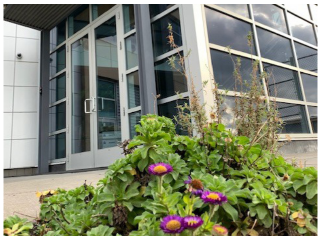
SEA LEVEL RISE ADAPTATION ASSESSMENT

City of Millbrae, CA

Supported by Climate Ready SMC, an initiative of the County of San Mateo Office of Sustainability



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Acronyms and Abbreviations

Term	Definition
0.2% annual chance	flood event with 0.2% chance of occurring within a given year
1% chance event	flood event with 1% chance of occurring within a given year
Airport	San Francisco International Airport
ASCE	American Society of Civil Engineers
Assessment	Sea Level Rise Adaptation Assessment
AVP	Asset Vulnerability Profile
BART	Bay Area Regional Transit
Bay	San Francisco Bay
Bay Area	San Francisco Bay Area
BCDC	San Francisco Bay Conservation and Development Commission
BFE	base flood elevation
CDFW	California Department of Fish and Wildlife
City	City of Millbrae
County	San Mateo County
County's Assessment	*San Mateo County Sea Level Rise Vulnerability Assessment*
FEMA	Federal Emergency Management Agency
FIRMs	Flood Insurance Rate Maps
FIS	Flood Insurance Studies
GHG	greenhouse gas
grant	San Mateo County Community Resilience Grant
HMP	*San Mateo County Hazard Mitigation Plan*
I-280	Interstate 280
LiDAR	light detection and ranging
MHHW	mean higher high water
NAVD88	North American Vertical Datum of 1988
NFIP	National Flood Insurance Program
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration

Acronyms and Abbreviations

Term	Definition
NPDES	National Pollutant Discharge Elimination System
OCOF	Our Coast, Our Future
OLU	Operational Land Unit
PG&E	Pacific Gas & Electric
Reclamation	U.S. Department of the Interior Bureau of Reclamation
RWQCB	Regional Water Quality Control Board
SFEI	San Francisco Estuary Institute
TAC	Technical Advisory Committee
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
WPCP	City of Millbrae Water Pollution Control Plant

1. INTRODUCTION AND BACKGROUND

This Sea Level Rise Adaptation Assessment (Assessment) was prepared by the City of Millbrae with the support of a grant from the San Mateo County Office of Sustainability to better understand and prepare for the risks of sea level rise in the City of Millbrae (City). This Assessment seeks to expand the understanding of sea level rise risks to the City, communicate these risks to the community, and plan for sea level rise by identifying potential mitigations, adaptation and hazard mitigation strategies. To understand, communicate, and plan sea level rise adaptations, this Assessment discusses regional collaboration and community engagement, risk assessment, and regional and local mitigation strategies. This chapter presents the need for the Assessment, a summary of available reference studies and ongoing regional efforts to understand and mitigate sea level rise.

1.1 Introduction

The Assessment provides recommendations to plan, fund, design and construct measures and move forward with local and regional stakeholder engagement. Potential mitigations fall into two main categories: shoreline protections that depend on regional collaboration and local protections that can be prioritized and executed by the City.

Shoreline protection must be a regional effort for several reasons as listed below.

- Sea level rise inundation will not stop at jurisdictional boundaries. A continuous line of defense is needed from South San Francisco to the City of San Mateo.
- Large-scale solutions are expensive and beyond the City's ability to fund alone.
- The City does not own the majority of its shoreline and must work with others to construct protection.
- Any shoreline solutions must be agreed upon by neighboring jurisdictions in order to provide the same level of protection.

Local solutions will generally be smaller-scale opportunities to mitigate risk that fall either entirely within the City's ability to plan, design and execute, or involve collaboration with only one or two external entities. Such solutions may have a shorter planning horizon and are opportunities to mitigate near term risks. Funding from outside the City may still be needed to construct local solutions.

This chapter provides a background on the regional setting and reference studies, existing flood and sea level rise risks, and integration with regional and local efforts (including existing plans, programs, and studies). The chapter concludes with a brief overview of the report chapters.

1.2 Background

The City is located in the middle of San Mateo County (County) and halfway between San Francisco and Silicon Valley. The City lies on the eastern side of the hills that separate the Pacific Ocean from the San Francisco Bay (the Bay). The City is bordered to the south by the City of Burlingame, to the north by the City of San Bruno, and to the northeast by the San Francisco International Airport (Airport), as shown on

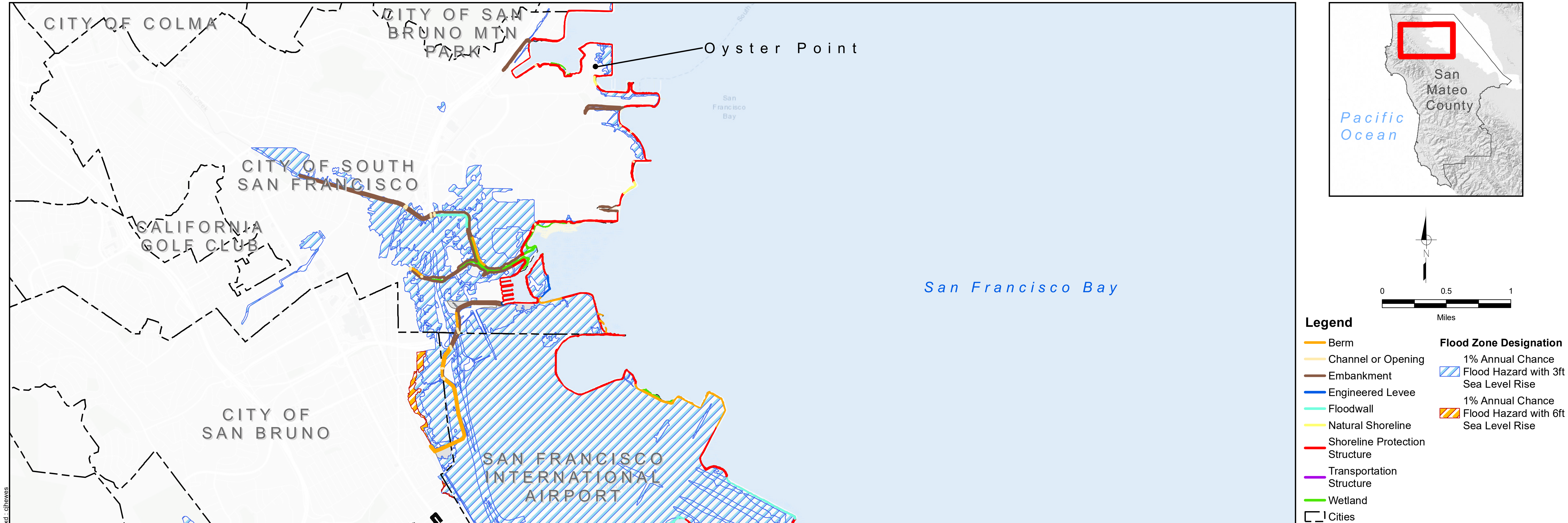
Figure 1-1. The City is home to over 21,000 people, and, as a transportation hub, serves thousands more throughout the San Francisco Bay Area (Bay Area) each day.

Due to its idyllic location along the Bay, the City is particularly vulnerable to the impacts of future climate change. Sea level rise, storm surge, and extreme temperatures are projected to increase significantly in the coming decades. In order to maintain its high quality of life, prosperous businesses, productive ecosystems, and vibrant neighborhoods, the City is proactively planning for the challenges that a changing climate may bring. To do so, the City has begun by developing this Sea Level Rise Adaptation Assessment (Assessment) to better understand the risks of rising sea levels, identify potential local and regional adaptation measures, and identify opportunities to integrate recommended actions into existing or future City plans to fund and construct the necessary infrastructure to protect the City.

1.2.1 Regional Setting and Existing Flood Control

Elevations within the City range from 620 feet North American Vertical Datum of 1988 (NAVD88) to 0 feet on the City's western boundary near sea level at the Bay. With this topography, the area west of Interstate 280 (I-280) drains into San Andreas Lake, and I-280 and the areas east of I-280 generally drain through the City to the Bay. Water from San Andreas Lake does not cross I-280 and enter the City. The City's drainage system consists of a network of 21 miles of storm drains, three pump stations, and approximately 3 miles of open creeks and ditches that route storm runoff through the City to the Bay. Two canals, Cowan Canal and Lomita Canal, are shared with the City's neighboring cities. Cowan Canal runs along the City's southern border with the City of Burlingame. Maintenance of the channel, as well as the pump station near its eastern end, are shared with the City of Burlingame. Lomita Canal is owned by the Airport and both the Airport and City utilize and maintain the Airport Pump Station at its southern terminus to pump water into Highline Canal and out into the Bay. During large storm events, a portion of the City of San Bruno may also drain to Lomita Canal.

Existing regional shoreline protection of the City is provided by both natural high ground and topographic alterations that have taken place since the City was founded. Natural high ground to the west is provided by the mountains. The natural high ground to the north of the City is San Bruno Mountain in South San Francisco, which runs down to the shoreline. Natural high ground to the south is located at Coyote Point, in the City of San Mateo. Coyote Point represents a narrowing of the low-lying Bay shore that could present an opportunity to isolate the region from areas to the south, rather than a complete cutoff from other inundation areas (Moffat & Nichol, 2019). Rising sea water could enter the City from any point along the shoreline from South San Francisco to San Mateo and flood low-lying areas of all the land in between including portions of South San Francisco, San Bruno, the Airport, Millbrae, Burlingame and San Mateo. This region has been dubbed the Colma-San Bruno Operational Land Unit (OLU) by the San Francisco Estuary Institute's Bay Shoreline Adaptation Atlas, as discussed later in this chapter. The region is shown on Figure 1-1.



