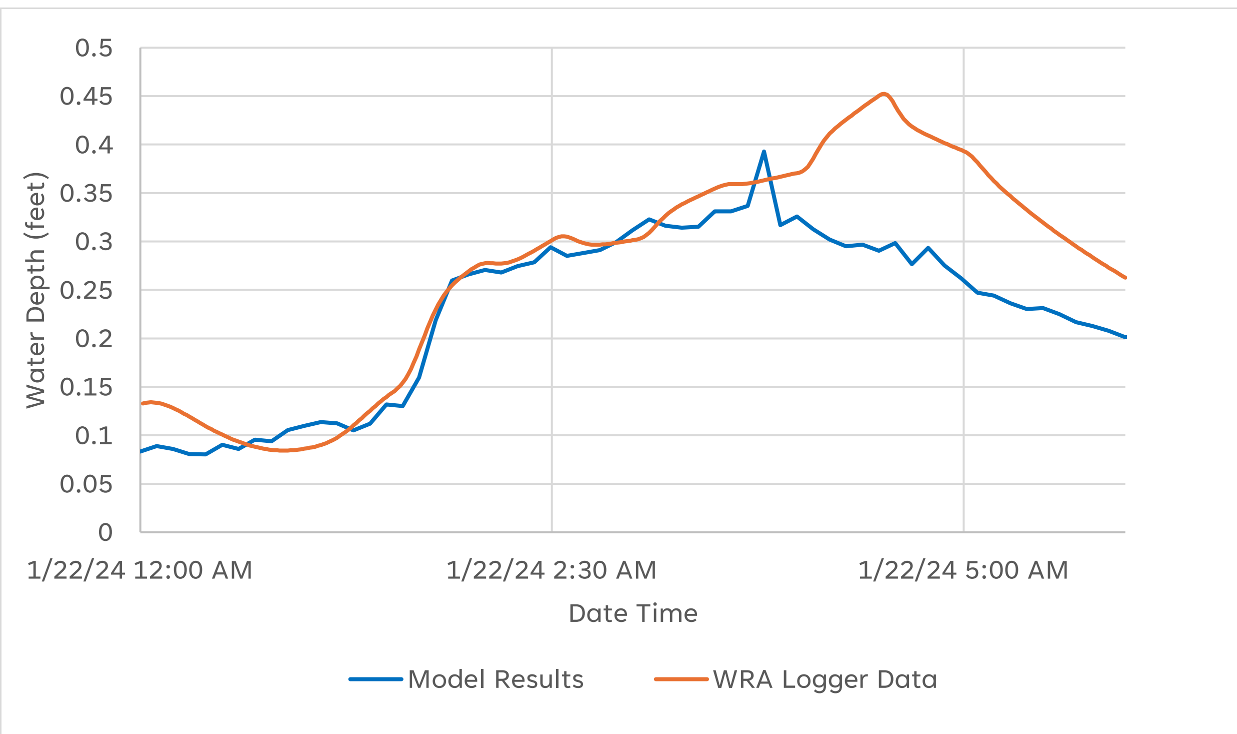

Exhibit 7. Logger 2 high watershed calibration model results and measured depth data

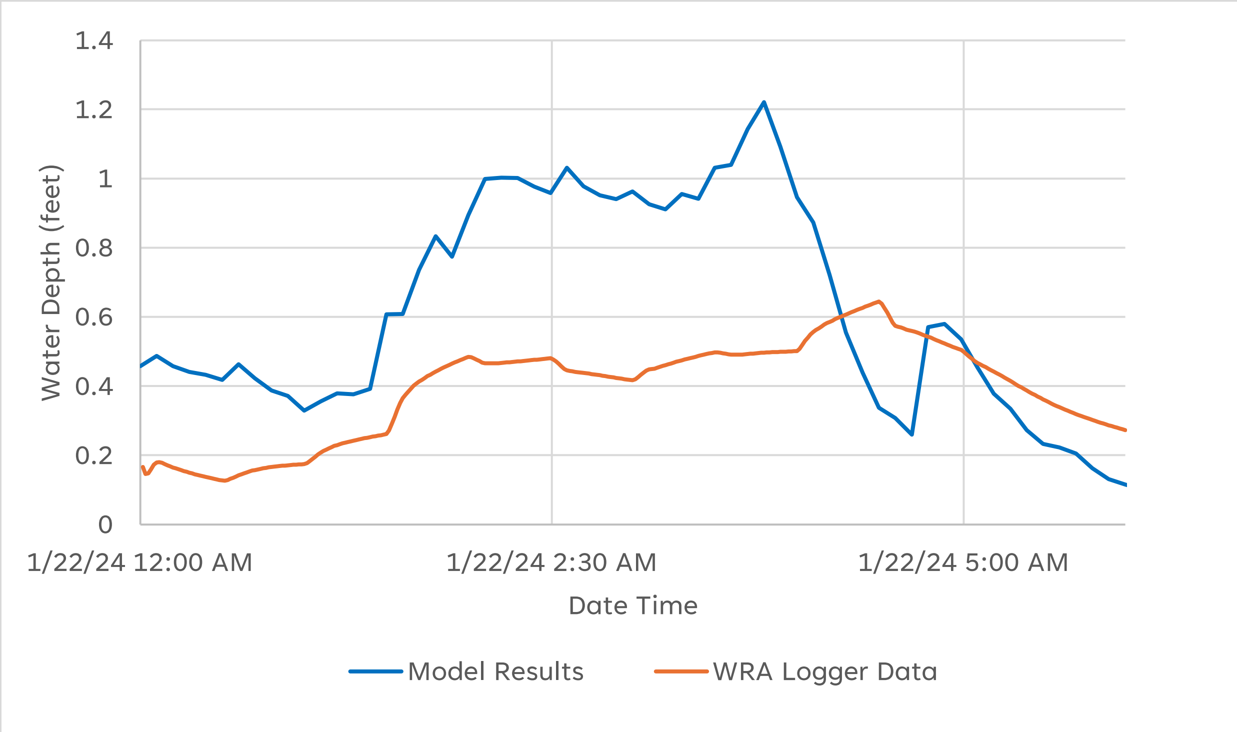

Exhibit 8. Logger 11 mid watershed calibration model results and measured depth data

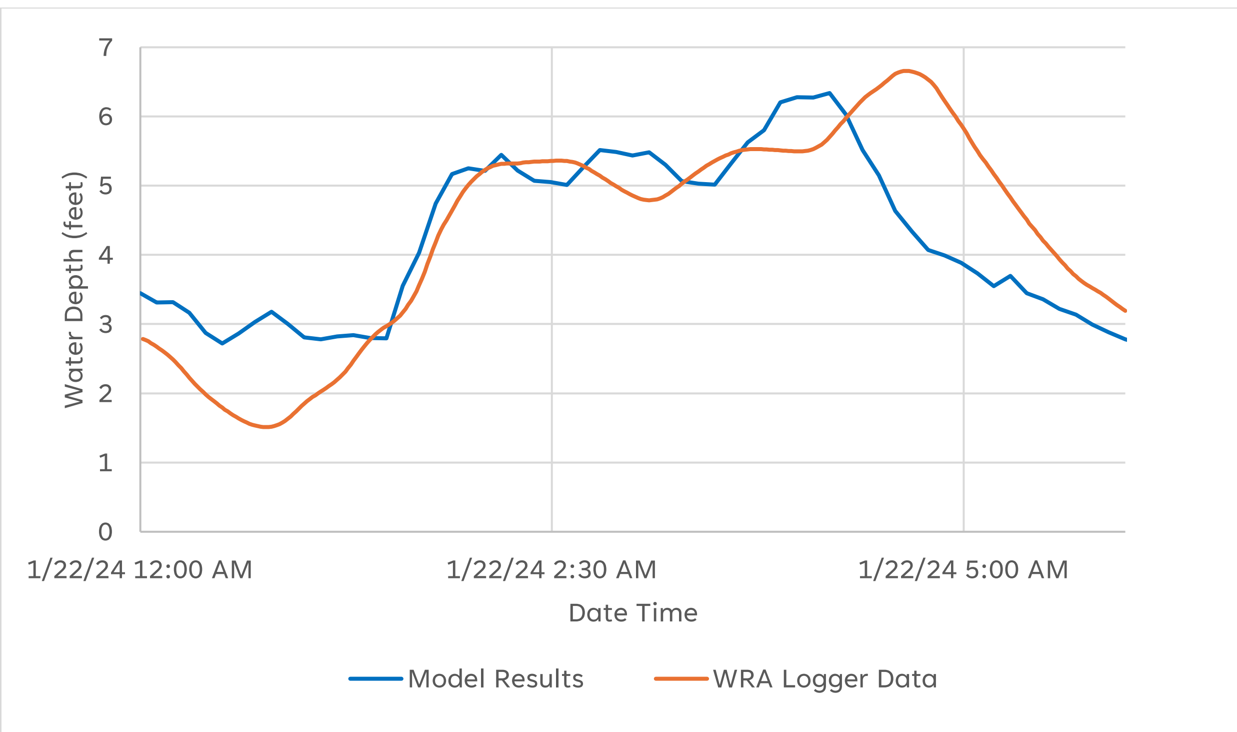

Exhibit 9. Logger 8 low watershed calibration model results and measured depth data

Findings during the model calibration suggest Pulgas watershed hydrographs are highly dependent on rainfall intensity patterns. The system is capable of quickly flushing through peak events throughout all but the lower watershed. Accurate modeling of the peaks and troughs of the hydrograph is contingent on having sufficiently high-resolution precipitation data. While previous recommendations to alleviate flooding in the downstream reaches involved increasing capacity of flood infrastructure, there may be opportunity to alleviate the downstream flood issues via detention of water from the upstream reaches.

MODEL OUTPUT AND ASSESSMENT

Model outputs provide quantitative context for assessing the watershed's flood risk. The model outputs can also be used to understand which bridges, storm drain conduits, or creek segments have insufficient capacity and also which features have unused capacity that could be used for detention. When using model outputs, it is important to acknowledge that the model assumes all storm drain features are working as designed and that proper maintenance was performed prior to any storm so that sediment does not enter the storm drain system. The model results discussed will be inaccurate for sediment-driven flooding areas in the watershed. These inaccuracies can be resolved with proper sediment treatment for runoff prior to entering the storm drain network and diligent inspection and maintenance of the watershed and storm drain system.

A map view of the 10-year storm event shows flooding in the lower watershed with depths in the surrounding parking lots and roads ranging from 0.5 to 1.5 feet (Figure 6). A map view of the 25-year storm event shows flooding in the lower watershed with depths in the surrounding parking lots and roads ranging from 0.5 to 2.5 feet (Figure 7). A map view of the 100-year storm event shows flooding in the lower watershed with depths in the surrounding parking lots and roads ranging from 0.5 to 2.5 feet (Figure 8).

Results from the modeling suggest most of the high watershed has sufficient storm drain capacity to prevent flooding. Profile view results of depths along the Pulgas Creek alignment from the headwaters to Smith Slough, and Brittan Creek alignment from the headwaters to the confluence with Brittan Creek at El Camino Real, are shown in Figure 9 to Figure 14 for each of the studied storm events. The profile views of Pulgas Creek show shallow depths in the upper and middle watershed in creek segments, with depths increasing in magnitude in the lower watershed. The profile views of Brittan Creek show a similar behavior to Pulgas Creek in the upper watershed, but an increase in depth in the middle watershed due to a change in channel slope from 2.5% to 1.5%. Pulgas Creek quickly conveys flows down to the lower watershed without an opportunity for water to pile up while Brittan Creek shows some attenuation behavior, retaining some flood waters in the middle watershed.

Most non-sediment-related flood effects are observed and predicted where the City topography flattens out around mid-watershed starting near Cedar Street and Grand Street. Flood risk of the low watershed near the Bay is tied to insufficient drainage capacity during extreme event peaks with higher tides. Improving slope stability in the high watershed is key to reducing flood risk in the region. The downstream reaches of the Pulgas Creek watershed where historic flooding occurs remains vulnerable to extreme events and rising tides.

An analysis of the flood inundation area indicates the primary location of flooding is from overbanking on Pulgas Creek downstream of Old County Road due to limitations in bridge and channel capacity. A comparison of the 100-year flood event hydrograph to the capacity of the bridges and channel downstream of Old County Road provide quantitative characteristics that need to be addressed to prevent flooding.

The recommended approach to prevent flooding is twofold:

1. Increase capacity of the bridges and channel as much as possible given the site constraints downstream of Old County Road and
2. Reduce the peak flow by adding detention features throughout the watershed.

An example of this approach would be:

> Model results indicate the existing capacity downstream of Old County Road is approximately 360 cfs resulting in 97 acre-ft of stormwater floods the surrounding area (*Exhibit 10*). Two options which are likely infeasible are to:
> 1. increase capacity to approximately 650 cfs or
> 2. add detention basins to temporarily hold 97-acre feet of stormwater in the watershed for approximately four hours.
>
> A more feasible solution would be to:
> 1. increase capacity to 500 cfs and
> 2. add detention basins to temporarily hold approximately 60 acre-feet of stormwater in the watershed for approximately four hours.

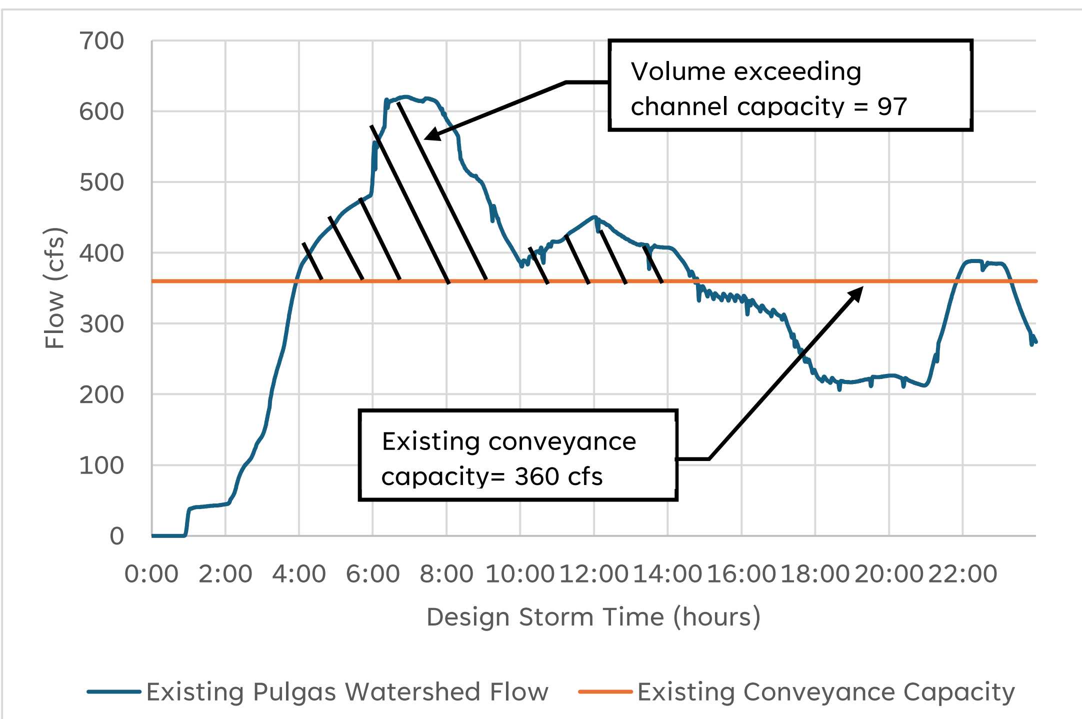

Exhibit 10. 100-year Hydrograph of Pulgas Creek downstream of Old County Road

SUMMARY

- The watershed is susceptible to landslides due to geologic processes which have a substantial impact on flood capacity.
- Due to sedimentation, inspections and maintenance to the storm drain network are critical functions in maintaining flood conveyance.
- Rising tide and ground water elevations increase risk of flooding in the lower watershed for both local storm drains and the main stem of the Pulgas Creek watershed.
- Opportunities exist for creek flow attenuation in the upper and middle watershed by adding detention basins in locations with sufficient capacity and feasible construction access.
- The lower watersheds flat hydraulic grade line is an indicator of reduced stormwater and sediment transport capacity.
- The strategy for improving the watershed and reducing flood risk is to focus on reducing the peak flow using detention basins in the upper and middle watershed while increasing capacity in the lower watershed.

LIMITATIONS

The model developed for this study is based on limited available data. Different climate characteristics, antecedent precipitation, groundwater intrusion, and more site-specific flow records would improve accuracy of the models. Adjustments to the existing conditions model were focused on areas of known discrepancy between modeled and real results. A whole model validation of all input parameters and results was not performed. The model was adjusted from data available at the time both recorded for this project's purposes and previously recorded data provided by the City of San Carlos. Figures presented in this memorandum are not intended to be used as reference material for determining construction locations or features.

Accounting for site-specific geomorphic conditions and topographic adjustments were not within the scope of this study. Flooding extents and depths shown in this study do not account for complications due to debris flow, nor other geotechnically related complicating factors such as landslides, earthquakes, bank failures, etc.

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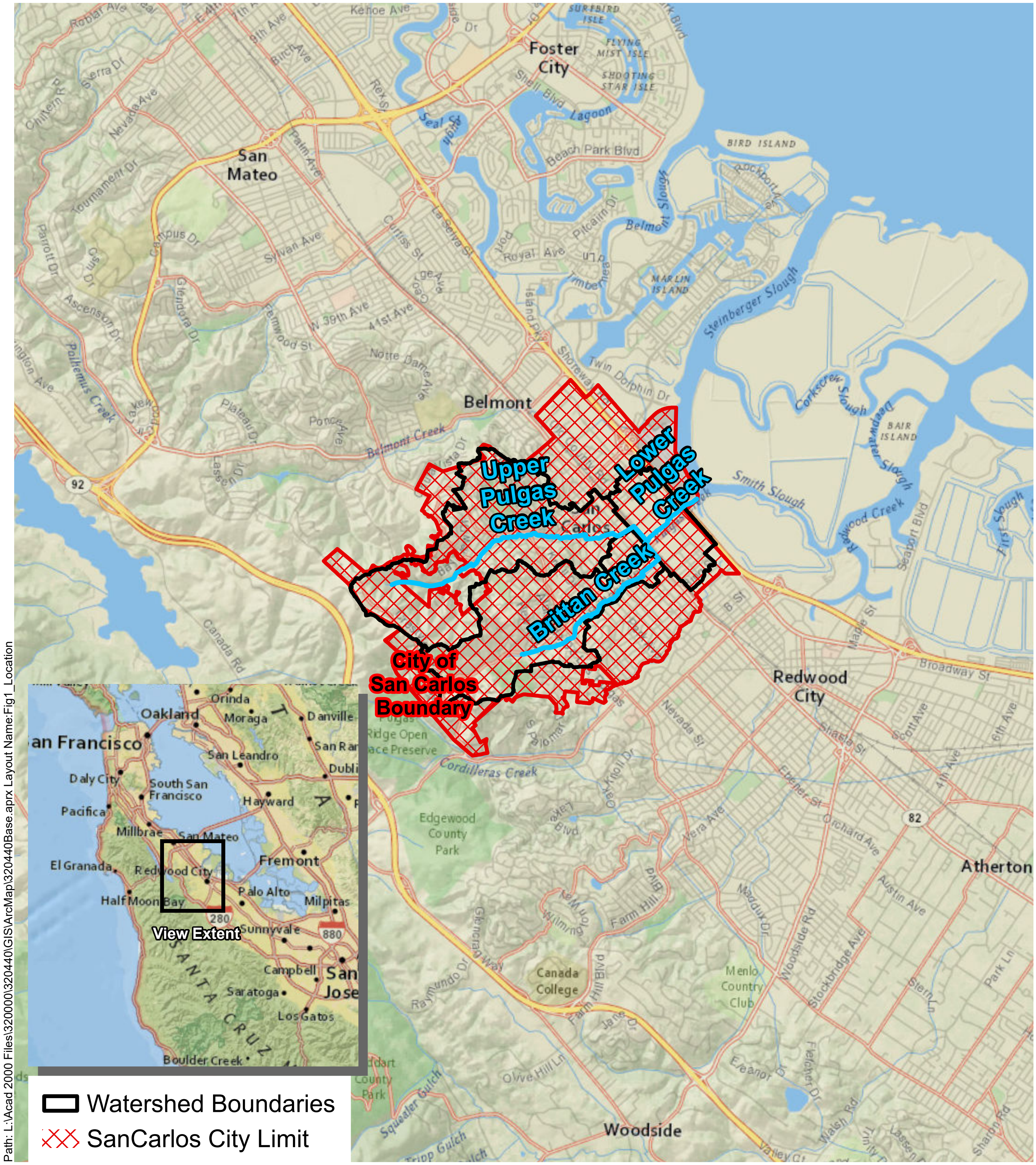
ATTACHMENTS

Attachment A. Figures

Attachment A.

Figures



Sources: National Geographic, WRA | Prepared By: junjie.chen, 6/21/2024

Figure 1. Regional Location Map

Pulgas Watershed Study
Existing Conditions H&H Memo
City of San Carlos, San Mateo, CA

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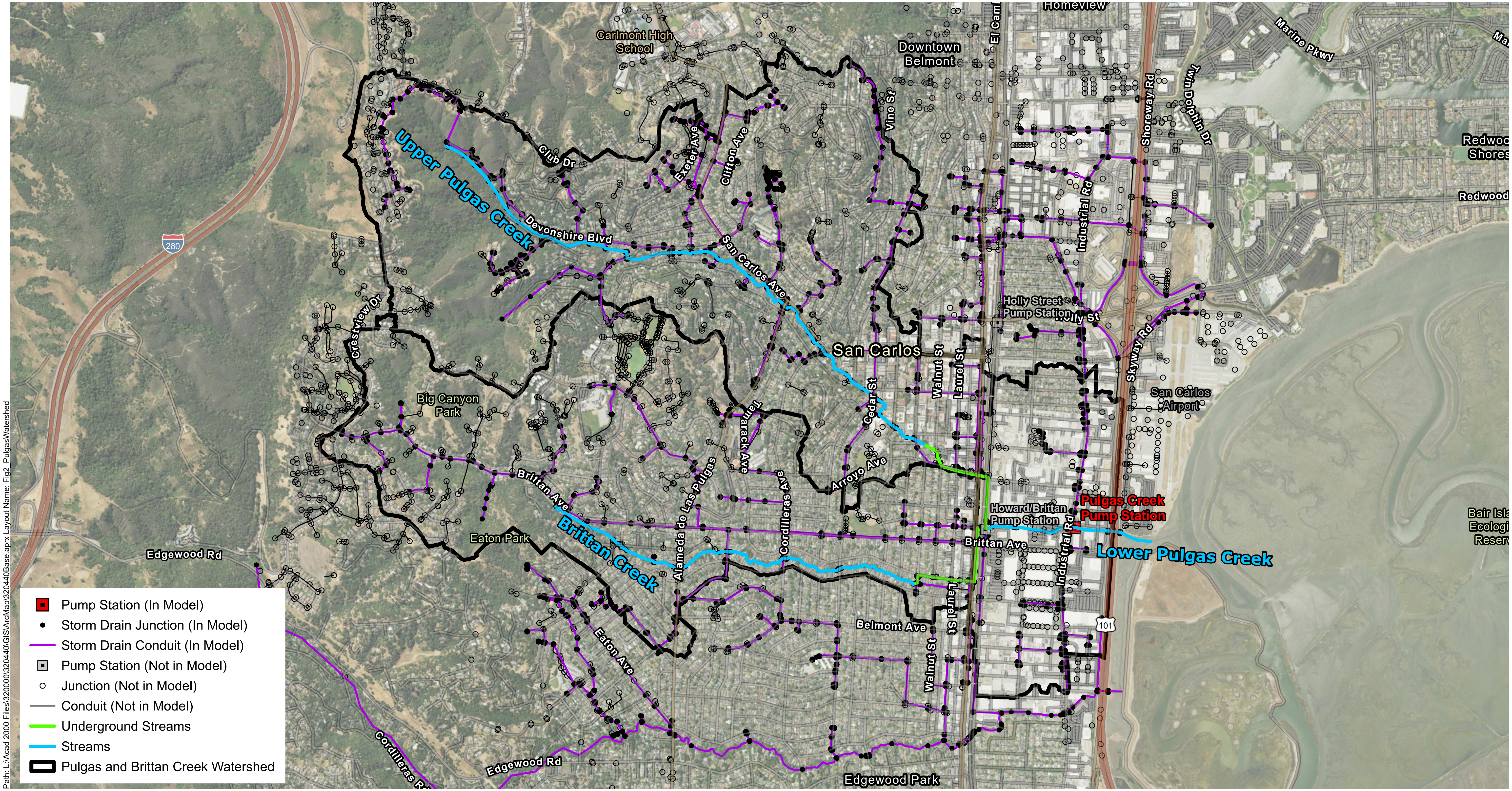

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Sources: USDA NAIP Imagery 2020, WRA | Prepared By: junjie.chen, 6/21/2024

Figure 2. Pulgas Watershed Drainage System

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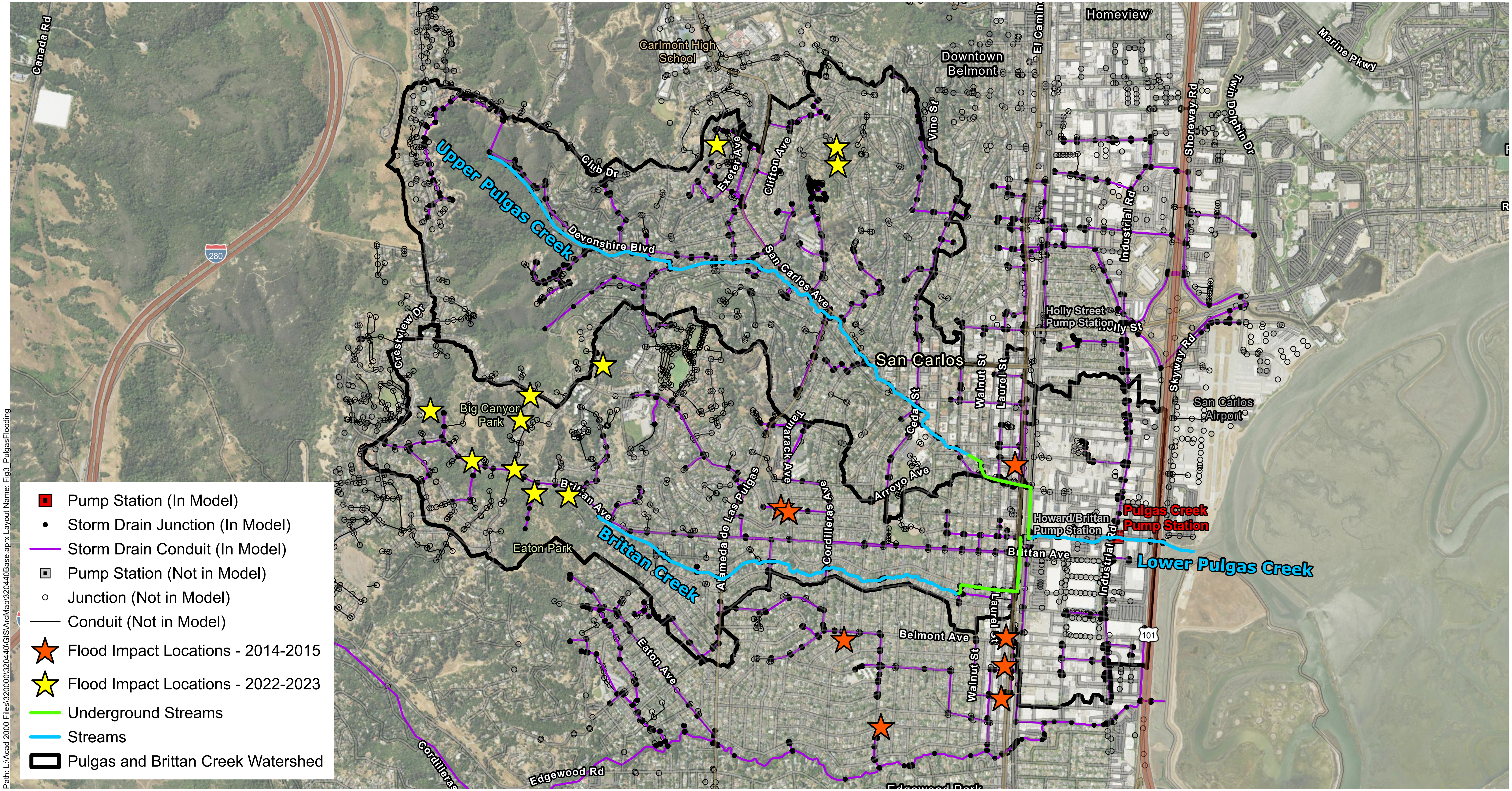
Pulgas Watershed Study
Existing Conditions H&H Memo
City of San Carlos, San Mateo, CA



Sources: USDA NAIP Imagery 2020, WRA | Prepared By: junjie.chen, 6/21/2024

Figure 3. Pulgas Watershed Regions Impacted by Flooding

Pulgas Watershed Study
Existing Conditions H&H Memo
City of San Carlos, San Mateo, CA

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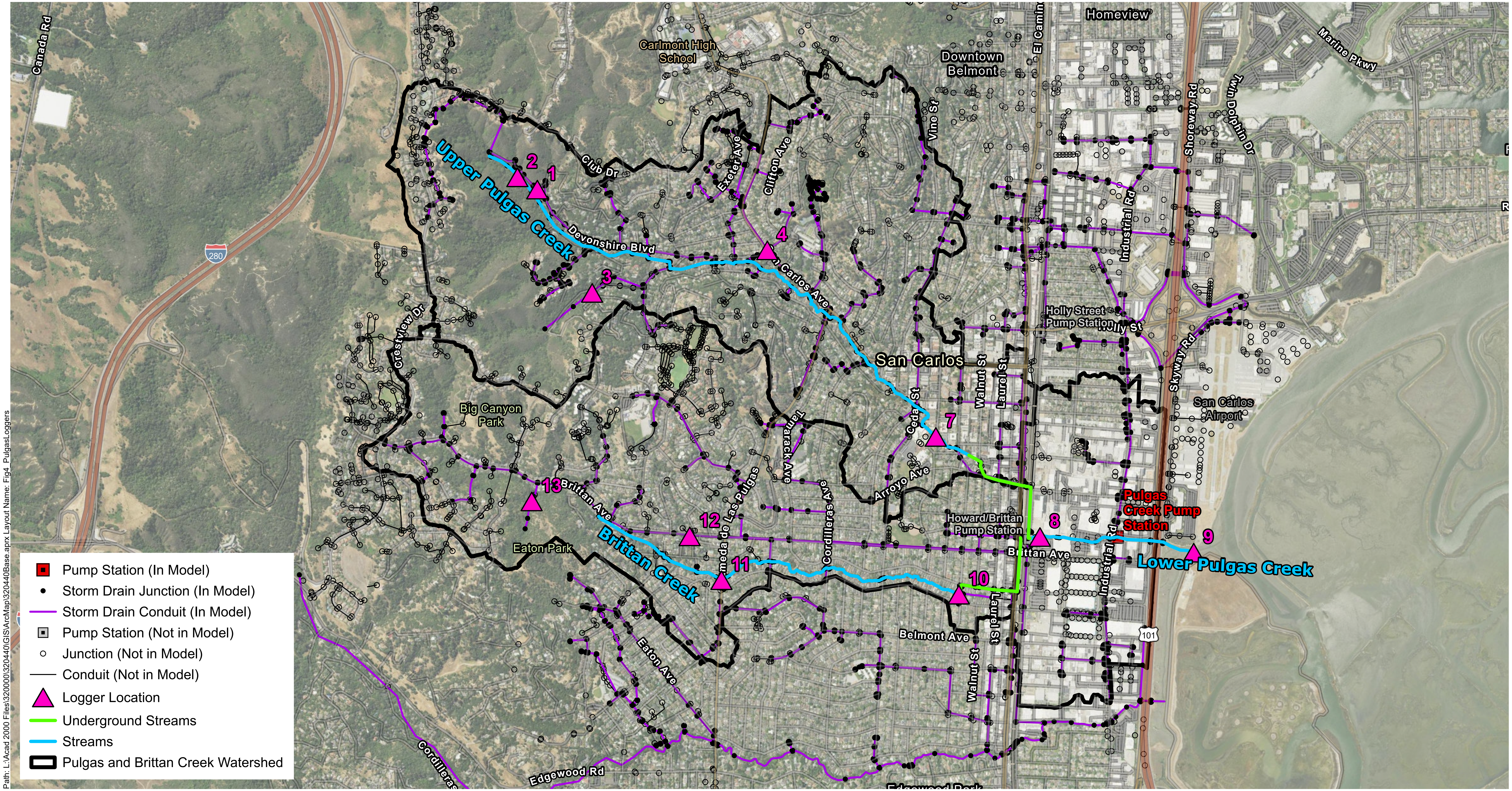

Sources: USDA NAIP Imagery 2020, WRA | Prepared By: junjie.chen, 6/21/2024

Figure 4. Storm Drain System Logger Locations

Pulgas Watershed Study
Existing Conditions H&H Memo
City of San Carlos, San Mateo, CA

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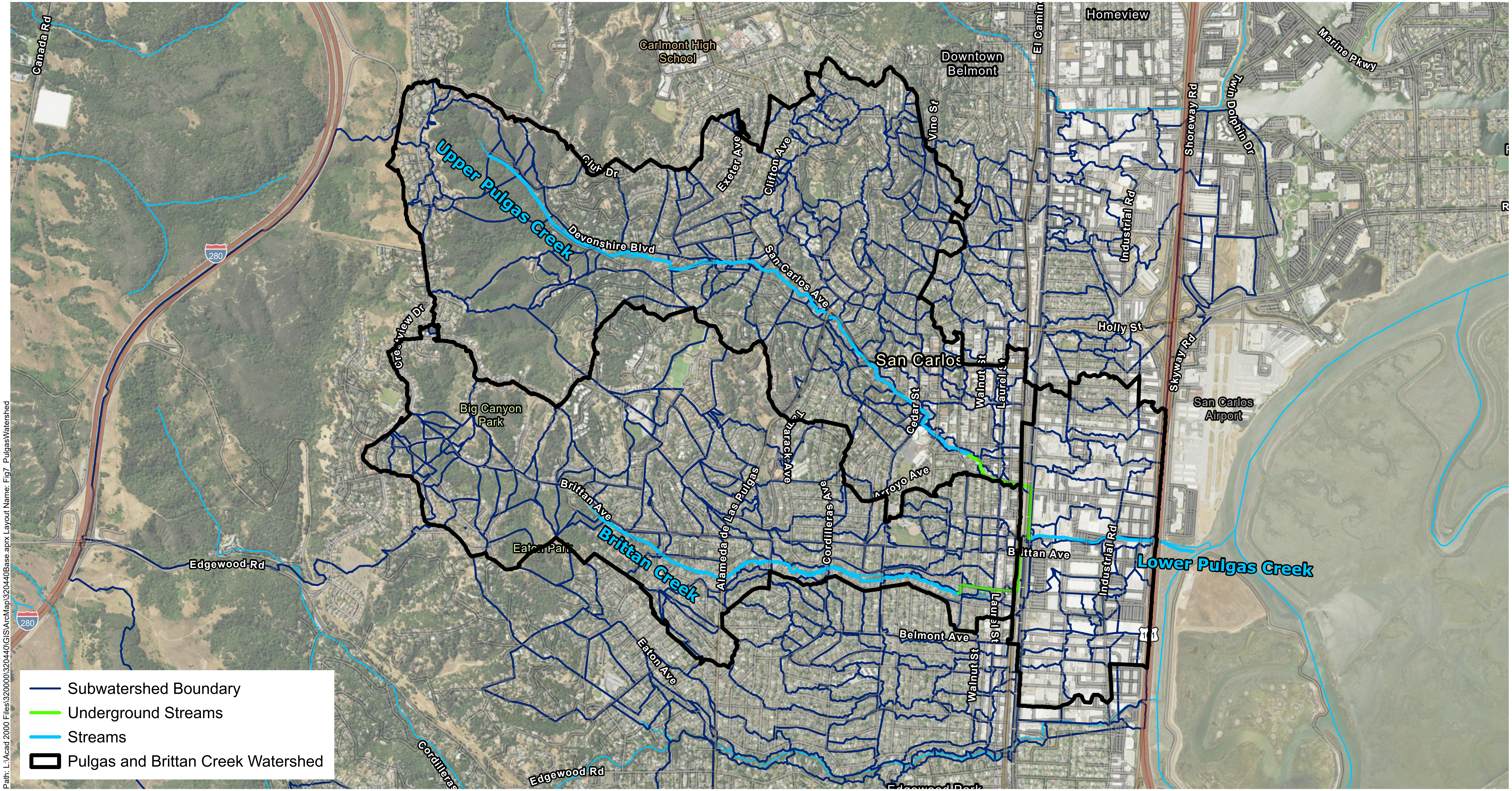

Sources: USDA NAIP Imagery 2020, WRA | Prepared By: junjie.chen, 6/21/2024

Figure 5. Sub-watersheds - Pulgas Creek Watershed

Pulgas Watershed Study
Existing Conditions H&H Memo
City of San Carlos, San Mateo, CA

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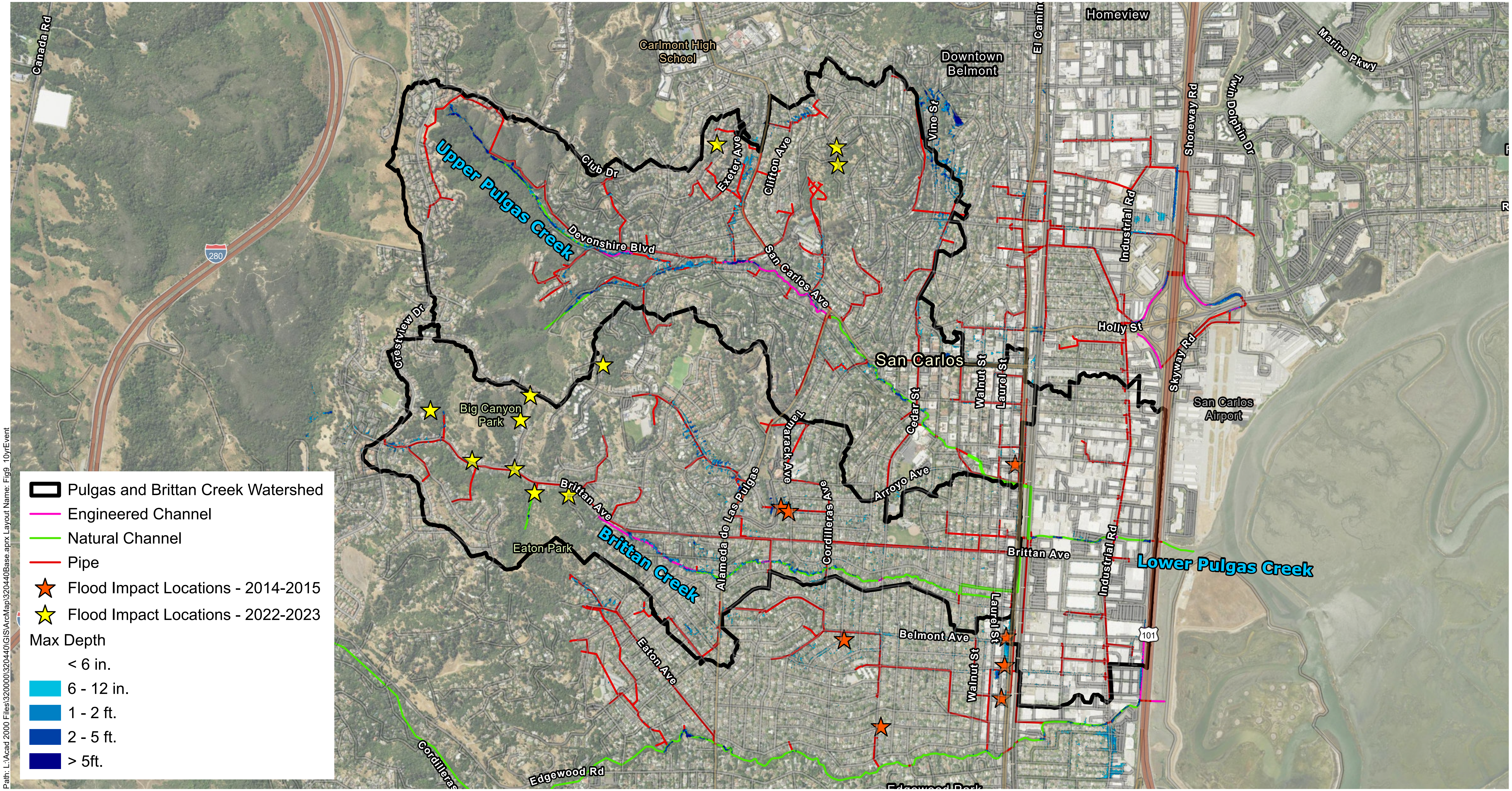

Sources: USDA NAIP Imagery 2020, WRA | Prepared By: junjie.chen, 6/21/2024

Figure 6. 10-year Flood Event (AMC II) Base Conditions

Pulgas Watershed Study
Existing Conditions H&H Memo
City of San Carlos, San Mateo, CA

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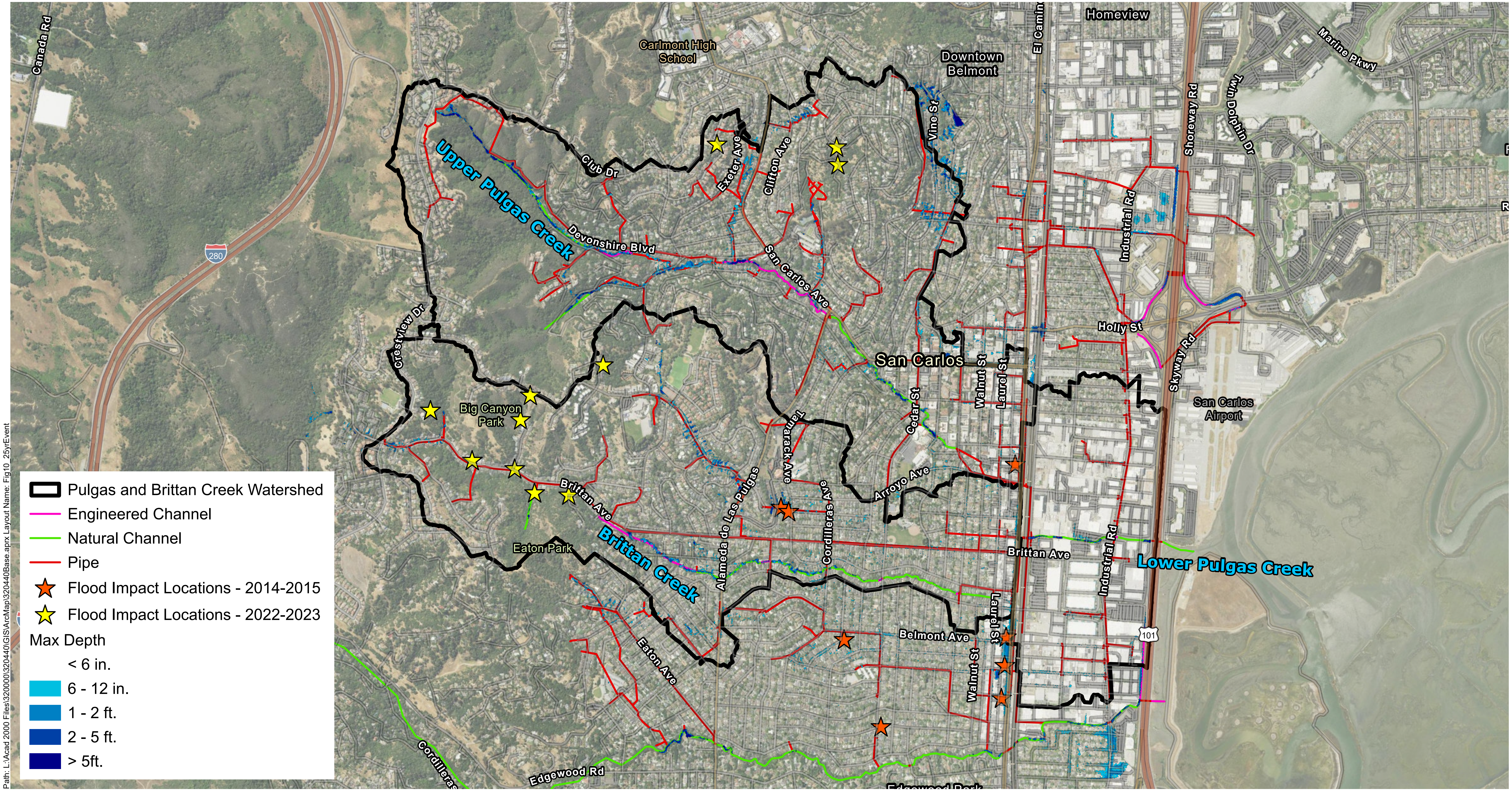