Sources:
1. Flood zone designations were estimated with sea level rise of 3.3 feet and 6.6 feet using data obtained from the Federal Emergency Management Agency (FEMA) Flood Map Service Center: https://msc.fema.gov/portal/home
2. Bay Shore Features were obtained from San Francisco Estuary Institute's (SFEI) Resilience Atlas.
3. Base imagery is USDA National Agriculture Imagery Program (NAIP) orthoimage for San Mateo County (2016) and was obtained from the USDA Geospatial Data Gateway: https://datagateway.nrcs.usda.gov/GDGHome_DirectDownLoad.aspx

MILLBRAE CLIMATE READY SAN MATEO COUNTY WEST YOST ASSOCIATES

Figure 1-1

Colma-San Bruno Operational Land Unit Sea Level Rise Inundation Areas

City of Millbrae
Sea Level Rise Adaptation Assessment

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1.3 Reference Studies

This Assessment builds upon recent efforts to understand and prepare for sea level rise in the Bay Area and in San Mateo County (the County). Several resources provided the foundation for this Assessment in defining the area, extent of analysis, and an appropriate regional planning boundary and are summarized in within this section

1.3.1 County Sea Level Rise Vulnerability Assessment

In 2018, the County completed a Sea Level Rise Vulnerability Assessment (County's Assessment) (County, 2018) that identified areas and assets within the County at risk of inundation under future sea level rise conditions. The study looked at a variety of economic and social impacts from sea level rise. Three locations within the City received a detailed evaluation, called an Asset Vulnerability Profile: Highline Canal, Millbrae Station, and the Bayshore Freeway. In addition, the County collected data on the City's areas at risk that can be leveraged in future analyses. This Assessment has been funded in part by a County Community Resilience Grant (grant). One of the goals of the grant is to leverage the County's Assessment into action at the local level. Thus, this Assessment builds upon information provided in the County's Assessment.

1.3.2 Federal Emergency Management Agency Flood Insurance Study

The Federal Emergency Management Agency (FEMA) prepares Flood Insurance Studies (FIS [FEMA, 2019]) and Flood Insurance Rate Maps (FIRMs) for communities throughout the United States to promote an understanding of the risk of flooding to developed areas nationwide. FEMA's FIS 06081C001D-003D discuss flood hazards for the City. Both 1% annual chance and 0.2% annual chance Base Flood Elevations (BFEs) are mapped on the City's FIRMs (Panels 06081C0131F-0134F and 0151F). Although the most recent update to the FIRMs was released in April 2019, the hydraulics of the City's drainage system were last analyzed by FEMA in 1980. Flood hazards are based on analyses of riverine flooding due to runoff as well as Stillwater high tides on the Bay.

The County's Assessment identified areas at risk from sea level rise based on an increase from the mapped BFEs. Since the County's Assessment was completed, FEMA revised the FIRMs and FIS for the City. This study therefore updated the mapping of the risks from sea level rise based on the new FIRMs. This effort is further discussed in Chapter 3.

1.3.3 The San Francisco Estuary Institute Bay Shoreline Adaptation Atlas

The San Francisco Estuary Institute's (SFEI) Bay Shoreline Adaptation Atlas (Adaptation Atlas [SFEI, 2019]) identifies, based on physical and ecological processes around the Bay Area, a set of OLUs that have similar characteristics and are suitable for similar types of sea level rise adaptations. SFEI's Colma-San Bruno OLU was used to define the regional planning boundary for this Assessment, as shown on Figure 1-1. The Adaptation Atlas shoreline inventory provided the basis for mapping existing shoreline protection features and its recommended adaptation measures offered a variety of adaptation strategies that were considered during this Assessment. The region is further discussed in Chapter 2.

1.4 Flood Risks

There are two types of potential flooding within the City under existing conditions: Bay flooding caused by high tides and storm events, and inland flooding caused by high rainfall and runoff. The two types of flooding can occur at the same time and such combined flooding presents the greatest flood hazard. The City has existing challenges in drainage system performance and when sea level rise is considered, these challenges are expected to increase.

1.4.1 Existing Flood Risks

The primary cause of existing flooding is runoff that exceeds the capacity of the drainage system. This system is generally designed to contain the 10-year storm event runoff. Larger events flow toward the Bay through developed areas and are impeded from leaving the City by the railroad embankment that runs parallel to the shoreline, among other features. The City's Storm Drain Master Plan (City, 2018) has analyzed storm drain system performance and highlighted locations with insufficient capacity that are further discussed in Chapter 5.

Although the cycle of higher and lower tides in the San Francisco Bay is predictable, winter storm events may result in higher-than-usual high tides, due to low atmospheric pressure, coupled with wind-driven waves and runup onto the shore. Such events are termed storm surge. Storm surge may occur during the same storms that cause high runoff events. When such events occur concurrently, the event is termed "combined flooding." Historically, the City has experienced minimal impacts from combined flooding.

1.4.2 Risks from Sea Level Rise

As climate change occurs, the intensity of rainfall events is expected to increase, leading to higher peak flows. Rising sea levels, coupled with this increased runoff, may overwhelm existing drainage systems more severely and more frequently. The City's Storm Drain Master Plan performed an analysis of higher Bay tides on the City's drainage system and found that the capacity of the lower end of the system would be overwhelmed by sea levels exceeding the 6-10 foot height of Highline and Cowan canals, with or without any runoff. At lesser amounts of sea level rise, or for storm events exceeding the 10-year event, the City would likely experience flooding.

In addition, the County has prepared preliminary modeling of the impacts of combined flooding on the extent of floodplains within the City and has shown that the true risk from flooding could expand significantly in the future.

Mid-Level and High-End Sea Level Rise Scenarios

This Assessment builds on the County's Assessment and therefore uses the same estimates of future sea level rise. The County's Assessment used sea level rise projections from Point Blue's Our Coast, Our Future (OCOF) tool (Point Blue, 2016). The baseline scenario shows the possible extent of flooding with a 1% annual chance storm. The City has existing development standards intended to reduce damage from the 1% annual chance storm. Therefore, this Assessment focuses on preparing for the mid-level and high-end scenarios. The mid-level scenario shows the possible extent of flooding during a 1% chance annual storm plus 3.3 feet of sea level rise. The high-end scenario shows the possible extent of flooding during a 1% chance annual storm plus 6.6 feet of sea level rise. According to a comparison of climate models by OCOF, these amounts of sea level rise could be seen between the years 2070 and 2100.

FEMA's FIRMs identify a 1% chance event BFE of 10 feet NAVD88, making the elevations of the mid-level and high-end scenarios 13.3 and 16.6 feet NAVD88, respectively. The extent of inundation under these scenarios was updated from the County's Assessment, and this mapping is discussed in Chapter 3.

BASELINE SCENARIO	1% annual chance flood (present-day extreme flood also known as 100 year flood)
MID-LEVEL SCENARIO	1% annual chance flood + 3.3 feet of sea level rise
HIGH-END SCENARIO	1% annual chance flood + 6.6 feet of sea level rise

Figure 1-2. Definition of Baseline, Mid-Level, and High-End Scenarios (Credit: County of San Mateo, 2018)

Assets at Risk

The County's Assessment identified assets at risk within the City, based on data available at the time, broken out by asset class, as defined by the American Society of Civil Engineers in *Flood Resistant Design and Construction* (American Society of Civil Engineers, 2014). With updated mapping, this Assessment has also updated and expanded the catalog of assets at risk. These assets, along with potential lost annual City tax revenue are detailed in Chapter 3.

1.5 Integration with Other Efforts

The Assessment must be integrated with other planning efforts to be effective. Some of the relevant regional and local efforts underway are summarized below. The outreach and engagement with owners of these efforts is further discussed in Chapter 2.

1.5.1 Regional Efforts

In addition to the County, FEMA, and SFEI studies discussed earlier, a number of other regional efforts are currently underway to better understand sea level rise impacts and propose adaptive measures. These include efforts by the County, the City of Burlingame, the City of Foster City, the City of San Mateo, and the Airport.

1.5.2 San Mateo Flood and Sea Level Rise Resiliency District

In March of 2018, the County began work to develop a new District focused on flooding and sea level rise. The District will consolidate the work of the existing Flood Control District and Flood Resiliency Programs within the County and initiate new countywide efforts to address sea level rise, flooding, coastal erosion, and large-scale stormwater infrastructure improvements through integrated regional planning, project implementation, and long-term maintenance. The City has signed a Memorandum of Understanding to participate in the efforts of this District as part of its adaptation and funding strategy.

1.5.3 Sea Change San Mateo County

In 2013 the County began work to create an Office of Sustainability and, in 2015, it launched Sea Change San Mateo County. One of the major outcomes of this initiative was the *Sea Level Rise Vulnerability Assessment* that formed the foundation of this Assessment (County of San Mateo, 2018). Sea Change San Mateo County continues to address the challenge of sea level rise by working together with and providing resources to local governments, stakeholder agencies and communities groups to create a prepared and stronger County.

1.5.4 City of Burlingame's Assessment

Concurrent with the City's Assessment, the City of Burlingame was funded to prepare a similar assessment to highlight the risks and vulnerabilities of sea level rise and to develop initial concepts for adaptation that address these risks. The City of Burlingame's assessment also builds on the County's Assessment, SFEI's *Bay Shoreline Adaptation Atlas* (SFEI, 2019), and FEMA's mapping to identify vulnerabilities. Burlingame's Assessment includes a Technical Advisory Committee (TAC) to bring stakeholders to the table and the City is participating in this TAC.

1.5.5 City of Foster City Levee Protection Planning Study

Foster City's efforts to prepare for and address sea level rise were presented in their 2015 *Levee Protection Planning Study* (Foster City, 2015). The City adopted sea level rise projections of up to 3 feet by 2100, based on the best available information at the time. Although they are not within the same OLU, their plans provide an excellent guidepost to expected planning, design, cost and regulatory issues that may be faced in implementing this Assessment.

1.5.6 City of San Mateo Planning Studies

The Coyote Point Recreation Area is managed by the County Parks Department on land granted by the City of San Mateo in 1965. To prepare for future sea level rise risks, the County developed the Coyote Point Sea Level Rise Vulnerability Assessment (Moffat & Nichol, 2019). The report highlights flood risks for 2030, 2050, and 2100 plus the 1%-annual-chance flood and the market and non-market economic impacts of flooding to the site. The sea level rise projection adopted for this study was the Ocean Protection Council's 2018 State of California Sea Level Rise Guidance (California Department of Natural Resource and the Ocean Protection Council, 2018) medium- to high-risk aversion level with up to

6.9 feet of sea level rise projected for 2100. This correlates to planning elevations up to 17.3 feet NAVD88. The Recreation Area is implementing construction projects identified in the Plan, including raising the Bay Trail, moving infrastructure inland, and reuse of dredge material.