Sources: USDA NAIP Imagery 2020, WRA | Prepared By: junjie.chen, 6/21/2024

Figure 7. 25-year Flood Event (AMC II) Base Conditions

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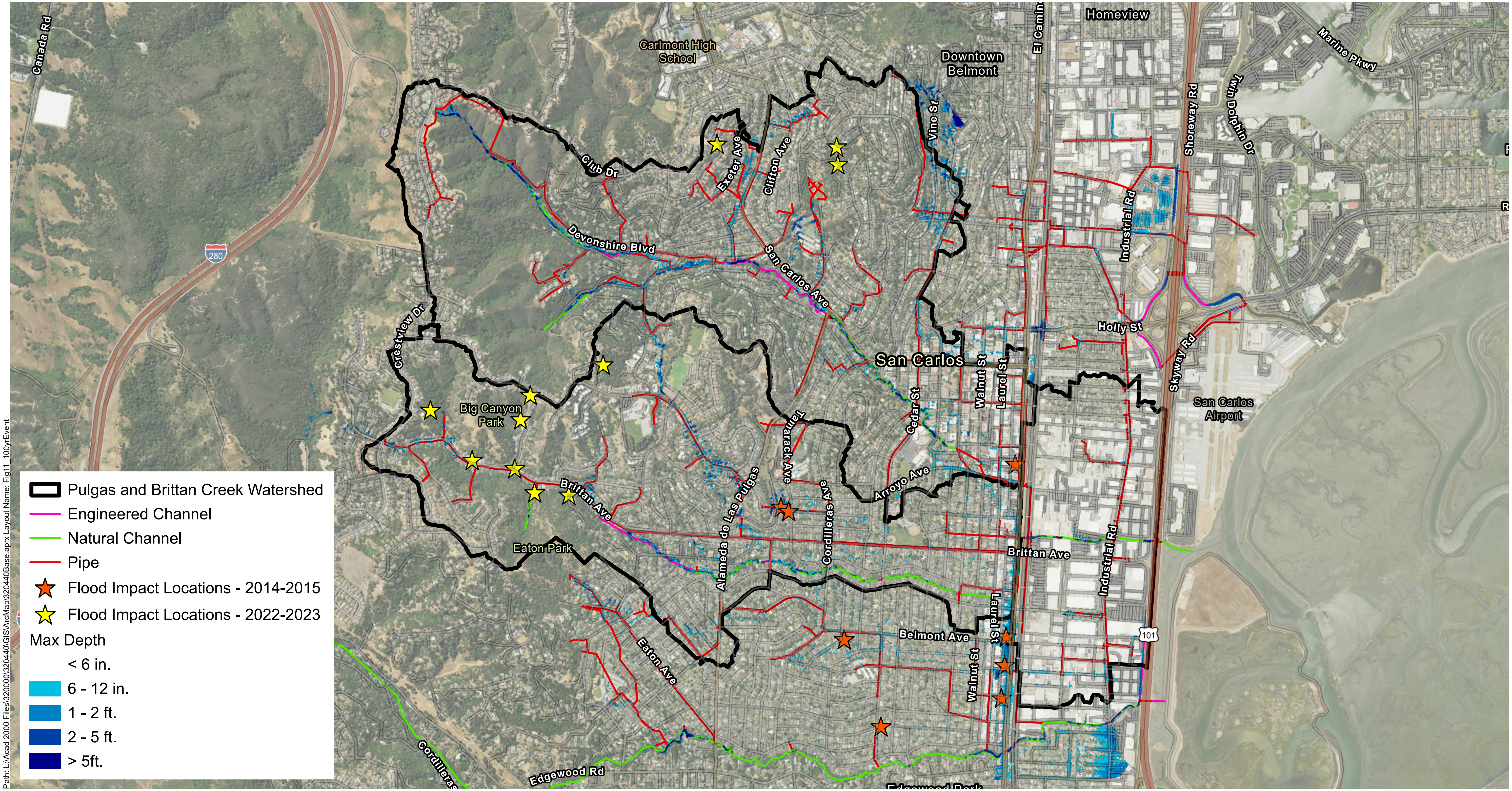
Pulgas Watershed Study
Existing Conditions H&H Memo
City of San Carlos, San Mateo, CA



Sources: USDA NAIP Imagery 2020, WRA | Prepared By: junjie.chen, 6/21/2024

Figure 8. 100-year Flood Event (AMC II) Base Conditions

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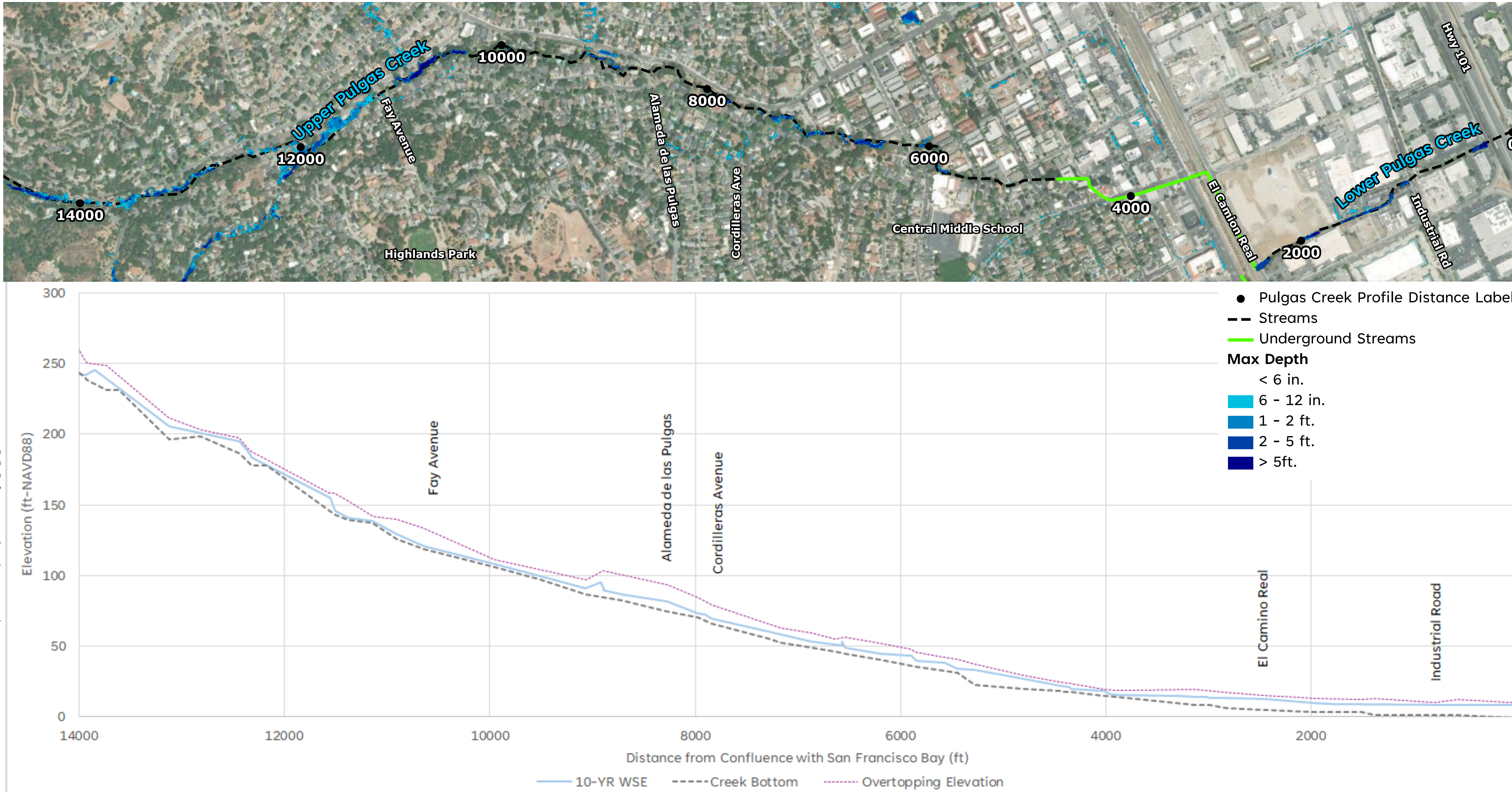
Pulgas Watershed Study
Existing Conditions H&H Memo
City of San Carlos, San Mateo, CA



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Sources: USDA NAIP Imagery 2020, WRA | Prepared By: junjie.chen, 6/24/2024

Figure 9. 10-Year Plan and Profile Views for Pulgas Creek

Pulgas Watershed Study
Existing Conditions H&H Memo
City of San Carlos, San Mateo, CA

0 0.25 0.5 Miles

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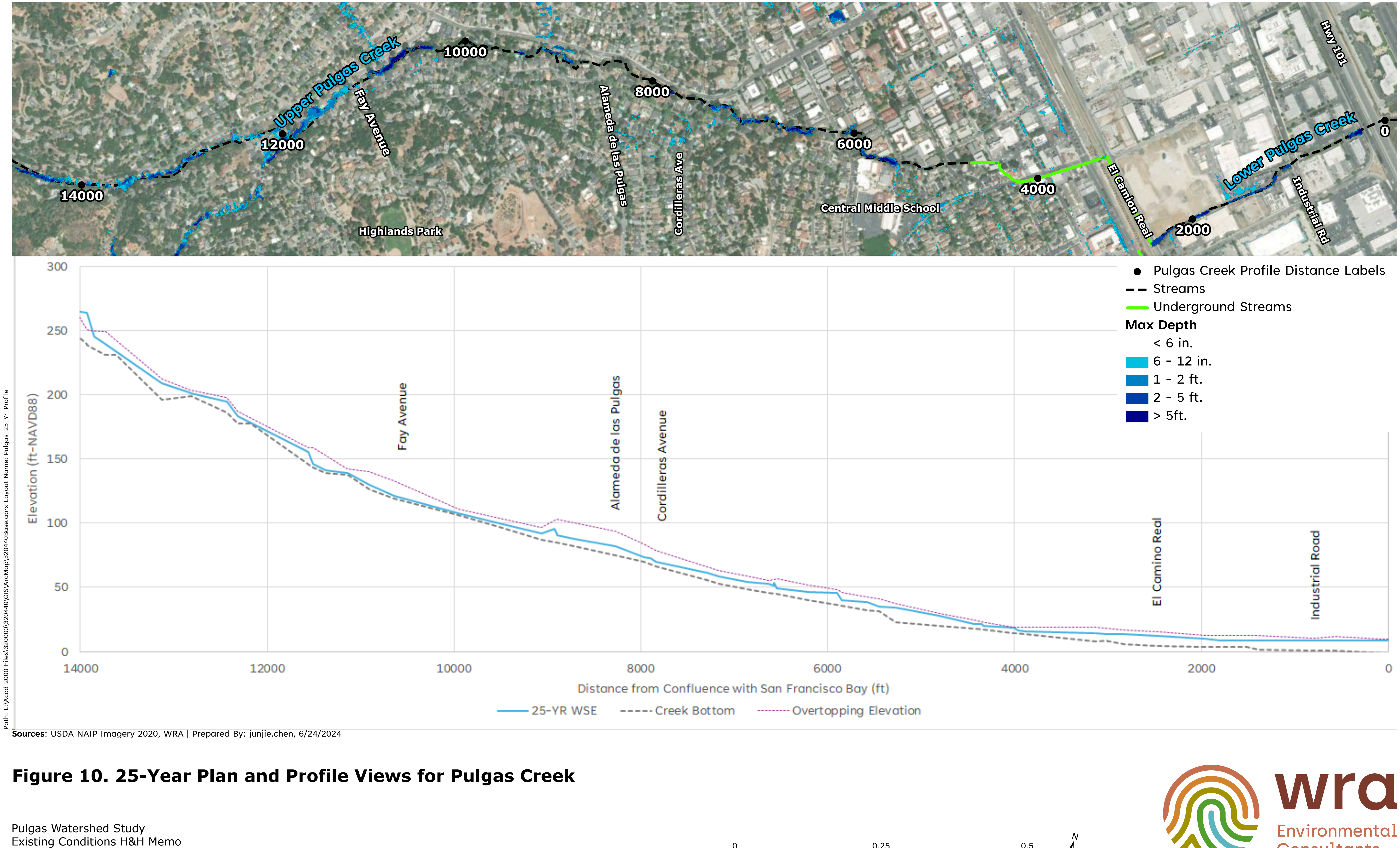

Sources: USDA NAIP Imagery 2020, WRA | Prepared By: junjie.chen, 6/24/2024

Figure 10. 25-Year Plan and Profile Views for Pulgas Creek

Pulgas Watershed Study
Existing Conditions H&H Memo
City of San Carlos, San Mateo, CA

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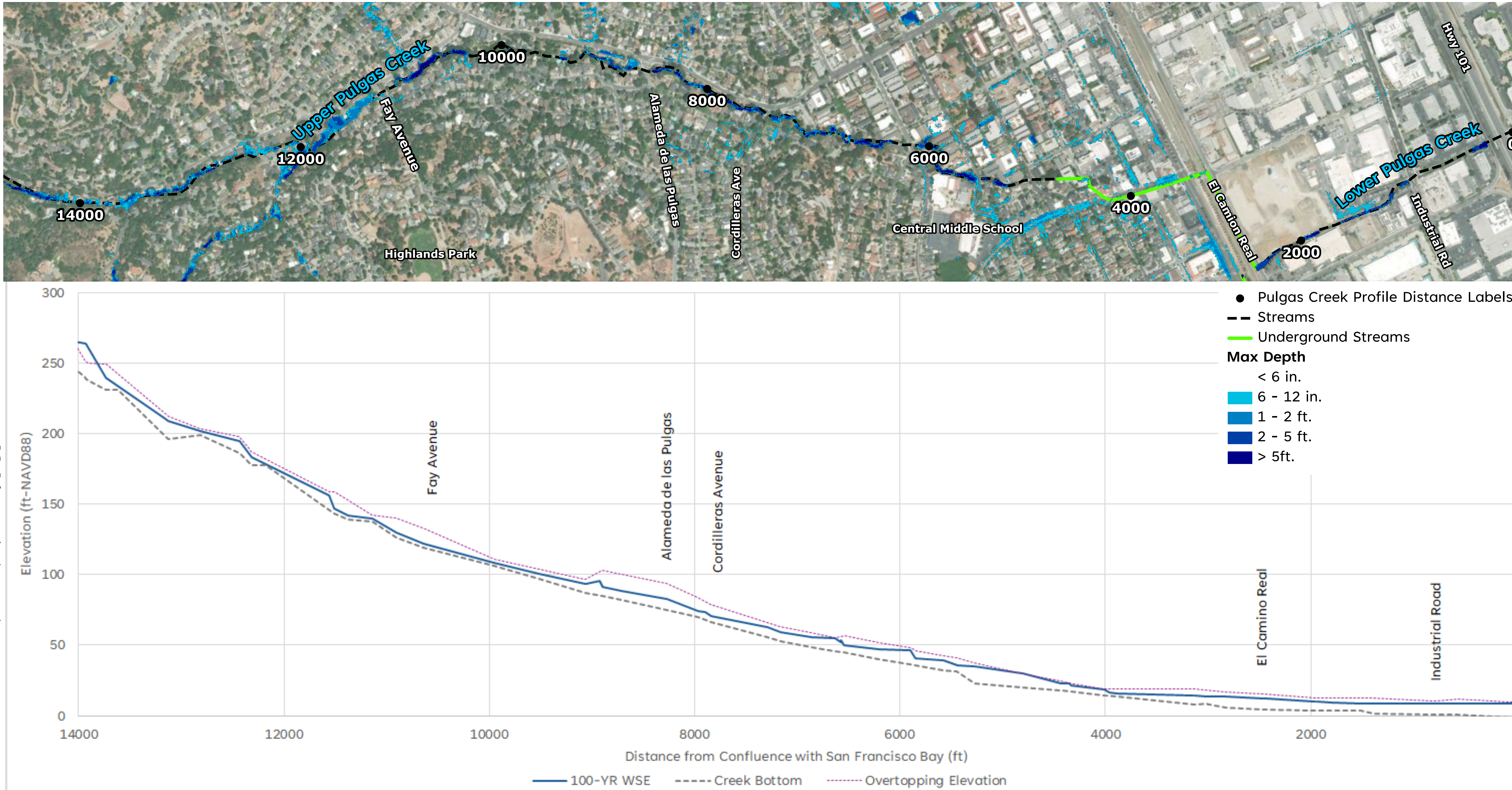

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Sources: USDA NAIP Imagery 2020, WRA | Prepared By: junjie.chen, 6/24/2024

Figure 11. 100-Year Plan and Profile Views for Pulgas Creek

Pulgas Watershed Study
Existing Conditions H&H Memo
City of San Carlos, San Mateo, CA

0 0.25 0.5 Miles
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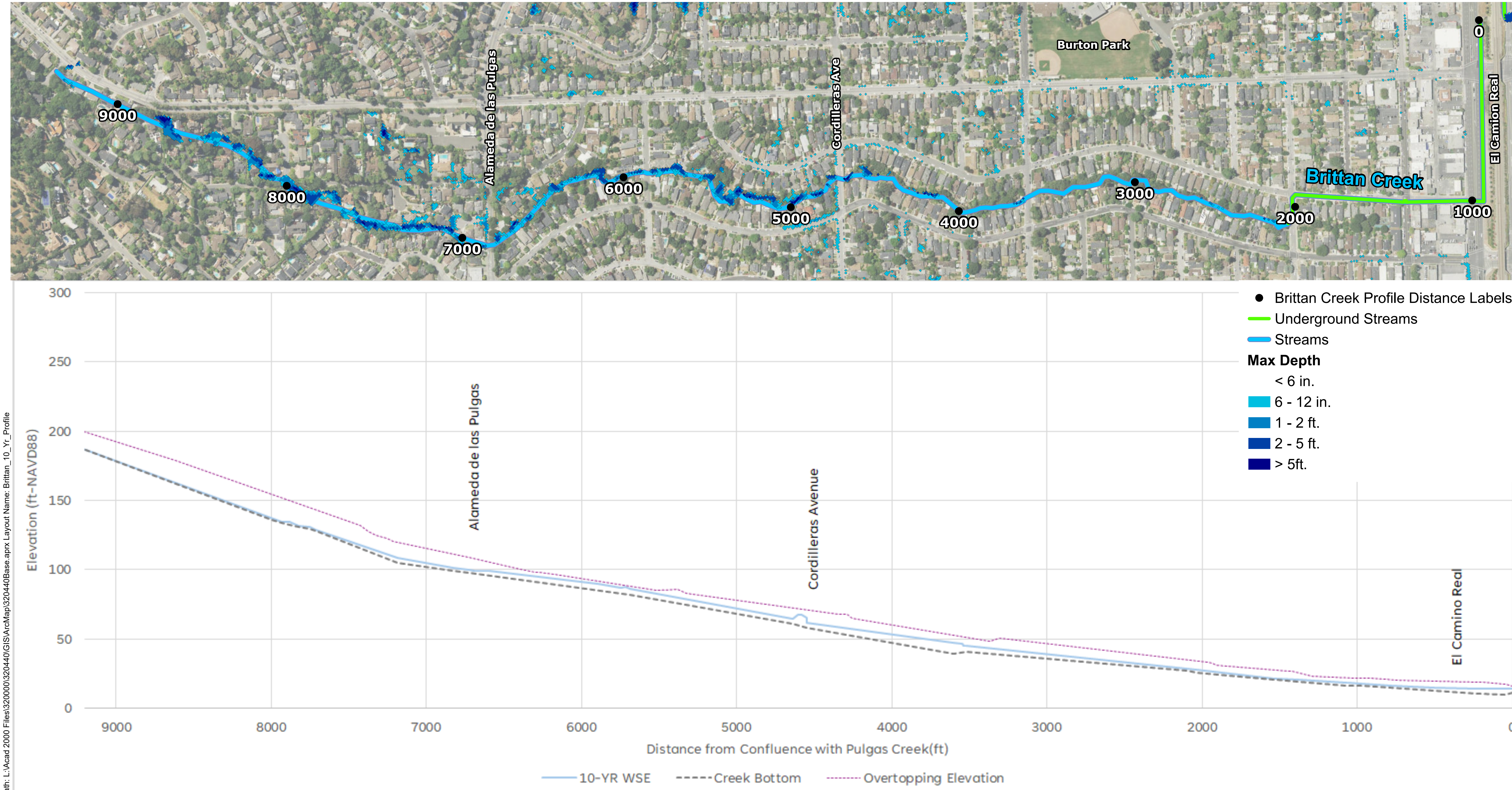

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Sources: USDA NAIP Imagery 2020, WRA | Prepared By: junjie.chen, 6/21/2024

Figure 12. 10-Year Plan and Profile Views for Brittan Creek

Pulgas Watershed Study
Existing Conditions H&H Memo
City of San Carlos, San Mateo, CA

0 0.25 0.5 Miles

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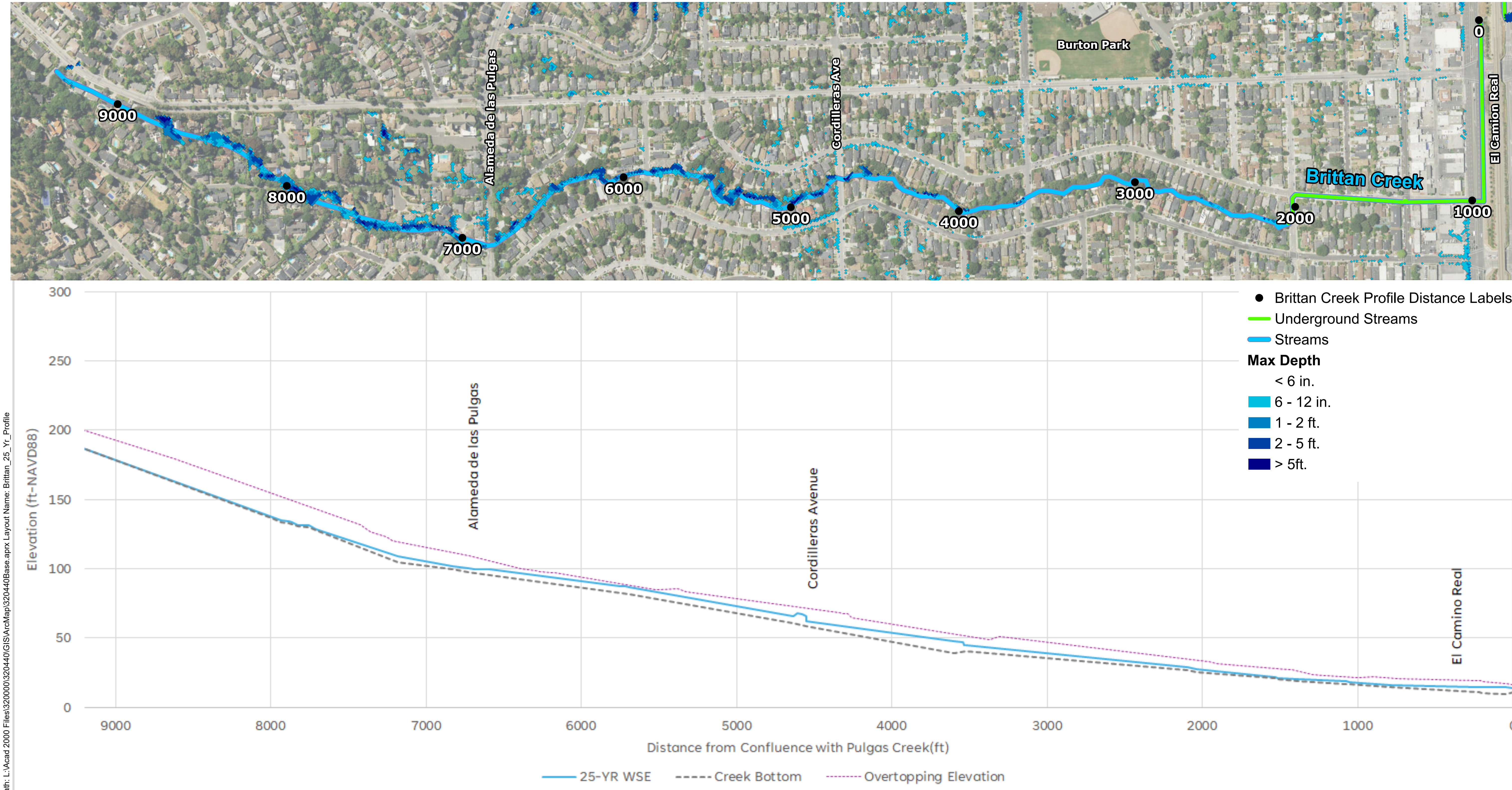

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Sources: USDA NAIP Imagery 2020, WRA | Prepared By: junjie.chen, 6/21/2024

Figure 13. 25-Year Plan and Profile Views for Brittan Creek

Pulgas Watershed Study
Existing Conditions H&H Memo
City of San Carlos, San Mateo, CA

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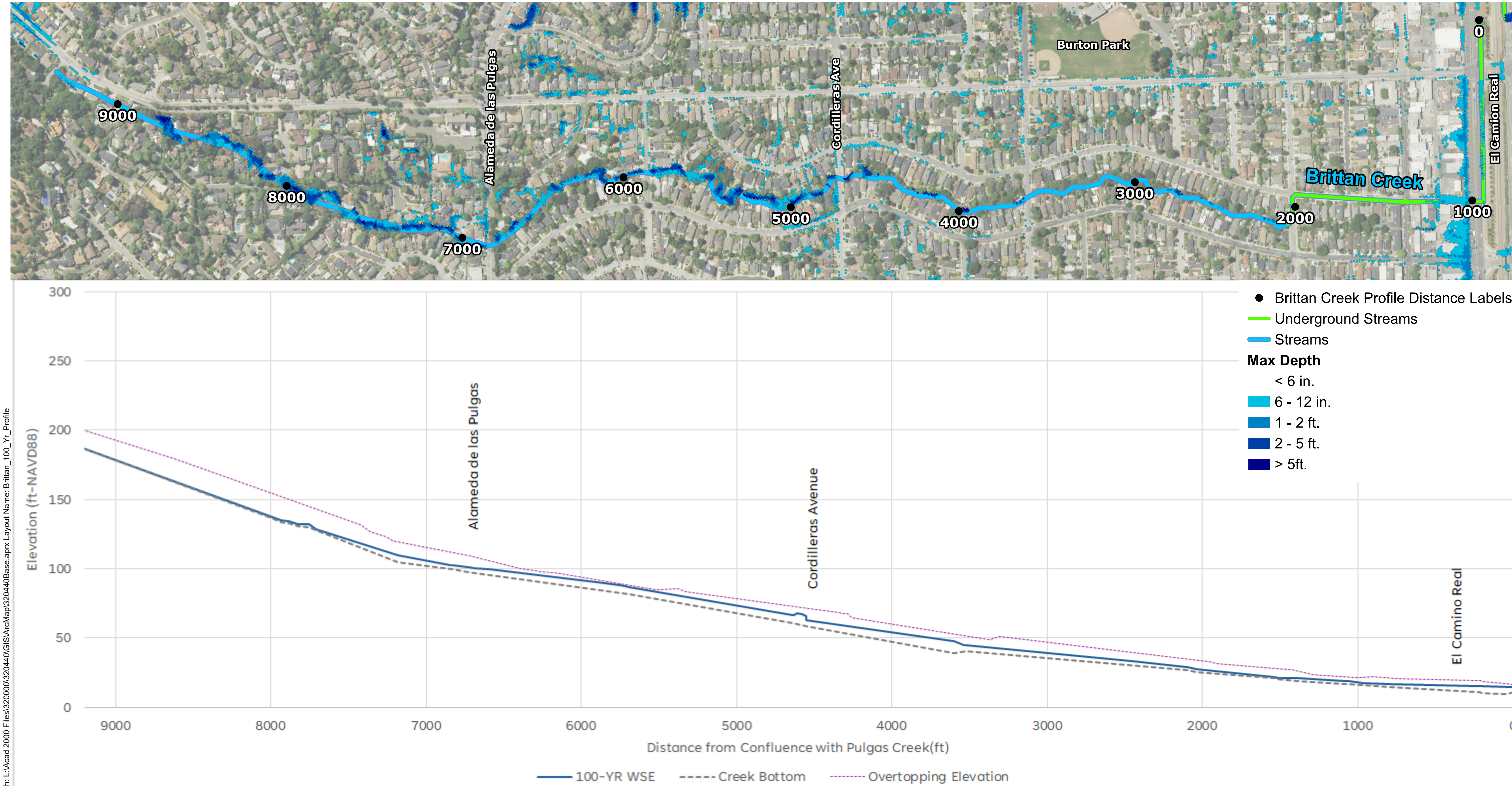
wra Environmental Consultants



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Sources: USDA NAIP Imagery 2020, WRA | Prepared By: junjie.chen, 6/21/2024

Figure 14. 100-Year Plan and Profile Views for Brittan Creek

Pulgas Watershed Study
Existing Conditions H&H Memo
City of San Carlos, San Mateo, CA

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Appendix B: Climate Change Memorandum

FREYER & LAURETA, INC.
Civil Engineers – Surveyors – Construction Managers

PULGAS CREEK WATERSHED CLIMATE CHANGE DRAFT MEMORANDUM

RE: City of San Carlos Pulgas Creek Watershed – DRAFT Climate Change Memorandum

Date: July 12, 2024

To: Grace Le, P.E/City of San Carlos

From: Camille Bandy, P.E. (F&L)
Mark Quito (F&L)
Andrea Garcia (F&L)

Reviewed: Jeffrey Tarantino, P.E. (F&L)

1. Introduction

The City of San Carlos (City) is highly vulnerable to the effects of climate change including rising sea levels, shallow groundwater rising, and increased precipiation intensity. Most specifically the lower portion of the City along the bayshore is most prone to flooding and coastal erosion increasing the risk to life, safety, and critical infrastructure. The San Mateo County's Sea Level Rise Vulnerability Assessment (San Mateo County, 2018) was finalized in 2018, highlighting San Mateo County as the most vulnerable county in California to sea level rise in terms of property value at risk. Modeling results from the vulnerability assessment showed potential flooding of the 1% (100 - Year FEMA Base Flood Elevation) plus 6.6 feet of sea level rise for a high-end scenario (Figure 1).

In 2019, the San Mateo County Board of Supervisors approved a Sea Level Rise Policy (SLR Policy) for County-Owned Assets. The SLR Policy requires that sea level rise is considered in all County-Owned and operated assets, design, construction projects, leases, and property acquisitions and dispositions. These projects must also consider local and regional sea level rise adaptation and flood mitigation projects that could reduce impacts on County-owned assets prior to developing plans to modify existing facilities. Acquisitions that are exempt from this policy: tax default properties; property condemned by the County for roads, sewers, and utilities; right of way, public utility easements; conservation easements; and public service easements. This policy does not apply to private development or development by other public entities.

In addition to the SLR policy, the San Mateo County Flood and Sea Level Rise Resiliency District (OneShoreline) began operating in 2020. OneShoreline is an independent government agency that addresses the design and building process to combat sea level rise, working with cities and developers to build resiliency through planning and coordinating efforts for multijurisdictional flood mitigation projects.

The SLR Policy and OneShoreline serve to coordinate countywide efforts for a solution to implement adaptive measures and policies to combat climate change. Utilizing the SLR Policy and OneShoreline efforts, this memorandum serves as a roadmap to implement existing policy recommendations to address sea level rise, shallow groundwater, and increased precipitation intensity and frequency.

2. Future Conditions

San Carlos is also expected to experience many impacts of climate changes such as sea level rise, droughts, extreme heat, inland flooding, landslide and debris flow, severe storms, and wildfires, groundwater level rise. Although all effects of climate change will impact the watershed, some of the key future conditions that will impact the watershed are sea level rise, severe storms, and groundwater level rise. The impacts of climate change can cause more frequent landslides, flooding, and even impact water quality.

Sea Level Rise

Higher temperatures also cause ocean water levels to rise, causing further rising sea levels along the bayshore. This is a gradual process that can take place over the span of years or decades. Eventually, sea level may increase enough to permanently flood low-lying areas in the eastern part of San Carlos or just adjacent to San Carlos. Many of the tidal marshes in eastern San Carlos are also expected to convert to another habitat type, a process called "downshifting," which will lead to different plant and animal species, and some features of wetlands may be altered or lost. The rise in sea levels can also result in larger flooding and would make the shoreline more susceptible to flooding even during normal rain conditions.

With sea level rise, the flooding risk will start to impact infrastructure that impacts not only San Carlos, but also the regionally, such as Highway 101, the San Carlos Airport, and the Silicon Valley Clean Water Wastewater Treatment Plant (SVCWWTP) in Redwood City that are all within low-laying areas of the San Francisco Bay. Flooding of major infrastrucutre could cause many distruptions to the community, including temporary closures of roads and businesses. Although the SVCWWTP is located within Redwood City, it is infrastructure that treats all of San Carlos' sanitary sewer. The SVCWWTP is highly vulnerable to the impacts of sea level rise due to most of the components being at or below seal level. If there was a failutre of the levee system that currently protects SVCWWTP, there could be major consequences, especially since there is no other facility that treats untreated wastewater in the service area.

Precipitation Intensity and Frequency

During recent years, California has experienced a series of dry years followed by the wettest weeks on record. San Mateo County was severely impacted by two atmospheric river storms that occurred between 2022 and 2023 and brought 75% of all precipitation for the year, resulting in major flooding. Future storm intensity and frequency are likely to become more common in the future, causing more frequent flooding events, especially in more low-lying areas in combination with the tides from the San Francisco Bay.

In the past years, flooding was mostly observed in the lower portion of San Carlos. In the most recent flooding years, the City has experienced floods in the upper portion towards the western hills comprising of parks and less developed spaces. Based on a comparison of flood events to hourly precipitation intensity data from the California Data Exchange Center (CDEC) station, the Pulgas Creek Watershed appears to be at risk of flooding for storm intensities at approximately 0.75 inches per hour. Climate change can affect the intensity and frequency of precipitation. The potential impacts of more severe and more frequent storms include soil erosion leading to more frequent landslides and an increase in sedimentation due to heavy precipitation. The increase in

Sea Level Rise Vulnerability Assessment, *County of San Mateo*	The County of San Mateo developed a baseline Sea Level Rise Risk Assessment of County-owned and operated assets and leased facilities.
San Mateo County Sea Level Rise Project Database, *County of San Mateo*	The county will develop and maintain a database to track major existing and planned sea level rise adaptation projects along the San Mateo County Bay and coast shorelines. The database will include a project overview, area covered, and proposed elevation. The database will be updated on an annual basis. The database will be used to inform the initial assessments at all County owned and operated assets and for new projects as they are developed. This will ensure that any site-based adaptation options within the Monitoring and Adaptation Plans will be designed with regional shoreline approaches considered. The County will collaborate with regional collaboratives or agencies to ensure the accuracy of the information in the database.
Map of Future Conditions, *OneShoreline*	OneShoreline has developed an interactive online map to accompany the OneShoreline Planning Policy Guidance document. The map illustrates the Bay Protection Standard and the proposed boundaries of the Overlay Districts for sea level rise and shallow groundwater rise recommended by OneShoreline.

Using the tools and resources above, the City should transition to climate-adaptive and prepared facilities by assessing new projects, monitoring existing facilities, tracking progress, and finding opportunities for restoration.

Adoption of a Sea Level Rise District

As climate changes and sea levels rise, San Carlos will likely experience more instances of flooding. It is crucial to identify the sea level rise area in San Carlos and ensure that the residents, businesses, and critical infrastructure are protected. By identifying the sea level rise area in San Carlos, the City can assess existing and new projects in the sea level rise area and further monitor sea level rise impacts to each location. This plan recommends that the City consider developing and adopting a Sea Level Rise Overlay District (SLR District) or Zone with associated land use regulations for site planning and minimum construction elevations that support appropriate mitigation and adaption in response to sea level rise.

Policies with the associated District or Zone could include:

- SLR District boundaries and map

sedimentation can lead to reducing capacity in storm drains or even blocking drainage systems, causing flooding, not only in the low-lying areas of San Carlos, but also in the upper watershed.

When precipitation-related flooding occurs at the same time as high tides, flooding can be more extreme since storm drain infrastructure and creeks would likely be at full capacity. Sea level rise will only elevate the risk of these type of events occurring.

Groundwater Level Rise

Shallow groundwater levels are predicted to rise, creating numerous potential impacts on the community, including buoyancy, seepage, infiltration, liquefaction, corrosion, and contaminant mobilization hazards. Initial studies identify shallow groundwater rise as one of the most consequential impacts of sea level rise. The best available science indicates that low-lying communities located inland from the Bay could experience flooding impacts from rising shallow groundwater long before sea level rise overtops the Bay shoreline. Even prior to experiencing flood impacts from rising shallow groundwater, rising groundwater levels will put existing infrastructure at risk, including increased infiltration into storm drain and sewer pipes, destabilizing foundations, and flooding within basements or other below-grade structures.

Groundwater level rise could contribute to contaminant mobilization. As groundwater levels rise within contaminated sites, there is an increased risk that contaminants from the site could be released and conveyed within groundwater. The contaminant mobilization can also impact how the mitigation and risk management of a contaminated site may perform, posing a risk to the surrounding environment.

3. Recommendations

To address future climate change, policies, standards, and guidelines will need to be created. Consistent with the County of San Mateo and OneShoreline goals, recommendations were developed to:

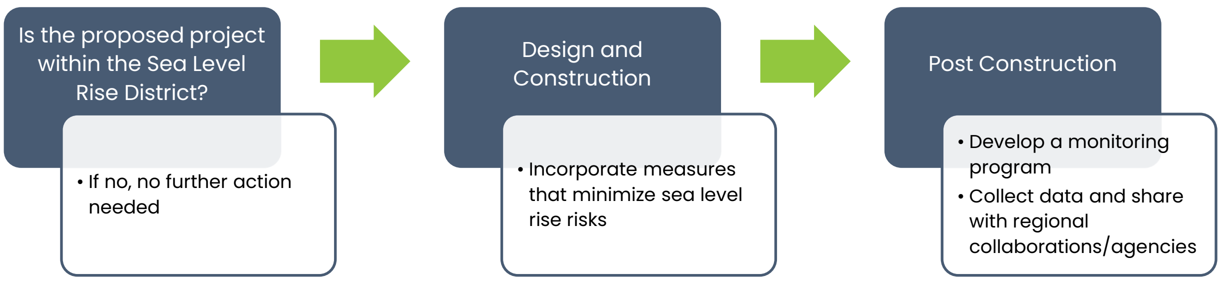
- Protect new and/or substantial construction from future conditions by incorporating climate science into land use planning, development review process, and policy change.
- Protect existing critical facilities and public infrastructure from future conditions.
- Prioritize natural-based infrastructure to the greatest extent feasible when adapting to future conditions.
- Develop regionally coordinated sea level adaptation measures and programs with regional stakeholders.

Infrastructure Evaluation

To implement the goals, OneShoreline has developed a number of resources and tools to address sea level rise concerns. The City is encouraged to utilize the tools and resources below when developing new infrastructure projects or evaluating existing infrastructure and facilities.

Tool Name	Description
Sea Level Rise Mapping Tool, *County of San Mateo*	San Mateo County established a GIS-based sea level rise map layer for use by departments in determining sea level rise inundation areas during the design process. The GIS map layer can be found in the County website and will be updated as needed.

- Development standards including floor elevation, floodproofing critical equipment, buffer zones from the San Francisco Bay Shoreline and creeks
- Additional Requirements for shoreline barriers
- Increasing the required amount of stormwater retention on-site
- Requiring fees to fund the restoration of creeks



As part of the SLR District, the City should utilize the boundaries to assess existing and new projects in the sea level rise area and continue to monitor the impacts of sea level rise in each location. All new projects should be screened using the SLR District boundaries and map to determine whether a project falls within the sea level rise inundation area as outlined in Figure 1. The first step would be a preliminary assessment to include initial consultation on sea level rise risks and potential protection provided by existing flood mitigation projects. Should the project lie outside the outlined inundation area, the assessment can stop here.

Once determined that the project or infrastructure lies within the inundation area, the City may want to increase the scale of new facilities for locations that are at high risk and sensitive or if the building is a critical facility that must maintain operations and access during flood events. It is also critical for developers and landowners to provide adequate space for future infrastructure development and the land rights to use that space to build resilience in communities. Additionally, new facility projects funded by the City shall be sited, designed, constructed, and adaptively managed to minimize sea level rise risks over the life of the project.

For existing facilities and infrastructure within the SLR District, it is recommended that continual monitoring occurs by an oversight department. The oversight department should work to establish thresholds and triggers for monitoring purposes. In the event of subsequent flooding, the oversight department should closely monitor to find the facilities and/or infrastructure that are being affected the most by such events. Data collected from monitoring the performance of existing facilities can help inform the City which facilities need to be prioritized and upgraded to adapt to SLR.

Ongoing capital projects located in areas of risk from sea level rise beyond what will be protected through local or regional planned sea level rise adaptation projects will incorporate an assessment of sea level rise risk and development of monitoring and adaptation strategies as needed.

As part of the Sea Level Rise Overlay District, OneShoreline recommended two different elevation standards in response to sea level rise: Sea Level Rise (SLR)- Base Flood Elevation (BFE) and the Bay Protection Standard. The

SLR-BFE is the recommended lowest floor elevation for a building located within the Sea Level Rise Overlay District. The SLR-BFE is three feet above the project site's BFE and can be found using the Federal Emergency Management Agency's (FEMA) Flood Insurance Rate Map (FIRM) at the time of project application.

The Bay Protection Standard is the minimum, post-settlement elevation required at the top of any shoreline along the San Francisco Bay Shoreline. The Bay Protection Standard is based on the Base Flood Elevation (BFE) and adding a 6-foot buffer to accommodate for an increase in hazards as sea levels rise. The Bay Protection Standard will vary depending on the location of interest. The Coastal BFE can be found on the FEMA and is based on the Zone VE elevations where available; otherwise, Zone AE elevations can be used.

In addition to adopting a Sea Level Rise Overlay District, it is recommended that the City continue to participate in and develop countywide strategies to update development standards and ordinances for at-risk areas. The City should also continue to collect relevant information and should share it with the regional collaboratives and/or agencies responsible for implementing sea level rise or flood mitigation projects.

Adoption of a Shallow Groundwater Rise Overlay District

As climate changes and sea levels rise, groundwater is also anticipated to also rise. Groundwater rise can create numerous potential impacts on the community. Groundwater rise can contribute to inland flooding in low-lying coastal communities It is necessary to identify the groundwater rise in San Carlos and ensure that the residents, businesses, and critical infrastructure are protected. This plan recommends that the City consider developing and adopting a Shallow Groundwater Rise Overlay District or Zone with associated land use regulations for site planning and standards that support appropriate mitigation and adaption in response to shallow groundwater. Policies with the associated District or Zone could include:

- Assessment of the project's vulnerability to shallow groundwater rise
- Incorporation of project measures that monitor and mitigate shallow groundwater impacts

The City should adopt a Shallow Groundwater Rise Overlay District and develop a policy that includes:

- Shallow Groundwater Overlay boundaries and map (Figure 2)
- Development standards to address future groundwater conditions, contaminated sites, liquefaction, below-grade structures and utilities, and roadway subgrades
- Requirement of additional performance standards such as geotechnical data collection, topographic data collection, vulnerability assessment and mitigation and real estate disclosure of hazards.

One requirement that the City could implement within the Shallow Groundwater Rise District, is to have developments install permanent monitoring wells onsite, especially if the site has known contaminated soils. As part of their development agreement, the owners would be required to monitor groundwater levels and test for levels of contamination. The City could utilize the information for city-wide purposes as well as ensure that owner-led mitigation efforts continue if groundwater rises or contamination levels change.