The City of San Mateo has a BFE of 10.4 feet NAVD88 and has used a sea level rise projection of 3.4 feet based on the high end of the 2100 high emissions "likely range" from the *State of California Sea Level Rise Guidance* (California Natural Resource Agency and the Ocean Protection Council, 2018) for a recent update to the wastewater treatment plant. This correlates to a planning elevation of 13.7 feet NAVD88.

1.5.7 Airport Shoreline Protection Program

The Airport is immediately adjacent to the City. Since the early 1980s, the Airport has been constructing various types of seawalls including earth berms, concrete dikes and vinyl sheet piles. However, there are gaps and low points of various lengths along the shoreline that may allow flooding. Recognizing the flood risks, in 2015 the Airport completed the *Airport Shoreline Protection Feasibility Study* (City and County of San Francisco, 2015) to better understand the deficiencies in its existing shoreline protection system. The study also provides recommendations on improvements needed to protect the Airport from a 1% annual change (100-year) flood and 11 inches of sea level rise. This led to ongoing Shoreline Protection planning to enhance protection of nearly 8 miles of shore to account for future sea level rise up to 36 inches. Many of the improvements are expected to be accomplished with vinyl sheet piles protected with riprap with self-deploying flood gates as needed at access points. The Airport expects to begin construction of the improvements in 2025 (San Francisco, 2019).

1.5.8 Local Efforts

This Assessment relies on information from City studies that have already been completed and must be reflected in future or ongoing City planning efforts in order to be implemented. Some of the local planning efforts include the following:

1.5.9 General Plan Update

The City's *General Plan* represents the community's view of its future and expresses the community's development goals. The *General Plan* contains the goals and policies upon which the City Council and Planning Commission will base their land use decisions through 2040. The City is currently undertaking an update to the *General Plan* that will reflect priority development areas around the City's transportation hub, the Millbrae Intermodal Transit Station. Development in this area will be subject to potential sea level rise.

1.5.10 County's Climate Action Plan

The County has two climate action plans currently in place: a *Government Operations Climate Action Plan* and a *Community Climate Action Plan* (County, 2011; County, 2013). The County's Office of Sustainability is responsible for the update and implementation of both plans, ensuring that the County meets its greenhouse gas (GHG) emissions reduction commitments. The City participates in this regional planning effort and will use applicable approaches in the *City of Millbrae Climate Action Plan* (January, 2020), currently in progress. Any actions to reduce GHG emissions may mitigate the impacts of sea level rise.

1.5.11 Storm Drain Master Planning

As discussed above, in 2018 the City prepared a *Storm Drain Master Plan* (City, 2018) that studied the hydraulics of its trunk drainage system and identified potential improvements to enhance system performance. The Master Plan also identified significant impacts from future sea level rise. The City is continuing to expand mapping and modeling of its existing drainage system, as well as reflecting new developments as they occur. These efforts will help the City to prepare for and mitigate the impacts of increased runoff as climate change.

1.5.12 City Floodplain Management Ordinance

With the release of updated FEMA FIS mapping in April 2019, the City reviewed its floodplain management ordinance. The City currently exceeds the minimum requirements of the National Flood Insurance Program (NFIP) for protection of development in floodplains by requiring structures to be elevated or flood proofed a minimum of two feet above the BFE. As a result of this Assessment, the City will assess whether further development restrictions may be appropriate to protect lives and property.

1.5.13 Local Hazard Mitigation Plan Annex

The *San Mateo County Hazard Mitigation Plan* (HMP) (County, 2016) is multi-jurisdictional and communities countywide have developed annexes to the plan to reflect disaster preparedness at the local level. The City is currently working on an update to the local annex that will reflect the potential impacts of climate change and sea level rise, and the County plans to embed multiple future climate hazards in the next update.

1.6 Assessment Report Structure

This Assessment includes the following chapters that describe work completed, identify local and regional strategies to mitigate risk, outline the community engagement strategies employed, and recommend future steps toward risk resiliency. Subsequent chapters cover the following topics:

- **Chapter 2, Regional Collaboration and Community Engagement—**This chapter discusses the efforts made toward a regional collaboration, input from stakeholders in regional and local mitigation strategies, and other outreach.
- **Chapter 3, Risk Assessment—**This chapter discusses the data collected and used for this Assessment, the update of the inundation mapping under the County's two sea level rise scenarios, and the updated catalog of assets at risk, as well as an asset vulnerability profile for the City's Water Pollution Control Plant.

- **Chapter 4, Regional Mitigation Strategies—**This chapter outlines regional mitigation strategies identified in previous studies, or through collaboration with regional partners, discusses the merits of each potential approach, and highlights strategies that should move forward to the next phase of planning.
- **Chapter 5, Local Mitigation Strategies—**Building on information about key assets identified in Chapter 3, this chapter outlines potential risk mitigation strategies that improve local drainage to meet the higher design criteria necessary to prevent future combined flooding, on-site mitigations for City-owned facilities, and potential modifications to development standards.
- **Chapter 6, Recommendations—**This chapter outlines the primary recommendations for next steps to plan, fund, design, and construct mitigations as well as to move forward with integration of future efforts and continue local and regional stakeholder engagement. This chapter discusses data collected and used for this Assessment, inundation mapping update based on the County's two sea-level rise scenarios, and an updated catalog of assets at risk.

  This chapter also presents an in-depth assessment of the City's Water Pollution Control Plant (WPCP) in an asset vulnerability profile. This assessment is in keeping with previously completed Asset Vulnerability Profiles (AVPs) for other City facilities that were prepared during the County's *Sea-Level Rise Vulnerability Assessment* (County Assessment) (County, 2018).
- **Chapter 7, References—**This chapter provides a list of references used in preparing this Assessment and understanding risks to the City and the region from sea level rise. Although new information is continuously under development, this list of references provides a useful foundation for future studies.

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2. REGIONAL COLLABORATION

This chapter discusses the efforts made toward a regional collaboration, outreach to, and input from stakeholders in the regional and local mitigation strategies.

2.1 Operational Land Unit Stakeholders

As addressed in Chapter 1, the current regional shoreline of the City is protection by natural high ground as well as the topographic alterations that have taken place since the founding of the City. To the north, the natural high ground is comprised of San Bruno Mountain in the City of South San Francisco and runs down to the shoreline at Oyster Point. To the South, natural high ground is located at Coyote Point within the City of San Mateo. As discussed in Chapter 1, the region is designated as the Colma-San Bruno OLU. SFEI's Atlas (SFEI, 2019) identifies OLUs as "connected geographic areas sharing certain physical characteristics that would benefit from being managed as a unit to provide particular desired ecosystem functions and services". Rising sea water could enter the City from any point along this portion of the shoreline and flood low-lying areas of all the land in between including the City and all or part of the following:

- The City of South San Francisco
- The City of San Bruno
- The Airport
- The City of Burlingame
- The City of San Mateo

Each of these jurisdictions must be partners in developing continuous shoreline solutions to sea level rise. Along with San Mateo County, they were considered the regional partners, or primary stakeholders, under this Assessment. It is anticipated that further outreach will be necessary as planning progresses to include non-profits, further utilities, and agencies.

2.2 Outreach to Stakeholders in the OLU

Outreach to regional partners was an important part of the Assessment. Efforts included participation in the TAC for the City of Burlingame's Assessment and individual meetings, correspondence, and calls with the Airport, the City of San Mateo, and the County of San Mateo. Communication was also initiated with Pacific Gas and Electric (PG&E), due to PG&E assets identified within the mid-level and high-end scenario inundation areas, as discussed in Chapter 3.

2.2.1 City of Burlingame

Since the City of Burlingame performed a sea level rise adaptation assessment concurrent with this Assessment, significant collaboration occurred between the cities in 2019. TAC meetings were held by Burlingame on July 10 and October 16, 2019 to review their progress and seek input. Similar to this Assessment, Burlingame selected the mid-level and high-end scenarios for evaluation of future sea level rise, with elevations of 13.3 feet and 16.6 feet, NAVD88 near Millbrae. Significant discussions around potential mitigation strategies took place and there was a general agreement on the definition of the OLU as the regional planning area and on approaches to mitigation.

2.2.2 San Francisco International Airport

As discussed in Chapter 1, since 2015, the Airport has been moving forward with planning, design, and construction of enhancements to the shoreline protection of its property. Once completed, approximately 8 miles of OLU shoreline to the north of the City will be protected. The Airport is currently pursuing a plan to isolate its property from the surrounding communities in order to obtain FEMA certification to remove the Airport from the floodplain. This will include shoreline improvements to ensure a unified level of protection along the shoreline and a backside levee along the property's west side.

The City met with the Airport's staff on February 7 and November 10, 2019 (City of San Francisco, 2019) to review the status of the *Shoreline Protection Plan*. Key information sharing included the potential design options considered by the Airport and the idea of a mitigation banking program that would allow cost sharing for shoreline infrastructure mitigations throughout the OLU. The reaches of Airport shoreline nearest to the City are reaches 14 and 15 in the Airport's plan. The Airport anticipates adding vinyl sheet pile wall with waterside riprap to fill gaps in protection, and to increase the height of existing protection to 15.3 feet NAVD88. This level of protection represents a sea level rise of 36 inches, with an additional 24 inches of freeboard to allow for FEMA certification.

2.2.3 Pacific Gas & Electric

PG&E owns and maintains powerlines, a sub-station, and gas lines through the City and supplies the region with power. On July 3, 2019, a meeting was held with PG&E staff to review information used by the utility to plan for climate change, ongoing efforts and future plans for infrastructure adaptation. In 2016, PG&E prepared a *Climate Vulnerability Assessment* (PG&E, 2016) that recommends ongoing actions to assess and address the concerns of multiple climate change impacts, including sea level rise. The sea level rise scenario for PG&E's risk assessment is 2 feet above mean higher high water (MHHW), based on the higher end of the 2050 sea level rise expected by the California Coastal Commission (California Coastal Commission, 2015). MHHW in Millbrae is approximately 6.69 feet NAVD88 based on a National Oceanic and Atmospheric Administration (NOAA) conversion for Oyster Point (NOAA, 2019). Therefore, it appears that PG&E is considering future sea level rise to an elevation of 8.69 feet NAVD88.

Because sea level rise is a longer-term risk, PG&E does not as of the writing of this Assessment have a strong sense of how assets will be protected. Currently, PG&E is participating in a variety of local government-led studies and initiatives to better understand and plan for potential impacts. In the near term, PG&E is also undertaking a more robust coastal flood risk analysis of at-risk assets using additional scenarios of sea level rise. However, with a SLR planning elevation of 8.69 feet NAVD88, PG&E facilities serving the City could be significantly impacted under both the mid-level and high-end scenarios.

2.2.4 City of San Mateo

In addition to shared participation on the City of Burlingame's TAC, the City held a coordination call with the City of San Mateo on sea level rise adaptation on November 8, 2019. This Assessment was introduced, and a discussion of future planning efforts took place. The City is aware of plans to prepare throughout the County but has not undertaken a City-wide study of sea level rise impacts to date.

2.3 Public Engagement

The long-term success of any planning effort is determined by the support of stakeholders. Due to the potential impacts to the City's downtown and the region as a whole, all of the City's citizens are considered important stakeholders in the Assessment process. Goals of the public engagement process for this Assessment included educating citizens of the local and regional risks and soliciting input on potential challenges and mitigation measures. The following outreach methods were employed to achieve these goals:

2.3.1 City of Millbrae's Website

The City's website was updated with a new page at focused on climate change (available at the following link: https://www.ci.millbrae.ca.us/departments-services/public-works/sea-level-rise-climate-assessment). The website introduces the Assessment to the public and references local and regional resources and data and solicits engagement in the Assessment process. Information distributed through the website included a Sea Level Rise Adaptation Assessment & Community Survey (see Section 2.3.4 below) and information and notices for the Community Meeting discussed in Section 2.3.3.

2.3.2 Social Media

In May 2019, the City began a social media campaign using Facebook, Nextdoor, and Twitter to increase awareness of the risks of sea level rise. Posts included an overview of the Assessment, encouragement to attend a public meeting, and encouragement to take the public survey described below. Information reflecting total number of individuals reached through each medium are summarized in Table 2-1.

Table 2-1. Number of Individuals Reached by social media campaign.

Media/Campaign	Sea Level Rise Adaptation Assessment & Community Survey	Special Community Meeting on Sea Level Rise Adaptation Assessment
Facebook	Individuals reached on 6/6/2019: **264** Individuals reached on 6/11/2019: **460**	Individuals reached on 5/28/2019: **1,207** Individuals reached on 6/13/2019: **212**
Nextdoor	Individuals reached on 6/6/2019: **667** Individuals reached on 6/11/2019: **675**	Individuals reached on 5/28/2019: **1,487** Individuals reached on 6/13/2019: **575**
Twitter	Individuals reached on 6/6/2019: **500** individuals reached on 6/11/2019: **322**	Individuals reached on 5/28/2019: **499** Individuals reached on 6/13/2019: **283**

2.3.3 Community Meeting

To introduce the Assessment and solicit input from citizens and other stakeholders, a City-wide public meeting was held on June 13, 2019. Topics of discussion included the following:

- How sea level rise and climate change are impacting the City
- What is being done to mitigate sea level rise
- Understanding local vulnerability
- Where mitigations efforts should be focused

A discussion of potential types of shoreline mitigations presented pros and cons of various types of infrastructure and solicited input on residents' concerns. Along with the results of the public survey, this input was used to inform the discussion of alternatives in Chapters 4 and 5 and make recommendations in Chapter 6.

2.3.4 Community and Stakeholder Online Survey

In support of the Assessment, the City developed an online survey with multiple choice and open-ended questions about sea level rise. Questions included questions about each respondent, and both focused questions and open-ended questions about potential mitigations. A total of 17 people responded to the survey and a complete set of responses is included in Appendix A with a summary of the open-ended responses included in this section. As shown in Figure 2-1, the survey found that most respondents live in Millbrae west of El Camino Real (generally in the potential sea level rise inundation areas) or east of El Camino Real (generally out of the potential inundation area and impacted indirectly). The remaining respondents work in, travel through, or are concerned with sea level rise in the City.

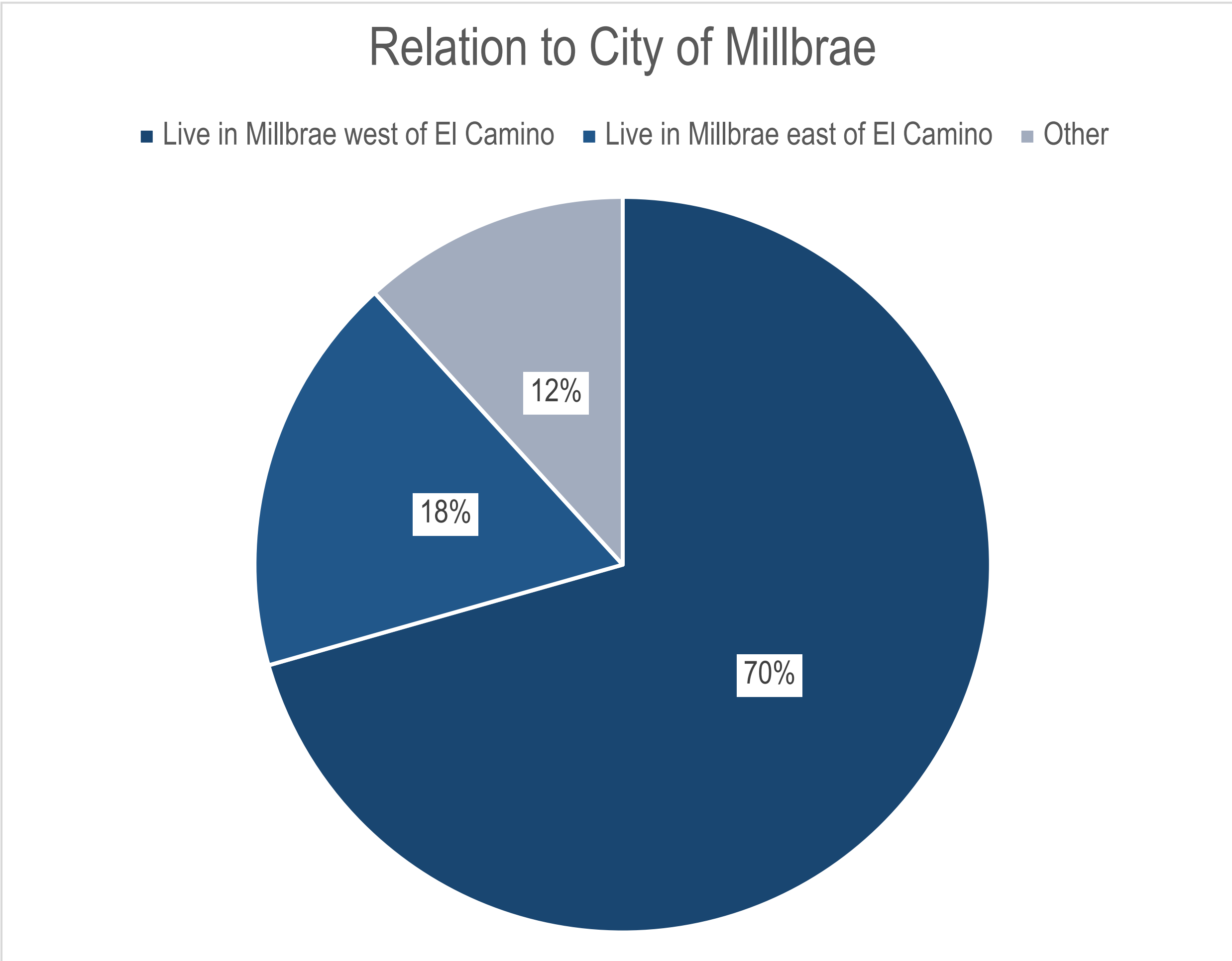

Figure 2-1. Survey Respondent Relation to the City of Millbrae.

A total of 71 percent of respondents keep up with information on sea level rise, but only 53 percent view sea level rise as a significant concern.

When weighing the responses of those who are concerned about sea level rise more heavily than those who are not concerned according to Table 2-2 below, maintaining views of the shoreline and recreational access and enhancing habitat where possible were top concerns as shown in Figure 2-2.

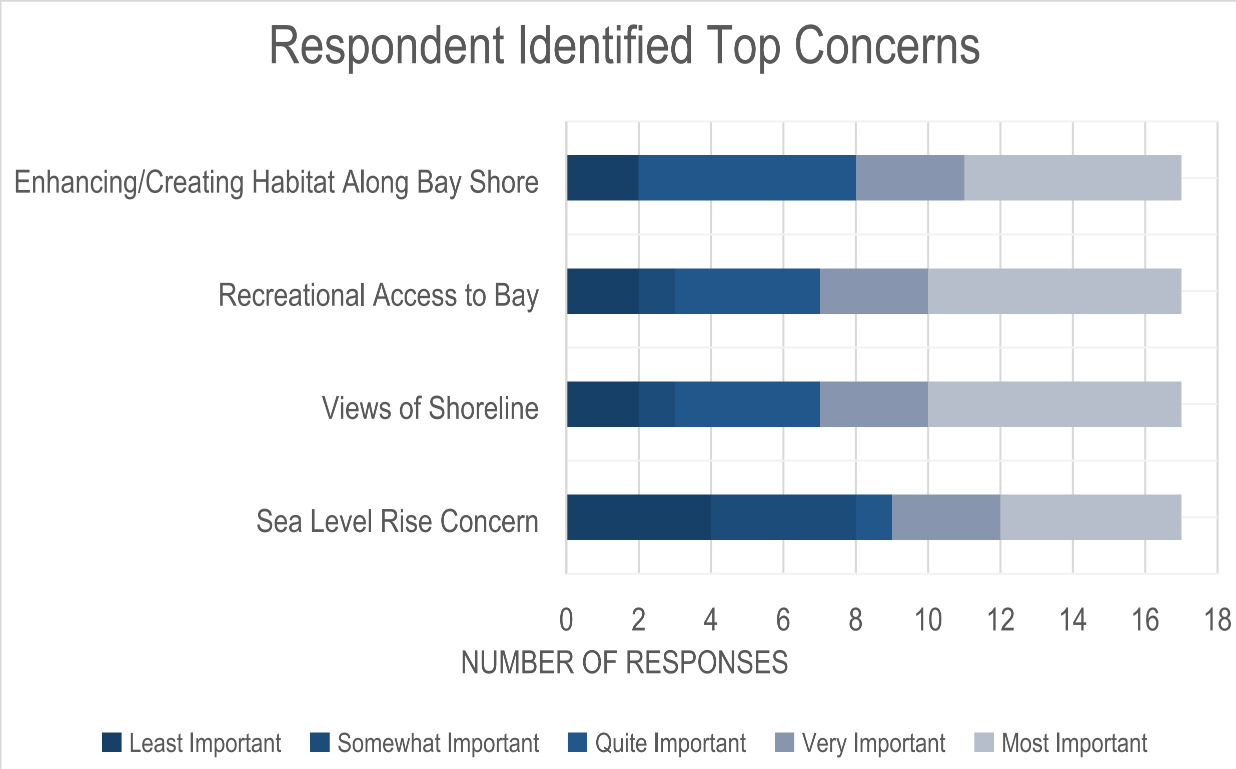

Figure 2-2. Survey Results of Respondent Identified Top Concerns.