The policy should be consistent with OneShoreline Planning Policy Guidance. It is also recommended that the City should continue to participate in and develop countywide strategies to update development standards and ordinances for at-risk areas of shallow groundwater rise. The City should also continue to collect relevant information and should share it with the regional collaboratives and/or agencies as standards are being developed for shallow groundwater rise areas.

FEMA CRS Study

San Carlos participates in the FEMA Community Rating System (CRS). CRS is a voluntary incentive program that recognizes and encourages community floodplain management practices that exceed the requirements of the National Flood Insurance Program (NFIP). CRS credits community efforts to surpass the minimum requirements and awards reduced flood insurance premiums for the community's property owners. San Carlos should continue to participate in CRS and study the full extent of the program's benefits, which reduce flood insurance premiums and can help save lives and property when a flood occurs. The goals of the CRS are to

(1) reduce and avoid flooding damage to insurable property,
(2) strengthen and support the insurance aspects of the NFIP, and
(3) foster comprehensive floodplain management.

Through CRS, flood insurance premium discounts can range from 5% to 45% and are discounted in increments of 5%. CRS rates communities based on the amount of credit points received, ranging anywhere between 0 to 4,500+ credit points. Class 10 is a community not participating and receives no discount up to the highest community rating. Class 1 community receives a 45% premium discount. San Carlos has participated in CRS since 2013 and is currently a Class 9 community, with a total of 717 credit points resulting in a 5% premium discount. In order for San Carlos to elevate to a Class 8 community, San Carlos will need to gain an additional 283 credit points. As a Class 8 community, San Carlos would obtain a 10% premium discount.

San Carlos can increase CRS credits through 19 creditable activities that can be organized under four categories

(1) public Information,
(2) mapping and regulations,
(3) flood damage reduction, and
(4) warning and response.

CRS provides opportunities to exceed the minimum requirements of NFIP, which could lead to further flood insurance premium rate discounts. Looking at the Mapping and Regulations category, it includes five subcategories that a community could earn credit, including:

(1) Flood Hazard Mapping
(2) Open Space Preservation
(3) Higher Regulatory Standards
(4) Flood Data Maintenance
(5) Stormwater Management

If credits are not already earned in these categories, the City could look into creating policies related to Stormwater Management. The Stormwater Management category includes stormwater management regulations (SMR) that allow for a maximum of 380 credits. The SMR includes policies related to:

- Size of Development (SZ): Credit is based on the minimum size of the area that is required to comply with stormwater management standards.
- Design Storms (DS): Credit is based on what design storm the community is using in the regulations.

- Low-Impact Development (LID): Credit is provided only if the community's stormwater management ordinance requires the use of LID.
- Public Maintenance (PUB): Credit is provided when the owners of all new facilities are required to allow the community to inspect stormwater management as necessary and perform the required maintenance.

In addition to the SMR, there is also a Watershed Master Plan (WMP) element that allows a community to earn a maximum of 315 credit points. The WMP credit is earned if the community implements the stormwater management regulations through an adopted watershed master plan. To receive credit points, the WMP must, at a minimum, address future development within the watershed and the impact of flows during a 100-year event. Credit is also provided for a WMP that

- evaluate future conditions and long-duration storms,
- impact of sea level rise and climate change,
- identify the wetlands and natural areas,
- address the protection of natural channels, and
- provide a dedicated funding source for implementing the plan.

This plan recommends that San Carlos conduct a study to understand the cost-benefit of implementing policies that surpass NFIP to improve the CRS score resulting in reduced flood fees. The study should investigate CRS policy recommendations, in all 19 creditable activities, to understand the associated CRS credit that allow for premium discounts. In addition, the study should help guide and establish policies that will continue to help prepare the community for future flood events.

Opportunities for Restoration

Public parks and open spaces typically present opportunities for the restoration of natural ecological systems or processes. Restoring natural ecological systems is an option to reduce vulnerability to climate change-related hazards while increasing the long-term adaptive capacity of coastal and inland areas. These open spaces could be tidal marshes, parks, rain gardens, and urban tree canopies and can include implementing projects such as revegetation. However, it also includes engineered systems and practices that use or mimic natural processes to conserve ecosystem values and functions, such as Low Impact Designs (LID) and detention basins. Further discussion of proposed capital improvement projects in public parks and open spaces can be found in the Flood Mitigation Evaluation Memorandum (WRA, 2024).

4. Conclusion

In order to combat the future climate change impacts, the City should consider implementing more than one of the proposed solutions to provide the best opportunities for the City in the future. Impacts of climate change, such as sea level rise, rise of groundwater levels, and increased precipitation frequency and intensity will need to be addressed not only by the City, but also with the neighboring cities and County of San Mateo. To address climate change, collaboration with adjacent cities and agencies is necessary and the City should continue to collect relevant information and should share it with the regional collaboratives and/or agencies responsible for implementing flood mitigation projects.

5. References

City of San Carlos. (2021). Climate Mitigation and Adaptation Plan.

County of San Mateo. (2018). Sea Level Rise Policy for County-Owned Assets.

Community Rating System. FEMA.gov. (2024). https://www.fema.gov/floodplain-management/community rating-system

OneShoreline. (2023). Planning Policy Guidance to Protect and Enhance Bay Shoreline Areas of San Mateo County

WRA, Inc. (2024). Flood Mitigation Evaluation Memorandum.

FIGURES

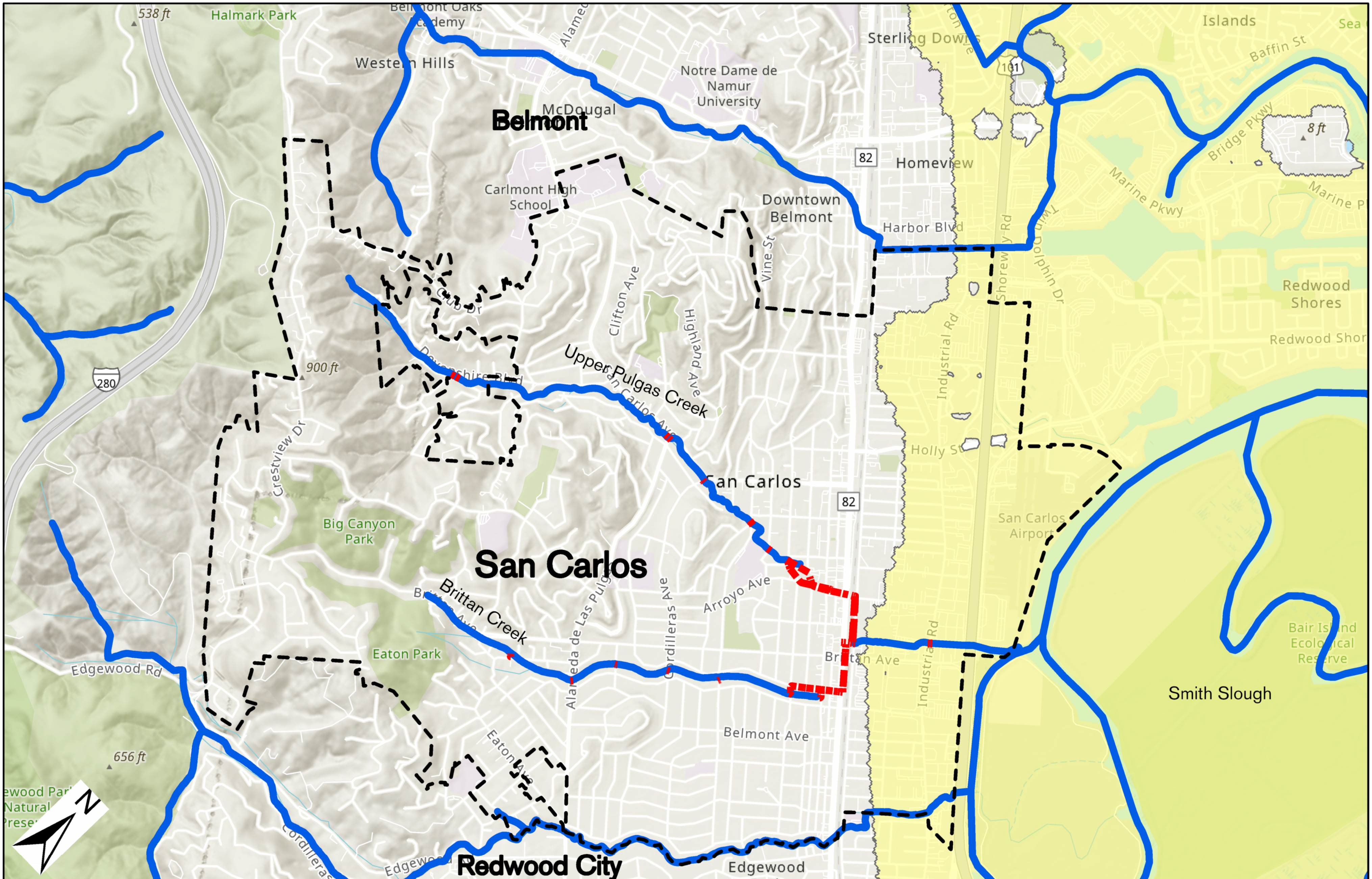


Figure 1
Sea Level Rise District Overlay
San Carlos

Job No.: 359001

Date: 07/23/2024

Legend

- San Carlos City Limit
- Sea Level Rise
- Streams
- Closed Creek Channel

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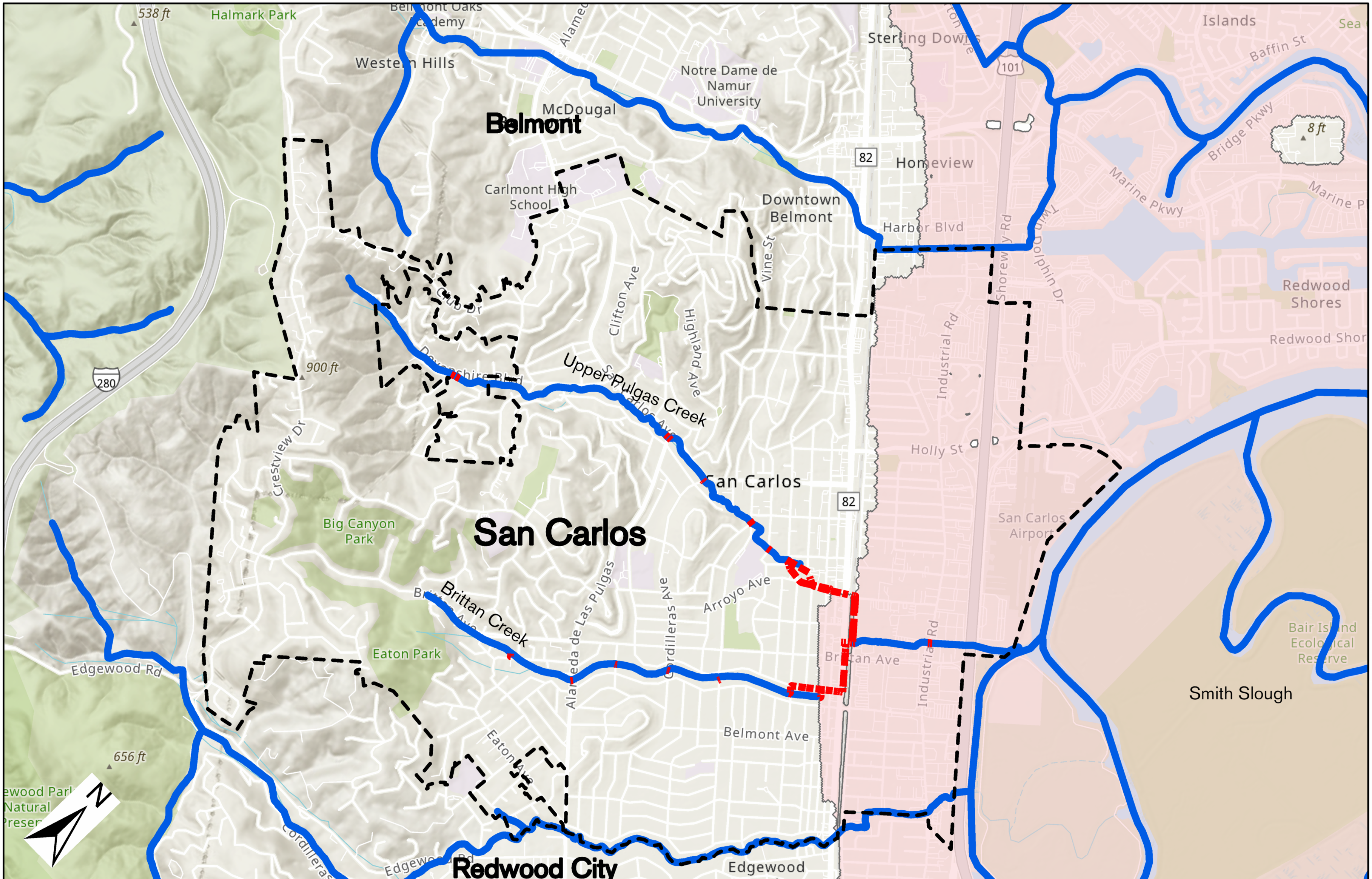

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Figure 2
Shallow Groundwater Rise District Overlay
San Carlos

Job No.: 359001

Date: 07/23/2024

Legend

- San Carlos City Limit
- Streams
- Closed Creek Channel
- Shallow Groundwater Rise

Appendix C: Flood Mitigation Evaluation Memorandum

MEMORANDUM - DRAFT

TO:	Grace Le, PE	**FROM:**	Andrew Smith, PE Chris Feng, PE Angela Hogan, PE
CC:	Camille, Bandy, PE, QSD Freyer & Laureta	Jeff Tarantino, PE Freyer & Laureta	
DATE:	December 19, 2024		
SUBJECT:	Pulgas Creek Watershed Study: Flood Mitigation Evaluation Memorandum Rev. 2		

BACKGROUND AND PURPOSE

The City of San Carlos, CA (City) is interested in developing a better understanding of the Pulgas Creek watershed (see *Figure **1*** and *Figure **2*** of Attachment A) and establishing a management plan with the aim of enabling creek restoration, increasing public access to sections of the creek, addressing existing flooding issues, and developing climate change mitigation strategies. A previous watershed study and hydraulic model was developed by GHD in 2017 as a part of the City's Storm Drain Master Plan (GHD, 2017). An update to the existing conditions model and assessment of existing flood risks are presented in the Hydrology and Hydraulics (H&H) memorandum by WRA.

This memorandum aims to assess potential options to re-naturalize the hydrograph and reduce existing flood risk throughout the Pulgas Creek watershed by:

- Assessing potential alternatives to reduce peak flows and add detention to the system (i.e., increase the time of concentration)
- Identifying ideal locations throughout the City for implementing alternatives
- Quantifying potential flood risk benefits from the suite of proposed alternatives on an individual and collective basis

FLOOD MITIGATION ALTERNATIVES TARGETS

As described in the Existing Conditions Hydraulics and Hydrology Memorandum (H&H Memo) by WRA, flooding in the Pulgas Creek watershed can be attributed to high sediment flow for the upper watershed and peak flow volume for the lower watershed 0.75 inch of rain in one hour (WRA, 2024). The aim of each alternative presented is to reduce risk of flooding by addressing causes and reducing peak flows. Reduction of flood risk in the upper watershed can be achieved by prevention or mitigation of erosion and landslides as well as capture of sediment prior to entering storm drains. Reduction of flood risk in the lower watershed can be achieved by detaining peak flows in the upper and middle watershed regions and increasing capacity. The Pulgas Creek channel downstream of Old County Road has an approximate capacity of 360 cubic feet per second (cfs) prior to overtopping and is limited by an existing box culvert. A 100-year event can produce a peak flow of over 620 cfs and have a duration exceeding 360 cfs for 10.5 hours causing approximately 97 acre-feet of stormwater to overtop the channel and flood the community (*Exhibit 1*). This flood reduction target assessment is based on existing conditions downstream from Old County Road and does not consider other constrictions immediately upstream where capacity issues can only be alleviated through upsizing pipes or culverts. The memorandum provides alternatives that could reduce the peak flows, detain specific volumes of stormwater, and increase capacity.

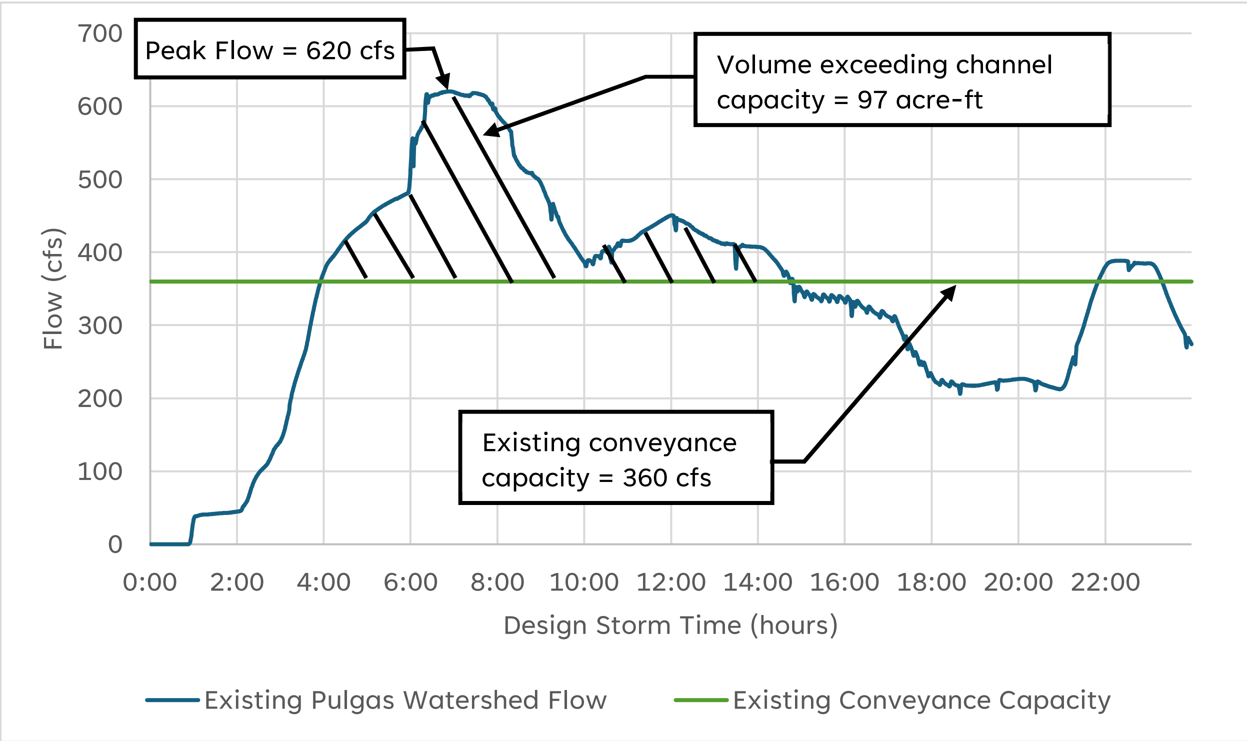

Exhibit 1. 100-year hydrograph of the Pulgas Creek watershed at Old County Road with capacity prior to flooding.

FLOOD MITIGATION ALTERNATIVES

WRA has identified seven flood mitigation alternatives focused on nature-based solutions and integration with existing City operations. The alternatives include:

A. Vegetation of existing exposed or sparsely vegetated slopes with strongly rooted native plants
B. Implementation of engineered flood plain detention basins where space is available, such as existing parks
C. Implementation of Low Impact Development (LID) and/or green infrastructure features throughout the City
D. Engineering analysis and site-specific plans for implementing nature-based solutions at specific creek crossings

E. Underground stormwater detention basins within public roadways, parks, right-of-way, etc.
F. Creekside public access through creek daylighting and establishment of small parks near public/private parcel intersections
G. Inspection and maintenance of historical problem sites

The alternatives differ in complexity, level of effort, and potential risks. Proposed locations for each alternative can be seen in *Figure **3*** of Attachment A. The ideal solution is likely a combination of the proposed alternatives. The objective for each alternative is to reduce flood risk throughout the Pulgas Creek watershed through attenuating flood flows by imitating the natural effect of floodplains and vegetation on water retention and detention. These alternatives are meant to represent a suite of options that vary in level of impact where one individual project may not resolve flooding issues for a region; however, once enough projects are undertaken, watershed scale flood benefits will be realized. Each alternative was roughly sized to accommodate a 10-year event or a 100-year event within the Federal Emergency Management Agency (FEMA) floodplain based on the City of San Carlos Design Guidelines (City of San Carlos, 2014).

Alternative A: Revegetation

Alternative A aims to address the dual impact of higher runoff and unstable slopes from low vegetative cover in regions of the Pulgas watershed, which can introduce sediment to the system and clog storm conveyance structures. Vegetation efforts are primarily concentrated on a landscape scale where land is available to be more densely vegetated, such as in the upland reaches of the Pulgas Creek watershed and around existing public parks, especially where landslide risk is prevalent. There are several locations primarily concentrated around existing parks where vegetation cover is dominated by non-native annual grasses that provide poor stability in the key wet months of October to December (*Exhibit **2***). The non-native annual grasses will yellow in the summer and only begin to re-establish in December when comprehensive vegetation coverage is needed to prevent landslides and capture precipitation. Establishment of native shrubbery and trees, which are persistent and deeply rooted, will likely decrease landslide risk, and provide precipitation absorption and abstraction throughout the year (Wilcox, et al., 2012). Attaining native establishment may involve a concerted annual effort to achieve success as establishment may be contingent upon a variety of factors such as soil suitability, existing soil microbial communities, nutrient availability, water availability, competition, and microclimate. An in-depth discussion of planting options and recommended planting palettes for the City are provided in Attachment B.

Impacts of land cover on precipitation can be quantified using a curve number (CN) with the Soil Conservation Service (SCS) method to calculate runoff rates for a given storm (USDA, 1999). Higher CN values indicate a more impermeable surface, such as concrete, with lower CN values indicating a more permeable surface. CN values are also dependent on the antecedent precipitation amounts where wet conditions or extreme storms can overwhelm the absorptive capacity of the soil and vegetation, resulting in an effectively increased value. Overly wet conditions can also continue to result in landslides and erosion, even with more deeply rooted native plants; thus, Alternative A aims to address landslide and runoff issues presented by a 10-year event.

Exhibit 2. Alternative A: opportunity for increased deeply rooted vegetative cover at Big Canyon Park. Photo credit: WRA

Alternative B: Floodplain Detention Basins

Alternative B aims to incorporate natural flood attenuation effects through construction of engineered flood plains. Flood plains naturally provide a variety of ecosystem benefits while calming high-flow energies to retain water within the floodplain, accrete sediment, and minimize erosion compared to a more typical engineered conveyance channel. While natural floodplains can have a large footprint, combining the morphology of a floodplain with a more typical detention basin design can provide increased ecological benefits with the intended sediment, peak flow, lowered footprint, and maintenance controls of a normal detention basin. These devices are intended to be placed in a tributary's natural flow path as it drains into the urban storm system and where there is sufficient lateral and longitudinal space, such as in San Carlos' existing parks.

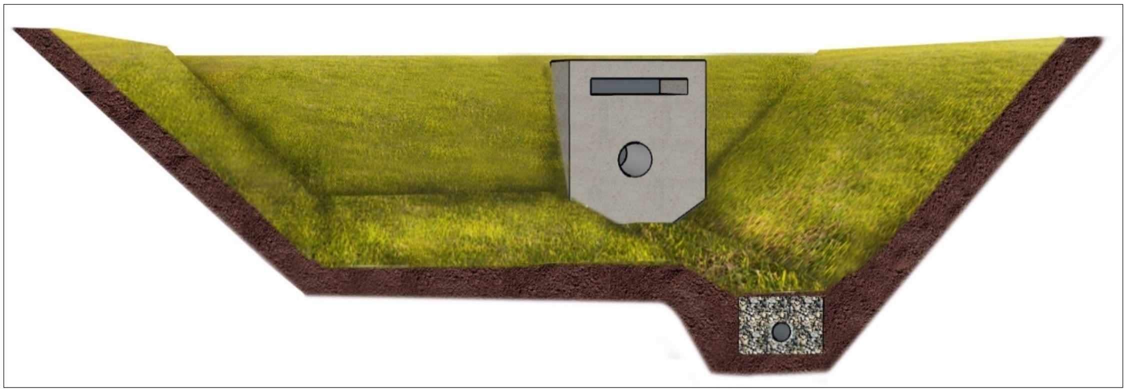

Exhibit 3. Alternative B: floodplain detention system concept for Arguello Park

Alternative C: LID Implementation

Alternative C aims to provide flood reduction benefits in the more urbanized environments of the City through implementation of LID. Currently, there are few well-implemented LID features within the public city limits. Existing LID features installed east of El Camino have limited effectiveness due to poor soil infiltration and a high groundwater table during flood events. Implementation of LID can represent a significant benefit to the City both in managing flood and water quality risks.

As LID project benefits are only expected to yield watershed scale benefits when reaching a critical mass, each road, park, or other public infrastructure project should be assessed for opportunities to implement LID features. Limitations and ideal scenarios for the LID options outlined in the C.3 Guidance are listed in the Green Infrastructure Plan (San Mateo Countywide Water Pollution Prevention Program, 2023) (City of San Carlos, 2019). It is recommended that City guidance for LID encourages targeting 1 inch of rain per hour for when detention in each LID feature activates, and the detention time be extended for four hours if possible.

Exhibit 4. Alternative C: incorporate LID into public projects. Photo credit: City of Burlingame

Alternative D: Creek Crossing Adjustments

Alternative D aims to consider opportunities to work directly in the creek by integrating multiple interests and project partners. Projects such as the bank stabilization project for privately owned streambanks should be thought of as opportunities for ecosystem restoration, flood risk mitigation, and parks planning. Currently, much of Pulgas and Brittan Creek exists underground in man-made storm conveyance features or within private parcels. Most creek crossings through public land involve tributary flow through parks or main channel flow through street crossings. In-channel work to alleviate flooding typically involves expansion of restrictive conveyance structures, or channel widening, which all require extensive funding and real estate. As a result, the opportunities for in-channel work capable of meeting flood reduction objectives for the City may be limited.

The primary lower watershed constraint of a series of bridges downstream of Old County Road was analyzed for a site-specific concept. The bridges consist of multiple box culverts spanning across private property lots and the Industrial Road and El Camino Real crossings. This analysis does not consider specific political, legal, and monetary viability widening, and is only intended to analyze the potential for flood reduction in the region.

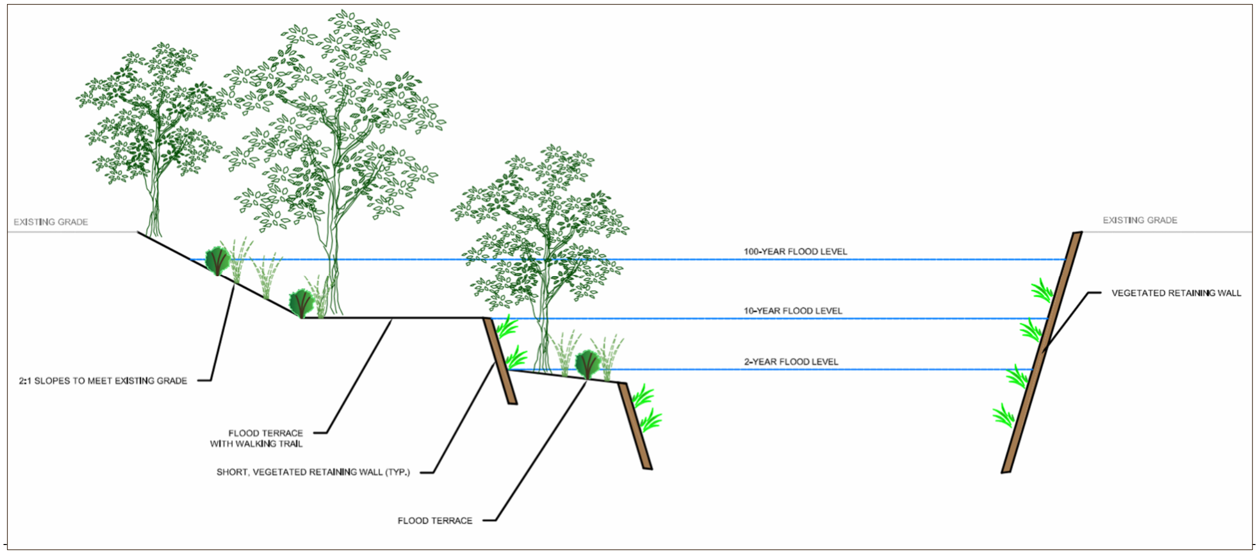

Exhibit 5. Alternative D: Specific Creek Alteration Concept (Widening)

Alternative E: Underground Detention Basins

Alternative E involves underground detention tanks which could be implemented by the City at Burton Park and a narrow space between the Caltrans railway and El Camino bounded by Arroyo Avenue and Brittan Avenue. The specific logistics of the detention tank design will not be discussed in this memo, including details of connections to existing storm drains and flow mechanics. It is assumed the detention tanks will have a rectangular configuration with a 10-ft depth and will operate in a way to fill during the peak flow of a storm event and drain beyond the peak flow.

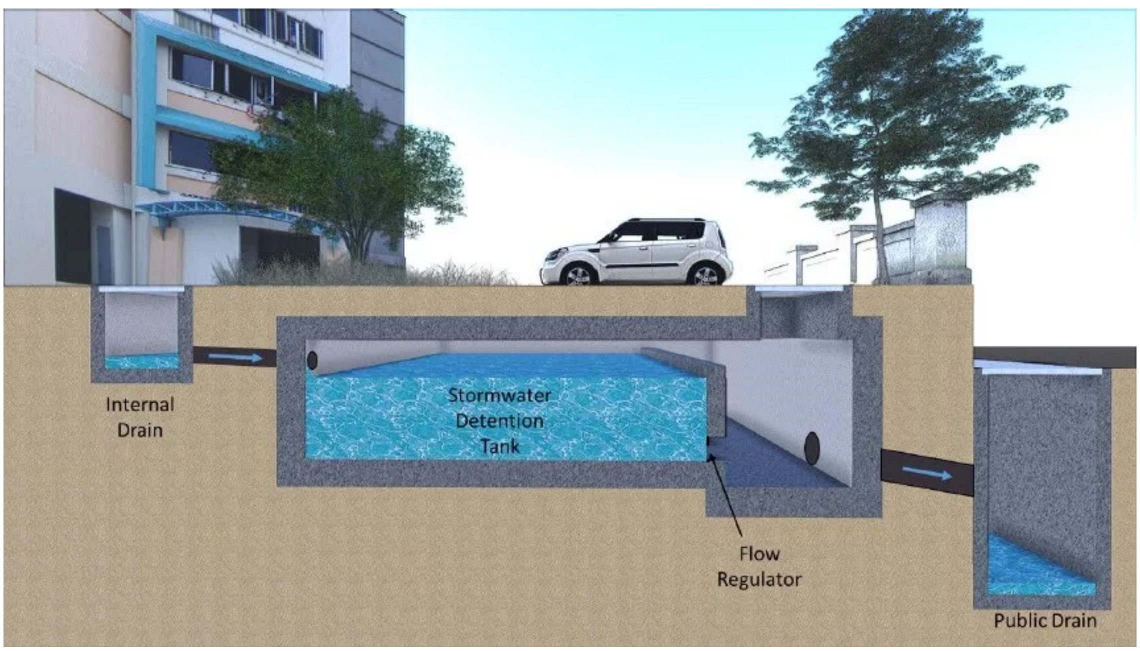

Exhibit 6. Alternative E: concept of underground storage tanks for detaining peak storm flows. Photo credit: (Stormwater Sydney, 2024)

Alternative F: Creekside Public Access

Alternative F is to establish Creekside public access and is focused more on increasing public park space and visibility of the City's creeks. There may be incorporation of flood mitigation benefits through the use of Alternatives A-D as a part of a parks project. Establishment of creekside parks can provide opportunity for resident engagement and foster a sense of shared responsibility for watershed management. There needs to be awareness of how the storm drain system is intended to work, potential failure points, and where to look for items to fix or report to better educate residents of the potential flood risks and actionable items on an individual level. Creekside parks present a unique opportunity to increase awareness, increase greenspace around the City, and increase resident education through placards.

Exhibit 7. Alternative F: Creekside pocket park example at Cordonices Creek in Berkeley/Albany, California. Photo credit: (Restoration Design Group, 2024)

Alternative G: Targeted Inspection and Maintenance

Alternative G of targeted inspection and maintenance activities is intended to proactively investigate historic flood locations where opportunities for improvement is limited. These can include regions where the cause of the flooding is entirely within private property, is limited in utilizable space, or where flood mitigation options are likely to yield low to no benefit.

SITE SPECIFIC MODEL OUTPUT AND ASSESSMENT

Impacts of alternatives highlighting a per-project site-specific scale are described below. The flood detention impacts are quantified on a per-project scale to estimate an upper bound for total watershed detention capacity based on the total area of alternatives shown in *Figure **3***. The modeled cumulative effect of alternatives is provided in the Compounding Alternatives section.

Adjustments of the existing conditions PC SWMM model made to represent Alternatives A-E are described in Attachment C.

Alternative A: Revegetation

The studied subbasin and design condition for Alternative A is in increasing native vegetation cover in Big Canyon Park to affect a 10-year event. The subbasin chosen drains to 3184 Brittan Avenue. Approximately 50% of the subbasin could be revegetated with native cover (*Exhibit **8***). The studied subbasin represents approximately 2% of the total proposed area for revegetation. Impacts of the revegetation on runoff were modeled through a change in CN values from existing to proposed of 82 to 70. This resulted in a peak runoff reduction from 2.5 cfs to 1.5 cfs, or a 40% reduction with a volume reduction of 0.13 acre-feet (*Exhibit **9***). These results projected onto the entire proposed planting area represent an upper bound of 6.5 acre-feet for the potential runoff volume reduction.

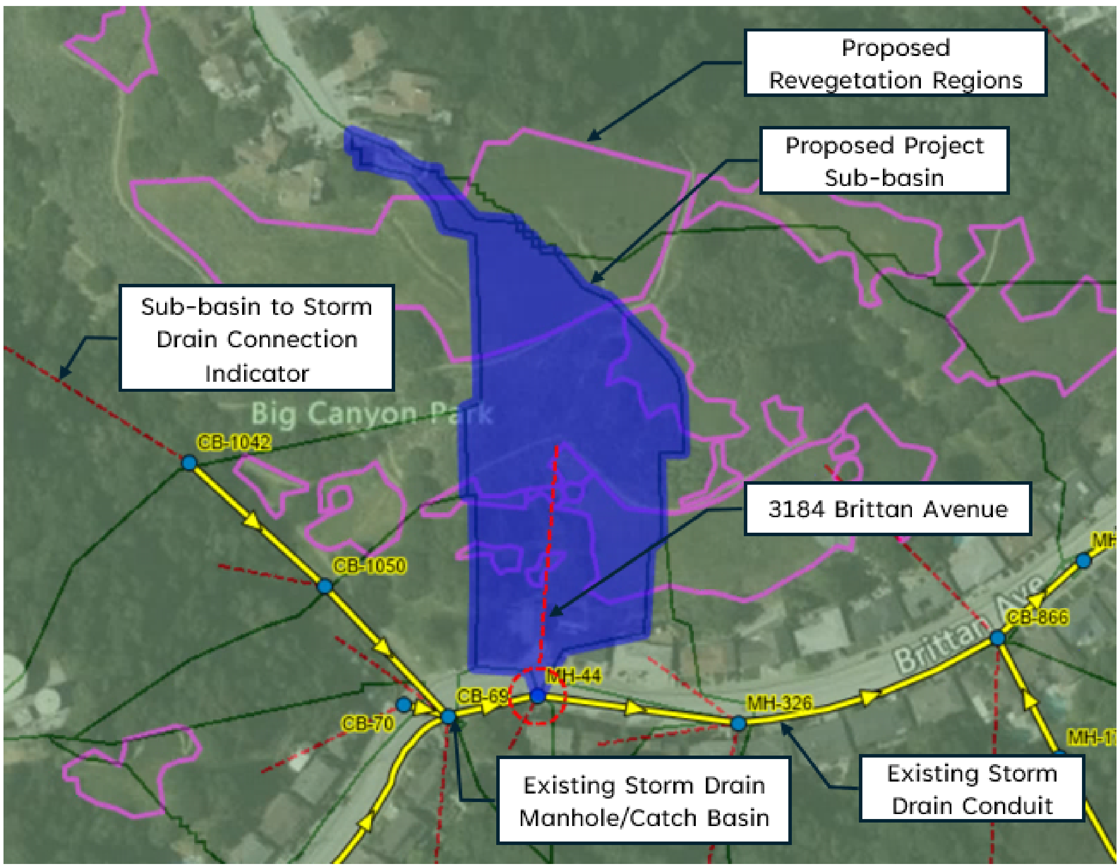

Exhibit 8. Location of studied subbasin for Alternative A – Revegetation

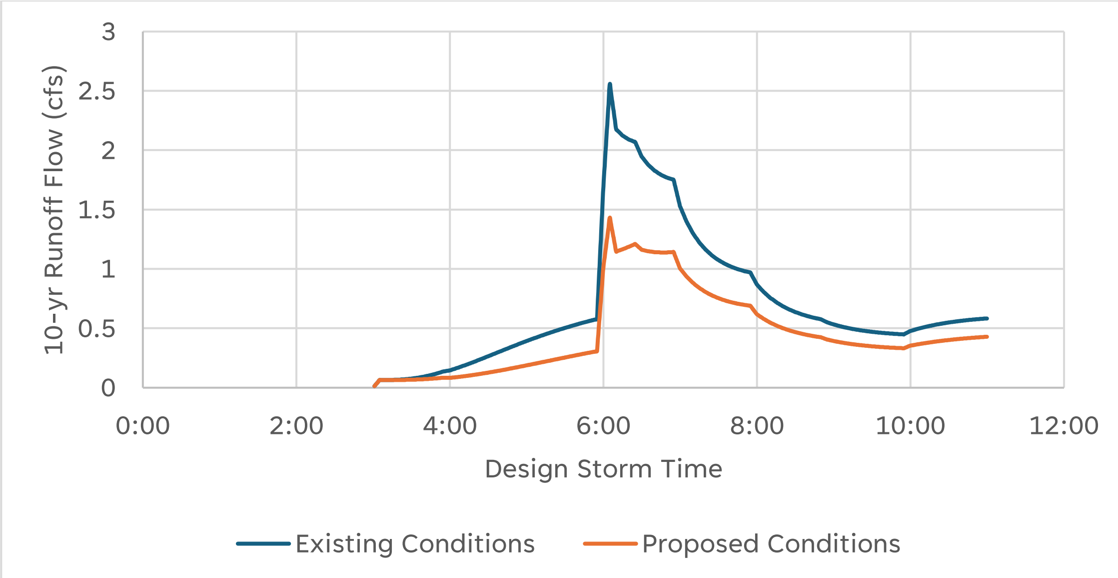

Exhibit 9. Change in peak flow rate from existing to proposed of the Alternative A studied subbasin

Alternative B: Floodplain Detention Basins

The studied subbasin and design condition for Alternative B is a series of three detention basins in Arguello Park that mimic floodplain behavior. The subbasin flows through Arguello Park with an approximate width-length-depth of 32'-115'-6' (*Exhibit* ***10***). The studied subbasin represents approximately three of 26 proposed locations where a floodplain detention basin may be viable. The actual available dimensions, and thus storage capacity, for each basin will vary. Possible designs may also differ from the concept shown in *Exhibit* ***3***. This resulted in a peak runoff reduction from 22 cfs to 13 cfs, or a 41% reduction with a volume reduction of 1.5 acre-feet (*Exhibit* ***11***). These results projected onto the entire proposed planting area represent an upper-bound of 13 acre-feet for the potential runoff volume reduction.

Exhibit 10. Proposed location for Alternative B – Floodplain Detention Basin in Arguello Park

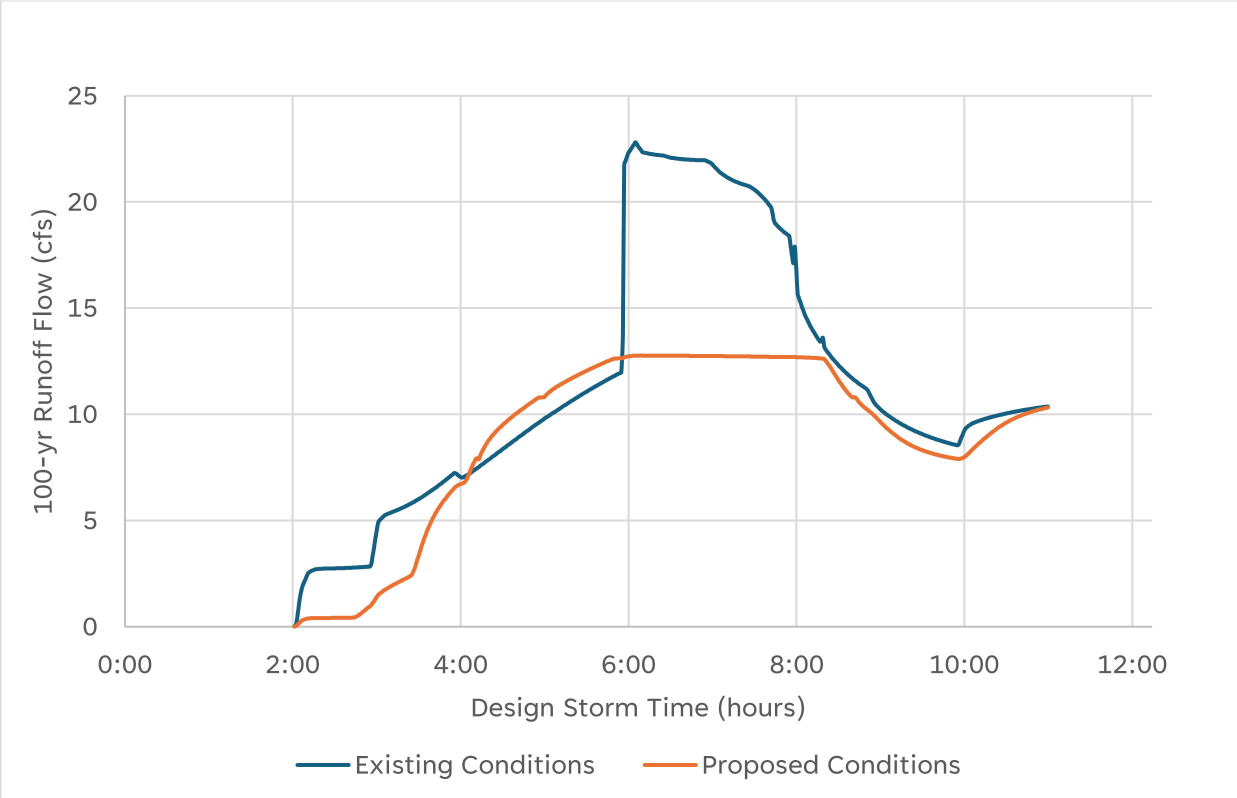

Exhibit 11. Change in peak flow rate from existing to proposed for the Alternative B studied subbasin

Alternative C: LID Implementation

The studied subbasin and design condition for Alternative C is bioretention LID designed for a 10-year event as described in the San Mateo County C3 Guidance and located at the intersection of Alameda de las Pulgas and Brittan Avenue (*Exhibit 12.*) (San Mateo Countywide Water Pollution Prevention Program, 2023) There is an existing roadway median approximately 1,780 square feet in area that has potential to be converted into a bio-retention cell to reduce the volume of runoff of lower storm events (i.e. 2-YR to 10-YR events). However, this area does not include prioritized parcels identified in the Green Infrastructure Plan and may involve privately owned parcels where direct City involvement is unnecessary (City of San Carlos, 2019). The modeled results after incorporating LID into the subbasin resulted in a peak runoff reduction from 6.4 cfs to 6.0 cfs and a volume reduction of 0.002 acre-feet (*Exhibit 13.*). Although the difference in peak values is minimal, the total volume of runoff is reduced by 45%, which can mediate flooding along Brittan Avenue. These results projected to the entire proposed LID implementation area represent an upper bound for the potential runoff volume reduction of 0.07 acre-feet. However, there may be a more pronounced individual effect in locations experiencing calmer flow patterns. LID designs and performance for the other proposed locations will differ from those modeled for the studied subbasin.