Support for a change in development patterns to reduce the impacts of future sea level rise was moderate, while 80 percent of residents would be willing to contribute financially to varying degrees.

Table 2-2. Number of Residents Willing to Contribute Financially to Mitigation.

Annual Contribution	Resident Respondents
$1,000 or more	3
$500 or more	2
$200 or more	5
Less than $200	2
Not willing to contribute	3

Key concerns of respondents included the potential loss of infrastructure and roadways, connectedness, environmental and recreational space and residential areas. A summary of the open-ended responses to each of the survey questions follows. In response to a question about impacts that should be considered, respondents indicated the following concerns:

- Loss of infrastructure
- Maintenance of infrastructure

- Environmental and recreational impacts
- A loss of access to endangered areas
- Traffic congestion
- Loss of life
- Loss of public and personal vehicles and homes
- Potential increase in crime and the homeless population in Millbrae

In response to a question about what shoreline solutions the City of Millbrae should consider constructing, respondents indicated:

- Vegetation and natural solutions that may have a mitigating effect, including marshland restoration
- Elevation and retreat, potentially for particular structures
- Consider no further solutions

Recommendations for adaptation included enhancing emergency preparedness within the community overall and implementing nature-based solutions. In addition to these responses, it is important to note that some responses were received that did not pertain directly to the questions asked, but provided useful input that should be considered. Some of these responses suggested:

- Frequent monitoring of sea level rise and repairs/adjustments as needed
- Warning/alarm equipment installation and testing, including public trainings and drills, and emergency instructions
- Implementing a requirement for residents to sign up for SMC Alert
- Cooperation with the Airport and City of Burlingame and other adjacent communities should continue
- Ensure the City's approach takes seriously the severity and need for immediate action to mitigate risks
- The City should undertake a canal retrofit
- The City should consider increasing the number of first responders

All of the input received during the public outreach was considered in the approaches discussed with Regional partners and recommended in Chapter 6.

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3. RISK ASSESSMENT

Chapter 3 discusses the risk assessment performed, as outlined in the following topics:

- Data collected and used for this risk assessment
- Updates to the inundation mapping prepared by the County for the mid-level and high-end sea level rise scenarios
- Updates to the catalog of assets at risk prepared by the County

This chapter also presents an in-depth assessment of the impacts from sea level rise to the City WPCP's facilities and operations summarized in an AVP. This assessment is consistent with AVPs for other City assets that were prepared during the County Assessment (County, 2018a).

3.1 Asset Vulnerability

One of the primary goals of this Assessment is to better quantify risks to the City from future sea level rise. This chapter identifies projected areas of inundation, impacted assets under the mid-level and high-end sea level rise scenarios, and describes potential financial impacts to the City under each inundation scenario.

3.2 Inundation Mapping

The focus of this Assessment is to better understand impacts from sea level rise and identify conceptual mitigations that could protect the City from the mid-level and high-end scenarios. Mapping inundation areas for these scenarios allows the identification of assets at risk and provides a baseline to compare conceptual mitigation alternatives.

If sea level rise is greater than anticipated, additional assets may be at risk, but topography rises at an increasing rate in the City; as a result, fewer and fewer assets would be missed at increasing heights of sea level rise.

3.2.1 Revised Inundation Areas

As discussed in Chapter 1, projected sea level rise inundation in the City is based on water surface elevations of 13.3 feet NAVD 88 under mid-level scenario conditions, and 16.6 feet NAVD88 under high-end scenario conditions. The County Assessments' inundation areas for the mid-level and high-end scenarios were based on FEMA's FIRMs, which were effective at the time of the County's Assessments. On April 5, 2019, an updated set of FEMA FIRMs were adopted by the City that, while reflecting the same base flood elevation of 10 feet, suggest a significantly expanded floodplain for the 100-year event.

FEMA's FIRM revision was based on updated topographic data. Likewise, for this Assessment, the boundaries of the mid-level and high-end scenarios were re-mapped (as presented in Figure 2-1) based on updated light detection and ranging (LiDAR) survey mapping and the base flood elevation of 10 feet NAVD88 plus 3.3 feet and 6.6 feet, respectively.

3.2.2 Combined Flooding

This Assessment builds on the County's Assessment, which, in turn, references FEMA mapping to identify risks. FEMA mapping of the City does not reflect the impacts of combined flooding. Rather, a Stillwater elevation in the Bay is used to project inland inundation, while separate riverine modeling predicts inundation from runoff. Combined flooding occurs when extreme precipitation coupled with a rise in sea levels prevents runoff from draining. Higher sea levels mean that surface drainage of the watershed must push to drain to the Bay, either by increased pumping to lift the runoff up to sea level or by backing up until the water surface inland is higher than sea level. Without intervention, extreme storms with sea level rise may result in a greater frequency and extent of flooding throughout the City. The City's storm drainage system already lacks the capacity to contain large storm events, and it is anticipated that sea level rise will exacerbate localized flooding, particularly in low-lying portions of the City. Mapping of inundation from increased overland flows along Lomita, Greenhills, and Millbrae creeks due to changes in precipitation intensity from climate change were beyond the scope of this Assessment.

3.3 Identification of Key Assets

The County's Assessment identified inundation areas under the mid-level and high-end scenarios of 187 acres and 254 acres, respectively, within the City. Impacted assets were classified by risk class as defined in the County Assessment and based on the American Society of Civil Engineers' (ASCE's) *Minimum Design Loads and Associated Criteria for Buildings and Other Structures 7-10* and *Flood Resistant Design and Construction 24-14* (ASCE 2013; ASCE 2015). The risk classes can be summarized as follows:

- Class 1: Assets representing a low risk to public safety and society in the event of failure.
- Class 2: Assets except those listed in Classes 1, 3, and 4.
- Class 3: Assets representing a substantial risk to human life and disruption in day-to-day activities in the event of failure.
- Class 4: Assets representing critical infrastructure designated as essential facilities with significant potential impacts to public safety in the event of failure.

The types of assets identified in the County Assessment represent many of the City's key assets. However, as part of this Assessment, the City also considered hotels a key asset, due to their importance to City revenue. Hotels represent Class 3 assets.

Based on the revised inundation areas as described in Section 3.2.1, more than 258 acres of the City would be inundated under the mid-level scenario. This represents a 38% larger inundation area than that identified in the County's Assessment. Similarly, more than 333 acres would be inundated under the high-end scenario, equating to a larger inundation area than that presented in the County Assessment by 31%. Within potentially inundated areas, parcel data from the County (County, 2019) was used to identify the type and value of assets at risk from sea level rise under the two inundation scenarios' conditions. The number of impacted assets was updated from the County Assessment, given the expanded inundation areas and number of assets. The assets are shown on Figures 3-1, 3-2, and 3-3 and are cataloged by class in Table 3-1. Figure 3-1 shows water and drainage infrastructure, Figure 3-2 shows transit and hazardous material infrastructure, and Figure 3-3 shows energy infrastructure, public buildings, and other structures.

Table 3-1. Assets Impacted by Mid-Level and High-End Inundation Areas. Comparison Between County Assessment and Current Assessment.

Asset Types and Classifications	County Assessment		Current Assessment	
	Mid-Level	High-End	Mid-Level	High-End
Class 4 Assets				
Communication towers	4	6	5	8
Electric substations	1	1	1	1
Gas stations and hazardous material sites	1	1	3	8
Highways and railway bridges	2	2	2	2
Highways (miles)	2.4	2.4	2.6	2.8
Levees and floodwalls (miles)	1.9	2	2.8	2.8
Natural gas pipelines (miles)	1.2	1.4	1.4	1.4
Class 3 Assets				
Hotels[a]	--	--	5	5
Rail (miles)	0	1.1	0.3	1.4
Rail stations	1	1	0	1
Roads (miles)	3.1	4.9	8.2	11.2
Storm drains (miles)	1.7	2.8	2.8	3.9
Stormwater pump stations	1	1	1	2
Transmission lines (miles)	3.1	3.8	3.5	4.0
Transmission towers	4	5	25	27
Underground chemical storage	1	2	2	2
Wastewater pump stations	2	2	2	2
Wastewater treatment plants	1	1	1	1
Parks	2	3	3	3

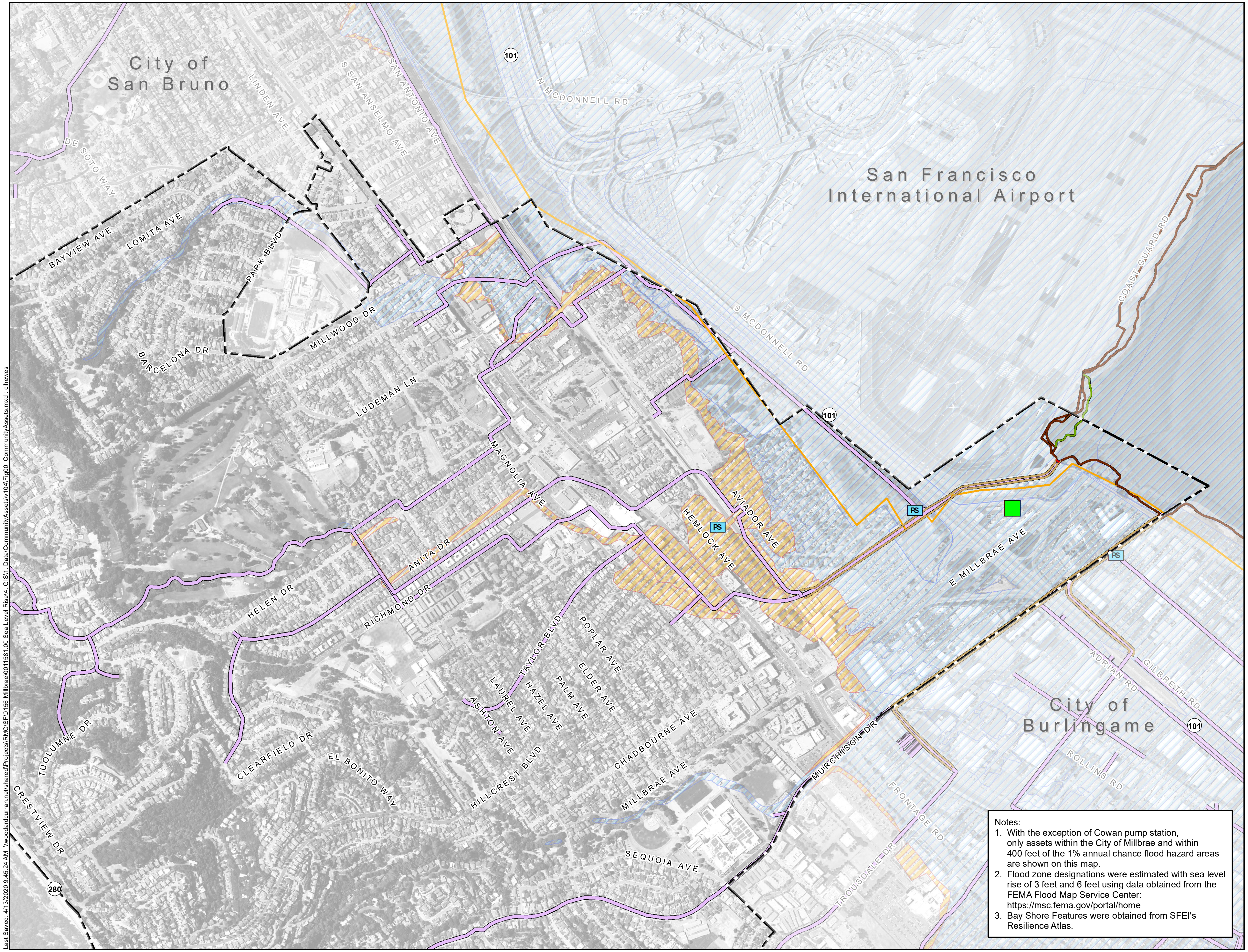
Table 3-1. Assets Impacted by Mid-Level and High-End Inundation Areas. Comparison Between County Assessment and Current Assessment.

Asset Types and Classifications	County Assessment		Current Assessment	
	Mid-Level	High-End	Mid-Level	High-End
Class 1 Assets				
Trails (miles)	1.4	1.8	1.6	2.0

[a]Hotels were not studied in the County's Assessment.
Note: No Class 2 assets were identified in either Assessment.

Hotels that were identified within the inundation areas included the Fairfield Inn and Suites, the Millwood, and the La Quinta Inn and Suites on El Camino Real; the Aloft San Francisco Airport on Millbrae Avenue; and the Westin San Francisco Airport on Old Bayshore Highway. Table 3-1 includes the *Millbrae Station Area Specific Plan* (City, 2016), known as "Transit-Oriented Development 2" buildout, which is underway at 200 Rollins Road, adjacent to the Millbrae Intermodal Transit Station. This development will comprise residential space (including affordable housing), commercial space, and a new hotel. The development is currently being designed and constructed to meet the City's proactive floodplain management standards, which exceed the FEMA minimum standards.

Identification of key assets for this Assessment was limited to risk from inundation, rather than risk from other external vulnerabilities such as a loss of access or supporting infrastructure caused by flooding.



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0 500 1,000

Scale in Feet

Legend

City of Millbrae

Assets

- Water Pollution Control Plant
- Storm Water Pump Station

Structures

- Engineered Levee
- Floodwall or Shoreline Protection Structure
- Water Control Structure
- Wetland
- WPCP Force Main
- Storm Drains

Flood Zone Designation

- 1% Annual Chance Flood Hazard with 3ft Sea Level Rise
- 1% Annual Chance Flood Hazard with 6ft Sea Level Rise

Notes:
1. With the exception of Cowan pump station, only assets within the City of Millbrae and within 400 feet of the 1% annual chance flood hazard areas are shown on this map.
2. Flood zone designations were estimated with sea level rise of 3 feet and 6 feet using data obtained from the FEMA Flood Map Service Center: https://msc.fema.gov/portal/home
3. Bay Shore Features were obtained from SFEI's Resilience Atlas.

MILLBRAE CLIMATE READY SAN MATEO COUNTY WEST YOST ASSOCIATES

Figure 3-1

Community Assets: Water and Drainage

City of Millbrae
Sea Level Rise Adaptation Assessment

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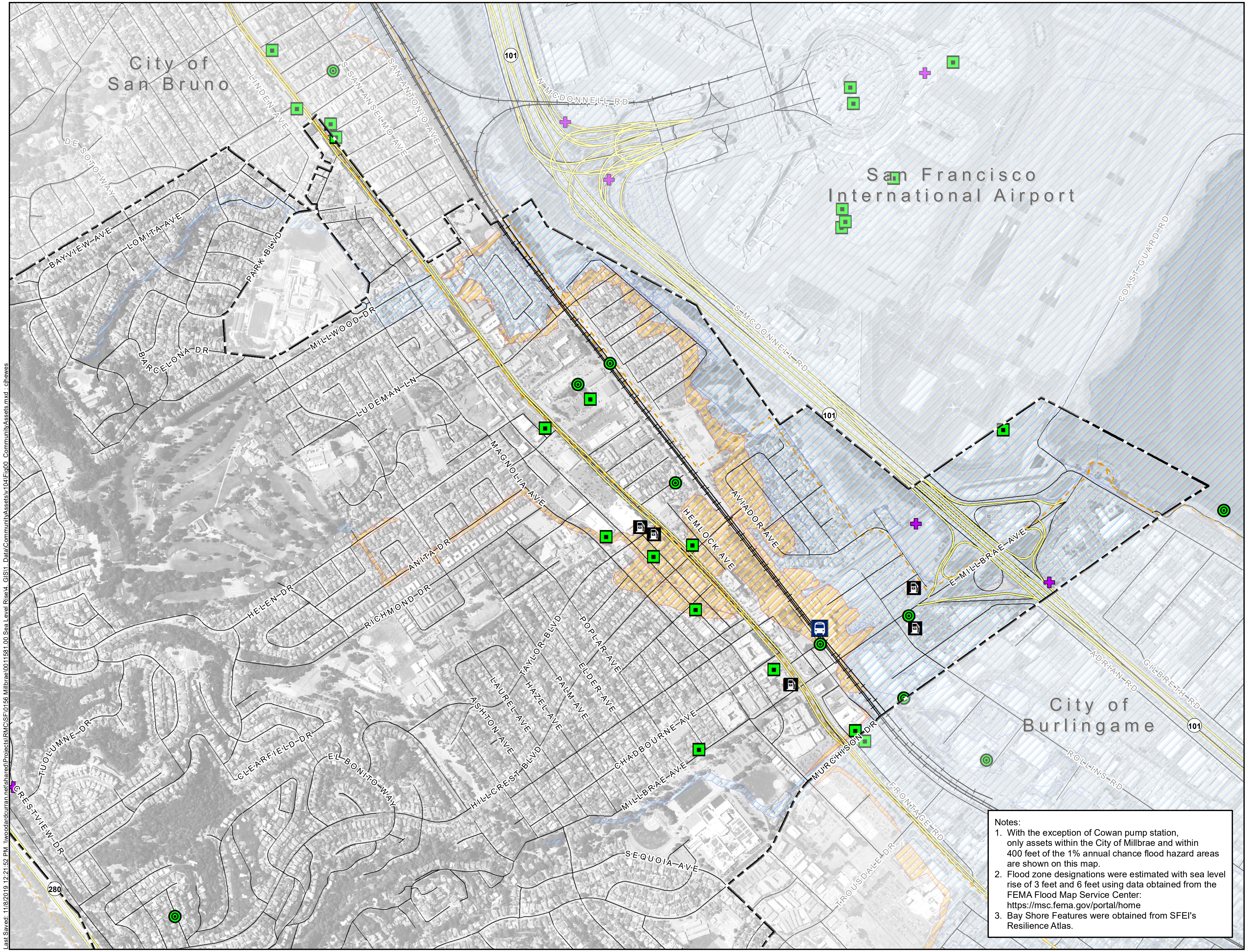

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0 500 1,000

Scale in Feet

Legend

City of Millbrae

Assets

- Millbrae Intermodal Station
- Gas Station
- Underground Storage Tanks
- Hazardous Material Cleanup Sites
- Highway/Railway Bridge

- Rail
- Trails
- Highways
- Streets

Flood Zone Designation

- 1% Annual Chance Flood Hazard with 3ft Sea Level Rise
- 1% Annual Chance Flood Hazard with 6ft Sea Level Rise

Notes:

1. With the exception of Cowan pump station, only assets within the City of Millbrae and within 400 feet of the 1% annual chance flood hazard areas are shown on this map.
2. Flood zone designations were estimated with sea level rise of 3 feet and 6 feet using data obtained from the FEMA Flood Map Service Center: https://msc.fema.gov/portal/home
3. Bay Shore Features were obtained from SFEI's Resilience Atlas.