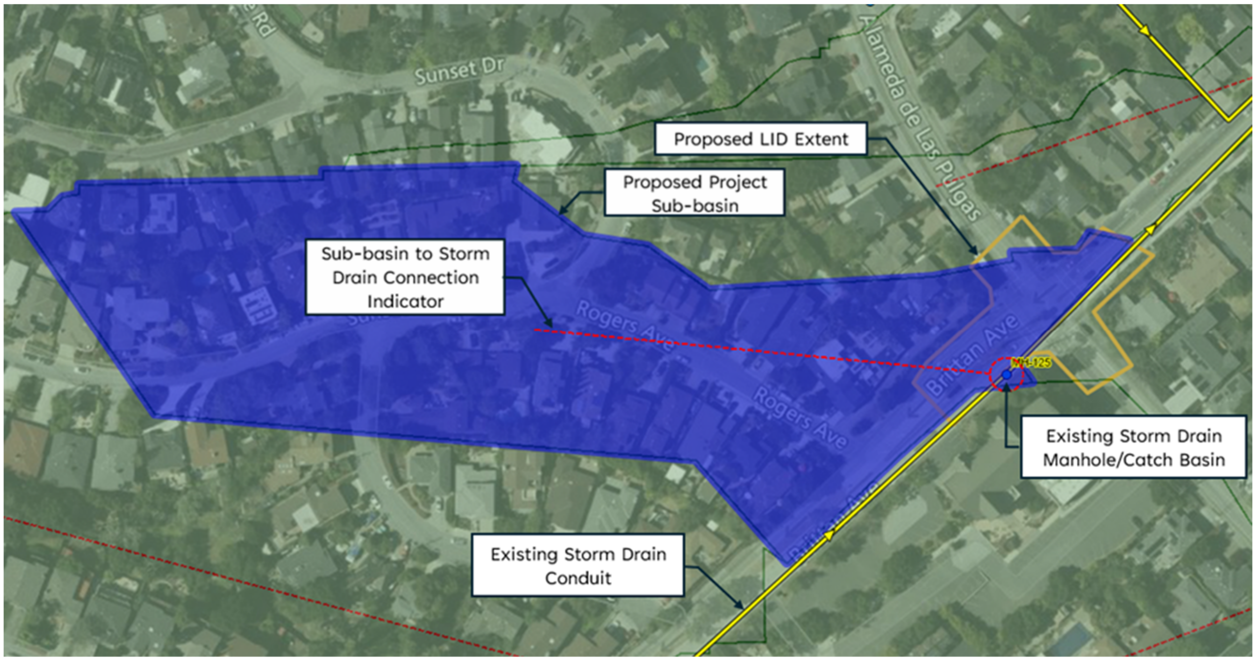

Exhibit 12. Proposed location for Alternative C – LID Implementation at San Carlos Avenue & Alameda de las Pulgas

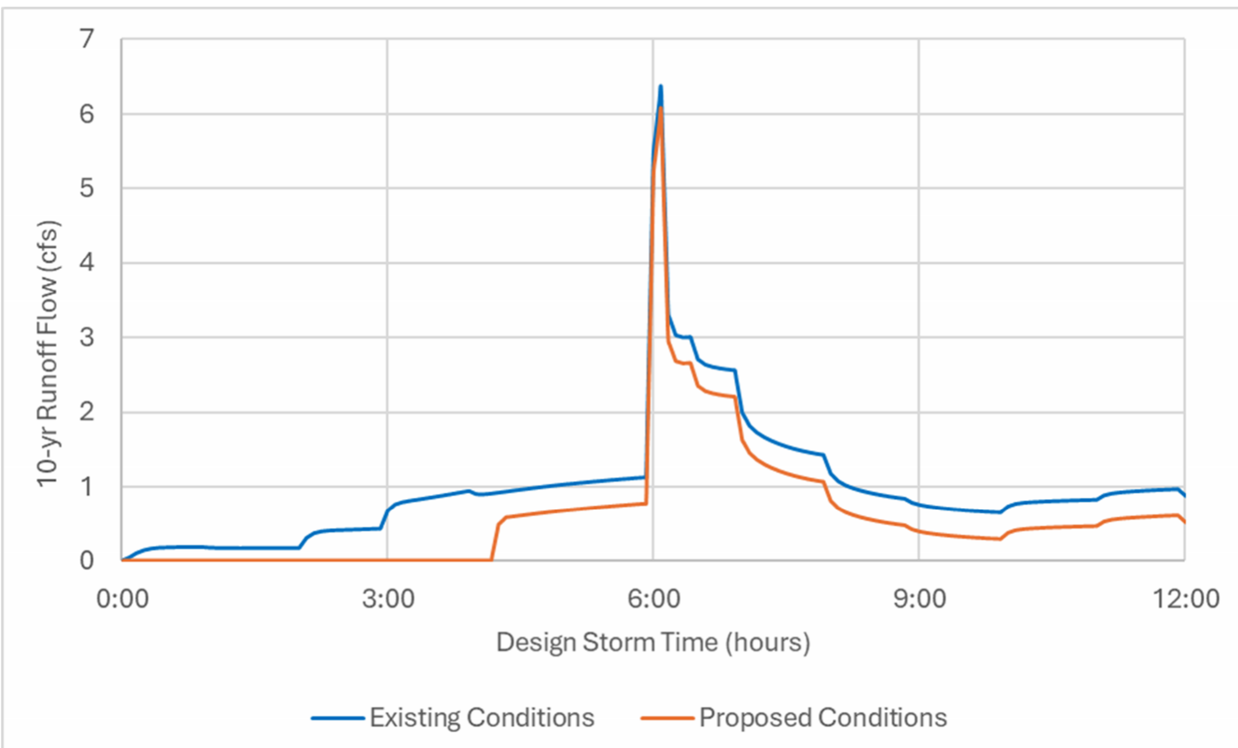

Exhibit 13. Change in peak flow rate from existing to proposed for the Alternative C studied subbasin

Alternative D: Creek Crossing Adjustments

The studied extent and design condition for Alternative D is improving capacity on a bridge crossing Pulgas Creek including some channel widening located between Old County Road and Industrial Road (*Exhibit **14***). The studied length includes alterations impacting approximately 1,500 linear feet of creek with the total proposed length of creek adjustments at 2,200 feet. The modeled results after widening portions of the Pulgas Creek channel indicate a flow capacity increase from 360 cfs to 1,300 cfs, or a 260% increase (*Exhibit **15***). Existing conditions are constrained by a double box culvert with a blocked opening, reducing its design capacity. The increase in capacity from widening could exceed the 100-year flow of 620 cfs, preventing flooding at the low watershed. Other creek-crossing adjustments can help alleviate local flooding due to capacity issues and can provide ecosystem and sediment transport benefits depending on design. Most adjustments are expected to have limited ability to attenuate flows due to limited space, but an increase in capacity can prevent local flooding while directing flows to alternative mechanisms for flow attenuation and peak flow reduction.

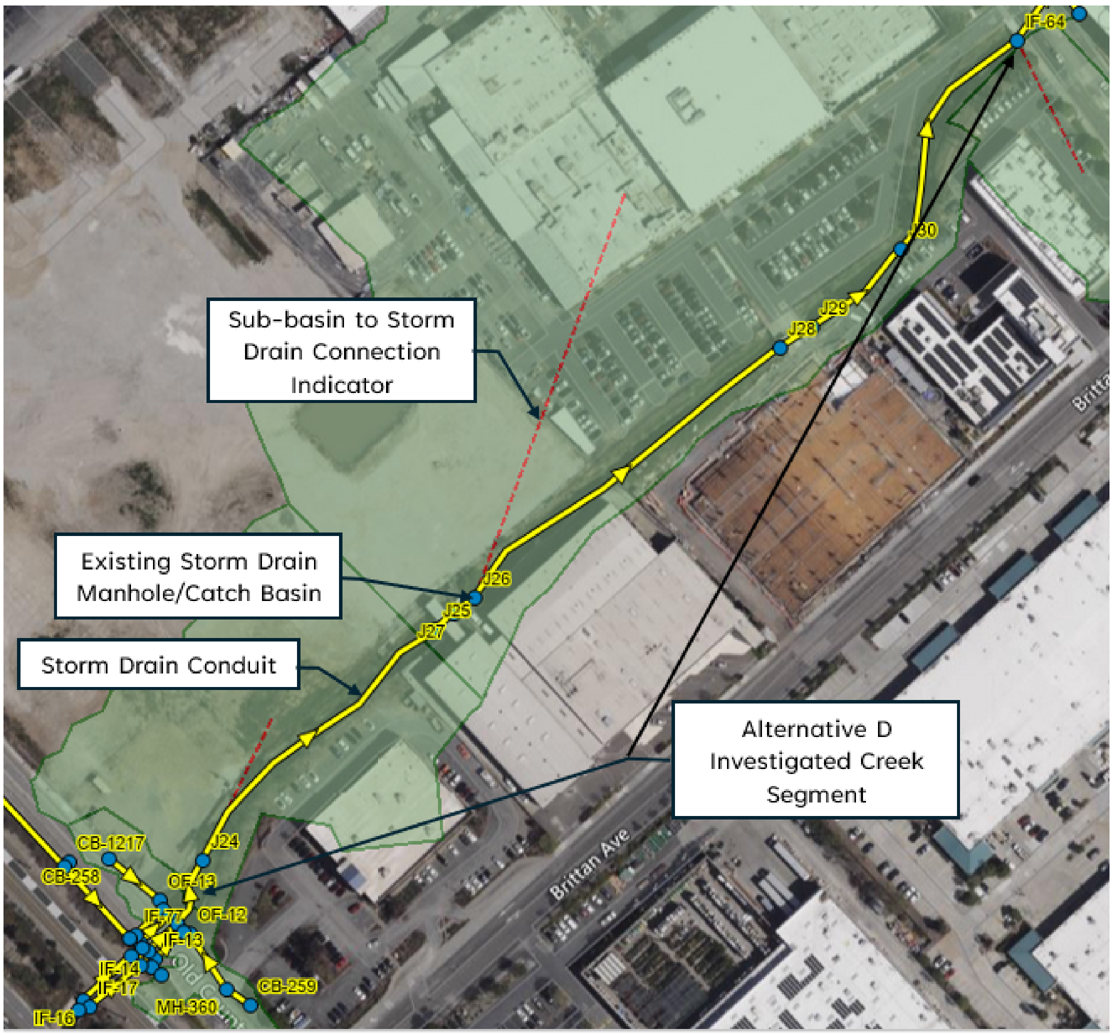

Exhibit 14. Proposed location for Alternative D:
Creek crossing adjustments between Old County Road and Industrial Road

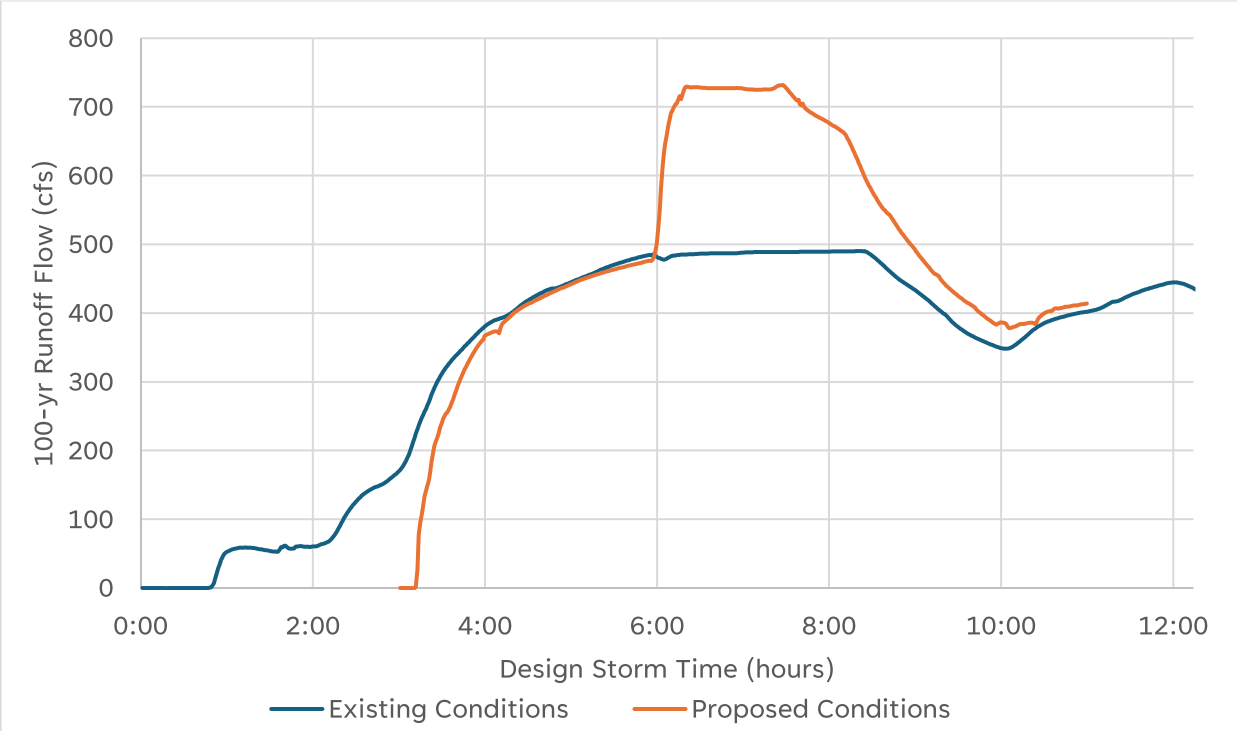

Exhibit 15. Change in peak flow rate capacity from existing to proposed for the Alternative D studied subbasin. Existing flow reaches gravity flow capacity at 360 cfs with flows higher indicating pressure flow or flooding.

Alternative E: Underground Detention Basins

Viability of Alternative E was assessed based on the calculated potential volume detention based on a target of lowering the 100-year peak flow over 4 hours. The calculation was based on the total available storage volume from the proposed basin footprint area with an assumed viable depth of 10 feet. The stored volume would be filled at a constant rate over 4 hours during a peak event, then allowed to discharge back to the storm drain system at a later time. The specific equipment and mechanisms needed for this process were not investigated. The reduction in peak flow was calculated from Equation 1 with results of the calculation provided in Table 1 below:

Equation 1. $$\textbf{Detained Flow } (cfs) = \frac{\textbf{Volume of Basin } (ft^3)}{\textbf{4 hours}}\ x\ \frac{\textbf{1 hour}}{\textbf{3600 seconds}}$$

Table 1. Summary of underground detention basin effectiveness

BASIN LOCATION	BASIN VOLUME (FT^3)	BASIN VOLUME (ACRE-FT)	DETAINABLE PEAK FLOW VOLUME (ACRE-FT)	PEAK FLOW REDUCTION (CFS)	PEAK FLOW REDUCTION (%)
Burton Park	4,000	0.09	9	0.3	1%
El Camino Real	300,000	6.9	84	20.8	5%

Effectiveness of underground detention basins are highly dependent on the available volume. The feasibility of basins will be dependent on site-specific conditions including the tie-in points of the storm drain network, available area, conflicting utilities, structural safety, groundwater depth, public opinion, and cost. Detention basins of less than 2 acre-feet are likely not viable cost-benefit wise compared to a normal above-ground detention basin or LID features.

COMPOUNDING ALTERNATIVES

Each alternative cannot independently address flood-risk issues in the watershed. Instead, a combination of these alternatives is assessed to demonstrate the plausibility of performance if the City invests in these alternatives. Extrapolating from the site-specific model outputs and applying to all potential site locations can provide context for watershed scale improvements. An estimate of the upper bound or best-case scenario for applying alternatives at all potential sites is presented in Table 2.

Table 2. Potential Upper Bound for Runoff Volume Reduction and Target Beneficiaries

ALTERNATIVE	RUNOFF VOLUME REDUCTION (ACRE-FT)	PRIMARY BENEFIT TARGET
A – Revegetation	6.5	Upper watershed entities
B – Floodplain Detention Basins	13	All entities in the Pulgas Watershed
C – LID Implementation	0.07*	All entities in the Pulgas Watershed
D – Creek Crossing Adjustments	0	Lower watershed entities
E – Underground Detention Basins	7	Middle and lower watershed entities
Total:	26.6	

*LID effectiveness highly depended on local conditions and design

It important to understand improvement to the watershed may vary spatially between the high, middle, and low watershed areas. Alternatives A-C are expected to have impacts on upper watershed sediment retention and alleviate flood risk in the region. The impacts on soil retention are not capable of being captured in the model; however, peak flows through the region are expected to decrease through the detention and abstraction mechanisms from the proposed alternatives. All proposed alternatives reduce peak flows to a total of 520 cfs from the existing 615 cfs crossing Alameda de las Pulgas from both Pulgas and Brittan Creeks.

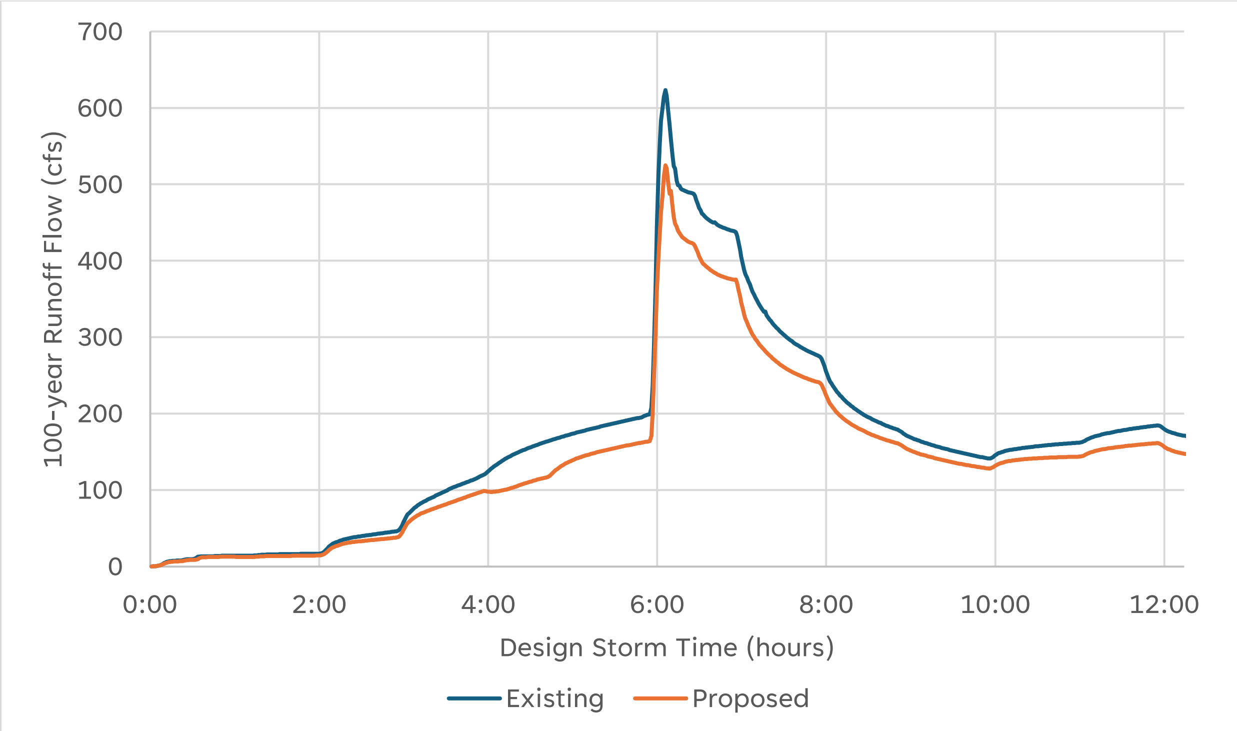

Exhibit 16. Upper watershed total flow hydrograph at Alameda de las Pulgas for Brittan and Pulgas Creeks with all alternatives compared to existing conditions hydrograph

The middle watershed is expected to primarily benefit from Alternatives C-E as the urbanization density increases. Benefits from the alternatives are expected to have a smaller impact per project than those in the upper watershed simply due to space constraints, which emphasizes the need for implementing alternatives wherever possible. All proposed alternatives reduce peak flows to a total of 765 cfs from the existing 875 cfs crossing El Camino Real from both Pulgas and Brittan Creeks.

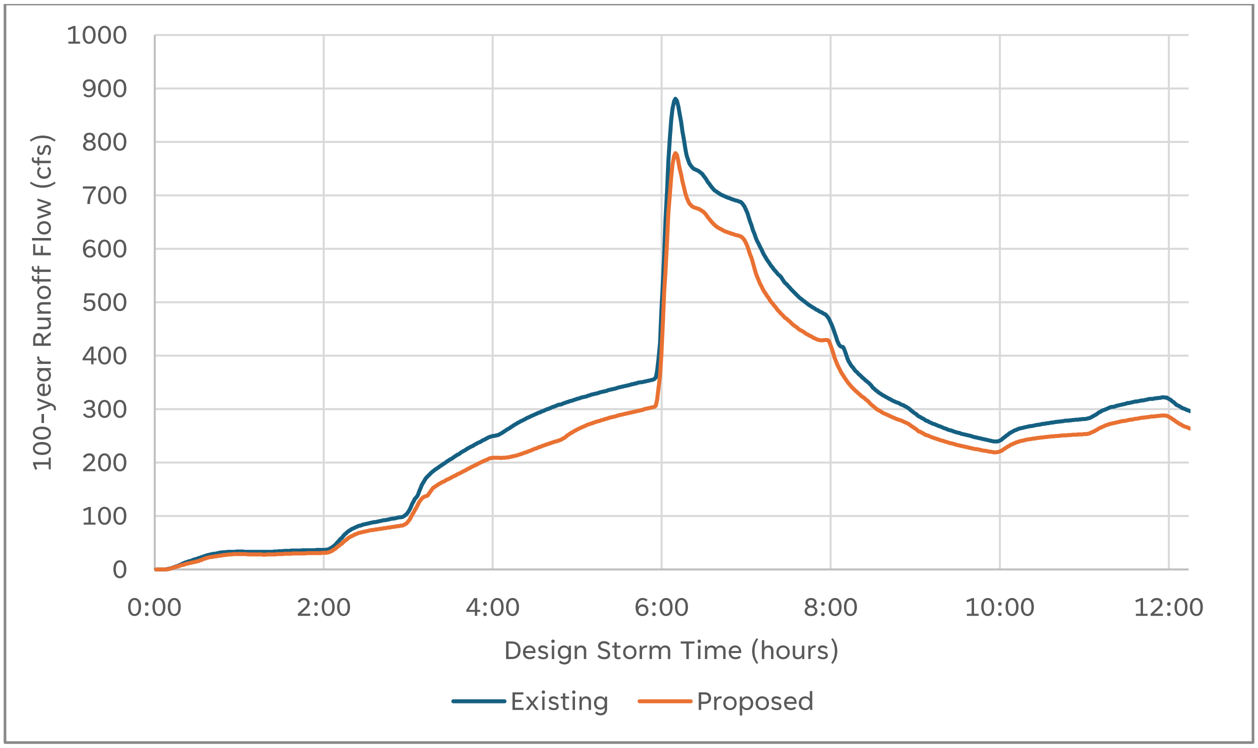

Exhibit 17. Middle watershed total flow hydrograph at El Camino Real for Brittan and Pulgas Creeks with all alternatives compared to existing conditions hydrograph

The lower watershed has limited viability for all alternatives due to the highest levels of urbanization, thereby space constraints, and groundwater factors limiting the effectiveness of Alternative C. The main improvement to be achieved in the lower watershed is a channel capacity increase. Combining the effects of a channel capacity increase with flow detention in the upper and middle watersheds will increase the flow threshold at which flooding occurs from the existing 360 cfs to 1,300 cfs. However, flow limiting and flood including factors upstream from Old County Road were not addressed. Due to the removal of the constriction in the lower watershed, the peak flow increases from 605 cfs to 655 cfs. Implementation of all proposed alternatives is expected to reduce flooding in the Pulgas Creek watershed.

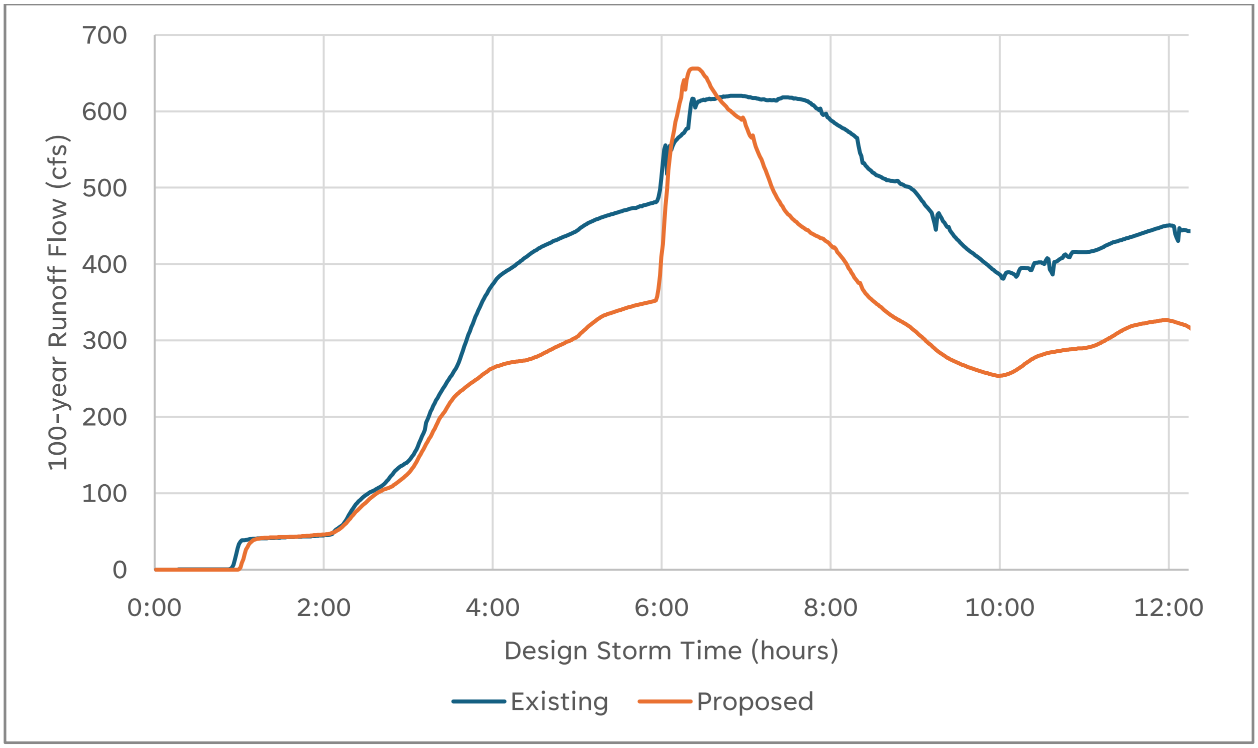

Exhibit 18. Lower watershed total flow hydrograph near Smith Slough for Brittan and Pulgas Creeks with all alternatives compared to existing conditions hydrograph

In analyzing the Pulgas Creek watershed, modeling suggests there are multiple flow constrictions in the lower watershed based on the decrease in peak flow from the middle to lower watershed. Flow through the channel is lost through flooding and flow constrictions that return to the main channel over time, resulting in the wider peak width under existing conditions. While the proposed alternatives lower the overall volume of flow encountered by the lower watershed, flooding issues are not resolved as demonstrated by the continued decrease in peak flow between the middle and lower watersheds under proposed conditions. It is unlikely that the Pulgas Creek watershed has sufficient opportunities for complete prevention of flooding impacts barring complete redevelopment of the City. However, there may be additional opportunities for flood mitigation not addressed in this analysis based on site specific flood control strategies, such as flood prevention measures for individual buildings while allowing street flooding up to an acceptable limit.

RISK ASSESSMENT

While viability of each alternative can depend on site-specific and time-dependent conditions not analyzed as a part of this evaluation, the generalized risks of each alternative can still be assessed. The ideal mix of solutions and alternatives to prevent flooding in the Pulgas Creek watershed may depend on a variety of factors including acceptable burden to City operations and maintenance, lifetime of project benefits in light of climate change, risk to life and safety of the City's residents, and potential available funding opportunities.

Risk Categories

Operations & Maintenance

The level of risk represents the expected potential problems or additional effort required throughout the lifetime of the alternative. For example, high risk to Operations & Maintenance (O&M) indicates an average increase in expected workload for O&M staff to address issues, even accounting for extreme events that occur during the project's lifetime. Alternative A is expected to require a medium level of risk as the first few years require annual attention to ensure planting success and manage invasives and maintain that level of risk as inevitable landslides require additional planting to restabilize slopes.

Resiliency

High resiliency risk represents an expectation of poor adaptation to changing climate conditions. Hard infrastructure built and designed for today is expected to perform poorly for sea-level rise, increases in extreme events, and require replacement prior to its projected end of life as priorities shift with changing local conditions.

Safety

High safety risk represents a high expectation of damaging flood events, landslides, wildfire, urban heat island, and sea-level rise impacts to occur contributed by undersized infrastructure and poorly managed vegetation cover.

Funding

High funding risk represents an expectation of difficulty in obtaining funding support or a high budget burden for the alternative. This can be due to expectation of local push back, lack of external funding opportunities for the project, or high expected design and construction costs. It does not consider the potential consequences or opportunity costs for alternatives.

Context for Risk

Vegetation may yield long-term benefits but will require significant effort to get a program started. Extended detention basins as proposed in currently easily accessible parks can provide significant benefits as a relatively small project. LID can have a small individual impact but will have a wider applicability throughout the urbanized regions of the City and requires additional expertise from City staff. Direct changes to the creek are expected to be the most difficult to implement under current conditions as the vast majority of the creek length is within private land, making comprehensive adjustments to the channel difficult to perform. While the City has opportunities to implement impactful solutions on its own, the current makeup of the City requires comprehensive planning, interagency cooperation, community engagement, and policy to meet the flooding challenges of now and the future. The general risks of each alternative plus a Without-Project condition based on these four categories are presented in Table 3.

Overall, it is expected that the Without-Project condition will yield an increased risk for resiliency and safety as designs will fail to adapt to changing conditions.

Table 3. Alternatives risk assessment. Higher risk indicates higher potential for problems, lower risk indicates low potential for problems.

ALTERNATIVE	OPERATIONS & MAINTENANCE	RESILIENCY	SAFETY	FUNDING
A – Revegetation	Medium	Low	Medium	Low
B – Floodplain Detention Basins	Medium	Low	Low	Low
C – LID Implementation	Medium	Medium	Medium	Medium
D – Creek Crossing Adjustments	Low	Medium	Medium	High
E – Underground Detention Basins	High	Medium	Low	Medium
F – Creekside Parks	Low	Low	Medium	Medium
G – Inspections and Maintenance	Low	Low	Low	Low
Without-Project	Medium	High	High	Medium

SUMMARY

- Flood risk mitigation alternatives focus on decreasing erosion and landslide risk, increasing detention of stormwater in the upper and middle watershed, and increasing capacity in the lower watershed
- Substantial flood risk reduction can be attained with proposed alternatives, but flood risk cannot be eliminated
- The available areas for alternative implementation differ from those proposed due to political, monetary, and physical factors that could be uncovered during a site-specific analysis
- Risk factors from implementing these alternatives are expected to be overall lower compared to the status quo

NEXT STEPS

Insights from this analysis can be used to strategize effective watershed-wide flood improvements in coordination with existing limitations throughout the City. Flooding throughout the City is due to a combination of factors, so a combination of solutions will be needed to address the issue. Prioritization of potential projects based on the alternatives will be incorporated into the greater Pulgas Creek Watershed Study. A cost-benefit analysis of the anticipated costs of alternatives versus the more hardscape-focused capital improvement projects presented by GHD in the City of San Carlos Storm Drain Master Plan (GHD, 2017). When funding opportunities arise, pilot projects should be pursued for the various alternatives to assess the construction viability, effectiveness, and compatibility with the City's goals and operations.

LIMITATIONS

The model developed for this study is based on limited available data. Different climate characteristics, antecedent precipitation, groundwater intrusion, and more site-specific flow records would improve accuracy of the models, but were not considered as a part of this study. The model adjustments and location viability assessments were adjusted from data available at the time both recorded for this project's purposes and previously recorded data provided by the City of San Carlos. Figures presented in this memorandum are not intended to be used as reference material for determining construction locations or features.

Accounting for site-specific geomorphic conditions and topographic adjustments were not within the scope of this study. Flooding extents and depths shown in this study do not account for complications due to debris flow, minute changes in topography on a regional scale such as curbs, nor other geotechnical-related complicating factors such as landslides, earthquakes, bank failures, etc. Modeled results represent a snapshot of expected conditions and do not represent the full extent of real possibilities that could affect flooding behavior such as future construction, local ground disturbance, recent climate history, etc. Flooding behavior can be greatly impacted by policy decisions and local cooperation not studied by this memorandum.

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ATTACHMENTS

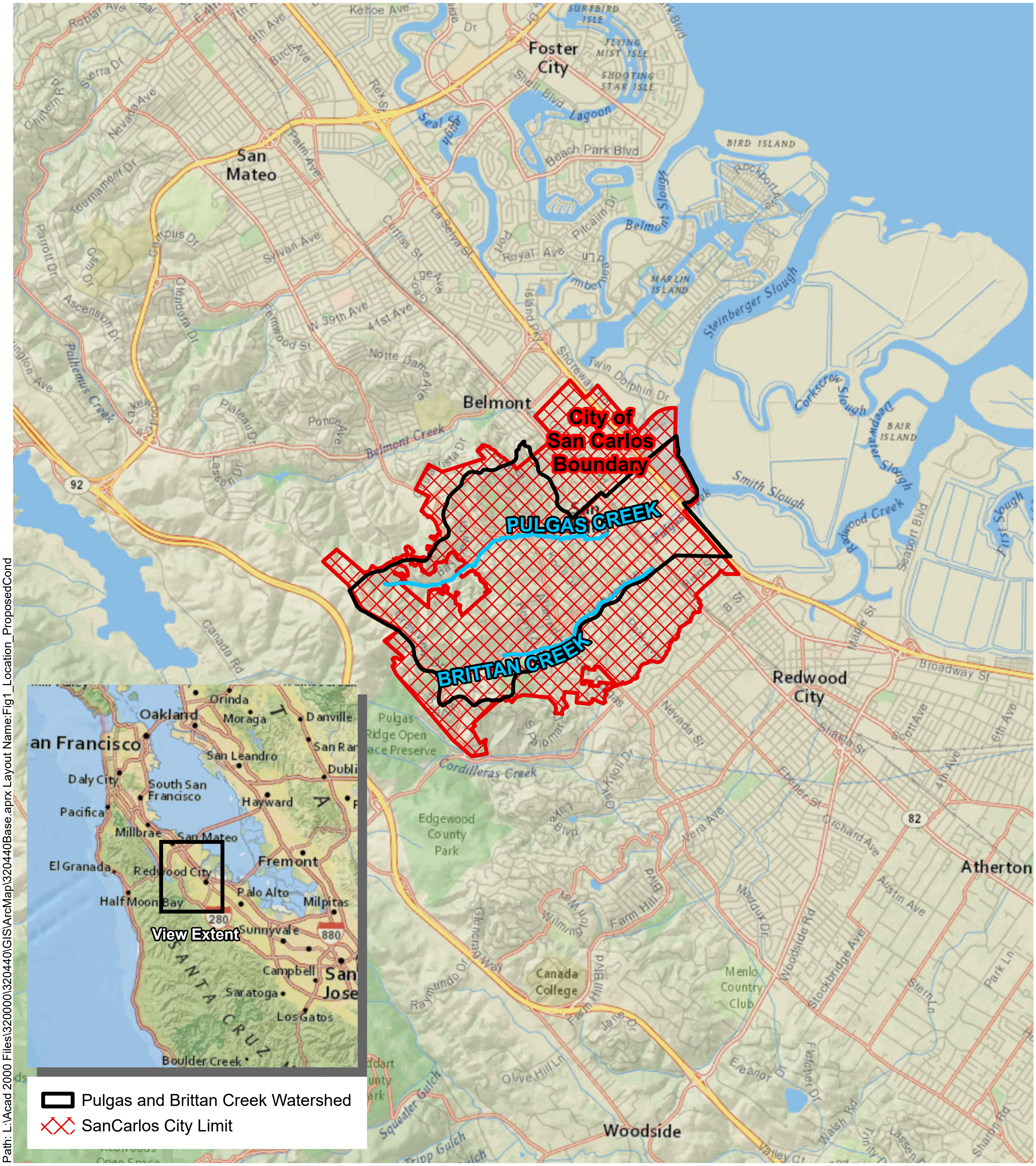
Attachment A. Figures

Figure 1. Regional Location Map
Figure 2. Pulgas Creek Watershed Drainage System
Figure 3. Proposed Flood Mitigation Alternatives Locations

Attachment B. Revegetation Benefits and Palettes for San Carlos
Attachment C. Alternatives Hydraulic Model Adjustments

Attachment A.

Figures



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Sources: National Geographic, WRA | Prepared By: junjie.chen, 5/24/2024

Figure 1. Regional Location Map

Pulgas Watershed Study
Flood Mitigation Evaluation Memo
City of San Carlos, San Mateo, CA

wra Environmental Consultants

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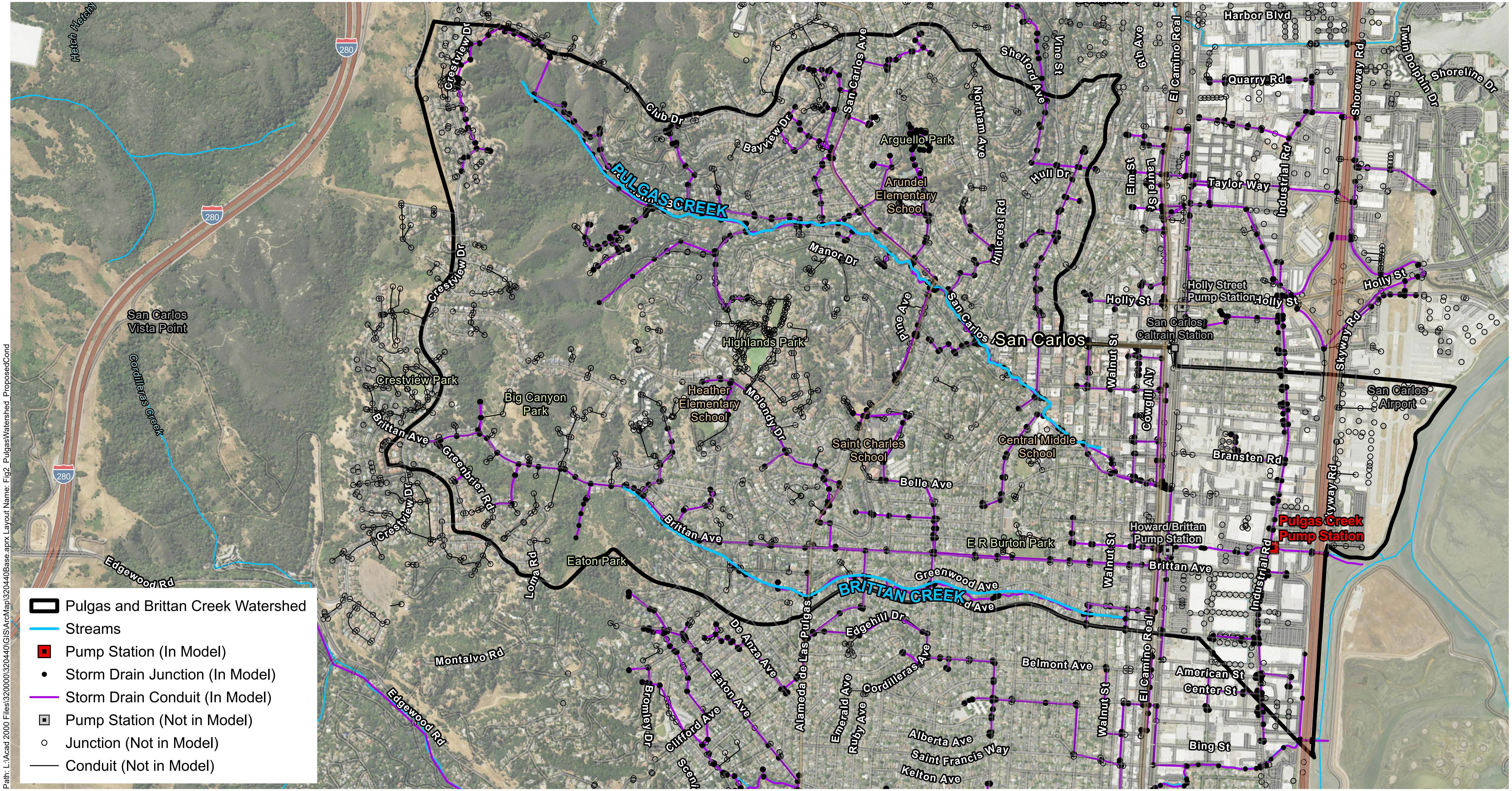

Sources: USDA NAIP Imagery 2020, WRA | Prepared By: junjie.chen, 5/24/2024

Figure 2. Pulgas Watershed Drainage System

Pulgas Watershed Study
Flood Mitigation Evaluation Memo
City of San Carlos, San Mateo, CA

0 0.25 0.5 Miles

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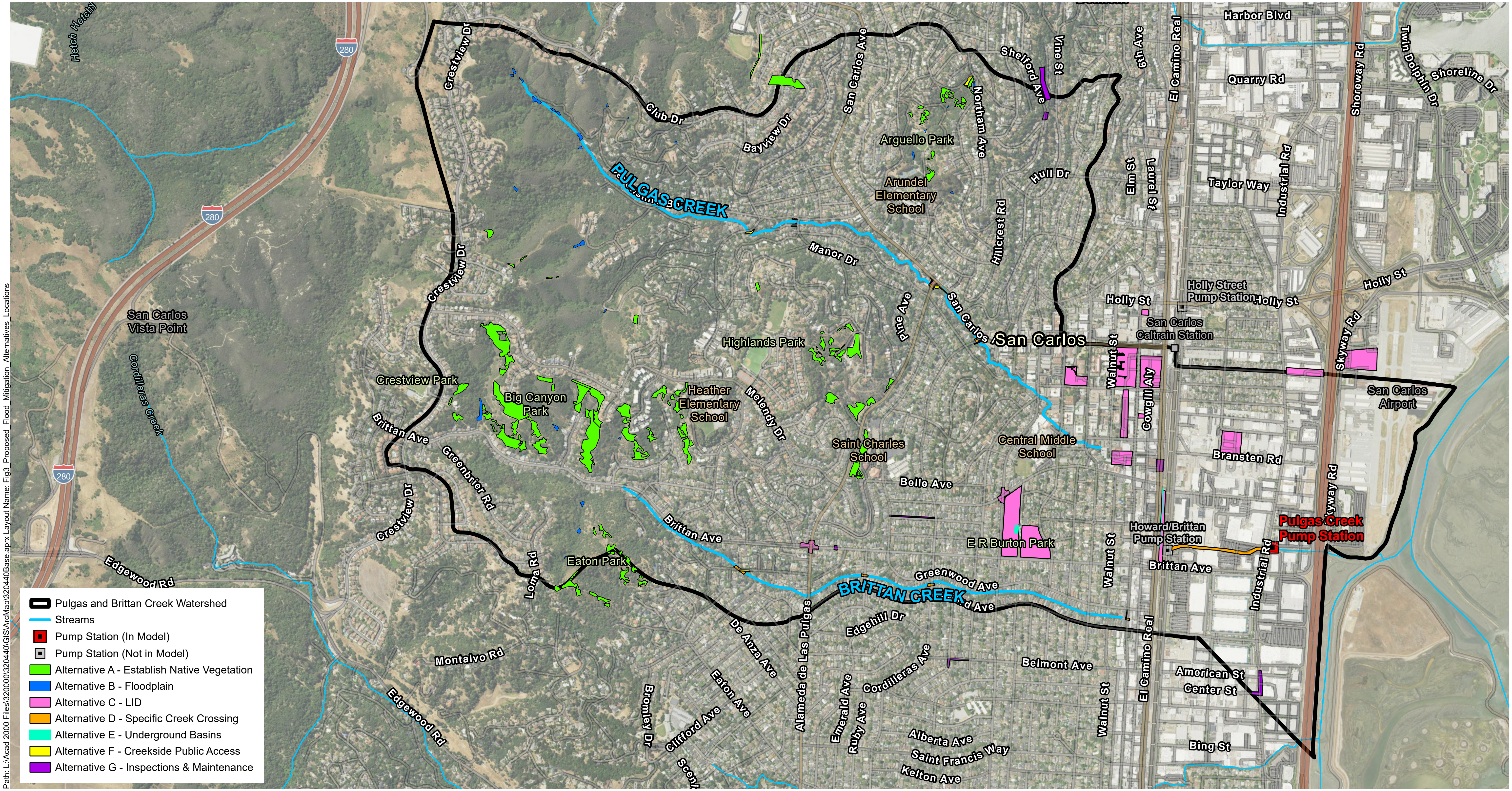


Sources: USDA NAIP Imagery 2020, WRA | Prepared By: junjie.chen, 5/24/2024

Figure 3. Proposed Flood Mitigation Alternatives Locations

Pulgas Watershed Study
Flood Mitigation Evaluation Memo
City of San Carlos, San Mateo, CA

0 0.25 0.5 Miles

wra Environmental Consultants

Attachment B.