MILLBRAE

CLIMATE READY SAN MATEO COUNTY

WEST YOST ASSOCIATES

Figure 3-2

Community Assets: Transit and Hazardous Materials

City of Millbrae

Sea Level Rise Adaptation Assessment

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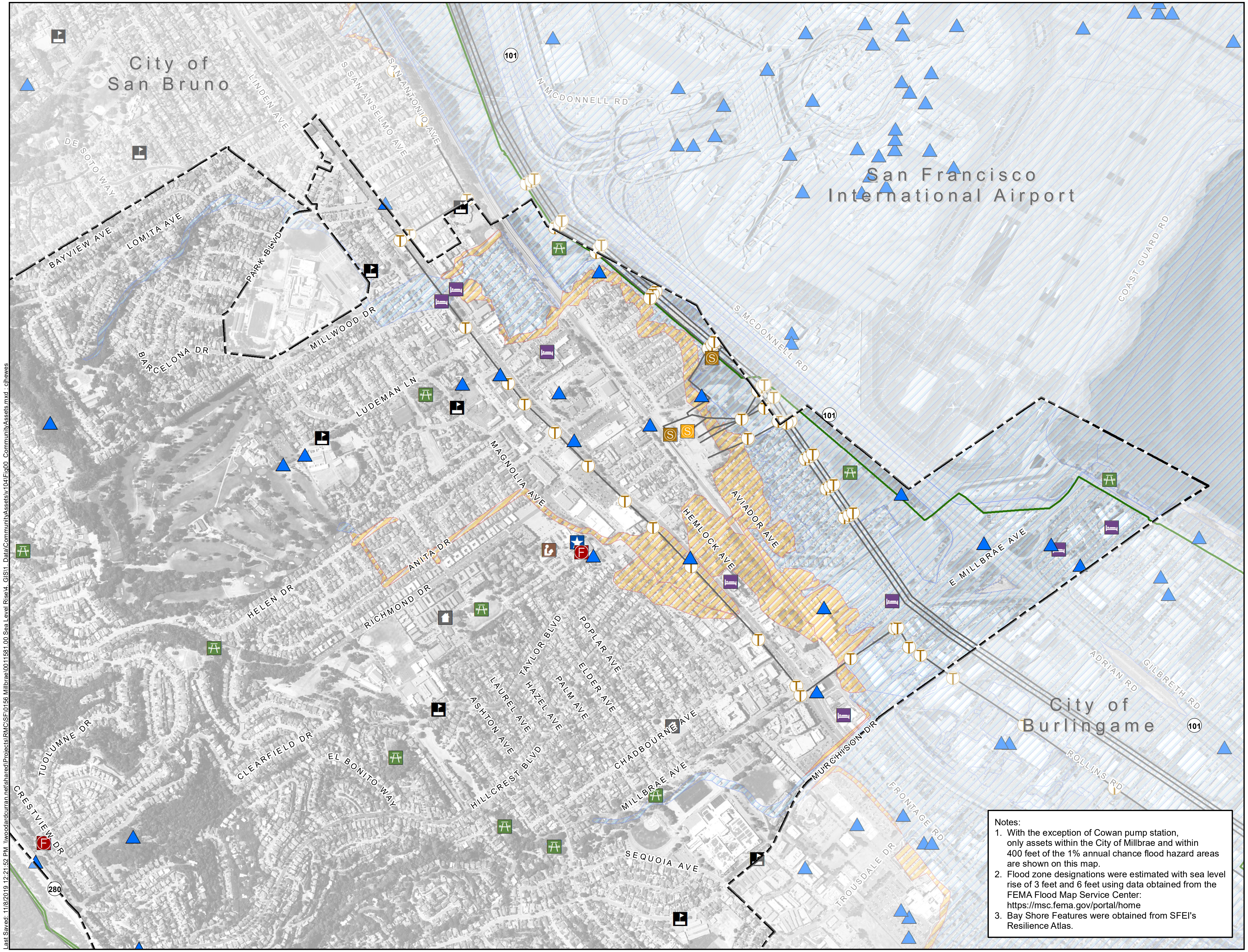

N

0 500 1,000

Scale in Feet

Legend

City of Millbrae

Assets

- PG&E Substation
- Private Substation
- Hotel
- Library
- Fire Station
- Police Department
- School
- Senior Center
- Park
- Communication Tower
- TransmissionTowers
- Transmission Lines
- Gas Lines

Flood Zone Designation

- 1% Annual Chance Flood Hazard with 3ft Sea Level Rise
- 1% Annual Chance Flood Hazard with 6ft Sea Level Rise

Notes:
1. With the exception of Cowan pump station, only assets within the City of Millbrae and within 400 feet of the 1% annual chance flood hazard areas are shown on this map.
2. Flood zone designations were estimated with sea level rise of 3 feet and 6 feet using data obtained from the FEMA Flood Map Service Center: https://msc.fema.gov/portal/home
3. Bay Shore Features were obtained from SFEI's Resilience Atlas.

MILLBRAE CLIMATE READY SAN MATEO COUNTY WEST YOST ASSOCIATES

Figure 3-3

Community Assets: Energy and Structures

City of Millbrae

Sea Level Rise Adaptation Assessment

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3.3.1 Asset Value

The value of properties directly impacted by sea level rise ranges from $250 to $380 million, under the mid-level and high-end scenarios, respectively. Using the *City's 1998 General Plan* land use (City, 1998), land uses were spatially overlain with the two updated inundation scenarios to compute acreage of each land use impacted. Tax revenue data from the San Mateo County Assessor's Office (County, 2019) and the percentage of land use inundated under each scenario were then used to estimate the value of economic impact to the City. Table 3-2 summarizes the City's potential loss from sea level rise under each scenario.

Table 3-2. Potential Lost Tax Revenue based on Land Use and Inundation Scenario (Millions of Dollars).

Inundation Level	Residential	Commercial	Industrial	Other	Total
Mid-Level Scenario	102.9	3.3	0.6	2.9	109.7
High-End Scenario	166.0	5.3	0.7	3.0	175.0

Although the land use dataset used is 21 years old, the City is generally built out, and land use characteristics have changed little since 1998. The estimated revenue impacts are likely conservative because the County Assessor's tax revenue data represents 2018 values, and sea level rise flooding is likely to have far-reaching consequences to the economy—beyond local impacts to inundated structures.

While key assets provide unique value to the City and must be protected to ensure proper functioning of the City in the future, the majority of these facilities are not City-owned, and therefore will necessitate a regional rather than a local mitigation effort. More immediate on-site mitigation efforts will be considered for publicly owned assets, such as those described below and detailed in the AVPs described in the following section.

3.3.2 Asset Vulnerability Profiles

The County's Assessment prepared AVPs for several facilities serving the City, including the Intermodal Transit Center, the Bayshore Highway, and the Highline Canal Tide Gates. These AVPs provide detailed insight into the possible impacts of sea level rise on specific infrastructure and discuss the wider regional implications of those impacts.

Figure 3-4. City's Corporate Yard and Operations Center

As part of this Assessment, an additional AVP (Appendix A) was prepared for the City's 3-million gallon per day Water Pollution Control Plant (WPCP). The site is also home to the City's Corporate Yard and Operations Center, shown in Figure 3-4. This facility was selected for additional study due to its criticality, elevation, and proximity to the shoreline. The goal of preparing the AVP was to better understand the WPCP's vulnerability to sea level rise and to identify potential adaptation concepts for future study and eventual implementation, should Regional shoreline protections fail to materialize.

The additional AVP describes the WPCP's function, along with its sensitivity to sea level rise. The AVP also characterizes the adaptive capacity of the WPCP, and discusses, in general terms, potential consequences that could result from its inundation. The information in the AVP was prepared with input from City staff. These City staff members are responsible for the WPCP and provided context for issues such as potential management or adaptation challenges. Additional supporting information for the WPCP AVP was derived from *Adapting to Rising Tides*.[1]

When considering *Adapting to Rising Tides* data, it is important to convert the mean higher high water (MHHW) datum to NAVD88 to understand the facility's water surface elevations in relation to the base flood elevation. There are two nearby NOAA tide stations as follows:[2]

- San Mateo Bridge station at latitude 37° 34.8' N, longitude 122° 15.2' W (approximately 7 miles southeast of the WPCP)
- Oyster Point station at latitude 37° 39.9' N, longitude 122° 22.6' W (approximately 4 miles northeast of the WPCP)

Due to the WPCP's location and the impact of storm surge, MHHW at these stations varies significantly, ranging from 0.9 feet NAVD88 at San Mateo Bridge station to 2.3 feet NAVD88 at Oyster Point station. NOAA's Vdatum software[3] was used to convert between MHHW and NAVD88 at each station. A weighted average was then used to estimate the conversion between datums at the WPCP.

Historically, the WPCP has never been inundated by external flooding. However, the approximately 200,000 square-foot WPCP site is highly vulnerable to future sea level rise. For example, sea level rise ranging from 2 to 3 feet would likely inundate approximately 30 percent of the WPCP. A 2019 insurance appraisal valued the WPCP property at $55 million, which equates to approximately $275 per square-foot. Therefore, if 30 percent of the WPCP property is inundated due to sea level rise, a 60,000 square-foot area is at risk of significant damages totaling an estimated $16.5 million.

3.4 Mitigation Reaches and Vulnerabilities

Any low point along the shoreline within the OLU may allow floodwaters to enter the City. While an analysis of all flooding pathways in the region is beyond the scope of this Assessment, local vulnerabilities were cataloged and are flagged on Figure 3-4. These vulnerabilities are discussed below by

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[1] https://explorer.adaptingtorisingtides.org/explorer

[2] https://tidesandcurrents.noaa.gov/stations.html?type=Datums

[3] https://vdatum.noaa.gov/vdatumweb/

reach, with reaches distinguished by ownership and/or type of potential mitigation. Figure 3-4 presents a map of the reaches evaluated and discussed in this section. Elevations along the shoreline, Highline Canal, and Cowan Canal were analyzed using LiDAR data and the SFEI's Bayshore structure data to identify potential low points. Cross sections were taken from the LiDAR data to confirm elevations.

There are uncertainties in the vulnerability information due to the resolution of elevation data in the LiDAR data. SFEI's data were also assembled at a County-wide scale. As a result, actual elevations along the canals and shoreline could be significantly higher or lower than the elevations presented in Figure 3-5. Before feasibility and planning and design efforts begin for conceptual mitigative solutions, each reach should be surveyed to confirm the true elevations.