Revegetation Benefits and Palettes for San Carlos

Attachment B.
Revegetation Benefits and Palettes for San Carlos

1.0 THE URBAN TREE CANOPY PROVIDES MULTIPLE BENEFITS

In recent decades, California communities have come to recognize the ecosystem services provided by the trees in local watersheds. Trees help reduce stormwater run-off, reduce urban temperatures, improve air quality, sequester carbon, enhance property values, provide wildlife habitat, and strengthen social connections in neighborhoods.

This report highlights a particular ecosystem service trees provide which contribute to watershed health—*trees reduce sediment transport and erosion by holding soils in place in the upper watershed.* Trees prevent soil erosion in several ways:

- Trees intercept rainfall which prevents splash erosion
- Trees reduce the amount of water in soil through transpiration
- Trees improve soil health and nurture seedlings
- Tree roots bind soil to sloping ground, preventing erosion and protecting topsoil
- Trees provide a wind break and prevent surface soil from blowing away

As the conservation nonprofit American Forests reminds us, "healthy forests are our most efficient, inexpensive, and natural systems to combat climate change." Both natural and urban forests play an essential role in reducing CO2, the main contributor to climate change. There are two direct ways that trees help (Canopy 2016):

Trees act as a CO2 sink:

- Trees sequester and store CO2, decreasing the concentration of CO2 in the atmosphere.
- Trees use CO2 during photosynthesis to produce sugars, which provide energy for trees as well as emitting oxygen as a by-product of the process.
- Planting more trees absorbs more CO2, reducing the overall concentration of CO2 in the atmosphere.
- An average-size tree can store hundreds of pounds of CO2 over its lifetime.

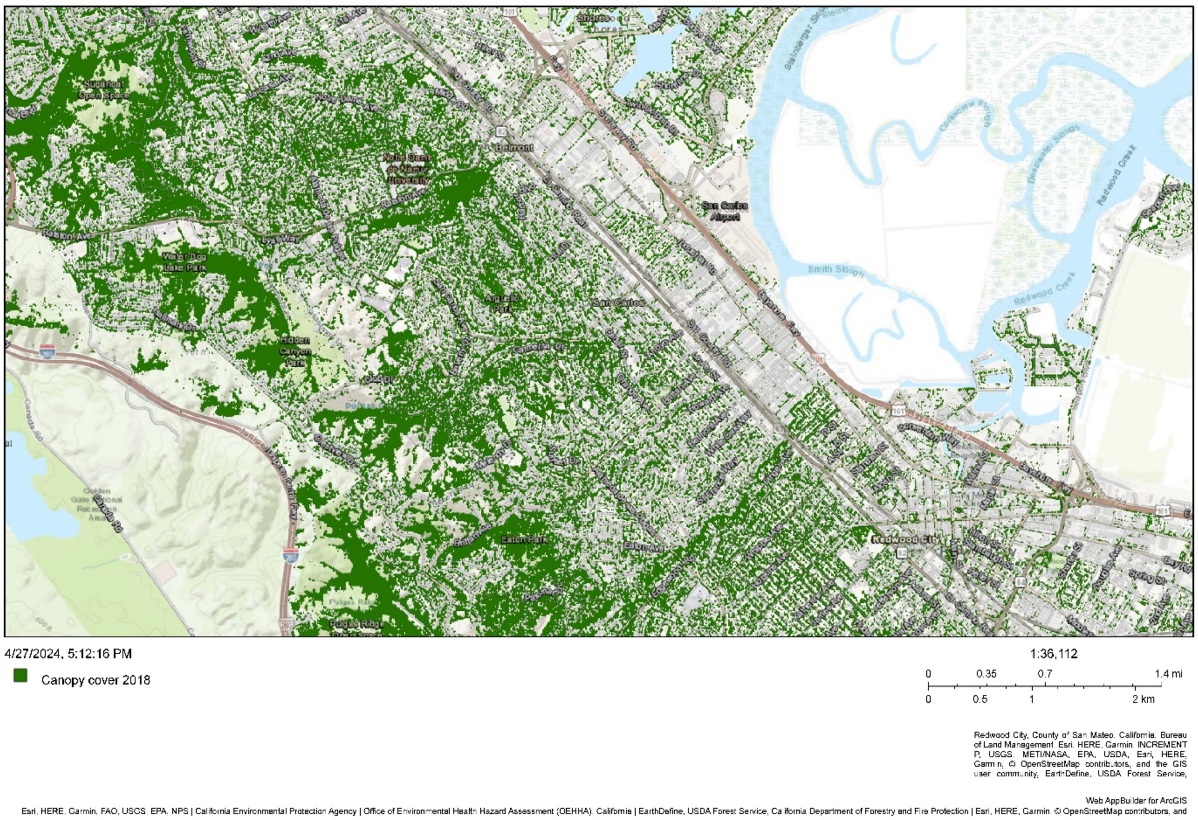
Trees reduce energy use:

- Neighborhoods well-shaded with street trees can be up to 6-10 degrees cooler than neighborhoods without, reducing overall energy needs.
- Three trees properly placed around a house can save up to 30% of energy use.

The ecosystem services trees provide also generate economic benefits. California's urban tree canopy covers 19% of the state's urban areas. It is estimated to contain 173 million trees; the annual value of ecosystem services from these trees has been estimated at $8.3 billion and the urban forest asset has been valued at $181 billion (McPherson et al. 2017).

According to the USFS and CAL FIRE, “understanding the extent and location of its existing tree canopy can help a community design and implement sound management practices to maximize those services: prioritizing locations for tree planting, establishing urban forestry master plans and sustainability plans, and managing threats to canopy loss.” The existing trees and tree canopy cover in the San Carlos are already mapped on the Urban Forest Ecosystems Institute (UFEI) California Urban Tree Map (CalPoly 2020) as well as the USFS and CAL FIRE Urban Tree Canopy in California (USFS & CAL FIRE 2018).

Urban Tree Canopy Map



With a land area of about 16 km^2, zip code 94070 has 1,425 urban street trees according to the California Urban Forest Inventory, including 59 genera and 77 species. The pie chart below graphically indicates the distribution of tree species.

Analysis of the existing forest reveals that almost all of the trees are non-native, most lack drought resistance, and several are invasive species that increase fire risk. To maximize the ecosystem services that trees provide in the upper watershed, it is important to plant large, native trees and shrubs, uniquely adapted to local site conditions, to increase climate resilience. A healthy forest ecosystem is self-sustaining; with adaptive management it will require minimal maintenance, expense, and energy inputs from the city while providing multiple benefits.

2.0 PLANT PALETTES

WRA has assembled proposed plant palettes for the upper watershed to enhance and expand the tree canopy for a sustainable forest ecosystem that will help reduce sedimentation and erosion. Tables 1 and 2 include representative tree and shrub species, respectively, which are appropriate for planting on upland slopes of the upper watershed. The best practices defined by CAL FIRE for defensible space and other fire-smart landscape practices (CAL FIRE 2024) should be consistently employed.

2.1 Native Trees and Shrubs for Revegetation Areas

Table 1. Native Oak Woodland Community Trees for Upland Slopes

COMMON NAME	BOTANICAL NAME	CANOPY SPREAD (FEET)	DECIDUOUS / EVERGREEN	SUN	WATER USE
California Buckeye	*Aesculus californica*	40'	Deciduous	Pt Sh, F Sun	VL, L
Hollyleaf Cherry	*Prunus ilicifolia*	20'	Evergreen	F Sun, Pt Sh	VL
Coast Live Oak	*Quercus agrifolia*	15 - 35'	Evergreen	F Sun, Pt Sh	L
Blue Oak	*Quercus douglasii*	30'	Deciduous	F Sun, Pt Sh	L
Garry's Oak	*Quercus garryana*	30'	Deciduous	F Sun, Pt Sh	L
Valley Oak	*Quercus lobata*	50'	Deciduous	F Sun	L
Interior Live Oak	*Quercus wislizeni*	10 - 50'	Evergreen	F Sun, Pt Sh	VL,L

Table 2. Native Shrubs for Upland Slopes

COMMON NAME	BOTANICAL NAME	CANOPY	DECIDUOUS / EVERGREEN	SUN	WATER USE
Chamise	*Adenostoma fasciculatum*	1 - 8'	Evergreen	F Sun	EL, VL
California Sagebrush	*Artemisia californica*	4'	Summer Deciduous	F Sun	EL, VL
Coyote Bush	*Baccharis pilularis*	12'	Evergreen	F Sun, Pt Shade	VL, L
Ceanothus	*Ceanothus cuneatus*	5 - 12'	Evergreen	F Sun	VL
Blueblossom Ceanothus	Ceanothus thyrsiflorus	2 - 40'	Evergreen	Pt Shade	L
Bush Monkey Flower	*Diplacus aurantiacus*	5'	Evergreen	Pt Shade, F Sun	VL, L
Coffeeberry	*Frangula californica*	5 - 15'	Evergreen	F Sun, Pt Shade	L,VL

Table 2. Native Shrubs for Upland Slopes

COMMON NAME	BOTANICAL NAME	CANOPY	DECIDUOUS / EVERGREEN	SUN	WATER USE
Coast Silktassel	*Garrya elliptica*	6 - 10'	Evergreen	Pt Shade, F Sun	VL
Toyon	*Heteromeles arbutifolia*	10 - 15'	Evergreen	F Sun, Pt Shade	EL, VL
Silver Lupine	*Lupinus albifrons*	2 - 3'	Evergreen	F Sun	VL
Black Elderberry	*Sambucus nigra*	10 - 20'	Deciduous		L

2.2 Trees and Shrubs for Riparian Areas (Creekside Projects)

Riparian trees help control erosion and sedimentation, lower stream temperatures, conserve soil moisture, and improve water quality. Riparian plants are highly adapted to frequent disturbance seasonal flooding and have evolved to recover and grow rapidly as nature's way of healing itself. Representative riparian trees and shrubs appropriate for drainages within the watershed are included in Tables 3 and 4, respectively.

Table 3. Representative Native Trees for Riparian Areas

COMMON NAME	BOTANICAL NAME	CANOPY	DECIDUOUS / EVERGREEN	SUN	WATER USE
California Buckeye	*Aesculus californica*	40'	Deciduous	Pt Shade, F Sun	VL, L
Coast Live Oak	*Quercus agrifolia*	15 - 35'	Evergreen	F Sun, Pt Shade	L

Table 4. Representative Native Shrubs for Riparian Areas

COMMON NAME	BOTANICAL NAME	CANOPY	DECIDUOUS / EVERGREEN	SUN	WATER USE
Oregon Grape	*Berberis nervosa*	7'	Evergreen	Pt Shade	L
California Hazel	*Corylus cornuta* ssp. *californica*	10'	Deciduous	Pt Shade	L
Western Leatherwood	*Dirca occidentalis*	12'	Deciduous	Pt Shade	L
California Coffeeberry	*Frangula californica* ssp. *californica*	10 - 15'	Evergreen	F Sun, Pt Shade	L
Ocean Spray	*Holodiscus discolor*	10 - 15'	Deciduous	Shade, Pt Shade	L, M, H
Black Twinberry	*Lonicera involucrata*	3 - 4'	Deciduous	Pt Shade, F Sun	M, H
Pacific Ninebark	*Physocarpus capitatus*	8'	Deciduous	F/Pt Shade	M, H, L
Hillside Gooseberry	*Ribes californicum*	2 - 6'	Deciduous	Pt Shade	L
Canyon Gooseberry	*Ribes menziesii*		Deciduous	Shade	L
Red Flowering Currant	*Ribes sanguineum*	7'	Deciduous	Pt Shade	L

Table 4. Representative Native Shrubs for Riparian Areas

COMMON NAME	BOTANICAL NAME	CANOPY	DECIDUOUS / EVERGREEN	SUN	WATER USE
California Wildrose	*Rosa californica*	10'	Deciduous	F Sun, F/Pt Shade	L, M, H
California Blackberry	*Rubus ursinus*	6'	Deciduous	F Sun, F/Pt Shade	M, H
Blue Elderberry	*Sambucus mexicana*	20'	Deciduous	F/Pt Shade, F Sun	L
Common Snowberry	*Symphoricarpos albus*	6'	Deciduous	F/Pt Shade	L, M, H

2.3 Recommended Street Trees

Planting trees in the neighborhoods with inadequate tree canopy cover will also help to reduce urban heat, absorb stormwater, sequester carbon, and improve walkability. Both street trees and trees on private property provide environmental, economic, social and personal health benefits. The **Tree Equity Score map (Figure 2.2)** by American Forests illustrates the areas with the greatest need (the lowest tree canopy cover). The **heat map (Figure 2.3)** shows a corresponding disparity in urban temperatures due to this lack of tree canopy in the lower watershed. The tree canopy goal for the census blocks in San Carlos is 30% tree canopy coverage. Many residential neighborhoods already meet this goal, however some neighborhoods in the lower watershed only have 5% tree canopy cover today.

Table 5. The City of San Carlos Approved Street Tree List

COMMON NAME	BOTANICAL NAME	HEIGHT	CANOPY	DECIDUOUS / EVERGREEN	WATER USE
Chinese Pistache	*Pistacia chinensis*	40’	25-35’	Deciduous	L
Crape Myrtle	*Lagerstroemia indica*	25’	25’	Deciduous	L
Peppermint Tree	*Agonis flexuosa*	35’	15-30’	Evergreen	L

In addition, WRA recommends the following trees for sidewalk locations, based on input from professional arborists and tree planting organizations in the vicinity. Considerations include suitability to local climate conditions, soils, drought tolerance, longevity, available nursery stock, quality of nursery stock, and pest and disease resistance. The list also includes climate-ready species for warmer, drier urban conditions.

Selecting the right tree species and planting it in the right place is the first step toward expanding the tree canopy. To minimize maintenance and avoid infrastructure damage and utility conflicts above and below ground, select tree species based on available planting space, and only plant small trees below power lines. UFEI’s SelecTree (2024) Tree Selection Guide provides preselected lists of trees OK for under power lines, shade trees, drought tolerant trees, native tree species, and trees with low water requirements.

Small Trees

- *Callistemon viminalis* / Weeping Bottlebrush
- *x Chitalpa tashkentensis* ‘Pink Dawn’ / Pink Dawn Chitalpa

- Magnolia grandiflora 'Little Gem' / Dwarf Southern Magnolia
- *Prunus cerasifera* 'Krauter Vesuvius' / Krauter Vesuvius Plum

Medium Trees

- *Arbutus unedo* 'Marina' / Marina Strawberry Tree
- *Crataegus phaenopyrum* / Washington Hawthorn
- *Pistacia chinensis* 'Keith Davey' / Chinese Pistache

Large Trees

- *Fraxinus angustifolia* (syn. Oxycarpa) 'Raywood' / Raywood Ash
- *Ginkgo biloba* 'Autumn Gold' / Ginkgo
- *Platanus x hispanica* (syn. P x acerifolia) 'Bloodgood' 'Columbia' 'Yarwood' / Sycamore*
- *Quercus agrifolia* / Coast Live Oak
- *Quercus suber* / Cork Oak
- *Ulmus parvifolia* 'Frontier' or 'Drake' or 'Pioneer' / Chinese Elm

2.4 Native Tree Species for private property, parks, and gardens

The following are tree and arborescent shrub species that are appropriate for private property, public parks, schoolyards, and gardens. Local native trees and shrubs are optimum for providing wildlife habitat throughout the city.

- *Aesculus californica* / California Buckeye
- *Prunus ilicifolia* subsp. *lyonii* / Catalina Cherry
- *Quercus agrifolia* / Coast Live Oak
- *Umbellularia californica* / California Bay Laurel

2.5 Tree Planting Organizations and Local Resources

Local tree planting organizations are excellent resources for guidance on tree stewardship, planning and planting a sustainable urban forest including street trees, parks, schools and open space trees.

- **Canopy** is a nonprofit tree planting organization in Mountain View https://canopy.org/
- San Francisco **Friends of the Urban Forest** plants and cares for street trees in San Francisco https://www.friendsoftheurbanforest.org/
- **California ReLeaf** supports grassroots efforts and build strategic partnerships that protect, enhance, and grow California's urban and community forests https://californiareleaf.org/
- **California Urban Forests Council** https://caufc.org/
- Funding and other resources are available from the **USDA Forest Service Urban and Community Forestry Program** https://www.fs.usda.gov/managing-land/urban-forests
- **The Vibrant Cities Lab** and **USDA Forest Service** partnered to create the Urban Forestry Toolkit, which provides a step-by-step guide to planning and implementing an urban forestry project. https://www.vibrantcitieslab.com/toolkit/
- **Urban Forest Management Plan Toolkit** website provides a "how-to" approach to develop an Urban Forest Management Plan (UFMP). The toolkit will lead you through a planning process. https://ufmptoolkit.net/

3.0 GREEN STORMWATER INFRASTRUCTURE AND LID FEATURES

3.1 Plants Suitable for Bioretention Areas

Swales are shallow channels designed to catch rainwater and reduce or prevent its flow off the site. Swales planted with appropriate vegetation are known as bioswales. They promote infiltration of rainwater into the soil and help filter and breakdown pollutants in the stormwater runoff. Bioswales can also add beauty and value to the landscape. This plant list features mostly California native species that are suitable for many vegetated swales. Non-native species are marked with an asterisk (*).

The plants on this list are from the San Mateo County (SMCWPPP) *Plant List for Landscape-based Biotreatment Measures* available at FlowsToBay.org (https://www.flowstobay.org/wp-content/uploads/legacy_media/plant-list-all.pdf). For a more extensive list of plants appropriate for stormwater treatment features, see Appendix B of the Alameda County Clean Water Program's publication, "C.3 Stormwater Technical Guidance: A Handbook for Developers, Builders and Project Applicants," May 14, 2013, which can be downloaded from www.cleanwaterprogram.org/resources/resources-development.html.

Table 6. Plant List for Landscape-based Biotreatment Measures

COMMON NAME	BOTANICAL NAME	HEIGHT	SPREAD	SUN / SOIL	WATER USE
Emergent Plants (can grow in water with part of the plant above the surface)					
Santa Barbara sedge	*Carex barbarae*	1-3'	1-3'	Full sun or part shade	M/VL
Slough sedge	*Carex obnupta*	1-3'	1-3'	Full sun or part shade	M
Pacific rush	*Juncus effusus*	1-2'	1-2'	Sun to part shade	H
Blue rush	*Juncus patens*	1-2'	1-2'	Sun to part shade	H/Drought Tolerant
Plants that Tolerate Periodic Inundation					
Big leaf maple	*Acer macrophyllum*	30-100'	30-100'	Sun to part shade	Occasional-Regular
Box elder	*Acer negundo californicum*	30-50'	30-50'	Full sun or part shade	M
Buckeye	*Aesculus californica*	15-20'	30'	Full sun	Very Low
Red alder	*Alnus rubra*	45-50'	20-30'	Sun or shade	Regular/Ample
Mountain mahogany	*Cercocarpus betuloides*	5-12'	5-12'	Full sun/Tolerates clay and serpentine	Very Low
Berkeley sedge	*Carex divulsa (tumulicola)*	1-2'	1-2'	Part sun to part shade	M-Occasional
California meadow sedge	*Carex pansa*	1'	1'	Sun to shade	M/Drought Tolerant
Rusty sedge	*Carex subfusca*	1-1.5'	1-1.5'	Sun to shade	M/Drought Tolerant
Western dogwood	*Cornus sericea*	15'	15'	Sun to shade	Occasional-Regular
Redosier dogwood	*Cornus stolonifera*	7-9'	12'	Full sun or light shade	Regular

Table 6. Plant List for Landscape-based Biotreatment Measures

COMMON NAME	BOTANICAL NAME	HEIGHT	SPREAD	SUN / SOIL	WATER USE
Cape rush	*Chondropetalum tectorum**	4-6'	4-6'	Sun to part sun	M-Occasional
Crocosmia	*Crocosmia* 'Lucifer'*	4'	2'	Sun, some shade when hot	Regular
Tufted hairgrass	*Deschampsia cespitosa*	1-2'	2'	Part shade	Low
Fortnight lily	*Dietes bicolor, D. iridioides**	3'	3'	Sun or part shade	Occasional-None
Blue wild rye	*Elymus glaucus*	1-2'	2'	Full to part sun	Low
Horsetail	*Equisetum hyemale*	4'	2'	Full sun or partial shade	H
California fescue	*Festuca californica*	1-2'	2-3'	Sun to part shade	Low
Idaho fescue	*Festuca idahoensis*	1-2'	1-2'	Full sun to part sun	Very Low
Red fescue	*Festuca rubra*	3-12"	1'	Full sun to part sun	Low
Molate fescue	*Festuca rubra* 'molate'	3-12"	1'	Full sun to part sun	Low
Creeping wild rye	*Leymus triticoides*	1-3'	1-2'	Full sun to part sun	Occasional
Deerweed	*Lotus scoparius*	3'	3'	Full sun to part shade	Very Low
Deergrass	*Muhlenbergia rigens*	3'	3'	Full sun to part shade	Low
Wax myrtle	*Myrica californica*	10-30'	10-30'	Sun or part shade	Low
Foothill needlegrass	*Nassella lepida*	1'	1'	Full sun/Good drainage	Very Low
Purple needlegrass	*Nasella pulchra*	1-2'	1-2'	Full sun/Good drainage	Very Low
Pacific ninebark	*Physocarpus capitatus*	8'	8'	Sun or shade	M-Regular
Western sycamore	*Platanus racemosa*	30-80'	20-50'	Full sun	M
Fremont cottonwood	*Populus fremontii*	50-70'	50'	Sun/Moisture-retentive	Occasional-Regular
Valley oak	*Quercus lobata*	100'	100'	Sun/Adaptable	Low
California wild rose	*Rosa californica*	3'	6'	Part shade	Low
Arroyo willow	*Salix lasiolepis*	6-9'	9-12'	Sun	H
Red willow	*Salix laevigata*	9-30'	9-30'	Sun	H
Elderberry	*Sambucus mexicana*	8-25'	8-25'	Sun to partial shade	Low
Blue-eyed grass	*Sisyrinchium bellum*	6-12"	6-18"	Full sun to light shade	Very Low
Tall fescue	*Stipa arundinacea**	2'	2'	Full sun	M-Occasional
Upland Plants (for the swale's upland zone/top of slope)					
Common yarrow	*Achillea millefolium*	12-30"	2-4'	Full sun/Reasonable drainage	Low
Chamise	*Adenostema fasciculatum*	6-15'	6-15'	Sun/Adaptable except alkaline	Drought Tolerant
Manzanita	*Arctostaphylos* spp.	Varies	Varies	Full sun to part shade	Low

Table 6. Plant List for Landscape-based Biotreatment Measures

COMMON NAME	BOTANICAL NAME	HEIGHT	SPREAD	SUN / SOIL	WATER USE
Sea pink	*Armeria maritima*	4-8"	6-12"	Full sun/Good drainage	Little-Occasional
Prostrate Coyote brush	*Baccharis pilularis* 'Twin Peaks'	1'	10-15'	Full sun	Low
Mulefat	*Baccharis salicifolia*	8'	8'	Full sun	Low
Ceanothus	*Ceanothus* spp.	Varies	Varies	Full sun to part shade	Low
California fuchsia	*Epilobium canum*	1'	4'	Full sun to part shade/Good drainage	Low
Flattop buckwheat	*Eriogonum fasciculatum*	2-3'	4'	Full sun/Good drainage	Low
California poppy	*Eschscholzia californica*	6-12"	6"	Full sun/Good drainage	Very Low
Beach strawberry	*Fragaria chiloensis*	10"	Spreading	Sun to part shade/Well drained	Infrequent to Occasional
Toyon	*Heteromeles arbutifolia**	10-20'	10-15'	Full sun to part shade/Good drainage	VL
Tree mallow	*Lavatera* spp.	Varies	Varies	Full sun/Good drainage	Low
Pitcher sage	*Lepechina calycina*	3-5'	1-2'	Full sun with pm shade/Good drainage	VL
Bush lupine	*Lupinus albifrons**	3-5'	3-5'	Full sun/Excellent drainage	VL
Common monkeyflower	*Mimulus aurantiacus*	3-4'	3-4'	Full sun to part shade	Low
Scarlet monkeyflower	*Mimulus cardinalis*	2-3'	2-3'	Full sun to part shade/Adaptable	Low
Coast silk tassle	*Garrya elliptica*	10-20'	10-20'	Afternoon shade inland	Low
Coffeeberry	*Rhamnus californica*	3-15'	6-8'	Sun or part shade/Good drainage	Low
Chaparral currant	*Ribes malvaceum*	5'	5'	Sun to part shade	Very Low
Goldenrod	*Solidago californica*	1-4'	1-2'	Part shade	VL
Snowberry	*Symphoricarpos albus*	3-5'	3-5'	Part shade	Occasional-Little

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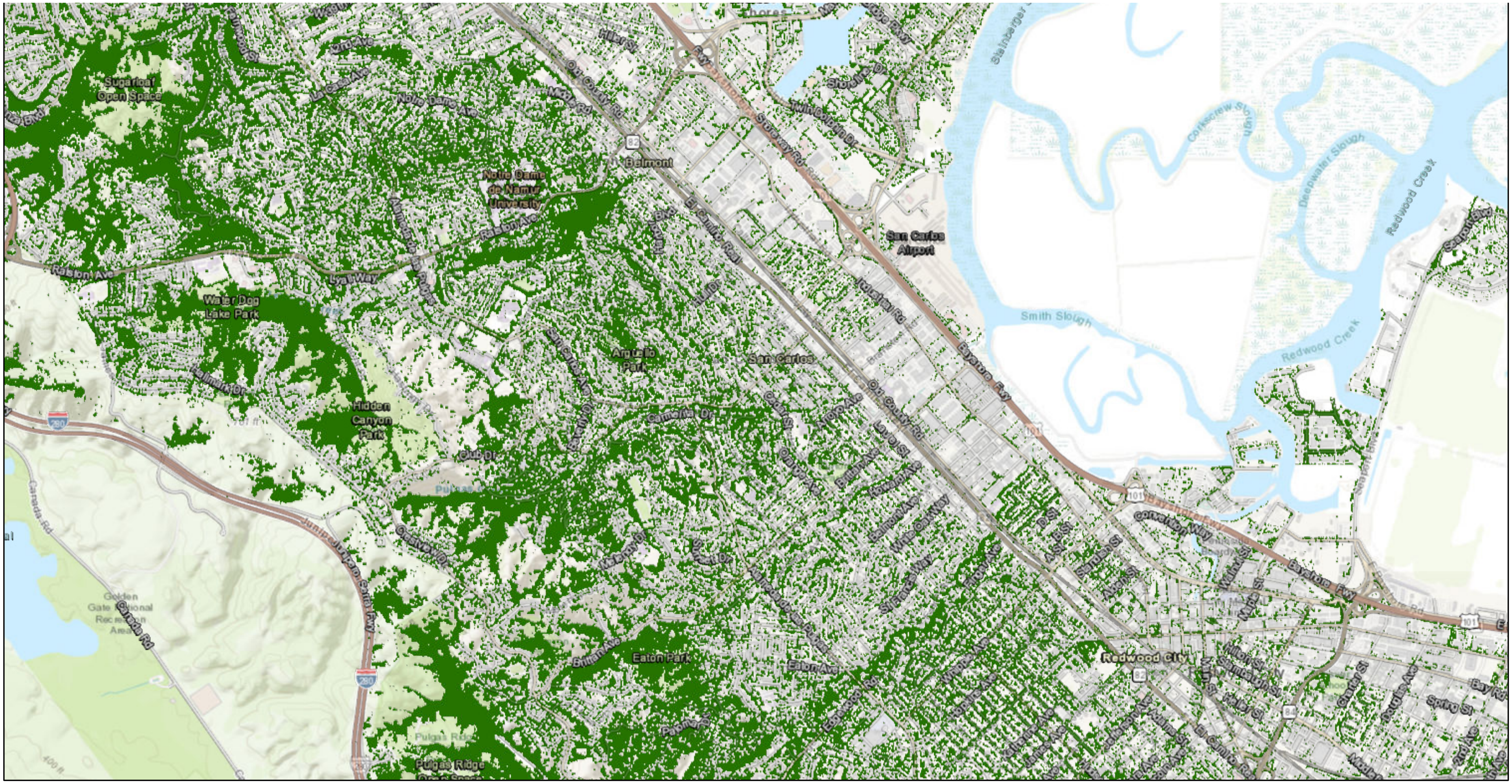

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Canopy cover 2018

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Redwood City, County of San Mateo, California, Bureau of Land Management, Esri, HERE, Garmin, INCREMENT P, USGS, METI/NASA, EPA, USDA, Esri, HERE, Garmin, © OpenStreetMap contributors, and the GIS user community, EarthDefine, USDA Forest Service,

Figure 2.1 Urban Tree Canopy Map

Pulgas Watershed Study
San Carlos, California

wra
Environmental Consultants

Date: 05/01/2024

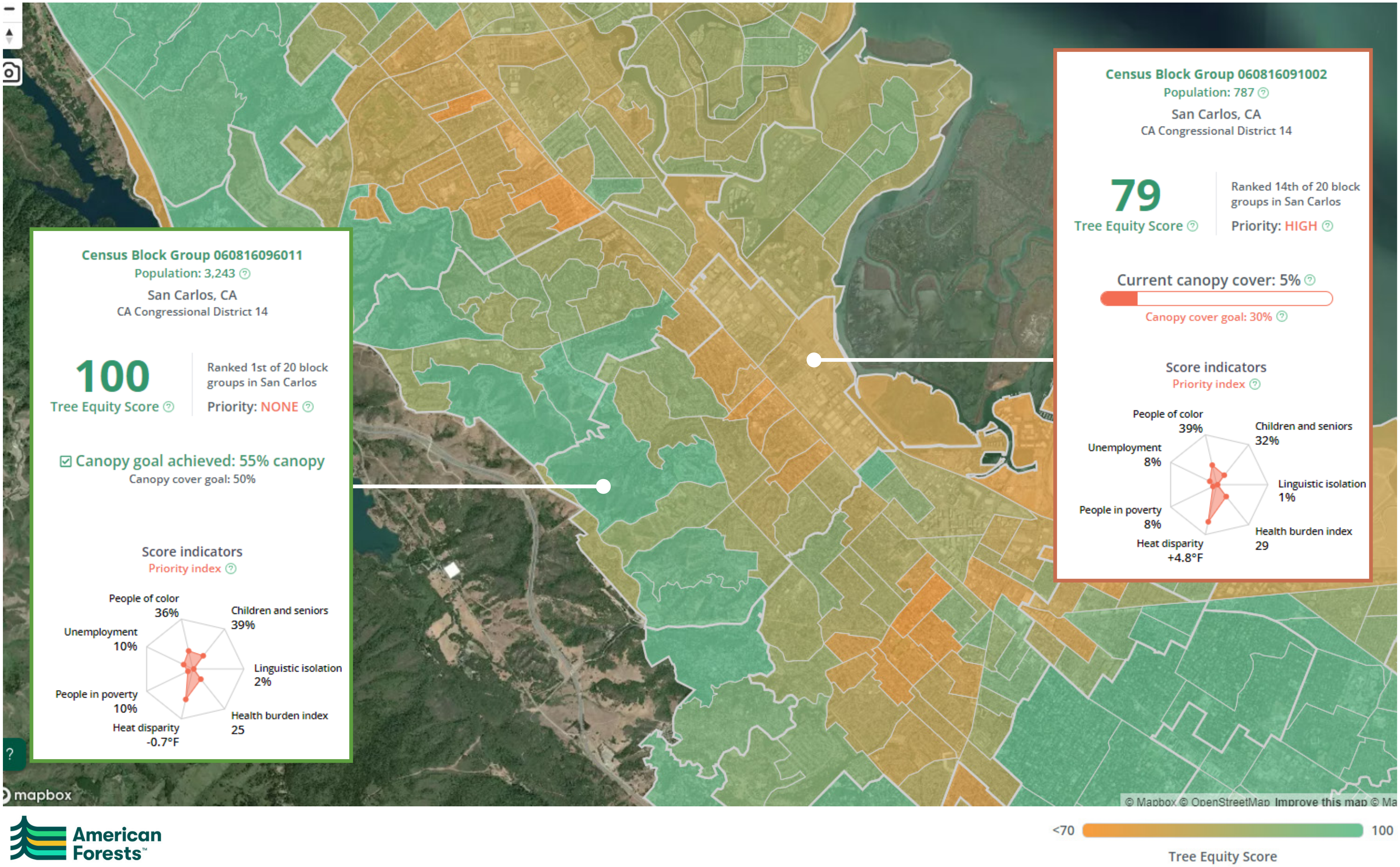

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Figure 2.2 American Forests Tree Equity Score Map

wra Environmental Consultants

Pulgas Watershed Study
San Carlos, California

Date: 05/01/2024

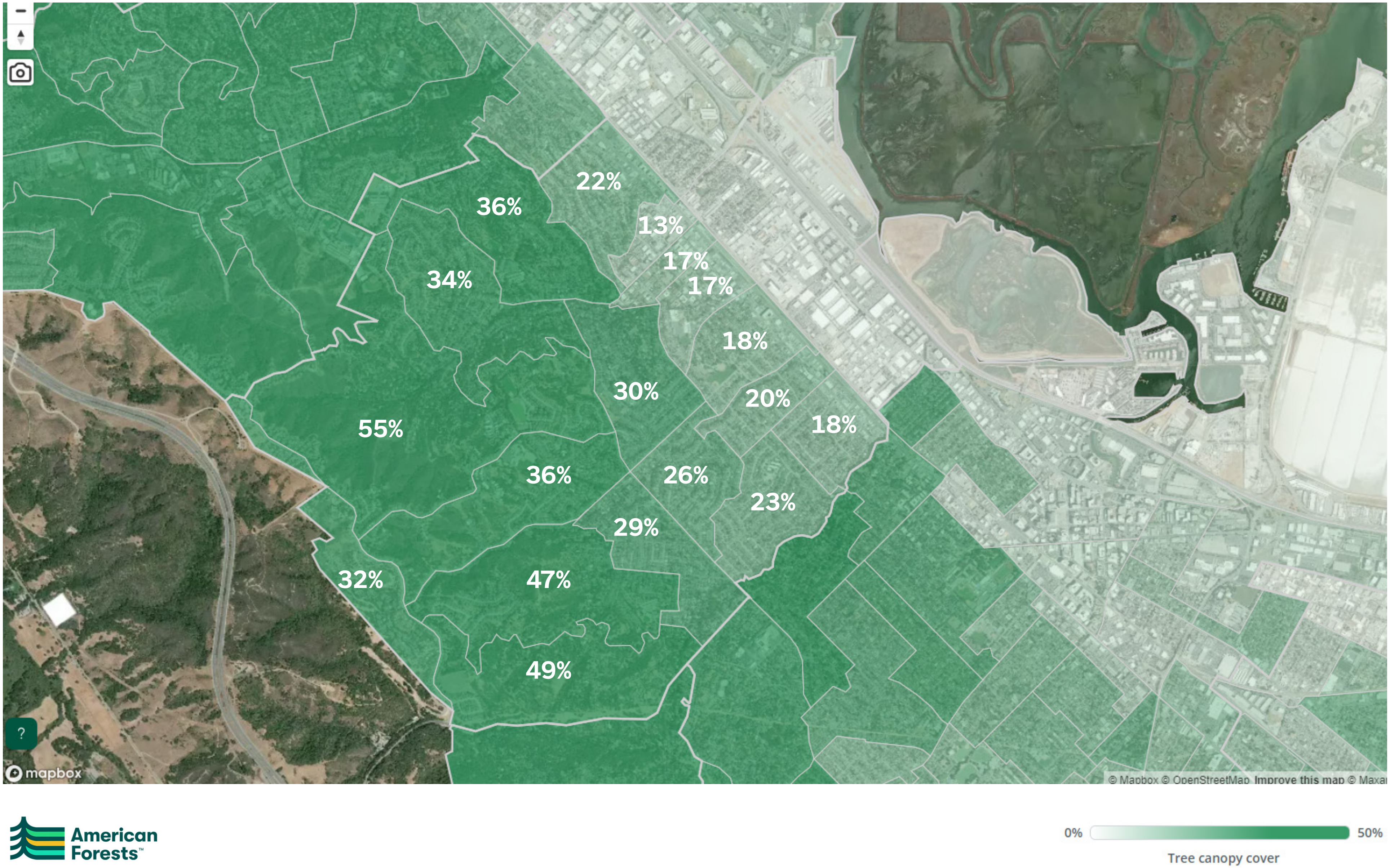

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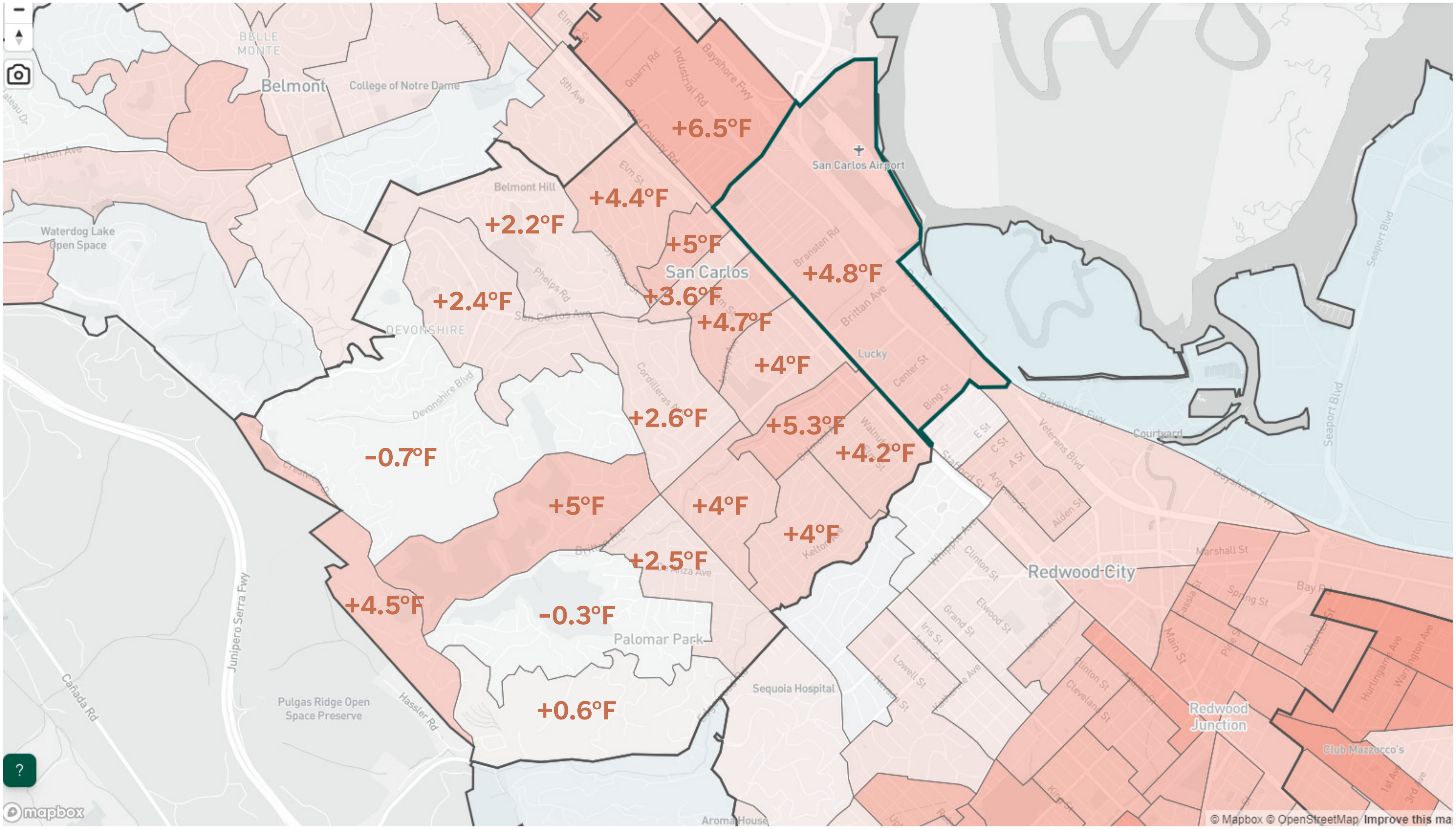
Figure 2.3 Tree Canopy Cover

wra Environmental Consultants

Pulgas Watershed Study
San Carlos, California

Date: 05/01/2024



American Forests™

-5°F +25°F

Heat disparity

Figure 2.4 Urban Temperatures

wra Environmental Consultants

Pulgas Watershed Study
San Carlos, California

Date: 05/01/2024

Attachment C.

Alternatives Hydraulic Model Adjustments

Attachment C.
Alternatives Hydraulic Model Adjustments

1.0 ALTERNATIVES HYDRAULIC MODEL

To assess potential flood reduction benefits, modifications were made to the existing conditions PC SWMM model discussed in the H&H Memo. The proposed conditions model for the 10, 25, and 100-year scenarios were re-run following incorporation of Alternatives A-E, with F and G not expected to yield quantifiable flood reduction impacts. Modifications made to subbasins, nodes, or junctions for each alternative is described below:

1.1 Alternative A: Revegetation

- Lowering of subbasin CN values by 2-12 points where revegetation is proposed

1.2 Alternative B: Floodplain Detention Basins

- Terrain modifications to incorporate a terraced floodplain, widened flow path, and outlet berm to prevent overflow flooding
- Adjustment of node connections at the outlet to incorporate a low flow and high flow outlet pipe to the existing downstream storm drain system
- Adjustment of conduit geometry to account for increase in storage volume

1.3 Alternative C: LID Implementation

- Addition of infiltration trench or bioretention cell LID parameters based on C3 guidance in PC SWMM to existing subbasin (San Mateo Countywide Water Pollution Prevention Program, 2023)

1.4 Alternative D: Creek Crossing Adjustments

- Terrain and roughness modifications to widen flow conduits of Pulgas Creek and Brittan Creek incorporating floodplain geometry to a conduit

1.5 Alternative E: Underground Detention Basins

- Modification of flow routing to the two proposed storage cells and connection back to the main flow path through pumping

Appendix D: Public Access Opportunities Memorandum

MEMORANDUM

TO:	Grace Le, PE	**FROM:**	Robin Graham
CC:	Camille Bandy, PE, QSD		
DATE:	November 15, 2024 (Rev.1)		
SUBJECT:	Pulgas Creek Watershed Plan Public Access Opportunities Memo		

1.0 INTRODUCTION

The City of San Carlos (City) is preparing a watershed plan that aims to provide guidance on improving the hydrology and flood resilience of Pulgas Creek and its tributaries. The headwaters of these creeks originate in the upland open spaces and undeveloped areas in San Carlos where Pulgas Creek and its tributaries exist as ephemeral natural channels. Downstream, the creeks are channelized or piped underground primarily through private property. The upland open spaces in San Carlos have steep slopes and soils which are prone to erosion which when combined with residential construction and winter rains on slopes of non-native annual grasslands result in landslides, sedimentation of stormwater infrastructure, and flooding. The Pulgas Creek Watershed Plan (Plan) will develop potential solutions for reducing the risk of these hazards.

1.1 Purpose and Need

To support the Plan, this memo has been prepared to identify potential public access and recreation improvements that can be paired with recommended watershed improvements. This memo supports multi-benefit public access, watershed and community health.

1.2 Planning Context

This memo and subsequent Plan are being prepared to support and align with existing City plans and municipal code. The following plans have been utilized in the preparation of recommendations discussed in the following section.

CITY OF SAN CARLOS BICYCLE AND PEDESTRIAN MASTER PLAN (2020)

Adopted in 2020, the Bicycle and Pedestrian Master Plan (BPMP) completed an inventory of existing bikeways, and sidewalks within the City which were analyzed on their level of safety, connectivity to public facilities including transit and schools, and user experience (City of San Carlos, 2020). A suite of goals, objectives, and policies were identified through a public and stakeholder outreach process. Recommendations for improvement of the bicycle and pedestrian access network were developed to address the policies identified and reflect the progress made since the previous Bicycle and Pedestrian Master Plan from 2012.

SAN CARLOS HILLSIDE TRAILS PLAN (2012)

The Hillside Trails Plan proposes new trail alignments with the City's open space areas, Big Canyon and Eaton Parks (City of San Carlos, 2012). One trail in each park is looked at in detail with regard to stream crossings and biological resources. Both trails have been constructed since the adoption of this Plan. The Plan provides best practices for minimizing biological, cultural, hydrological and air quality impacts. In addition, the Plan provides design guidelines for trail construction.

PARKS, OPEN SPACE, BUILDINGS, AND OTHER RECREATIONAL FACILITIES MASTER PLAN 2009-2029 (2008)

This Parks and Recreation Master Plan (PRMP) for San Carlos provides a holistic view of all the City's parks, open spaces, and community facilities such as libraries and museums (City of San Carlos, 2008). The PRMP includes community engagement to perform a needs assessment of the entire system of facilities. The PRMP describes how these needs are addressed through an action plan, and prioritization and implementation considerations.

EAST SIDE INNOVATION DISTRICT VISION PLAN (2021)

The ESID Vision Plan describes a future for an existing industrial area of the City that incorporates multi-modal transportation, public access along Pulgas Creek, and economic development (City of San Carlos, 2021). While this plan provides a broad range of goals for this area, salient to this memo, a key part of the vision is to restore the creek and create a new park and trail along its banks and provide additional trails that access the creek at multiple points. The ESID Vision Plan also incorporates nature-based flood resiliency design.

2.0 PULGAS CREEK WATERSHED PUBLIC ACCESS

Public access and recreation related opportunities for improvement were identified based on primary drainage improvement needs in the upper watershed of Pulgas Creek. Lower watershed opportunities are limited due to waterways being underground and largely on private property. Opportunities that are programmatic in nature may include signage or workdays at upper watershed sites but can be implemented City-wide. General constraints regarding site specific opportunities include surrounding private properties and existing development, as well as steep hill slopes.

In general, the constraints of expanding or improving public access and outdoor recreation include the steep, hilly topography, limited public land, and existing development. Opportunities include expanding public access to creeks, providing education on concepts of flood resiliency and low-impact design, and improving existing recreation opportunities.

2.1 Programmatic Opportunities

Key opportunities that can be implemented City-wide include programs related to educating the public about concepts of flood resiliency and low-impact design (LID), as well as volunteer opportunities to improve watershed health. Recommended program opportunities are discussed below and constraints related to these are discussed in Section 2.3 Feasibility Assessment.

- **Expand the existing Adopt-a-drain program** to include volunteer clean up days for park and open space ditches and drains. While the Public Works department maintains these, engaging the public and creating an ownership mentality on what causes problems and the challenges associated with maintenance can help raise awareness about how the watershed functions.

- **Create a program to educate property owners** about watershed related risks and how treatments on their property can impact or improve overall watershed health. Property owners adjacent to parks, open space areas, and stream corridors would be ideal participants where improving drainage and vegetation conditions could reduce landslide risk and improve water quality. This program could provide online information to all residents available via QR code at parks and open space sites. This program could also include specialized workshops and engagement for open space and stream corridor adjacent properties. These property owners could be engaged to learn how to make their property more resilient to landslides, prevent downstream sedimentation, improve drainage, as well as protect against wildfire hazards. This type of program could also offer incentives to property owners to take steps on their own property, such as a free property assessment.

- **Develop interpretive signage and programs** around drains, ditches, LID features, and stream crossings throughout the parks, open spaces, and City-wide to educate residents about flood resiliency, stormwater management, hydrology of the watershed, and other related topics. This can help raise awareness around resilient infrastructure.

2.2 Opportunity Sites

The following public access opportunity sites were identified through discussions around hydrologic needs and improvement areas. These areas typically focus on the upper watershed in Arguello, Big Canyon, Eaton, and Vista Parks, to reduce both immediate and downstream impacts. There are also opportunities in the lower watershed at road intersections such as the intersection of San Carlos Avenue and Alameda de las Pulgas where existing stormwater LID needs improvements. These locations and recommended improvements and constraints are discussed below with sites organized beginning with upper watershed areas moving east to end with lower watershed areas. General locations of recommendations can be found in Appendix A.

Another lower watershed site for public access improvement related to watershed improvements includes the section of daylighted creek between El Camino Real and Highway 101. However, the ESID Vision Plan describes detailed public access improvements in the lower watershed east of El Camino Real and builds off of the proposed bike and pedestrian improvements in the BPMP which are included here by reference rather than repeating the recommendations. Considerations for the restoration of this reach of Pulgas Creek include installing a detention basin within the proposed community open space adjacent to the creek. The creek trail and creek restoration should be designed as one to ensure proper functionality of the creek and riparian habitat while minimizing potential flooding of the creek-side trail. Additional considerations for this section of Pulgas Creek include management of potential use by individuals experiencing homelessness.

2.2.1 Vista Park

Vista Park contains flat paths with picnic tables and benches interspersed with native vegetation along Crestview Drive. There is a drainage basin along the eastern side of the park that is covered with grass turf.

RECOMMENDATIONS

Improve pedestrian and bike access
Improvements to pedestrian access to the park can be achieved by installing a crosswalk to connect Vista Park to North Crestview Park west of Crestview Drive. The BPMP calls for the installation of bike lanes along Crestview Drive which should be implemented, and bike racks should be provided at all parks.

Expand native vegetation
Native vegetation could be expanded into the drainage basin and the grass turf removed. Additional interpretive signage could discuss the design as a native vegetation, no pesticide park.

Grass drainage basin

Add seating and trail connections
Benches and accessible picnic tables could be added as identified in the PRMP. Additional opportunities discussed in the PRMP and Hillside Trails Plan would need to incorporate drainage needs into their design as they are proposed to overlap with the existing drainage basin including, an off-leash dog area and a trail connecting Vista Park to the "Top of the World" site via a trail easement.

CONSTRAINTS

Vehicle traffic on Crestview Drive is fast moving and should be mitigated through appropriate traffic calming around crosswalks and intersections. Maintaining the drainage basin may constrain the expansion of native vegetation into this area. Proposed uses in the PRMP including an off-leash dog park and trail connections should include considerations for minimizing potential visitor conflicts with existing picnic and landscape viewing uses.

2.2.2 Big Canyon

Big Canyon Park is located in the western hillside areas of San Carlos north of Brittan Avenue and contains natural surface trails. There are two designated trailheads and trails making up two loops and one out-and-back trail. During a site visit on April 12, 2024, WRA staff noted three landslides, none of which affected trails. There was evidence that recent trail repairs may have occurred. The trails were generally in good condition, contain many stream crossings, and few visitor created trails, limited to shortcuts and spurs leading onto private property.

Representative example of recent landslide and treatment at Big Canyon Park.

RECOMMENDATIONS

Improve trail stream crossings
Stream crossings could be improved by stabilizing the stream banks and installing hardened materials in the stream channel across the trail tread or puncheons or bridges over the stream. The Hillside Trails Plan provides best practices for trail construction including stream crossings.

While not a stream crossing, the drainage pipe crossing the Oak Meadow Trail can also be upgraded to improve visitor experiences. Alternative drainage options can be considered to remove the pipe. If removal is not feasible, adding educational signage explaining the importance of the pipe can improve experiences.

Left: example of existing stream crossing. Right: steps over drain pipe.

Expand volunteer opportunities
As soil stabilization through revegetation is implemented, volunteer programs can help monitor plant health, invasive species encroachment, and perform additional planting.

Improve trail conditions and pedestrian access
In coordination with a recommendation in the Flood Mitigation Evaluation Memorandum, as a detention basin is proposed near the Brittan Ave trailhead, the proposed ADA compliant trail from the Hillside Trails Plan can be implemented in the same construction effort. This trail will need to be delineated to limit off-trail travel and hardened to prevent muddy conditions that currently exist. This ADA trail and flood plain also provide an opportunity to create an interpretive area that explains the function of the detention basin or similar topics. Clear wayfinding signage identifying trail names and lengths is also needed in this area. A crosswalk across Brittan Avenue can also be installed to highlight the connection between Big Canyon and Eaton Parks, as well as allow visitors to park on both sides of the street and cross more safely.

Improve Oak Meadow Trail end point
There is an opportunity to create a vista point destination at the end of the Oak Meadow Trail. The end point could include fencing to limit off-travel travel onto private property, seating, and interpretive signage.

End of Oak Meadow Trail

CONSTRAINTS

Constraints include potential for special status species as noted in the Hillside Trails Plan, and wide variations in hydrologic conditions of ephemeral streams. Steep slopes and unstable soils are also present.

Parking may act as a constraint for implementation of an ADA compliant trail. High speed vehicle traffic on Brittan Ave should be mitigated with appropriate traffic calming around crosswalks.

2.2.3 Eaton Park

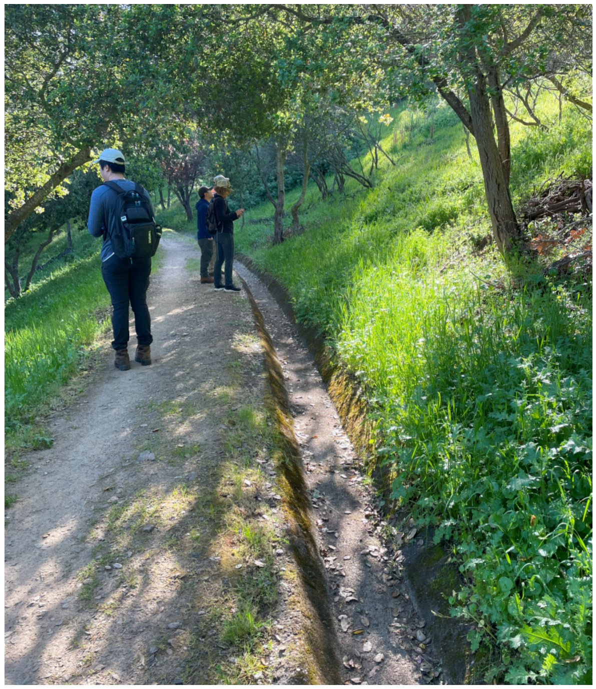
Eaton Park is located in the western hillside areas of San Carlos south of Brittan Avenue. There are four designated trailheads with trails connecting these points. This park currently has one major landslide which washed out a trail that has been rebuilt.

RECOMMENDATIONS

Implement City-wide programs including installing interpretive and informational signage at landslide areas and drainage ditches to inform visitors about the purpose of drains and ditches as well as provide safety information at landslides. The City could also host ditch cleaning days as part of a volunteer program for the ditch following Eaton Trail.

CONSTRAINTS

Constraints include steep hill slopes that limit space for signage and interpretive areas.



Drainage ditch on Eaton Trail

2.2.4 Arguello Park

Arguello Park is located in the northern hillside area along Wellington Drive. This park contains four tennis courts and one ball diamond in the lower elevations, while the upper elevations contain natural surface roads and trails. There are many visitor-created trails in the upper elevations of the park and a picnic area at Dartmouth Avenue. There is currently one landslide that washed out a trail that has not been rebuilt.

RECOMMENDATIONS

Improve trails and wayfinding signage
Reduce the proliferation of visitor-created trails to reduce soil erosion and improve slope stability. This can be accomplished through decommissioning visitor-created trails including decompacting and revegetating, delineating designated trails, and installing and maintaining additional wayfinding signage indicating trail closures, rehabilitation areas, and designated trails. Special attention should be paid to decommissioning visitor-created trails and improving wayfinding signage around the stream directly upslope from the ball field. A designated trail exists in this area but is unsigned and visitor-created trails following the stream channel are unstable.

Designated trails with absent or missing wayfinding signage

As part of the effort to improve trails and signage, the City could establish a volunteer trail maintenance program aimed at rehabilitating visitor-created trails and educating the public on the hazards that result from visitor-created trail erosion. The City has historically used neighborhood volunteers and county work furlough program to perform fire fuels reduction at Arguello Park which could be expanded to include trail maintenance. Hillside stabilization and erosion reduction work completed as part of park renovations in 2006 could be used as a baseline for ongoing erosion monitoring and maintenance.

Left: visitor-created trail on unstable stream bank. Right: visitor-created trails.

Add new facilities
The northern and highest point in Arguello Park near Northam Avenue and Dartmouth Avenue presents an opportunity to add new recreation facilities. This area currently has a picnic area on one side, and a drainage area on the other with a flat empty space in the middle. As improvements are made to the drainage area, it could also become an interpretive site as mentioned in the Arguello Park Master Plan (City of San Carlos, 2002). The PRMP calls for implementation of Phase 2 of the Arguello Park Master Plan which included renovation of a visitor-created BMX course located in the drainage area. It is unclear if creating a designated BMX course remains an option or a desire for this part of Arguello Park given current watershed management goals but activating this space with new facilities is recommended.

Improve pedestrian access
In coordination with recommendations in the Flood Mitigation Evaluation Memo, implementation of a detention area below the ball field can be paired with construction of a path to connect the ball field with the tennis courts. Currently, there is only road access and access via a visitor-created trail. Given the lack of dedicated pedestrian access between these facilities, an ADA compliant path would ensure equitable access.

CONSTRAINTS

Constraints related to trails and pedestrian access include steep hillslopes, and unstable soils making trail construction and maintenance challenging. If slopes are too steep for implementation of an ADA compliant path, a steeper hiking trail should still be considered to provide pedestrian access between the tennis courts and ball field. There is also limited parking, transit, bike and pedestrian access to the northern upper elevation of the park where new facilities are recommended. Additional constraints throughout the site are drainage and slope stability needs.

2.2.5 San Carlos Avenue + Alameda de las Pulgas

This intersection contains vegetated drainage swales that are meant to divert stormwater off the street and filter it through the vegetation and soil before the water drains to the creek which flows roughly parallel to San Carlos Ave in this location. Around these swales are pedestrian and bicycle intersection improvements. The BPMP called for medium priority sidewalk projects and several pedestrian spot improvements along the San Carlos Ave corridor (these spot improvements were listed as in progress in the BPMP and are assumed to have been implemented). The BPMP also included several high priority bikeway improvements in this corridor. However, there are opportunities for enhancements of the existing pedestrian infrastructure.

One of two LID treatments at San Carlos Ave and Alameda de las Pulgas with bike and pedestrian infrastructure.

RECOMMENDATIONS

Improve pedestrian access

Widen the sidewalk or provide a parkway strip east of the intersection along the south side of San Carlos Ave. The existing fence along the south side of San Carlos Ave appears to be beyond the boundary of the private parcels and with appropriate coordination with property owners could be removed to provide a much wider space for pedestrians with a vegetated buffer between the sidewalk and the road. Removal of this fence could also provide pedestrians with glimpses of the creek.

Fencing along San Carlos Ave sidewalk

Add signage

Provide wayfinding and interpretive signage around the intersection and LID. Once the LID is functioning properly, interpretive signage explaining the purpose and processes could be installed to educate the public about green infrastructure, local creeks, and resiliency. In addition, pedestrian and bicycle wayfinding signage could be added to this intersection to direct the public along the best routes, provide direction and distances to destinations like downtown Laurel Street. The BPMP includes recommendations and guidelines for wayfinding signage.

CONSTRAINTS

Constraints in this area include maintaining privacy for the properties that back on to San Carlos Ave and the creek. In addition, minimizing sign clutter and maintaining visibility for all road users should be a priority

2.3 Feasibility and Risk Assessment

2.3.1 Operations and Maintenance

Maintaining trails, widening and potentially building new trails were recommended in the PRMP noting attention to soil erosion and trail drainage. However, trails are not listed under items that maintenance staff manage. While more technical trail improvements, like stream crossings should be performed by specialist contractors, ongoing trail maintenance can be performed by City staff. Increased Operations and Maintenance (O&M) time and resources will need to be dedicated to trail maintenance. Trail maintenance work can also be performed by trained volunteers. The PRMP indicated that most of the existing trails in the City's open space areas were built by local Sierra Club volunteers. O&M time and resources would be needed in this scenario to manage volunteer groups and perform volunteer program administration.

The PRMP includes limited discussion of vegetation management in open space areas, citing fire fuels management as a priority. A vegetation management program is likely needed to perform volunteer program administration for restoration or monitoring efforts, removing invasive species and revegetating slopes for soil stabilization. O&M time and resources would be relied on to balance the need for soil stability, native vegetation and fuels management.

2.3.2 Resiliency

Implementation of physical improvements to parks and open spaces will improve the resiliency of trails and vegetation regarding erosion, landslides, and wildfire. Public engagement programs aimed at improving drainage systems can reduce downstream flooding and reduce the likelihood of landslides on private property adjacent to open spaces.

2.3.3 Safety

Risks associated with performing trail maintenance and vegetation management typically include personal injury from cuts or falls. Working on the steep slopes of Big Canyon, Eaton, and Arguello parks increase this risk. However, lack of vegetation and trail maintenance increases risk of personal injury including cuts and falls to visitors using the trails.

Lack of vegetation and trail improvements also increases the risk of future landslides, wildfire, and flooding, compromising the safety of staff, visitors, and properties adjacent to the parks and open spaces.

Risks to public and staff safety along roads, including at crosswalk and sidewalk recommendations, are high and can be reduced through upgrading road designs to slow vehicle speeds.

2.3.4 Funding

Increased funding will be needed to implement vegetation, trails, and signage improvements across all opportunity sites. As these elements require ongoing maintenance, it is recommended that these tasks be performed by trained City staff. However, some initial trail work may require contractors at higher rates.

Implementation of public engagement and other programs will require increased and ongoing program administration costs. While pilot programs can often be funded with grants, ongoing implementation requires dedicated funds. Public engagement programs, through raising awareness for watershed management issues can also increase the likelihood of public support for program and project funding.

Funding public access improvements solely on an as-needed basis after landslides, flooding, or wildfire is not recommended as ad hoc improvements are less likely to reduce the potential for hazards long term compared with preemptive and ongoing maintenance. The proactive improvements recommended here can also reduce the risk of emergency funding needed.

3.0 REFERENCES

City of San Carlos. (2002). *Arguello Park Master Plan* [Plan]. RRM Design Group.

City of San Carlos. (2008). *Parks, Open Space, Buildings, and Other Recreational Facilities Master Plan* [Plan]. Harris Design.

City of San Carlos. (2012). *San Carlos Hillside Trails Plan* [Plan]. The Planning Center | DC&E.

City of San Carlos. (2020). *Bicycle and Pedestrian Master Plan* [Plan]. Alta Planning + Design.

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Appendix A.

Opportunity Site Recommendation Locations

Figure 1. Vista Park

Pulgas Watershed Study
Publics Access Opportunities Memo
City of San Carlos, San Mateo, CA

Public Access Opportunities Region
Recommendations

0 50 100
Feet

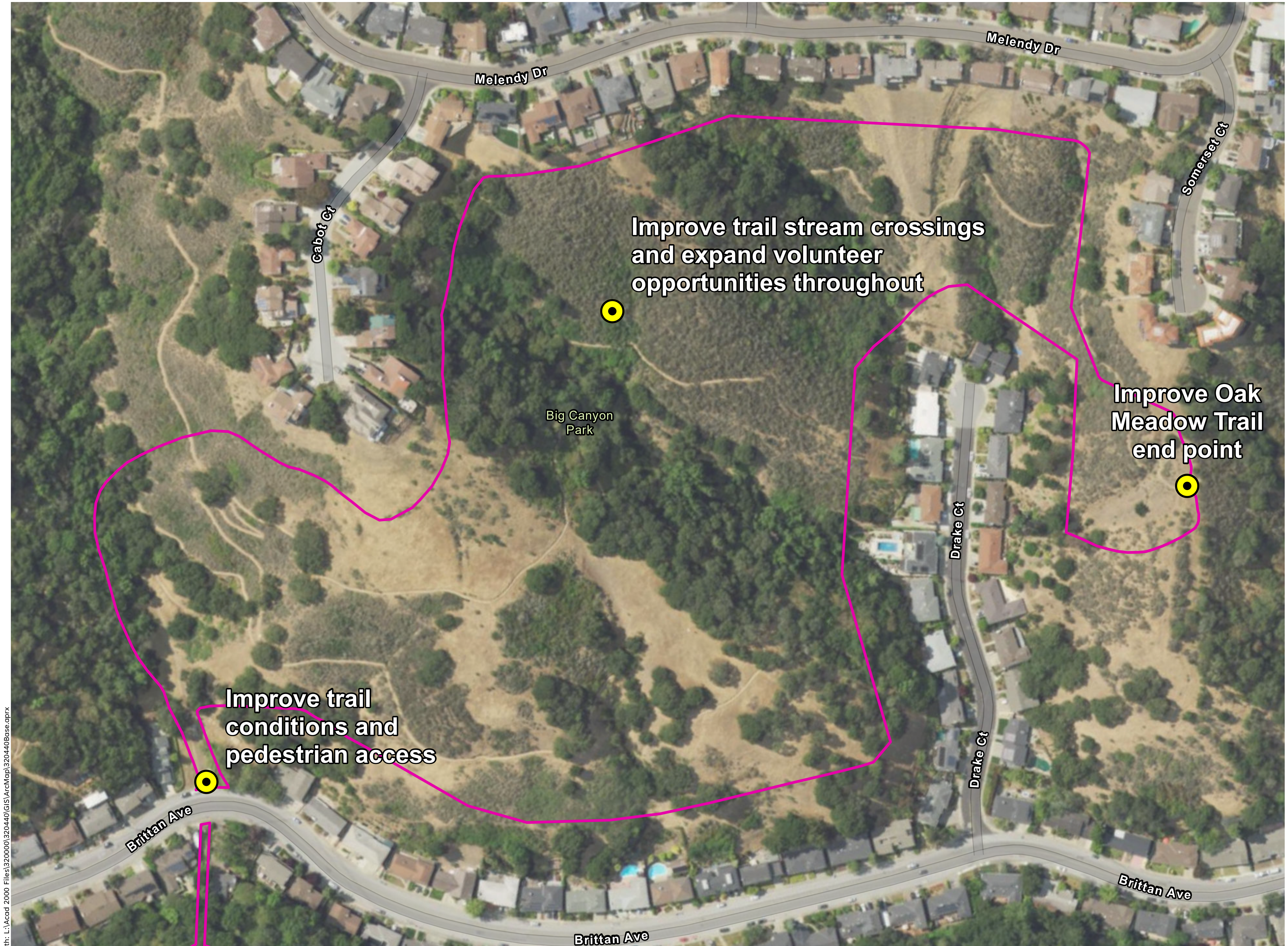
wra Environmental Consultants

Path: L:\Acad 2000 Files\320000\320440\GIS\ArcMap\320440Base.aprx

Sources: NRCS NAIP 2022 Aerial, WRA | Prepared By: junjie.chen, 6/7/2024

Figure 2. Big Canyon Park

Pulgas Watershed Study
Publics Access Opportunities Memo
City of San Carlos, San Mateo, CA



Public Access Opportunities Region

Recommendations

N

0 200 400
Feet

wra
Environmental Consultants

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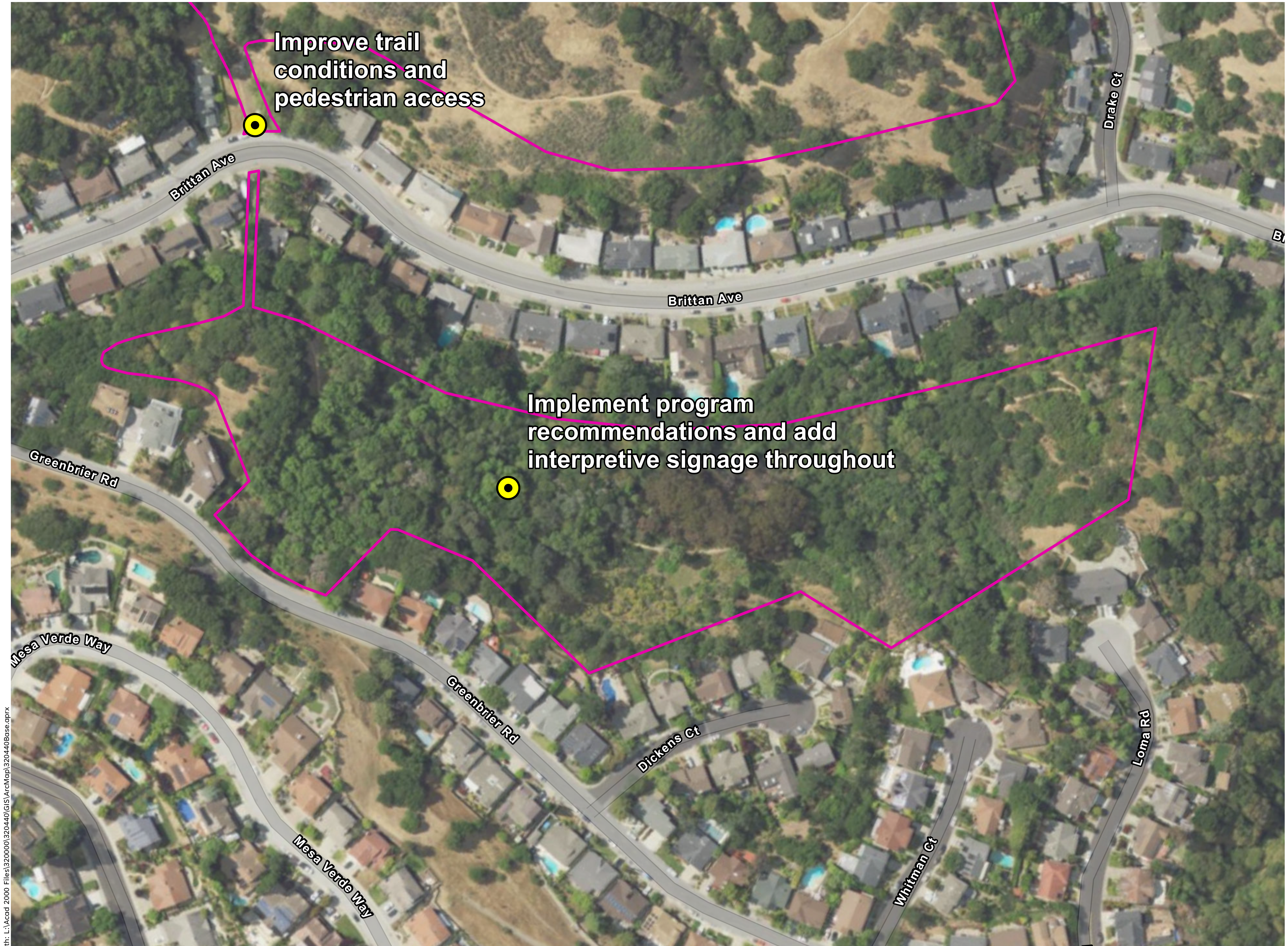
Sources: NRCS NAIP 2022 Aerial, WRA | Prepared By: junjie.chen, 6/7/2024

Figure 3.
Eaton Park

Pulgas Watershed Study
Publics Access Opportunities Memo
City of San Carlos, San Mateo, CA



Public Access Opportunities Region

Recommendations

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Feet

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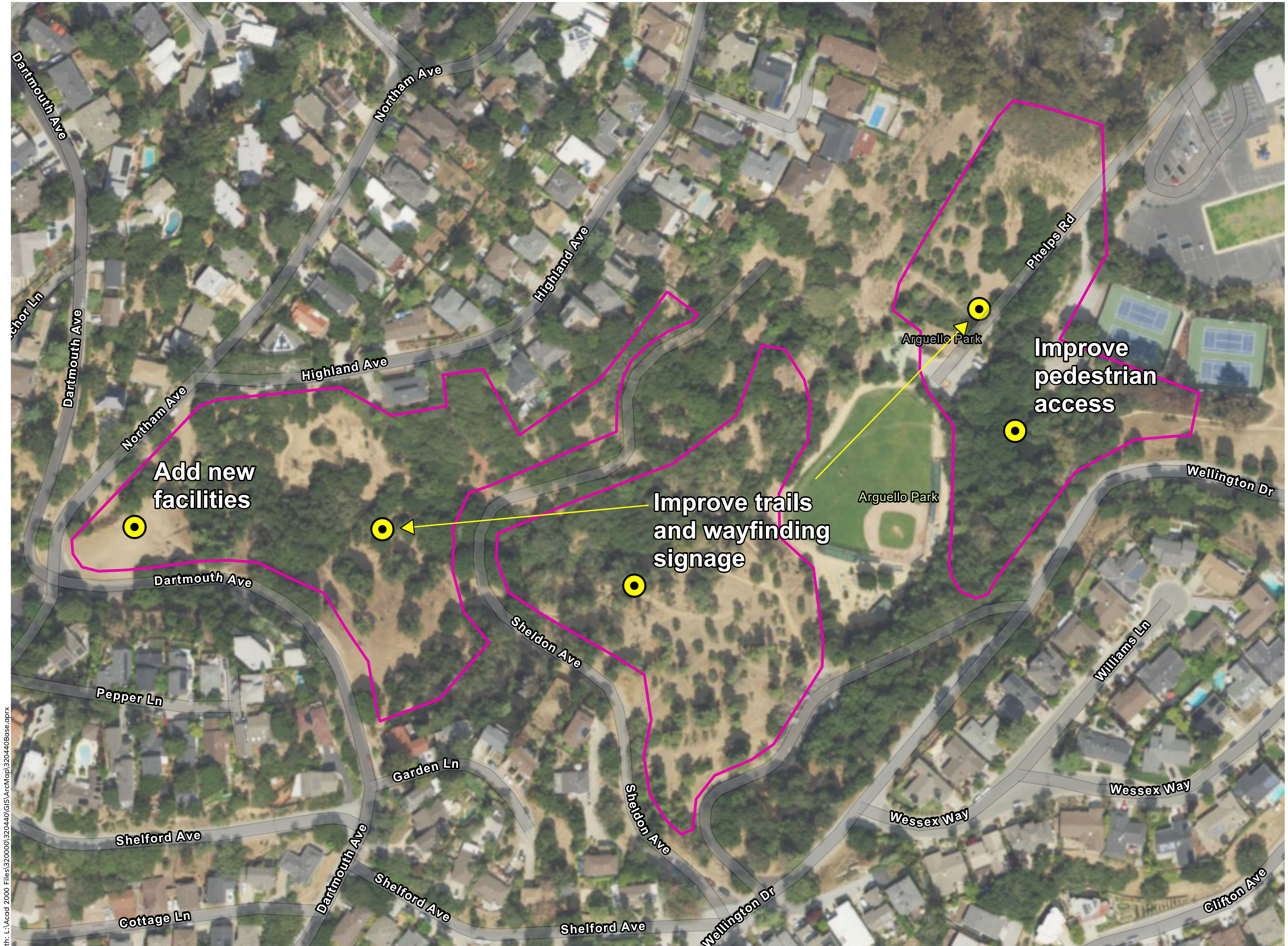
Sources: NRCS NAIP 2022 Aerial, WRA | Prepared By: junjie.chen, 6/7/2024

Figure 4. Arguello Park

Pulgas Watershed Study
Publics Access Opportunities Memo
City of San Carlos, San Mateo, CA



Public Access Opportunities Region

Recommendations

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Environmental Consultants

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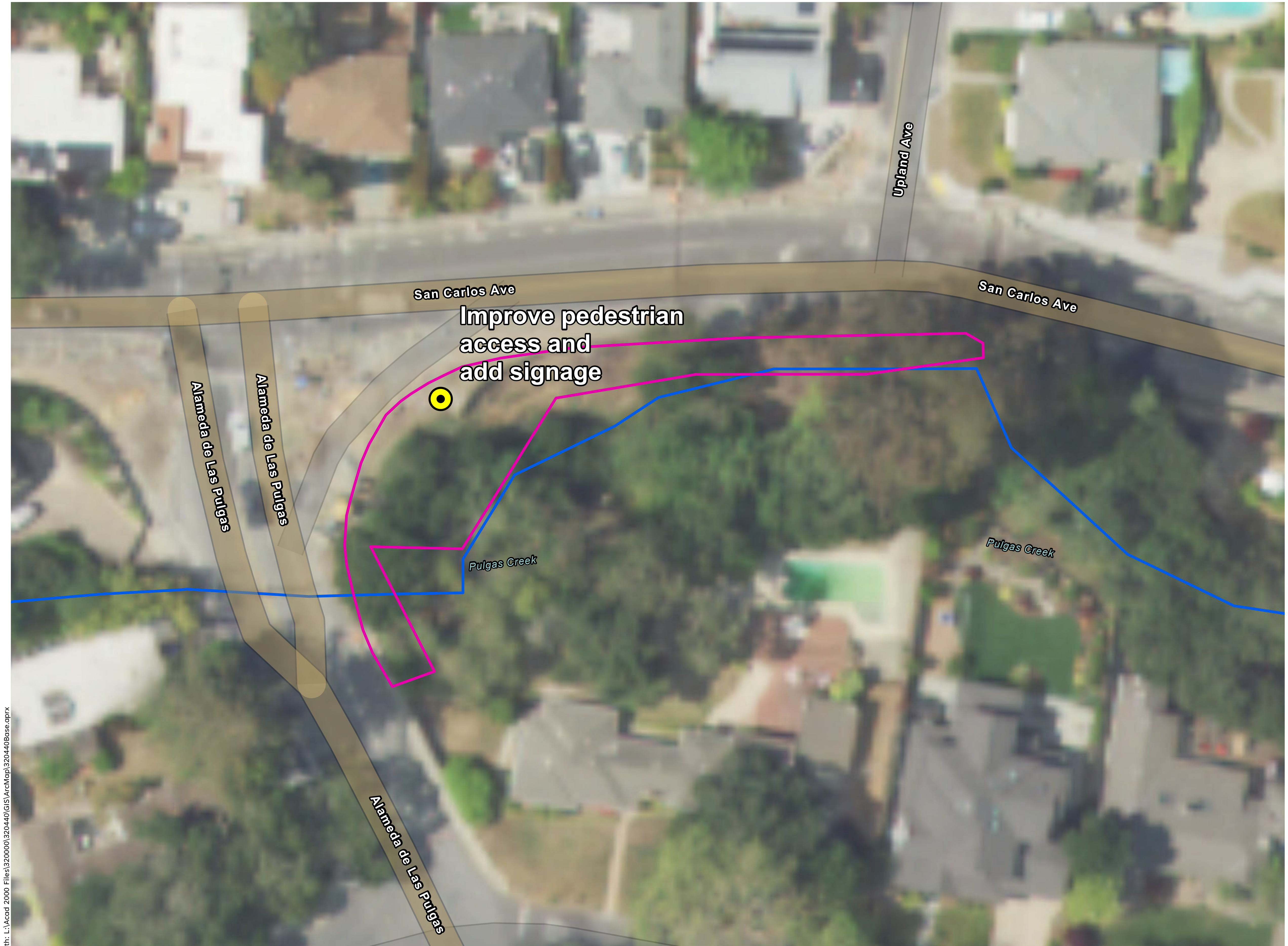
Sources: NRCS NAIP 2022 Aerial, WRA | Prepared By: junjie.chen, 6/7/2024

Figure 5.
San Carlos Ave

Pulgas Watershed Study
Publics Access Opportunities Memo
City of San Carlos, San Mateo, CA



Public Access Opportunities Region
Recommendations
PulgasCreek

N
0 25 50
Feet

wra Environmental Consultants

Path: L:\Acad 2000 Files\320000\320440\GIS\ArcMap\320440Base.aprx

Sources: NRCS NAIP 2022 Aerial, WRA | Prepared By: junjie.chen, 6/6/2024

Appendix E: Revegetation Benefits and Planting Palettes

1.0 The Urban Tree Canopy Provides Multiple Benefits

In recent decades, California communities have come to recognize the ecosystem services provided by the trees in local watersheds. Trees help reduce stormwater run-off, reduce urban temperatures, improve air quality, sequester carbon, enhance property values, provide wildlife habitat, and strengthen social connections in neighborhoods.

This report highlights a particular ecosystem service trees provide which contribute to watershed health—trees reduce sediment transport and erosion by holding soils in place in the upper watershed. Trees prevent soil erosion in several ways:

- Trees intercept rainfall which prevents splash erosion
- Trees reduce the amount of water in soil through transpiration
- Trees improve soil health and nurture seedlings
- Tree roots bind soil to sloping ground, preventing erosion and protecting topsoil
- Trees provide a wind break and prevent surface soil from blowing away

As the conservation nonprofit American Forests reminds us, "healthy forests are our most efficient, inexpensive, and natural systems to combat climate change." Both natural and urban forests play an essential role in reducing CO_2, the main contributor to climate change. There are two direct ways that trees help (Canopy 2016):

Trees act as a CO_2 sink:

- Trees sequester and store CO_2, decreasing the concentration of CO_2 in the atmosphere.
- Trees use CO_2 during photosynthesis to produce sugars, which provide energy for trees as well as emitting oxygen as a by-product of the process.
- Planting more trees absorbs more CO_2, reducing the overall concentration of CO_2 in the atmosphere.
- An average-size tree can store hundreds of pounds of CO_2 over its lifetime.

Trees reduce energy use:

- Neighborhoods well-shaded with street trees can be up to 6-10 degrees cooler than neighborhoods without, reducing overall energy needs.
- Three trees properly placed around a house can save up to 30% of energy use.

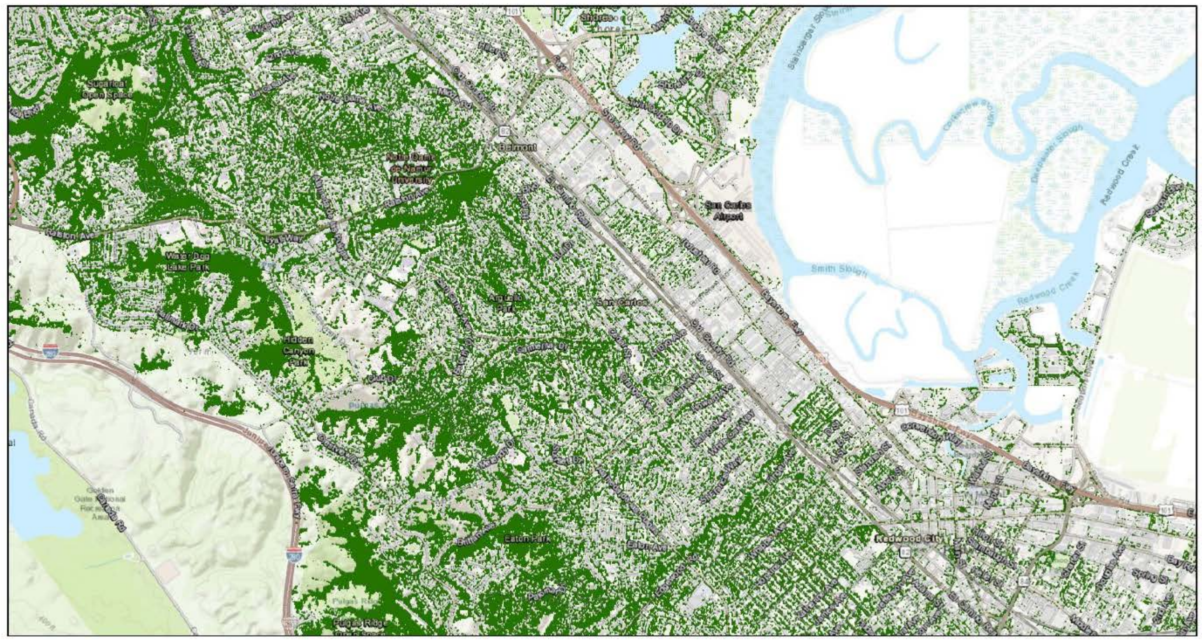
The ecosystem services trees provide also generate economic benefits. California's urban tree canopy covers 19% of the state's urban areas. It is estimated to contain 173 million trees; the annual value of ecosystem services from these trees has been estimated at $8.3 billion and the urban forest asset has been valued at $181 billion (McPherson et al. 2017).

According to the USFS and CAL FIRE, “understanding the extent and location of its existing tree canopy can help a community design and implement sound management practices to maximize those services: prioritizing locations for tree planting, establishing urban forestry master plans and sustainability plans, and managing threats to canopy loss.” The existing trees and tree canopy cover in the San Carlos are already mapped on the Urban Forest Ecosystems Institute (UFEI) California Urban Tree Map (CalPoly 2020) as well as the USFS and CAL FIRE Urban Tree Canopy in California (USFS & CAL FIRE 2018).

With a land area of about 16 km2, zip code 94070 has 1,425 urban street trees according to the California Urban Forest Inventory, including 59 genera and 77 species. The pie chart below graphically indicates the distribution of tree species.

Analysis of the existing forest reveals that almost all of the trees are non-native, most lack drought resistance, and several are invasive species that increase fire risk. To maximize the ecosystem services that trees provide in the upper watershed, it is important to plant large, native trees and shrubs, uniquely adapted to local site conditions, to increase climate resilience. A healthy forest ecosystem is self-sustaining; with adaptive management it will require minimal maintenance, expense, and energy inputs from the city while providing multiple benefits.

Urban Tree Canopy Map



4/27/2024, 5:12:16 PM

Canopy cover 2018

1:36,112

0 0.35 0.7 1.4 mi

0 0.5 1 2 km

Redwood City, County of San Mateo, California, Bureau of Land Management, Esri, HERE, Garmin, INCREMENT P, USGS, METI/NASA, EPA, USDA, Esri, HERE, Garmin, © OpenStreetMap contributors, and the GIS

2.0 Plant Palettes

WRA has assembled proposed plant palettes for the upper watershed to enhance and expand the tree canopy for a sustainable forest ecosystem that will help reduce sedimentation and erosion. Tables 1 and 2 include representative tree and shrub species, respectively, which are appropriate for planting on upland slopes of the upper watershed. The best practices defined by CAL FIRE for defensible space and other fire-smart landscape practices (CAL FIRE 2024) should be consistently employed.

2.1 Native Trees and Shrubs for Revegetation Areas

Table 1: Native Oak Woodland Community Trees for Upland Slopes

COMMON NAME	BOTANICAL NAME	CANOPY SPREAD (FEET)	DECIDUOUS/EVERGREEN	SUN	WATER USE
California Buckeye	*Aesculus californica*	40’	Deciduous	Pt Sh, F Sun	VL, L
Hollyleaf Cherry	*Prunus ilicifolia*	20’	Evergreen	F Sun, Pt Sh	VL
Coast Live Oak	*Quercus agrifolia*	15 - 35’	Evergreen	F Sun, Pt Sh	L
Blue Oak	*Quercus douglasii*	30’	Deciduous	F Sun, Pt Sh	L
Garry’s Oak	*Quercus garryana*	30’	Deciduous	F Sun, Pt Sh	L
Black Oak	*Quercus kelloggii*	35’	Deciduous	F Sun, Pt Sh, F Sh	L
Valley Oak	*Quercus lobata*	50’	Deciduous	F Sun	L
Interior Live Oak	*Quercus wislizeni*	10 - 50’	Evergreen	F Sun, Pt Sh	VL, L
California Laurel	*Umbellularia californica*	3 - 30’	Evergreen	F Sun, Pt Sh	L

Table 2: Native Shrubs for Upland Slopes

COMMON NAME	BOTANICAL NAME	CANOPY	DECIDUOUS/EVERGREEN	SUN	WATER USE
Chamise	*Adenostoma fasciculatum*	1 - 8'	Evergreen	F Sun	EL, VL
California Sagebrush	*Artemisia californica*	4'	Summer Deciduous	F Sun	EL, VL
Coyote Bush	*Baccharis pilularis*	12'	Evergreen	F Sun, Pt Shade	VL, L
Ceanothus	*Ceanothus cuneatus*	5 - 12'	Evergreen	F Sun	VL
Blueblossom Ceanothus	*Ceanothus thyrsiflorus*	2 - 40'	Evergreen	Pt Shade	L
Bush Monkey Flower	*Diplacus aurantiacus*	5'	Evergreen	Pt Shade, F Sun	VL, L
Coffeeberry	*Frangula californica*	5 - 15'	Evergreen	F Sun, Pt Shade	L,VL
Coast Silktassel	*Garrya elliptica*	6 - 10'	Evergreen	Pt Shade, F Sun	VL
Toyon	*Heteromeles arbutifolia*	10 - 15'	Evergreen	F Sun, Pt Shade	EL, VL
Silver Lupine	*Lupinus albifrons*	2 - 3'	Evergreen	F Sun	VL
Black Elderberry	*Sambucus nigra*	10 - 20'	Deciduous		L

2.2 Trees and Shrubs for Riparian Areas (Creekside Projects)

Riparian trees help control erosion and sedimentation, lower stream temperatures, conserve soil moisture, and improve water quality. Riparian plants are highly adapted to frequent disturbance seasonal flooding and have evolved to recover and grow rapidly as nature's way of healing itself. Representative riparian trees and shrubs appropriate for drainages within the watershed are included in Tables 3 and 4, respectively.

Table 3: Representative Native Trees for Riparian Areas

COMMON NAME	BOTANICAL NAME	CANOPY SPREAD (FEET)	DECIDUOUS/EVERGREEN	SUN	WATER USE
Big Leaf Maple	*Acer macrophyllum*	65'	Deciduous	Pt Shade, Full Sun	M - H
Box Elder	*Acer negundo*	40'	Deciduous	Pt Shade, Full Sun	M - H
California Buckeye	*Aesculus californica*	40'	Deciduous	Pt Shade, F Sun	VL, L
White Alder	*Alnus rhombifolia*	35'	Deciduous	F Sun, Pt Shade	M - H
Red Alder	*Alnus rubra*	45'	Deciduous	F/Pt Shade	M - H
Fremont Cottonwood	*Populus fremontii*	35'	Deciduous	Full Sun	M - H
Coast Live Oak	*Quercus agrifolia*	15 - 35'	Evergreen	F Sun, Pt Shade	L
Sandbar Willow	*Salix exigua*		Deciduous	Full Sun	M - H
Red Willow	*Salix laevigata*	30 - 50'	Deciduous	F Sun, Pt Shade	M - H
Shining Willow	*Salix lasiandra*		Deciduous	Pt Shade	M - H
Arroyo Willow	*Salix lasiolepis*	15'	Deciduous	Full Sun	M - H

Table 4: Representative Native Shrubs for Riparian Areas

COMMON NAME	BOTANICAL NAME	CANOPY SPREAD (FEET)	DECIDUOUS/EVERGREEN	SUN	WATER USE
Oregon Grape	*Berberis nervosa*	7'	Evergreen	Pt Shade	L
California Hazel	*Corylus cornuta ssp. californica*	10'	Deciduous	Pt Shade	L
Western Leatherwood	*Dirca occidentalis*	12'	Deciduous	Pt Shade	L
California Coffeeberry	*Frangula californica ssp. californica*	10 - 15'	Evergreen	F Sun, Pt Shade	L
Ocean Spray	*Holodiscus discolor*	10 - 15'	Deciduous	Shade, Pt Shade	L, M, H
Black Twinberry	*Lonicera involucrata*	3 - 4'	Deciduous	Pt Shade, F Sun	M, H
Pacific Ninebark	*Physocarpus capitatus*	8'	Deciduous	F/Pt Shade	M, H, L
Hillside Gooseberry	*Ribes californicum*	2 - 6'	Deciduous	Pt Shade	L
Canyon Gooseberry	*Ribes menziesii*		Deciduous	Shade	L
Red Flowering Currant	*Ribes sanguineum*	7'	Deciduous	Pt Shade	L
California Wildrose	*Rosa californica*	10'	Deciduous	F Sun, F/Pt Shade	L, M, H
California Blackberry	*Rubus ursinus*	6'	Deciduous	F Sun, F/Pt Shade	M, H
Blue Elderberry	*Sambucus mexicana*	20'	Deciduous	F/Pt Shade, F Sun	L
Common Snowberry	*Symphoricarpos albus*	6'	Deciduous	F/Pt Shade	L, M, H

2.3 Recommended Street Trees and Shrubs for Riparian Areas (Creekside Projects)

Planting trees in the neighborhoods with inadequate tree canopy cover will also help to reduce urban heat, absorb stormwater, sequester carbon, and improve walkability. Both street trees and trees on private property provide environmental, economic, social and personal health benefits. The Tree Equity Score map (Figure 2.2) by American Forests illustrates the areas with the greatest need (the lowest tree canopy cover). The heat map (Figure 2.3) shows a corresponding disparity in urban temperatures due to this lack of tree canopy in the lower watershed. The tree canopy goal for the census blocks in San Carlos is 30% tree canopy coverage. Many residential neighborhoods already meet this goal, however some neighborhoods in the lower watershed only have 5% tree canopy cover today.

Table 5: The City of San Carlos Approved Street Tree List

COMMON NAME	BOTANICAL NAME	HEIGHT	CANOPY	DECIDUOUS/ EVERGREEN	WATER USE
White Mulberry	*Morus alba*	50’	30-50’	Deciduous	M
London Plane	*Platanus x acerifolia*	80’	50-70’	Deciduous	M
Maidenhair Tree	*Ginkgo biloba*	70’	25’	Deciduous	M
Chinese Pistache	*Pistacia chinensis*	40’	25-35’	Deciduous	L
Chinese Hackberry	*Celtis sinensis*	70’	30’	Deciduous	M
Brazilian Pepper	*Schinus terebinthifolia*[6]	30’	15-30’		L
Willow Peppermint	*Eucalyptus nicholii*	50’	15-40’	Evergreen	M
Aristocrat Pear	*Pyrus calleryana ‘Aristocrat’6*	40’	20’	Deciduous	M
Water Gum	*Tristaniopsis laurina*	40’	15-30’	Evergreen	M

6 *Potential invasiveness: This plat is classified as potentially invasive in specific areas of California by the California Invasive Plant Council (Cal-IPC).*

Table 5: The City of San Carlos Approved Street Tree List (Continued

COMMON NAME	BOTANICAL NAME	HEIGHT	CANOPY	DECIDUOUS/ EVERGREEN	WATER USE
Sumac	*Rhus lanceolata*	25'	15-20'	Deciduous	L
Flowering Cherry	*Prunus sp.*	25'	15-25'	Deciduous	M
Flowering Crabapple	*Malus floribunda*	25'	18-30'	Deciduous	M
Red Maple	*Acer rubrum 'Red Sunset'*	50'	25-40'	Deciduous	M
Crape Myrtle	*Lagerstroemia indica*	25'	25'	Deciduous	L
Peppermint Tree	*Agonis flexuosa*	35'	15-30'	Evergreen	L

In addition, WRA recommends the following trees for sidewalk locations, based on input from professional arborists and tree planting organizations in the vicinity. Considerations include suitability to local climate conditions, soils, drought tolerance, longevity, available nursery stock, quality of nursery stock, and pest and disease resistance. The list also includes climate-ready species for warmer, drier urban conditions.

Selecting the right tree species and planting it in the right place is the first step toward expanding the tree canopy. To minimize maintenance and avoid infrastructure damage and utility conflicts above and below ground, select tree species based on available planting space, and only plant small trees below power lines. UFEI's SelecTree (2024) Tree Selection Guide provides preselected lists of trees OK for under power lines, shade trees, drought tolerant trees, native tree species, and trees with low water requirements.

Small Trees

- Callistemon viminalis / Weeping Bottlebrush
- x Chitalpa tashkentensis 'Pink Dawn' / Pink Dawn Chitalpa
- Magnolia grandiflora 'Little Gem' / Dwarf Southern Magnolia
- Prunus cerasifera 'Krauter Vesuvius' / Krauter Vesuvius Plum

Large Trees

- Fraxinus angustifolia (syn. Oxycarpa) 'Raywood' / Raywood Ash
- Ginkgo biloba 'Autumn Gold' / Ginkgo
- Platanus x hispanica (syn. P x acerifolia) 'Bloodgood' 'Columbia' 'Yarwood' / Sycamore*
- Quercus agrifolia / Coast Live Oak
- Quercus suber / Cork Oak
- Ulmus parvifolia 'Frontier' or 'Drake' or 'Pioneer' / Chinese Elm

2.4 Native Tree Species for Private Property, Parks, and Gardens

The following are tree and arborescent shrub species that are appropriate for private property, public parks, schoolyards, and gardens. Local native trees and shrubs are optimum for providing wildlife habitat throughout the city.

- Acer circinatum / Vine Maple
- Alnus rhombifolia / California White Alder
- Aesculus californica / California Buckeye
- Ceanothus 'Ray Hartman' / California Wild Lilac
- Cercis occidentalis / Western Redbud
- Garrya elliptica / Silk Tassel
- Heteromeles arbutifolia / Toyon
- Platanus racemosa / Western Sycamore
- Prunus ilicifolia subsp. lyonii / Catalina Cherry
- Quercus agrifolia / Coast Live Oak Rhamnus (Frangula) californica / California Coffeeberry
- Sambucus mexicana / Blue Elderberry
- Sequoia sempervirens 'Aptos Blue' or 'Soquel' / Coast Redwood Tree Fruit Trees
- Umbellularia californica / California Bay Laurel

2.5 Tree Planting Organizations and Local Resources

- Local tree planting organizations are excellent resources for guidance on tree stewardship, planning and planting a sustainable urban forest including street trees, parks, schools and open space trees.
- Canopy is a nonprofit tree planting organization in Mountain View https://canopy.org/
- San Francisco Friends of the Urban Forest plants and cares for street trees in San Francisco https://www.friendsoftheurbanforest.org/
- California ReLeaf supports grassroots efforts and build strategic partnerships that protect, enhance, and grow California's urban and community forests https://californiareleaf.org/
- California Urban Forests Council https://caufc.org/
- Funding and other resources are available from the USDA Forest Service Urban and Community Forestry Program https://www.fs.usda.gov/managing-land/urban-forests
- The Vibrant Cities Lab and USDA Forest Service partnered to create the Urban Forestry Toolkit, which provides a step-by-step guide to planning and implementing an urban forestry project. https://www.vibrantcitieslab.com/toolkit/
- Urban Forest Management Plan Toolkit website provides a "how-to" approach to develop an Urban Forest Management Plan (UFMP). The toolkit will lead you through a planning process. https://ufmptoolkit.net/

3.0 Green Stormwater Infrastructure & LID Features

3.1 Plants Suitable for Bioretention Areas

Swales are shallow channels designed to catch rainwater and reduce or prevent its flow off the site. Swales planted with appropriate vegetation are known as bioswales. They promote infiltration of rainwater into the soil and help filter and breakdown pollutants in the stormwater runoff. Bioswales can also add beauty and value to the landscape. This plant list features mostly California native species that are suitable for many vegetated swales. Non-native species are marked with an asterisk (*).

The plants on this list are from the San Mateo County (SMCWPPP) Plant List for Landscape-based Biotreatment Measures available at FlowsToBay.org (https://www.flowstobay.org/wp-content/uploads/legacy_media/plant-list-all.pdf). For a more extensive list of plants appropriate for stormwater treatment features, see Appendix B of the Alameda County Clean Water Program's publication, "C.3 Stormwater Technical Guidance: A Handbook for Developers, Builders and Project Applicants," May 14, 2013, which can be downloaded from www.cleanwaterprogram.org/resources/resources-development.html.

Table 6: Plant List for Landscape-based Biotreatment Measures

COMMON NAME	BOTANICAL NAME	HEIGHT	SPREAD	SUN/SOIL	WATER USE
Emergent Plants (can grow in water with part of the plant above the surface)					
Santa Barbara sedge	*Carex barbarae*	1-3'	1-3'	Full sun or part shade	M/VL
Slough sedge	*Carex obnupta*	1-3'	1-3'	Full sun or part shade	M
Pacific rush	*Juncus effusus*	1-2'	1-2'	Sun to part shade	H
Blue rush	*Juncus patens*	1-2'	1-2'	Sun to part shade	H/Drought Tolerant

Table 6: Plant List for Landscape-based Biotreatment Measures

COMMON NAME	BOTANICAL NAME	HEIGHT	SPREAD	SUN/SOIL	WATER USE
			Plants that Tolerate Periodic Inundation		
Big leaf maple	*Acer macrophyllum*	30-100'	30-100'	Sun to part shade	Occasional-Regular
Box elder	*Acer negundo californicum*	30-50'	30-50'	Full sun or part shade	M
Buckeye	*Aesculus californica*	15-20'	30'	Full sun	Very Low
Red alder	*Alnus rubra*	45-50'	20-30'	Sun or shade	Regular/Ample
Mountain mahogany	*Cercocarpus betuloides*	5-12'	5-12'	Full sun/Tolerates clay & serpentine	Very Low
Berkeley sedge	*Carex divulsa (tumulicola)*	1-2'	1-2'	Part sun to part shade	M-Occasional
California meadow sedge	*Carex pansa*	1'	1'	Sun to shade	M/Drought Tolerant
Rusty sedge	*Carex subfusca*	1-1.5'	1-1.5'	Sun to shade	M/Drought Tolerant
Western dogwood	*Cornus sericea*	15'	15'	Sun to shade	Occasional-Regular
Redosier dogwood	*Cornus stolonifera*	7-9'	12'	Full sun or light shade	Regular
Cape rush	*Chondropetalum tectorum**	4-6'	4-6'	Sun to part sun	M-Occasional
Crocosmia	*Crocosmia 'Lucifer'**	4'	2'	Sun, some shade when hot	Regular
Tufted hairgrass	*Deschampsia cespitosa*	1-2'	2'	Part shade	Low

Table 6: Plant List for Landscape-based Biotreatment Measures

COMMON NAME	BOTANICAL NAME	HEIGHT	SPREAD	SUN/SOIL	WATER USE
Fortnight lily	*Dietes bicolor, D. iridioides**	3'	3'	Sun or part shade	Occasional-None
Blue wild rye	*Elymus glaucus*	1-2'	2'	Full to part sun	Low
Horsetail	*Equisetum hyemale*	4'	2'	Full sun or partial shade	H
California fescue	*Festuca californica*	1-2'	2-3'	Sun to part shade	Low
Idaho fescue	*Festuca idahoensis*	1-2'	1-2'	Full sun to part sun	Very Low
Red fescue	*Festuca rubra*	3-12"	1'	Full sun to part sun	Low
Molate fescue	*Festuca rubra 'molate'*	3-12"	1'	Full sun to part sun	Low
Creeping wild rye	*Leymus triticoides*	1-3'	1-2'	Full sun to part sun	Occasional
Deerweed	*Lotus scoparius*	3'	3'	Full sun to part shade	Very Low
Deergrass	*Muhlenbergia rigens*	3'	3'	Full sun to part shade	Low
Wax myrtle	*Myrica californica*	10-30'	10-30'	Sun or part shade	Low
Foothill needlegrass	*Nassella lepida*	1'	1'	Full sun/Good drainage	Very Low
Purple needlegrass	*Nasella pulchra*	1-2'	1-2'	Full sun/Good drainage	Very Low
Pacific ninebark	*Physocarpus capitatus*	8'	8'	Sun or shade	M-Regular

Table 6: Plant List for Landscape-based Biotreatment Measures

COMMON NAME	BOTANICAL NAME	HEIGHT	SPREAD	SUN/SOIL	WATER USE
Western sycamore	*Platanus racemosa*	30-80'	20-50'	Full sun	M
Fremont cottonwood	*Populus fremontii*	50-70'	50'	Sun/Moisture-retentive	Occasional- Regular
Valley oak	*Quercus lobata*	100'	100'	Sun/Adaptable	Low
California wild rose	*Rosa californica*	3'	6'	Part shade	Low
Arroyo willow	*Salix lasiolepis*	6-9'	9-12'	Sun	H
Red willow	*Salix laevigata*	9-30'	9-30'	Sun	H
Elderberry	*Sambucus mexicana*	8-25'	8-25'	Sun to partial shade	Low
Blue-eyed grass	*Sisyrinchium bellum*	6-12"	6-18"	Full sun to light shade	Very Low
Tall fescue	*Stipa arundinacea**	2'	2'	Full sun	M-Occasional
Upland Plants (for the swale's upland zone/top of slope)					
Common yarrow	*Achillea millefolium*	12-30"	2-4'	Full sun/Reasonable drainage	Low
Chamise	*Adenostema fasciculatum*	6-15'	6-15'	Sun/Adaptable except alkaline	Drought Tolerant
Manzanita	*Arctostaphylos spp.*	Varies	Varies	Full sun to part shade	Low
Sea pink	*Armeria maritima*	4-8"	6-12"	Full sun/Good drainage	Little-Occasional

Table 6: Plant List for Landscape-based Biotreatment Measures

COMMON NAME	BOTANICAL NAME	HEIGHT	SPREAD	SUN/SOIL	WATER USE
Prostrate Coyote brush	*Baccharis pilularis 'Twin Peaks'*	1'	10-15'	Full sun	Low
Mulefat	*Baccharis salicifolia*	8'	8'	Full sun	Low
Ceanothus	*Ceanothus spp.*	Varies	Varies	Full sun to part shade	Low
California fuchsia	*Epilobium canum*	1'	4'	Full sun to part shade/Good drainage	Low
Flattop buckwheat	*Eriogonum fasciculatum*	2-3'	4'	Full sun/Good drainage	Low
California poppy	*Eschscholzia californica*	6-12"	6"	Full sun/Good drainage	Very Low
Beach strawberry	*Fragaria chiloensis*	10"	Spreading	Sun to part shade/Well drained	Infrequent to Occasional
Toyon	*Heteromeles arbutifolia**	10-20'	10-15'	Full sun to part shade/Good drainage	VL
Tree mallow	*Lavatera spp.*	Varies	Varies	Full sun/Good drainage	Low
Pitcher sage	*Lepechina calycina*	3-5'	1-2'	Full sun with pm shade/Good drainage	VL
Bush lupine	*Lupinus albifrons**	3-5'	3-5'	Full sun/Excellent drainage	VL
Common monkeyflower	*Mimulus aurantiacus*	3-4'	3-4'	Full sun to part shade	Low
Scarlet monkeyflower	*Mimulus cardinalis*	2-3'	2-3'	Full sun to part shade/Adaptable	Low

Table 6: Plant List for Landscape-based Biotreatment Measures

COMMON NAME	BOTANICAL NAME	HEIGHT	SPREAD	SUN/SOIL	WATER USE
Coast silk tassle	*Garrya elliptica*	10-20'	10-20'	Afternoon shade inland	Low
Coffeeberry	*Rhamnus californica*	3-15'	6-8'	Sun or part shade/Good drainage	Low
Chaparral currant	*Ribes malvaceum*	5'	5'	Sun to part shade	Very Low
Goldenrod	*Solidago californica*	1-4'	1-2'	Part shade	VL
Snowberry	*Symphoricarpos albus*	3-5'	3-5'	Part shade	Occasional-Little

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Appendix F: Cost Estimate Memorandum

FREYER & LAURETA, INC.
Civil Engineers – Surveyors – Construction Managers

Memorandum

Re:	Draft Pulgas Creek Watershed Cost Estimate Memorandum Rev.1
Date:	December 18, 2024
To:	Grace Le, P.E.
From:	Camille Bandy, P.E., Freyer & Laureta, Inc.
	Mark Quito, Freyer & Laureta, Inc.
Reviewed:	Jeffrey Tarantino, P.E., Freyer & Laureta, Inc.

1 Introduction

The City of San Carlos (City) is vulnerable to the effects of climate change including rising sea levels, shallow groundwater rising, and increased precipitation. Most specifically the lower portion of the City along the bayshore is most prone to flooding and coastal erosion increasing the risk to life, safety, and critical infrastructure. The Pulgas Creek Watershed Management Plan identifies a variety of proposed projects, programs, and policies that the City could choose to pursue. This memorandum is to summarize potential projects that the City can consider implementing.

2 Summary of Proposed Projects

The project team developed six proposed projects that the City may consider implementing within the Pulgas Creek Watershed. Conceptual drawings for each project can be found in Appendix A, which includes a project description, justification, duration, status, future impact on operating budget and estimated budget.

2.1 Underground Detention Basin – E.R. Burton Park

The largest, feasible underground detention basin in E.R. Burton Park involves installing a 12-million-gallon underground precast concrete stormwater detention facility under the existing baseball fields to capture and manage storm flow from two parallel storm drains mains (24” and 48”) on Brittan Avenue and the runoff from streets north of E.R. Burton Park. The facility will temporarily detain stormwater during peak flows and gradually release it back into the piped storm drain system via pump on Brittan Ave. after storms subside.

The proposed 12-million-gallon underground detention facility is the largest practical facility that the City could consider constructing within E.R. Burton Park. The potential underground detention facility planning requires coordination with the City’s pending Park’s Master Plan effort. Ultimately, a small underground detention facility may be preferred by the City such as limiting the footprint to be within the existing parking lot to minimize temporary disruption to the baseball field.

2.2 Underground Detention Basin -El Camino Real

The proposed underground detention basin involves installing a 2.5-million-gallon underground precast concrete stormwater detention facility within an unimproved parcel located between El Camino Real and Caltrain to capture

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East Bay Office
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Alameda, CA 94501
(510) 937-2310

South Bay Office
20863 Stevens Creek Blvd, Ste 400
Cupertino, CA 95014
(408) 516-1090

and manage runoff from Arroyo Creek. The detention basin would be located on property owned by SamTrans, and the City would be required to either secure an easement for the proposed facility or acquire the property. The proposed underground improvements would not prohibit SamTrans from continuing to utilize the parcel for staging materials, equipment, and other maintenance activities so a subterranean easement may be the most appropriate pathway for the City. The facility will temporarily detain stormwater during peak flows and gradually release it into Pulgas Creek via pump after storms subside.

2.3 Floodplain Detention Basin – Big Canyon Park

The proposed project involves the installation of a floodplain detention basin near the entrance to Big Canyon Park on Brittan Avenue. The basin will temporarily detain stormwater during peak flows and gradually release it into public storm drain after a storm subsides. The system comprises a sediment forebay with a capacity of 500 gallons of water, located uphill from the main floodplain detention basin, which has a capacity of 2,500 gallons. The total water storage capacity is therefore 3,000 gallons. The main floodplain basin will contain a non-floatable mulch layer under laying native erosion-resistant plants, soil media mix, and a gravel layer.

2.4 Bioretention Planter – Brittan Avenue and Alameda de las Pulgas

The proposed project at Brittan Avenue and Alameda de las Pulgas involves installing bioretention in the City's right-of-way to capture and manage runoff Alameda de las Pulgas and Brittan Avenue. The facility consists of approximately 400 square feet of bioretention area and will treat stormwater at a designed ponding depth and slowly release it into the stormwater system. As part of the installation of bioretention, there is opportunities to introduce bulb outs and updated curb ramps at this intersection. The Project would include new curb, sidewalk, and storm drain infrastructure.

The proposed bioretention planter specifically identified for the intersection of Brittan Avenue and Alameda de las Pulgas can also be modified for any number of locations throughout San Carlos. The City is already implementing similar improvements as part of its annual pavement management program and the proposed improvements presented in Appendix A are also intended to provide guidance for future City projects including developing site specific budgets.

2.5 Pervious Pavement – City of San Carlos Corporation Yard

The Project involves implementing pervious pavement on a city-owned parcel, City of San Carlos Corporation Yard, to capture and manage onsite runoff. The pavement will filter pollutants and allow for water to flow through and gradually release into the ground. Pervious pavement is best suited for parking lots, walkways, and areas that don't have heavy vehicular traffic. Two options are provided (porous asphalt and pervious concrete) in Appendix A to provide guidance for future City projects for developing site specific budgets.

2.6 Native Planting – Big Canyon Park

The Project involves planting native plants, treating topsoil, irrigation, and monitoring runoff in the Big Canyon Park. The replacement and planting of native plants will help stabilize the soil through natural means and lessen the effects of erosion and soil transportation to further points downstream in the watershed. Once planted, revegetation sites should be regularly weeded and watered to ensure plant establishment. The site should be formally monitored for species composition, percent survival, and percent cover every year for five years.

3 Summary of Estimated Costs

The total estimated cost of the projects includes preliminary design, permitting, construction documents, and construction with a 50% contingency. A summary of the estimated cost for each project can be found in Table 1 below.

Table 1. Summary of Proposed Project Costs

Proposed Project	Cost Estimate
Underground Detention Basin, E.R. Burton Park	$33,550,000
Underground Detention Basin, El Camino Real	$14,740,000
Floodplain Detention Basin, Big Canyon Park	$1,150,000
Bioretention Planter, Brittan Avenue and Alameda de las Pulgas	$870,000
Pervious Pavement, City of San Carlos Corporation Yard (Porous Asphalt)	$1,560,000
Pervious Pavement, City of San Carlos Corporation Yard (Pervious Concrete)	$2,230,000
Native Planting, Big Canyon Park	$401,000

Underground Detention Basin Installation – E.R. Burton Park			
Fund Number:		**Location:**	900 Chestnut St, San Carlos, CA 94070
Department:	DPW	**Strategic Plan:**	
Project Manager:		**Priorities:**	
Category:		**Priority Rating:**	

Description

The Project involves installing a 12-million-gallon underground stormwater detention facility under E.R. Burton Park to capture and manage storm flow from two, existing parallel storm drains (24" and 48") on Brittan Ave. and the runoff from streets north of the Park. The facility will temporarily store stormwater during peak flows and gradually release it back into the piped storm drain system on Brittan Ave. after storms subside.

The system comprises of intake structures, intake piping, a modular detention basin, and an outlet back into an existing 54" storm drain on Brittan Ave. The intake structures are designed as manholes with motorized slide gates that would allow flow diversion from the main storm drain into the detention basin. These slide gates can be fully automated and controlled based on a local level sensor, or they can be remotely operated based on rainfall predictions, allowing for proactive management of stormwater.

Total Estimated Cost (Including Preliminary Design, Permitting, Construction Documents, and Construction with a 50% Contingency) is $33.55M, which translates into approximately $2.79/gallon of storage.

Justification

1. *Flood Mitigation*: The project will increase storm drain capacity, leading to an estimated 27% reduction in flooding. This will improve public safety and reduce property damage during heavy rainfall events.
2. *Optimized Land Use*: The project leverages underground storage capacity under E.R. Burton Park, within the City.
3. *Multi-Functional Design*: The top of the detention facility will be restored to its initial recreational functionality.

Duration

- CEQA (6 months to 9 months)
- Design (12 months to 15 months)
- Construction (18 months to 24 months)

Status

10% Design Drawings

Future Impact on Operating Budget

Slide Gates at Intake Structures
Detention Basin Inspection
Detention Basin Cleaning
Pumping System Maintenance
Pumping System Replacement

Underground Detention Basin Installation – E.R. Burton Park			
Fund Number:		**Location:**	900 Chestnut St, San Carlos, CA 94070
Department:	DPW	**Strategic Plan:**	
Project Manager:		**Priorities:**	
Category:		**Priority Rating:**	

Current Strategic Plan Objective

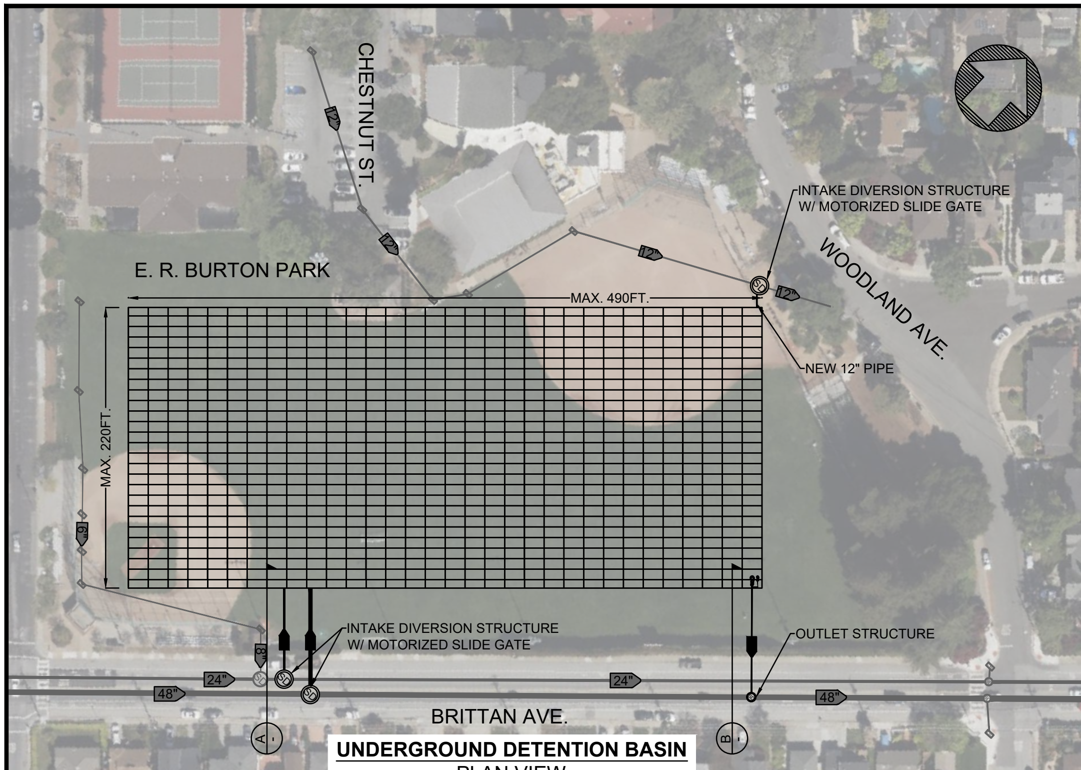
	Child Care
X	Climate Change Mitigation, Adaptation & Resilience
	Downtown
	Housing
	Mobility, Traffic & Transportation Infrastructure
	Northeast Area Specific Plan
	Recreation Services

Capitalization Project		**Non- Capitalized Project**		

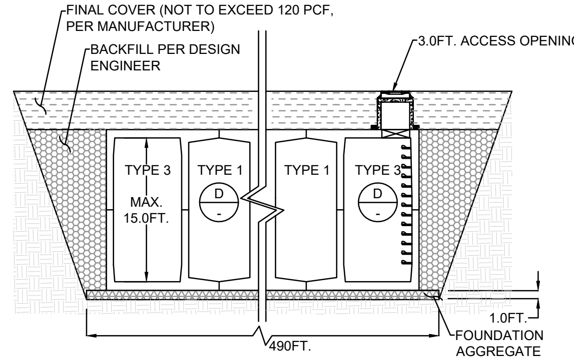
Budget

Planning*	$	2,475,000
Design Phase	$	2,475,000
Advertise / Bid / Award	$	100,000
Construction	$	28,500,000
Post Construction	$	-
Total	**$**	**33,550,000**

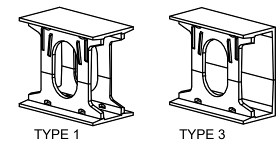
* Includes Surveying, Geotechnical Report, Utility Investigation, Alternatives Development, Structural Engineering Report, Permitting



UNDERGROUND DETENTION BASIN
PLAN VIEW
SCALE 1:150



C / - **STORMTRAP MODULES**
SCALE: N.T.S.



D / - **STORMTRAP MODULES**
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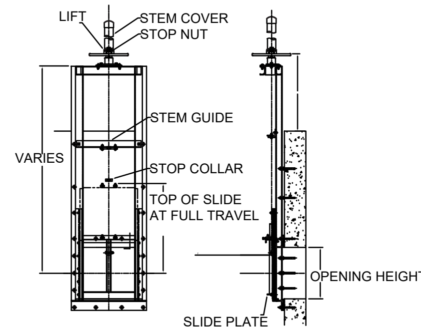
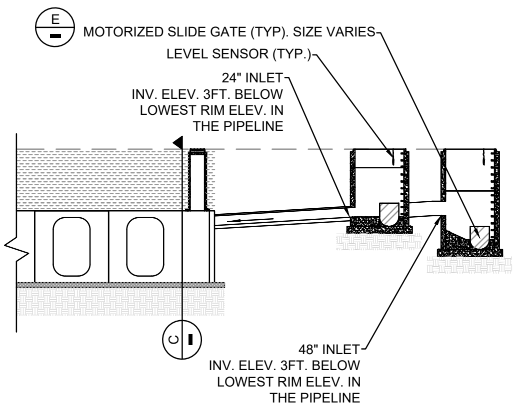
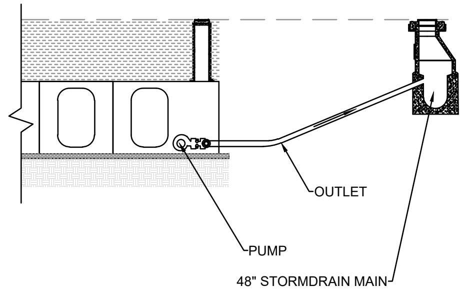


E / - **MOTORIZED SLIDE GATE (SIZE VARIES)**
SCALE: N.T.S.



A / - **INTAKE DIVERSION STRUCTURES**
SCALE: N.T.S.



B / - **OUTLET STRUCTURE**
SCALE: N.T.S.

MAX. DIMENSIONS OF DETENTION BASIN: 490 FT. x 220 FT.
MAX. DEPTH: 15 FT.

MAX. TOTAL VOLUME OF DETENTION BASIN: 1,620,000CF.

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UNDERGROUND BASIN DETENTION FACILITY
E.R. BURTON PARK
PULGAS CREEK WATERSHED
SAN CARLOS, CA

SHEET
1
OF
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Table A.1
Conceptual Opinion of Probable Project Cost for Pulgas Creek Watershed
Underground Detention Basin
E.R. Burton Park, San Carlos

Item No.	Description	Units	Quantity	Unit Price	Budget
Conceptual Opinion of Probable Construction Cost					
1	Mobilization/Demobilization	%	10.00%	-	$ 1,501,700
2	Dewatering	ls	1	$ 100,000	$ 100,000
3	84" Diversion Structure	ea	3	$ 125,000	$ 375,000
4	60" Standard Manhole	ea	1	$ 75,000	$ 75,000
5	Excavation (including offhaul and disposal)	cy	100000	$ 25	$ 2,500,000
6	StormTrap Modules	ls	1	$ 11,000,000	$ 11,000,000
7	48" HDPE Intake Pipe	lf	90	$ 600	$ 54,000
8	6" HDPE Outlet Pipe	lf	40	$ 300	$ 12,000
9	Flygt Pump (Flygt N 3069)	ea	2	$ 40,000	$ 80,000
10	Flygt Pump (Sump Pump)	ea	1	$ 20,000	$ 20,000
11	PG&E Connection	ls	1	$ 50,000	$ 50,000
12	Foundation Bedding	cy	2000	$ 33	$ 66,000
13	Backfill (Overexcavation and top cover)	cy	9000	$ 30	$ 270,000
14	36" H-20 Covers w/ grade rings	ea	9	$ 20,000	$ 180,000
15	48" Motorized Slide Gate	ea	1	$ 40,000	$ 40,000
16	24" Motorized Slide Gate	ea	1	$ 25,000	$ 25,000
17	12" Motorized Slide Gate	ea	1	$ 20,000	$ 20,000
18	Park Resurfacing	cy	750	$ 100	$ 75,000
19	Control Panel Cabinet	ls	1	$ 75,000	$ 75,000
20	Contingency	%	50%	$ 16,518,700	$ 8,259,350
Subtotal - Conceptual Opinion of Probable Construction Cost (1)					**$ 24,778,000**
Engineering and Administration Cost					
21	Design	%	10%	$ 24,778,000	$ 2,477,800
22	Environmental/Permitting	%	5%	$ 24,778,000	$ 1,238,900
23	Advertise/Bid/Award	ls	1	$ 100,000	$ 100,000
24	Construction Management/ Inspection	%	15%	$ 24,778,000	$ 3,716,700
25	District Administration	%	5%	$ 24,778,000	$ 1,238,900
Subtotal - Engineering and Administration Cost (1)					**$ 8,772,000**
Total Conceptual Opinion of Probable Project Cost (1)					**$ 33,550,000**

Notes
(1) Subtotals and total rounded to the nearest $1,000

Abbreviations

ls	Lump Sum
lf	Linear Foot
ea	Each
sf	Square Foot

Underground Detention Basin Installation – El Camino Real			
Fund Number:		**Location:**	237 CA-82, San Carlos
Department:	DPW	**Strategic Plan:**	
Project Manager:		**Priorities:**	
Category:		**Priority Rating:**	

Description

The Project involves installing a 2.5-million-gallon underground precast concrete stormwater detention facility within an unimproved parcel located between El Camino Real and Caltrain to capture and manage runoff from Arroyo Creek. The detention basin would be located on property owned by SamTrans, and the City would be required to either secure an easement for the proposed facility or acquire the property. The proposed underground improvements would not prohibit SamTrans from continuing to utilize the parcel for staging materials, equipment, and other maintenance activities so a subterranean easement may be the most appropriate pathway for the City. The facility will temporarily store stormwater during peak flows and gradually release it into Pulgas Creek via pump after storms subside.

The system comprises an intake structure in Arroyo Creek, intake piping, a modular detention basin, and a new outfall structure in Pulgas Creek.

Total Estimated Cost (Including Preliminary Design, Permitting, Construction Documents, and Construction with a 50% Contingency) is $14.74 M, which translates into approximately $5.90/gallon of storage.

Justification

1. *Flood Mitigation*: The project will increase storm drain capacity, leading to an estimated 5% reduction in flooding. This will improve public safety and reduce property damage during heavy rainfall events.
2. *Optimized Land Use*: The project leverages an underutilized location within the City.
3. *Multi-Functional Design*: The top of the detention facility can be repurposed to serve the community's needs, potentially as a parking lot or other public amenity as determined by the City, hence maximizing the value of existing public land.

Duration

- CEQA (6 months to 9 months)
- Design (12 months to 15 months)
- Construction (18 months to 24 months)

Status

10% Design Drawings

Future Impact on Operating Budget

Intake at Arroyo Creek Inspection and Maintenance

Detention Basin Inspection

Detention Basin Cleaning

Pumping System Maintenance

Pumping System Replacement

Outlet at Pulgas Creek Inspection and Maintenance

TideFlex CheckMate Valve Replacement

Underground Detention Basin Installation – El Camino Real			
Fund Number:		**Location:**	237 CA-82, San Carlos
Department:	DPW	**Strategic Plan:**	
Project Manager:		**Priorities:**	
Category:		**Priority Rating:**	

Current Strategic Plan Objective

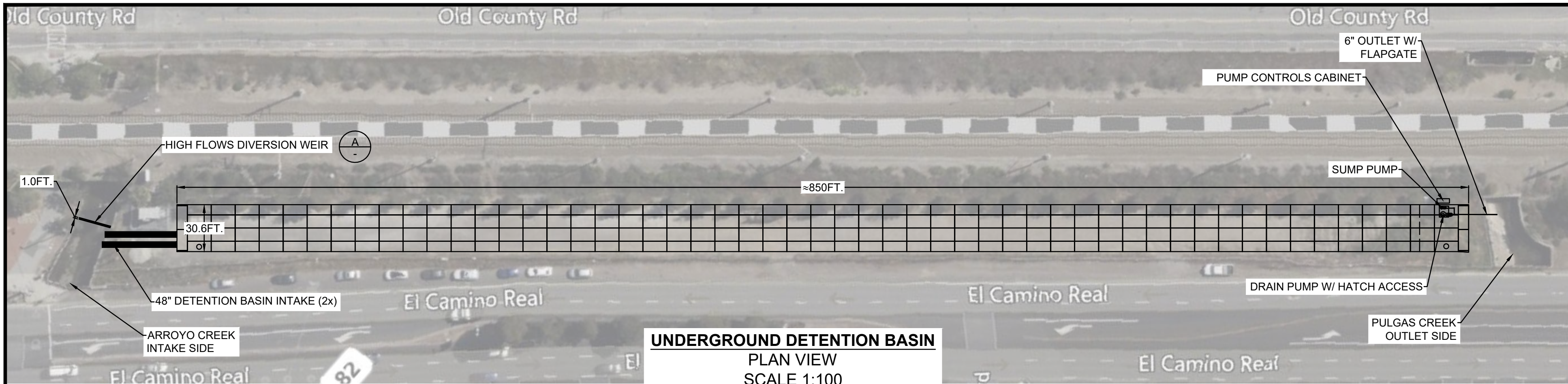
	Child Care
X	Climate Change Mitigation, Adaptation & Resilience
	Downtown
	Housing
	Mobility, Traffic & Transportation Infrastructure
	Northeast Area Specific Plan
	Recreation Services

Capitalization Project		**Non- Capitalized Project**		

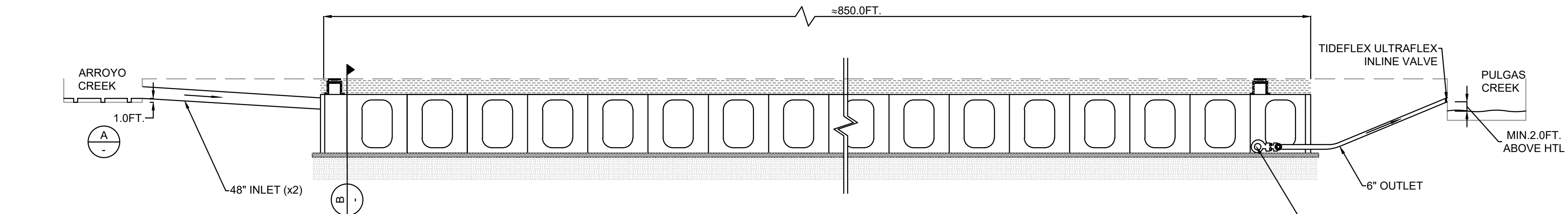
Budget

Planning*	$	1,085,000
Design Phase	$	1,085,000
Advertise / Bid / Award	$	100,000
Construction	$	12,470,000
Post Construction	$	-
Total	**$**	**14,740,000**

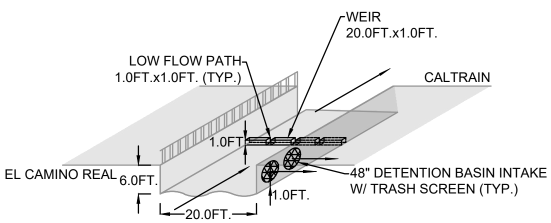
* Includes Surveying, Geotechnical Report, Utility Investigation, Alternatives Development, Structural Engineering Report, Permitting



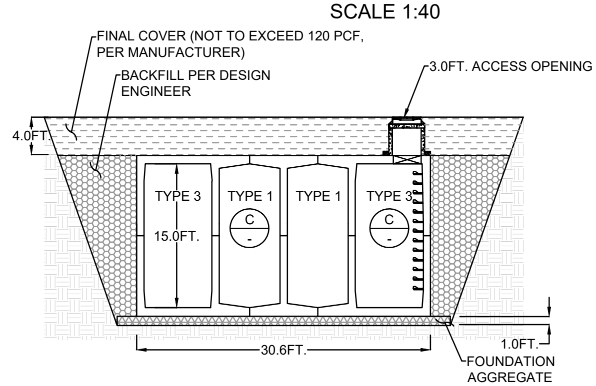
UNDERGROUND DETENTION BASIN
PLAN VIEW
SCALE 1:100



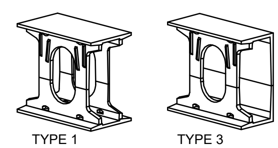
UNDERGROUND DETENTION BASIN
PROFILE VIEW
SCALE 1:40



A - **ARROYO CREEK WEIR DETAIL**
SCALE: 1:40



B - **DETENTION BASIN SECTION**
SCALE: 1:20



C - **STORMTRAP MODULES**
SCALE: N.T.S.

LENGTH OF DETENTION BASIN: 850 FT.
USABLE CROSS SECTION AREA: 397 SF.

TOTAL VOLUME OF DETENTION BASIN: 337,450 CF.

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UNDERGROUND BASIN DETENTION FACILITY

PULGAS CREEK WATERSHED
SAN CARLOS, CA

SHEET 1 OF 1

Table A.2

Conceptual Opinion of Probable Project Cost for Pulgas Creek Watershed

Underground Detention Basin

El Camino Real, San Carlos

Item No.	Description	Units	Quantity	Unit Price	Budget
Conceptual Opinion of Probable Construction Cost					
1	Mobilization/Demobilization	%	10.00%	-	$ 657,202
2	Dewatering	ls	1	$ 100,000	$ 100,000
3	Weir Structure	ls	1	$ 100,000	$ 100,000
4	Excavation (including offhaul and disposal)	cy	29000	$ 25	$ 725,000
5	StormTrap Modules	ls	1	$ 4,500,000	$ 4,500,000
6	48" HDPE Intake Pipe	lf	90	$ 600	$ 54,000
7	6" HDPE Outlet Pipe	lf	40	$ 300	$ 12,000
8	Flygt Pump (Flygt N 3069)	ea	2	$ 40,000	$ 80,000
9	Flygt Pump (Sump Pump)	ea	1	$ 20,000	$ 20,000
10	PG&E Connection	ls	1	$ 50,000	$ 50,000
11	Foundation Bedding	cy	551	$ 20	$ 11,019
12	Final Cover Backfill	cy	300	$ 10	$ 3,000
13	Backfill	cy	16000	$ 10	$ 160,000
14	36" H-20 Covers w/ grade rings	ea	9	$ 20,000	$ 180,000
15	12" TideFlex CheckMate Inline Valve	ea	1	$ 2,000	$ 2,000
16	Pavement Resurfacing	cy	10000	$ 50	$ 500,000
17	Control Panel Cabinet	ls	1	$ 75,000	$ 75,000
18	Contingency	%	50%	$ 7,229,220	$ 3,614,610
Subtotal - Conceptual Opinion of Probable Construction Cost (1)					**$ 10,844,000**
Engineering and Administration Cost					
19	Design	%	10%	$ 10,844,000	$ 1,084,400
20	Environmental/Permitting	%	5%	$ 10,844,000	$ 542,200
21	Advertise/Bid/Award	ls	1	$ 100,000	$ 100,000
22	Construction Management/ Inspection	%	15%	$ 10,844,000	$ 1,626,600
23	District Administration	%	5%	$ 10,844,000	$ 542,200
Subtotal - Engineering and Administration Cost (1)					**$ 3,895,000**
Total Conceptual Opinion of Probable Project Cost (1)					**$ 14,739,000**

Notes

(1) Subtotals and total rounded to the nearest $1,000

Abbreviations

ls	Lump Sum
lf	Linear Foot
ea	Each
sf	Square Foot

Floodplain Detention Basin Installation – Big Canyon Park

Fund Number:	**Location:** Big Canyon Park
Department:	**Strategic Plan:**
Project Manager	**Priorities:**
Category:	**Priority Rating:**

Description

The Project involves the installation of a floodplain detention basin in the Pulgas Creek Watershed region of San Carlos at Big Canyon. The basin will temporarily store stormwater during peak flows and gradually release it into public storm drain after a storm subsides.

The system comprises a sediment forebay with a capacity of 500 gallons of water, located uphill from the main floodplain detention basin, which has a capacity of 2,500 gallons. The total water storage capacity is therefore 3,000 gallons. The main floodplain basin will contain a non-floatable mulch layer under laying native erosion-resistant plants, soil media mix, and a gravel layer.

The total estimated cost (Including preliminary design, permits, construction documents, and construction with 50% contingency) is $1.15M, which is approximately $380/gallon of storage.

Justification

1. *Flood Mitigation:* The project will increase storm drain capacity downstream by reduction in the peak discharge of approximately 22%. This will improve public safety and reduce property damage during heavy rainfall events.

2. *Optimized Land Use:* The project leverages an underutilized location within the City.

3. *Multi-Functional Design:* The floodplain detention facility can include education signage and upgraded trail access for the community.

Duration

- CEQA (6 months to 9 months)
- Design (12 months to 15 months)
- Construction (15 months to 18 months)

Status

10% Design Drawings

Future Impact on Operating Budget

Floodplain Detention Basin Inspection

Floodplain Detention Basin Cleaning

Floodplain Detention Basin Installation – Big Canyon Park

Fund Number:	**Location:** Big Canyon Park
Department:	**Strategic Plan:**
Project Manager	**Priorities:**
Category:	**Priority Rating:**

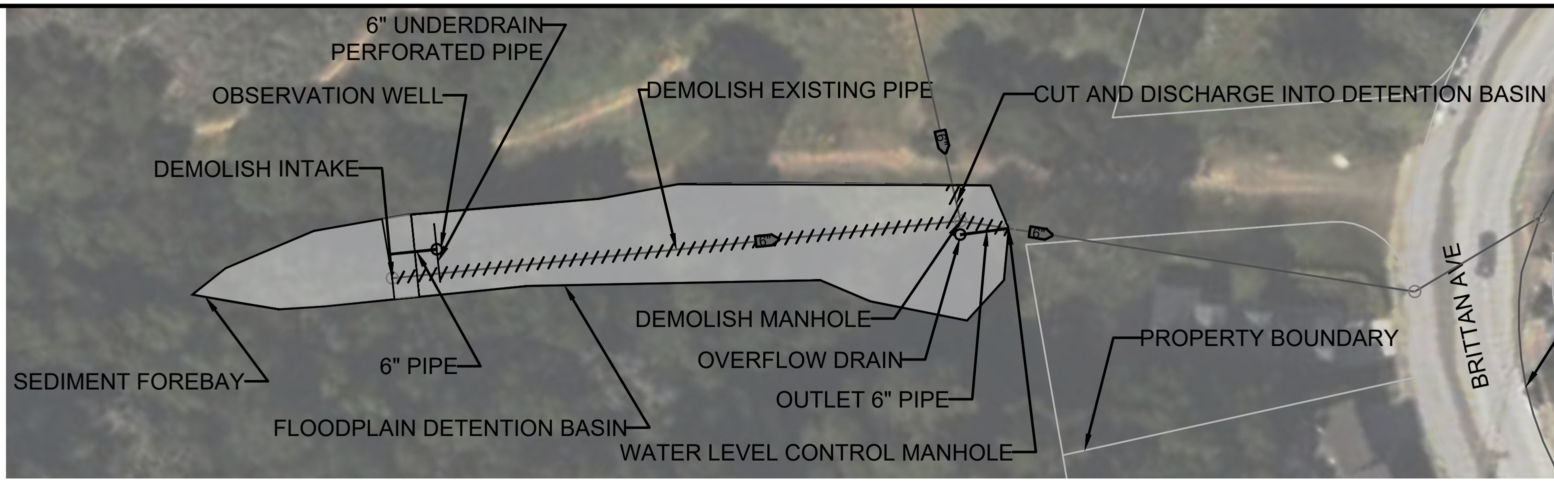
Current Strategic Plan Objective

	Child Care		
x	**Climate Change Mitigation, Adaptation & Resilience**		
	Downtown		
	Housing		
	Mobility, Traffic & Transportation Infrastructure		
	Northeast Area Specific Plan		
	Recreation Services		
Capitalization Project		**Non- Capitalized Project**	

Budget

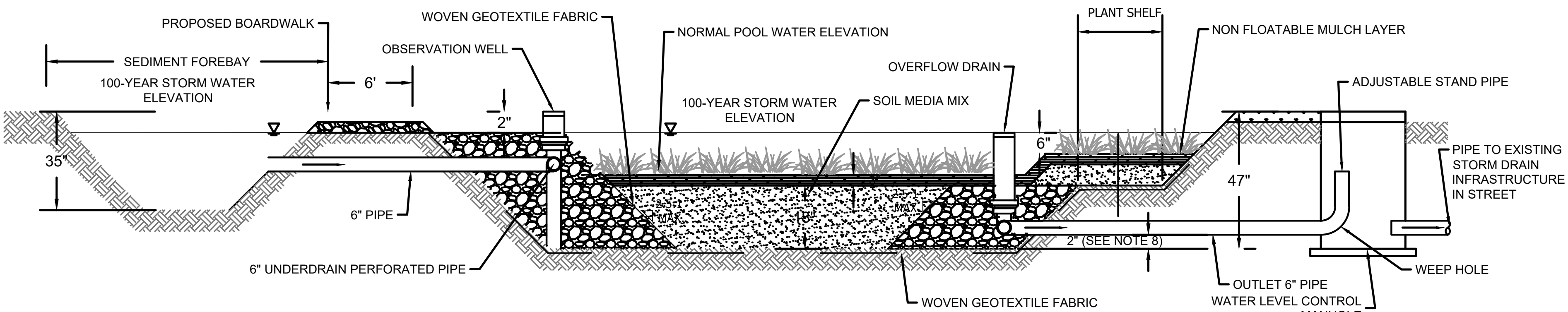
Planning*	$	80,000
Design Phase	$	80,000
Advertise / Bid / Award	$	100,000
Construction	$	890,000
Post Construction	$	-
Total	**$**	**1,150,000**

* Includes Surveying, Geotechnical Report, Utility Investigation, Alternatives Development, Structural Engineering Report, Permitting



FLOOD PLAIN DETENTION BASIN

PLAN VIEW 1:80



FLOOD PLAIN DETENTION BASIN

PROFILE VIEW NTS

NOTES:

1. AVOID INSTALLATION ON SLOPES GREATER THAN 3.00%. AVOID COMPACTING NATIVE SOILS. SCARIFY ANY COMPACTED SOIL.
2. LENGTH TO WIDTH RATIO SHOULD RANGE FROM 2 TO 3.
3. STONE STORAGE OPTIONS ARE CALTRANS CLASS 2 PERMEABLE MATERIAL, OR SIMILARLY MUNICIPALITY-APPROVED MATERIAL. NO RECYCLED MATERIALS.
4. MINIMUM DISTANCE OF 2 FEET BETWEEN BOTTOM OF BMP AND SEASONALLY HIGH GROUNDWATER LEVEL.
5. UNDERDRAINS ARE REQUIRED IN TYPICAL CLAYEY SOILS WHERE INFILTRATION RATES ARE LESS THAN 0.5 INCH/HOUR. MAXIMUM OF 1 UNDERDRAIN PER 30 FEET. PROVIDE A SOIL REPORT DOCUMENTING NATIVE INFILTRATION RATE TO FOREGO UNDERDRAINS.
6. MINIMUM UNDERDRAIN BEDDING OF TWO INCHES, MAXIMUM OF 12 INCHES.

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FLOODPLAIN DETENTION BASIN
PULGAS CREEK WATERSHED
SAN CARLOS, CA

Table A.3

Conceptual Opinion of Probable Project Cost for Pulgas Creek Watershed

Floodplain Detention Basin

Big Canyon Park, San Carlos

Item No.	Description	Units	Quantity	Unit Price	Budget
Conceptual Opinion of Probable Construction Cost					
1	Mobilization/Demobilization	%	10.00%	-	$ 46,935
2	Excavation	cy	1,170	$ 75	$ 87,750
3	Trench Backfill	cy	40	$ 10	$ 400
4	Woven geotextile fabric	sf	7,580	$ 3	$ 23,650
5	Observation well (6" PVC)	ea	1	$ 300	$ 300
7	Soil Media mix	ls	100	$ 125	$ 12,500
8	Gravel (river rocks)	cy	500	$ 36	$ 18,000
9	Landscape Materials (plants, irrigation, etc.)	ls	1	$ 100,000	$ 100,000
10	Overflow Drain (6" pvc)	ea	3	$ 48	$ 144
11	6" HDPE SDR17	lf	50	$ 300	$ 15,000
12	Precast Concrete Manhole	ea	1	$ 137,000	$ 137,000
13	Non floatable mulch layer	cy	90	$ 729	$ 65,610
14	Underdrain perforated pipe 6" HDPE	lf	30	$ 300	$ 9,000
15	Contingency	%	50%	$ 516,289	$ 258,144
Subtotal - Conceptual Opinion of Probable Construction Cost (1)					**$ 774,000**
Engineering and Administration Cost					
16	Design	%	10%	$ 774,000	$ 77,400
17	Environmental/Permitting	%	5%	$ 774,000	$ 38,700
18	Advertise/Bid/Award	ls	1	$ 100,000	$ 100,000
19	Construction Management/ Inspection	%	15%	$ 774,000	$ 116,100
20	District Administration	%	5%	$ 774,000	$ 38,700
Subtotal - Engineering and Administration Cost (1)					**$ 371,000**
Total Conceptual Opinion of Probable Project Cost (1)					**$ 1,145,000**

Notes

(1) Subtotals and total rounded to the nearest $1,000

Abbreviations

ls Lump Sum

lf Linear Foot

ea Each

sf Square Foot

Bioretention Planter Installation – Alameda de las Pulgas			
Fund Number:		**Location:**	Alameda de las Pulgas/Brittan Avenue
Department:	DPW	**Strategic Plan:**	
Project Manager:		**Priorities:**	
Category:		**Priority Rating:**	

Description

The Project involves installing bioretention in the City's right-of-way to capture and manage runoff Alameda de las Pulgas and Brittan Avenue. The facility consists of approximately 400 square feet of bioretention area and will treat stormwater at a designed ponding depth and slowly release it into the stormwater system. As part of the installation of bioretention, there is opportunities to introduce bulb outs and updated curb ramps at this intersection. The Project would include new curb, sidewalk, and storm drain infrastructure.

Total Estimated Cost (Including Preliminary Design, Permitting, Construction Documents, Construction with 50% Contingency) is $870,000.

Justification

1. *Flood Mitigation:* The project will increase storm drain capacity.

2. *Optimized Land Use:* The project leverages an underutilized location within the City.

Duration

- CEQA (6 months to 9 months)
- Design (9 months to 12 months)
- Construction (12 months to 18 months)

Status

10% Design Drawings

Future Impact on Operating Budget

Bioretention planter Inspection

Bioretention planter Cleaning

Current Strategic Plan Objective

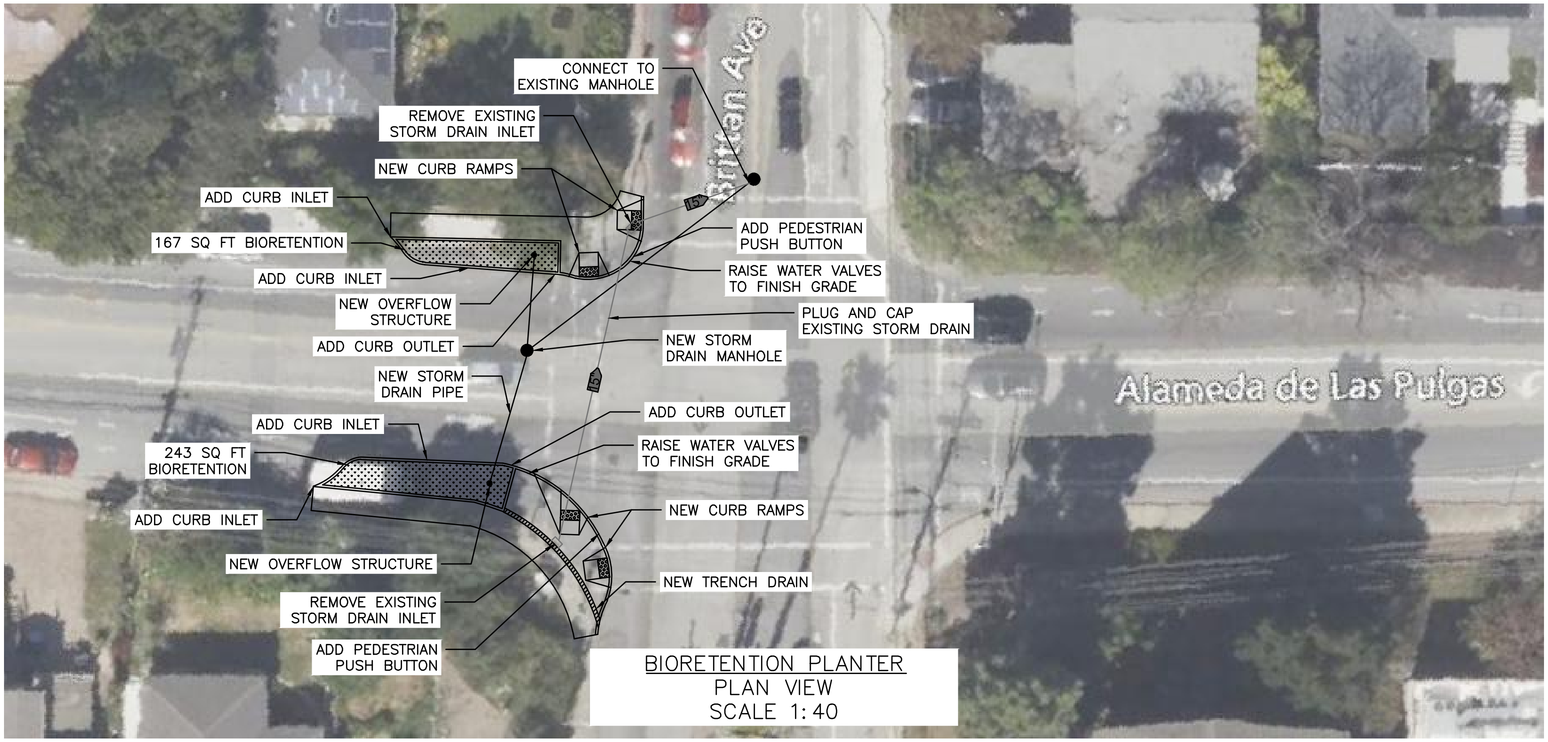
	Child Care
X	Climate Change Mitigation, Adaptation & Resilience
	Downtown
	Housing
	Mobility, Traffic & Transportation Infrastructure
	Northeast Area Specific Plan
	Recreation Services

Capitalization Project		**Non- Capitalized Project**		

Bioretention Planter Installation – Alameda de las Pulgas			
Fund Number:		**Location:**	Alameda de las Pulgas/Brittan Avenue
Department:	DPW	**Strategic Plan:**	
Project Manager:		**Priorities:**	
Category:		**Priority Rating:**	

Budget		
Planning*	$	65,000
Design Phase	$	65,000
Advertise / Bid / Award	$	20,000
Construction	$	720,000
Post Construction	$	-
Total	**$**	**870,000**

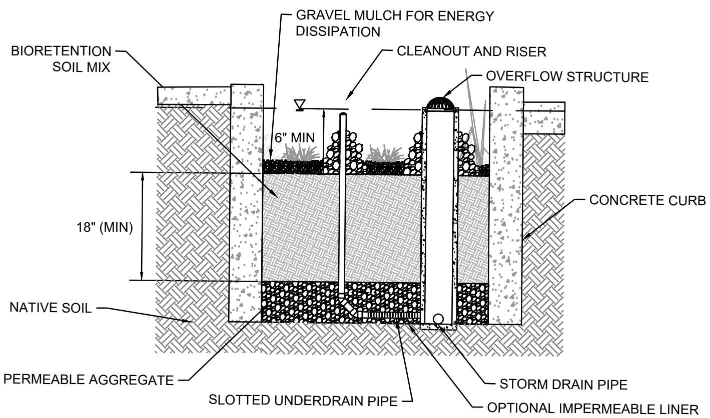
* Includes Surveying, Geotechnical Report, Utility Investigation, Alternatives Development, Structural Engineering Report, Permitting



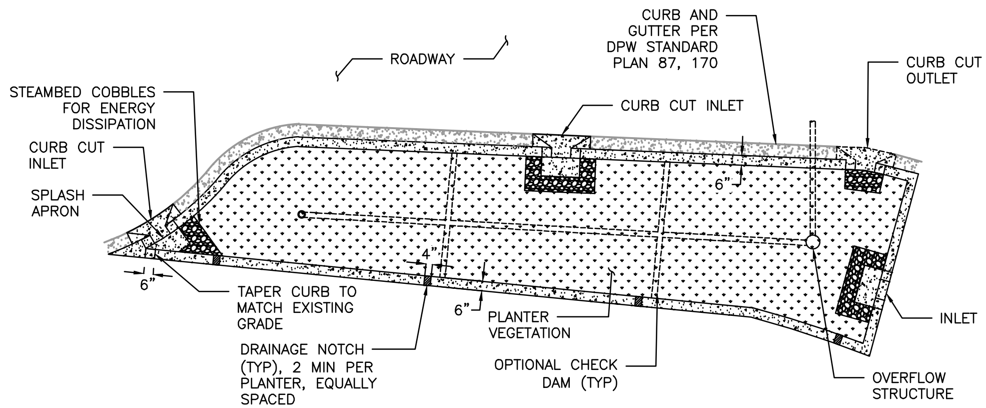
BIORETENTION PLANTER
PLAN VIEW
SCALE 1:40

NOTES:

1. BIORETENTION AREAS TO CONFORM TO COUNTY OF SAN MATEO C–3 REGULATED PROJECTS GUIDE



1 — BIORETENTION PLANTER SECTION DETAIL
NTS



2 — CURB SECTION DETAIL
NTS

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BIORETENTION PLANTER

PULGAS CREEK WATERSHED
SAN CARLOS, CA

SHEET 1 OF 1

Table A.4
Conceptual Opinion of Probable Project Cost for Pulgus Creek Watershed
Curb Ramp and Bioretention Construction
Alameda de las Pulgas, San Carlos

Item No.	Description	Units	Quantity	Unit Price	Budget
Conceptual Opinion of Probable Construction Cost					
1	Mobilization/Demobilization	%	10.00%	-	$ 38,150
2	Traffic Control	ls	1	$ 30,000	$ 30,000
3	Demolition	ls	1	$ 13,500	$ 13,500
4	New Trench Drain	ls	1	$ 3,000	$ 3,000
5	Bioretention Construction	ls	1	$ 165,000	$ 165,000
6	Curb Ramps and Sidewalk	ls	1	$ 100,000	$ 100,000
7	Pedestrian Push Buttons	ls	1	$ 10,000	$ 10,000
8	New Stormwater Infrastructure	ls	1	$ 50,000	$ 50,000
9	Stormwater Pollution Prevention & Control	ls	1	$ 10,000	$ 10,000
10	Contingency	%	50%	$ 419,650	$ 209,825
Subtotal - Conceptual Opinion of Probable Construction Cost (1)					**$ 629,000**
Engineering and Administration Cost					
11	Design	%	10%	$ 629,000	$ 62,900
12	Environmental/Permitting	%	5%	$ 629,000	$ 31,450
13	Advertise/Bid/Award	ls	1	$ 20,000	$ 20,000
14	Construction Management/ Inspection	%	15%	$ 629,000	$ 94,350
15	District Administration	%	5%	$ 629,000	$ 31,450
Subtotal - Engineering and Administration Cost (1)					**$ 240,000**
Total Conceptual Opinion of Probable Project Cost (1)					**$ 869,000**

Notes
(1) Subtotals and total rounded to the nearest $1,000

Abbreviations
ls Lump Sum
lf Linear Foot
ea Each
sf Square Foot

Pervious Pavement Installation – Bransten Road			
Fund Number:		**Location:**	1000 Bransten Road
Department:	DPW	**Strategic Plan:**	
Project Manager:		**Priorities:**	
Category:		**Priority Rating:**	

Description

The Project involves implementing pervious pavement on a city-owned parcel, City of San Carlos Corporation Yard, to capture and manage onsite runoff. The pavement will filter pollutants and allow for water to flow through and gradually release into the ground. Pervious pavement is best suited for parking lots, walkways, and areas that don't have heavy vehicular traffic. Two options have been provided: Porous Asphalt and Pervious Concrete.

Total Estimated Cost (Including Preliminary Design, Permitting, Construction Documents, Construction with 50% Contingency) is $1,560,000 (Porous Asphalt) and $2,230,000 (Pervious Concrete).

Justification

1. *Improve Water Quality:* Reduce runoff and the amount of pollutants that enter creeks and the bay.
2. *Optimized Land Use:* The project leverages an underutilized location within the City.
3. *Multi-Functional Design:* The pavement can be integrated as parking lots and areas, maximizing the function of existing public land.

Duration

- CEQA (6 months to 9 months)
- Design (6 months to 9 months)
- Construction (6 months to 9 months)

Status

10% Design Drawings

Future Impact on Operating Budget

Pervious Pavement Maintenance

Current Strategic Plan Objective

	Child Care
X	Climate Change Mitigation, Adaptation & Resilience
	Downtown
	Housing
	Mobility, Traffic & Transportation Infrastructure
	Northeast Area Specific Plan
	Recreation Services

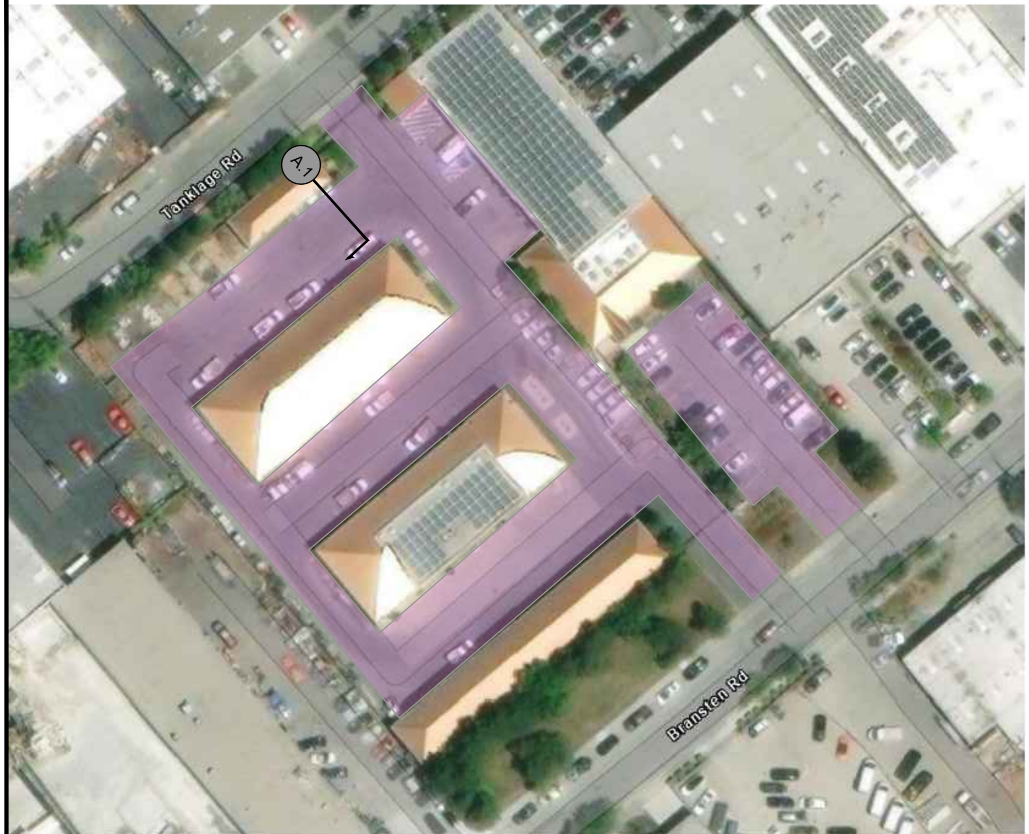
Capitalization Project		**Non- Capitalized Project**		

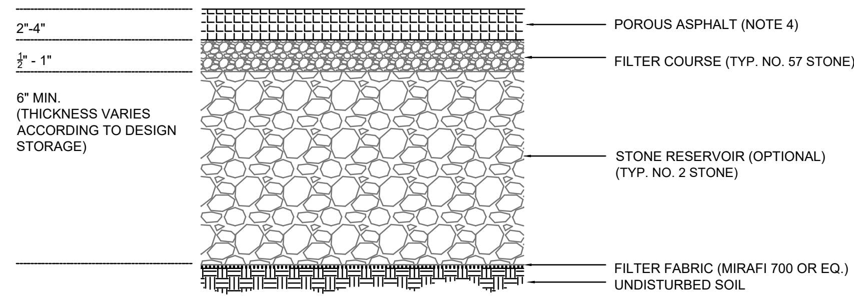
Pervious Pavement Installation – Bransten Road			
Fund Number:		**Location:**	1000 Bransten Road
Department:	DPW	**Strategic Plan:**	
Project Manager:		**Priorities:**	
Category:		**Priority Rating:**	

Budget

	Porous Asphalt Option	Pervious Concrete Option
Planning*	$ 110,000	$ 160,000
Design Phase	$ 110,000	$ 160,000
Advertise / Bid / Award	$ 100,000	$ 100,000
Construction	$ 1,240,000	$ 1,810,000
Post Construction	$ -	$ -
Total	**$ 1,560,000**	**$ 2,230,000**

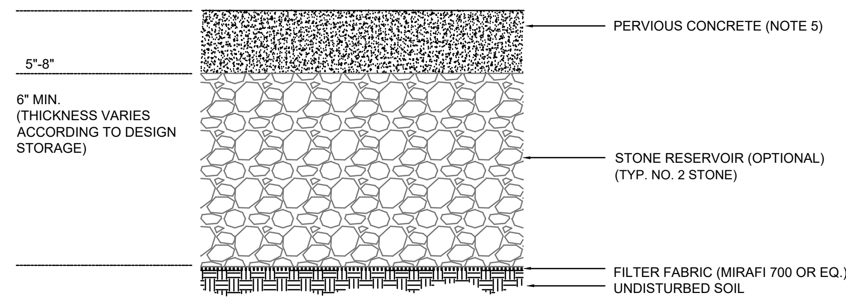
* Includes Surveying, Geotechnical Report, Utility Investigation, Alternatives Development, Permitting





A.1 – POROUS ASPHALT SECTION DETAIL

NTS



A.2 – PERVIOUS CONCRETE SECTION DETAIL

NTS

POROUS ASPHALT PROPOSED LOCATION
PLAN VIEW
(FOR PERVIOUS PAVEMENT ALTERNATIVES SEE DETAILS A.2)

NOTES:

1. DEPENDING ON LOCATION AND DESIRED LANDSCAPE DESIGN, PERMEABLE PAVEMENT CAN BE POROUS ASPHALT, PERVIOUS CONCRETE, PERMEABLE PAVERS OR PERVIOUS PAVERS.
2. IN ORDER TO AVOID CONTAMINATION OF GROUNDWATER, THE BOTTOM OF THE BASE OF THE PERVIOUS PAVEMENT SYSTEM MUST BE AT LEAST 5 FT. ABOVE THE HIGH GROUNDWATER LEVEL AT THE PROPOSED LOCATION, UNLESS A DIFFERENT SEPARATION METHOD IS RECOMMENDED BY THE GEOTECHNICAL ENGINEER.
3. THE SUBGRADE BELOW THE PERVIOUS PAVEMENT SYSTEM MUST BE RELATIVELY FLAT (MAX. 2% SLOPE), TO PROMOTE INFILTRATION ACROSS THE ENTIRE AREA.
4. SURFACE VOID CONTENT FOR POROUS ASPHALT SHALL BE 12-20%.
5. SURFACE VOID CONTENT FOR PERVIOUS CONCRETE SHALL BE 15-25%.
6. SITE TESTS SHOULD BE PERFORMED TO DETERMINE SOIL CONDITIONS INCLUDING: PERCOLATION RATE, INFILTRATION CAPABILITIES, DEPTH TO SEASONAL HIGH WATER TABLE, DEPTH TO BEDROCK, AND SOIL CONTAMINATION. AN UNDERDRAIN MAY BE USED IN SOILS WITH LOWER INFILTRATION RATE IN ORDER TO OBTAIN THE MINIMUM PERMEABILITY RATE. PERCOLATION TESTING TO IDENTIFY THE INFILTRATION RATE OF THE NATIVE SOIL WILL DETERMINE THE DEPTH OF BASE ROCK FOR THE STORAGE OF STORMWATER, AND WHETHER AN UNDERDRAIN SYSTEM IS NECESSARY.

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PERVIOUS PAVEMENT

PULGAS CREEK WATERSHED
SAN CARLOS, CA

Table A.5
Conceptual Opinion of Probable Project Cost for Pulgus Creek Watershed
Pervious Asphalt Replacement
1000 Bransten Road, San Carlos

Item No.	Description	Units	Quantity	Unit Price	Budget
Conceptual Opinion of Probable Construction Cost					
1	Mobilization/Demobilization	%	10.00%	-	$ 65,351
2	Traffic Control	ls	1	$ 15,000	$ 15,000
3	Demolition	cy	462	$ 550	$ 254,100
4	Excavation (including offhaul and disposal)	cy	1,845	$ 78	$ 143,910
5	New Ashphalt Porous	ls	1	$ 230,497	$ 230,497
6	Stormwater Pollution Prevention & Control	ls	1	$ 10,000	$ 10,000
7	Contingency	%	50%	$ 718,858	$ 359,429
Subtotal - Conceptual Opinion of Probable Construction Cost (1)					**$ 1,078,000**
Engineering and Administration Cost					
8	Design	%	10%	$ 1,078,000	$ 107,800
9	Environmental/Permitting	%	5%	$ 1,078,000	$ 53,900
9	Advertise/Bid/Award	ls	1	$ 100,000	$ 100,000
10	Construction Management/ Inspection	%	15%	$ 1,078,000	$ 161,700
11	District Administration	%	5%	$ 1,078,000	$ 53,900
Subtotal - Engineering and Administration Cost (1)					**$ 477,000**
Total Conceptual Opinion of Probable Project Cost (1)					**$ 1,555,000**

Notes
(1) Subtotals and total rounded to the nearest $1,000

Abbreviations
ls Lump Sum
lf Linear Foot
ea Each
sf Square Foot

Table A.6
Conceptual Opinion of Probable Project Cost for Pulgus Creek Watershed
Pervious Concrete Replacement
1000 Bransten Road, San Carlos

Item No.	Description	Units	Quantity	Unit Price	Budget
Conceptual Opinion of Probable Construction Cost					
1	Mobilization/Demobilization	%	10.00%	-	$ 95,387
2	Traffic Control	ls	1	$ 15,000	$ 15,000
3	Demolition	cy	462	$ 550	$ 254,100
4	Excavation (including offhaul and disposal)	cy	1,845	$ 78	$ 143,910
5	New Concrete Pervious	ls	1	$ 530,859	$ 530,859
6	Stormwater Pollution Prevention & Control	ls	1	$ 10,000	$ 10,000
7	Contingency	%	50%	$ 1,049,256	$ 524,628
Subtotal - Conceptual Opinion of Probable Construction Cost (1)					**$ 1,574,000**
Engineering and Administration Cost					
8	Design	%	10%	$ 1,574,000	$ 157,400
9	Environmental/Permitting	%	5%	$ 1,574,000	$ 78,700
9	Advertise/Bid/Award	ls	1	$ 100,000	$ 100,000
10	Construction Management/ Inspection	%	15%	$ 1,574,000	$ 236,100
11	District Administration	%	5%	$ 1,574,000	$ 78,700
Subtotal - Engineering and Administration Cost (1)					**$ 651,000**
Total Conceptual Opinion of Probable Project Cost (1)					**$ 2,225,000**

Notes
(1) Subtotals and total rounded to the nearest $1,000

Abbreviations

ls	Lump Sum
lf	Linear Foot
ea	Each
sf	Square Foot

Native Plant Pilot Program – Big Canyon Park

Fund Number:		**Location:**	**Big Canyon Park**
Department:		**Strategic Plan:**	
Project Manager		**Priorities:**	
Category:		**Priority Rating:**	

Description

The project involves installing and replacing native plants, treating topsoil, irrigation, and monitoring runoff in the Pulgas Creek Watershed region of San Carlos at Big Canyon Park. The replacement and planting of native plants will help stabilize the soil through natural means and lessen the effects of erosion and soil transportation to further points downstream in the watershed.

Site preparation includes minor grading, topsoil preparation, and incorporation of soil amendments. Planting basins are flagged and excavated, and irrigation is laid out. Cages and wire fencing can be installed to prevent herbivore damage to young plants. Planting will occur in winter through mid-spring to take advantage of water availability. Once planted, revegetation sites are regularly weeded and watered to ensure plant establishment. Dead or dying plants are removed and replaced within the first year. The site should be formally monitored for species composition, percent survival, and percent cover every year for five years.

The total estimated cost (including preliminary design, permits, construction documents, and construction with a 50% contingency) is $401,000.

Justification

1. *Landslide Mitigation:* The project will increase vegetation and ground cover, reducing soil erosion. This will improve public safety and reduce property damage during heavy rainfall events.

2. *Optimized Land Use:* The project leverages an underutilized location within the City, providing habitat for wildlife and enhancing the aesthetic appeal of an existing park.

Duration

- CEQA (6 months to 9 months)
- Design (4 months to 6 months)
- Construction (4 months to 6 months)
- Monitoring and replanting (5 years)

Status

10% Design Drawings

Future Impact on Operating Budget

Native Plant Revegetation Inspection

Native Plant Revegetation Replacement and Monitoring

Native Plant Pilot Program – Big Canyon Park	
Fund Number:	**Location:** Big Canyon Park
Department:	**Strategic Plan:**
Project Manager	**Priorities:**
Category:	**Priority Rating:**

Current Strategic Plan Objective

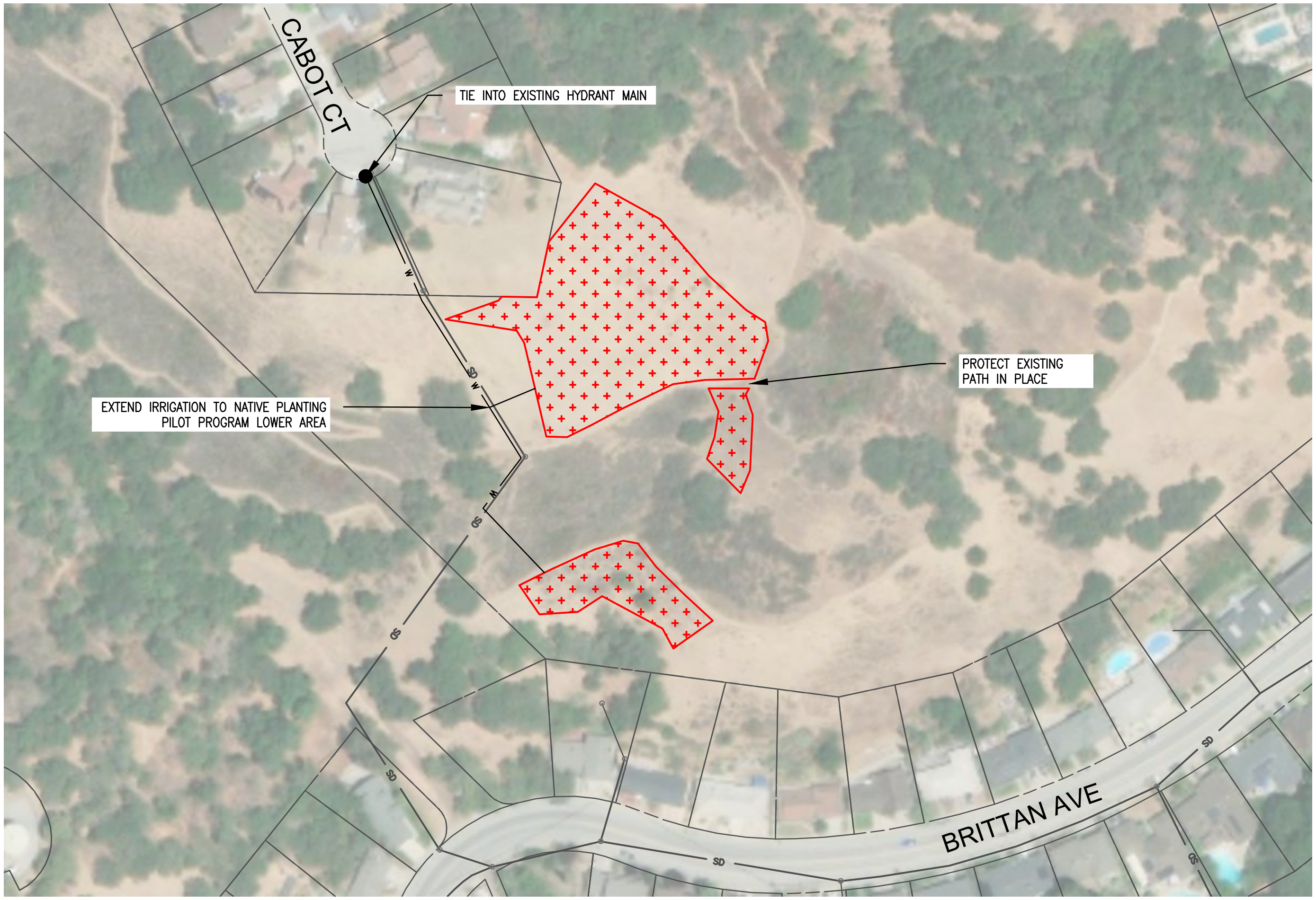
	Child Care
x	Climate Change Mitigation, Adaptation & Resilience
	Downtown
	Housing
	Mobility, Traffic & Transportation Infrastructure
	Northeast Area Specific Plan
	Recreation Services

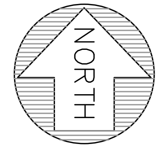
Capitalization Project		Non- Capitalized Project	

Budget

Planning*	$	55,700
Design Phase	$	22,300
Advertise / Bid / Award	$	100,000
Construction	$	223,000
Post Construction	$	-
Total	**$**	**401,000**

* Includes Surveying, Geotechnical Report, Utility Investigation, Alternatives Development, Structural Engineering Report, Permitting





LEGEND:

- NATIVE PLANTING AREA
- PARCEL LINE
- NEW WATER LINE
- EXISTING STORM WATER INFRASTRUCTURE

APPROXIMATE NATIVE PLANTING AREA:

62,122-SQFT
1.43-ACRES

NATIVE PLANTING DESIGN

PLAN VIEW 1:200

NOTES:

1. ONLY WATER MAIN LINES SHOWN. IRRIGATION LATERALS AND LAYOUT TO BE DESIGNED BY IRRIGATION CONSULTANT/LANDSCAPE ARCHITECT.
2. NATURAL PLANTING REVEGETATION SITES WILL BE REGULARLY WEEDED AND WATERED TO ENSURE PLANT ESTABLISHMENT.
3. DYING PLANTS ARE TO BE REPLANTED WITHIN THE FIRST YEAR.
4. SITES ARE FORMALLY MONITORED FOR SPECIES COMPOSITION, PERCENT SURVIVAL, AND PERCENT COVER EVERY YEAR FOR FIRST FIVE YEARS.
5. EASEMENT MAYBE NEEDED TO CONNECT TO EXISTING HYDRANT.

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NATIVE PLANTING DESIGN
PULGAS CREEK WATERSHED
SAN CARLOS, CA

Table A.7

Conceptual Opinion of Probable Project Cost for Pulgas Creek Watershed

Native Planting Pilot Program

Big Canyon Park, San Carlos

Item No.	Description	Units	Quantity	Unit Price	Budget
Conceptual Opinion of Probable Construction Cost					
1	Mobilization/Demobilization	%	10.00%	-	$ 13,539
2	Weeding	sy	6,960	$ 1	$ 6,960
3	Minor grading and topsoil preperation	ea	1	$ 3,554	$ 3,554
4	Weed/soil fabric	sy	6,960	$ 3	$ 20,880
5	Excavation Planting Pit	cy	330	$ 158	$ 52,140
6	Irrigation layout	lf	7,500	$ 2	$ 15,000
7	Plant protection (Cages)	ea	200	$ 80	$ 16,000
8	Replanting	ea	132	$ 158	$ 20,856
9	Contingency	%	50%	$ 148,929	$ 74,465
Subtotal - Conceptual Opinion of Probable Construction Cost (1)					**$ 223,000**
Engineering and Administration Cost					
10	Design	%	10%	$ 223,000	$ 22,300
11	Environmental/Permitting	%	5%	$ 223,000	$ 11,150
18	Advertise/Bid/Award	ls	1	$ 100,000	$ 100,000
19	Construction Management/ Inspection	%	15%	$ 223,000	$ 33,450
20	District Administration	%	5%	$ 223,000	$ 11,150
Subtotal - Engineering and Administration Cost (1)					**$ 178,000**
Total Conceptual Opinion of Probable Project Cost (1)					**$ 401,000**

Notes

(1) Subtotals and total rounded to the nearest $1,000

Abbreviations

ls	Lump Sum
lf	Linear Foot
ea	Each
sf	Square Foot
sy	Square Yard
cy	Cubic Yard

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