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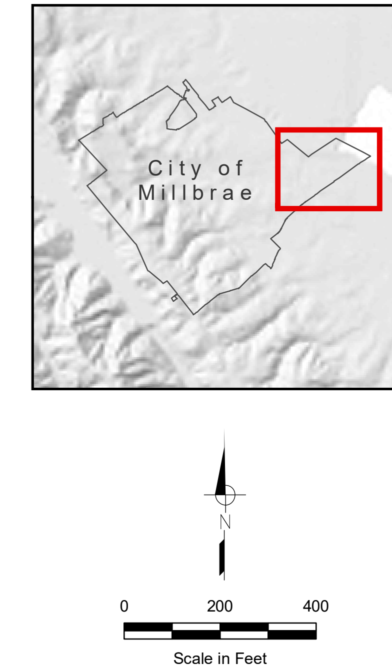

Legend

- Vulnerable Sections
- City of Millbrae

Structures

- Engineered Levee
- Floodwall or Shoreline Protection Structure
- Water Control Structure
- Wetland

Land Surface Elevation (ft)

≤ 4	12 - 14	22 - 24
4 - 6	14 - 16	24 - 26
6 - 8	16 - 18	26 - 28
8 - 10	18 - 20	28 - 30
10 - 12	20 - 22	> 30

Notes:
1. Vulnerable sections are based on SFO's LiDAR data.
2. Highlighted sections are elevations of the canals that are less than 8 feet above sea level.
3. According to the Adapting to Rising Rides Bay Area Sea Level Rise and Shoreline Analysis maps, there could be an area between the Highline Canal and the floodwalll just several feet north which could be susceptible to sea level rise.

MILLBRAE CLIMATE READY SAN MATEO COUNTY WEST YOST ASSOCIATES

Figure 3-5

Sea Level Rise Vulnerabilities

City of Millbrae
Sea Level Rise Adaptiation Assessment

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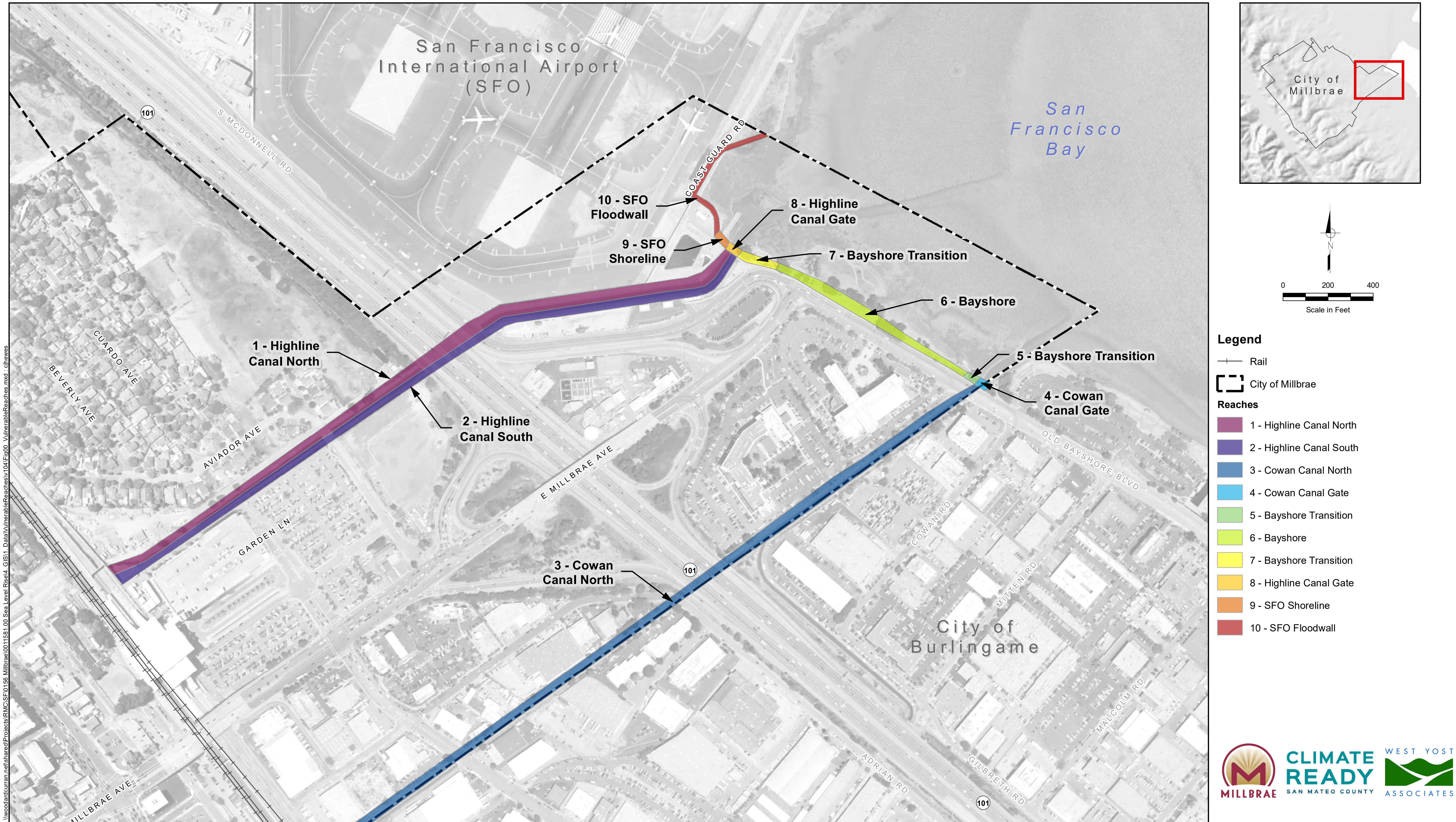

Figure 3-6

Vulnerable Reaches

City of Millbrae
Sea Level Rise Adaptation Assessment

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3.4.1 Reach 1—Highline Canal North

Based on the LiDAR survey data, there appear to be significant low points on the northern embankment along Highline Canal (Figure 3-7). West of Highway 101, elevations on the northern embankment range from 6 to 8 feet NAVD88, while the southern embankment crest is stays approximately 10 feet NAVD88. The Highline Canal Tide Gate is currently unable to close completely. If the Tide Gate is not repaired, Bay tides will dictate water levels in the canal. Under either the mid-level or high-end scenarios, the northern embankment of Highline Canal could be overtopped, flooding the City and the OLU. The Highline Canal has also experienced seepage in the past along this reach, making its repair and improvement advisable.

Figure 3-7. Highline Canal

3.4.2 Reach 2—Highline Canal South

Generally, the southern embankment of Highline Canal, as seen in Figure 3-7, has crest elevations above 10 feet NAVD88. Due to the lower embankment crest of Reaches 1 and 8, Reach 2 could not be the first to cause flooding. However, with crest elevations below water surface elevations of both the mid-level and high-end scenario conditions, improvement to the Highline Canal South is recommended. Improvements to Reach 2's embankment can also benefit the area between the Highline and Cowan Canals that the Highline Canal South protects.

3.4.3 Reach 3—Cowan Canal North

The northern embankment of Cowan Canal has several areas with elevations of 7 and 8 feet NAVD88. Although the canal's tide gates (Reach 4) isolate it from Bay flooding, higher Bay water surface elevations will likely prevent runoff from to moving through the tide gate without pumping. This backup of runoff could overtop the canal under both mid-level and high-end scenario conditions during times of increased runoff.

3.4.4 Reach 4—Cowan Canal Tide Gate

Figure 3-8. Cowan Canal Tide Gate

The tide gates at Cowan Canal, as seen in Figure 3-8, constitute a reach that is defined by both the shared ownership of the City of Millbrae and the City of Burlingame, and the constrained width that limits potential structural mitigations. With an elevation of less than 8 feet above sea level, Reach 4 is the lowest of all reaches along the City's shoreline and thus the first point of entry for flooding, unless the Highline Canal Tide Gates (see Reach 8 below) remain unrepaired. Any modification of the tide gate structure on Cowan Canal requires collaboration with the City of Burlingame.

3.4.5 Reach 5—Cowan Canal Tide Gate Transition to Bayfront Park

Reach 5 represents a sub-reach of Reach 6 (as described in Section 3.4.6 below) along the Bayfront Park alignment, as seen in Figure 3-9. This reach could be treated separately under a mitigation alternative where a levee is placed along the Bayfront Park portion of Reach 6. Thus, Reach 5 could be a transition from the floodwall on Reach 4 to a levee embankment on Reach 6. If other mitigations were selected for Reach 6 (i.e., a floodwall in Bayfront Park or a floodwall along the Old Bayshore Highway), Reach 5 could not need to be separated from the rest of Reach 6. Existing elevations along Reach 5 are generally above 10 feet NAVD88.

Figure 3-9. Bayfront Park

3.4.6 Reach 6—Bayshore

Cowan and Highline canals are connected by both Bayfront Park and the Old Bayshore Highway, as seen in Figure 3-9. Bayfront Park provides public open space and Bay access for residents. It also represents the longest and widest portion of the City’s Bay frontage. Elevations in the park range from 10 to 15 feet NAVD88. The San Francisco Airport owns Bayfront Park. The City owns the portion of the Old Bayshore Highway that lies along the western edge of Bayfront Park, which is generally lower in elevation, ranging from 8 to 10 feet NAVD88.

3.4.7 Reach 7—Bayshore Transition to Highline Canal Tide Gate

Similar to Reach 5, Reach 7 represents a sub-reach of Reach 6, along the Bayfront Park alignment (Figure 3-9). This reach could be treated separately under a mitigation alternative with a levee placed along the Bayfront Park portion of Reach 6. Reach 7 could be a transition from the levee embankment to a floodwall on Reach 8. If other mitigations were selected for Reach 6 (i.e., a floodwall in Bayfront Park or a floodwall along the Old Bayshore Highway), Reach 7 could not need to be separated from the rest of Reach 6. Existing elevations along Reach 7 range from 10 to 12 feet NAVD88.

3.4.8 Reach 8—Highline Canal Tide Gate

Figure 3-10. Highline Canal Tide Gate

The tide gate structure on Highline Canal (Figure 3-10) appears to have the lowest elevation of any reach along the shoreline at approximately 9 feet NAVD88 and is currently in need of repair. Due to sedimentation at the outfall, the gates are unable to fully close, leading to a loss of hydraulic capacity in Highline Canal. If the tide gates were repaired, this gate structure would become a part of the first line of defense for the Highline Canal and the City. Several sections of the Highline Canal embankment crest are at an elevation less than 7 feet NAVD88, meaning that unchecked inflows from the Bay through the tide gate could cause significant flooding under both the mid-level and high-end scenarios.

3.4.9 Reach 9—San Francisco Airport Shoreline

The Airport, shown in Figure 3-11, owns a section of shoreline without flood protection between the Highline Canal Tide Gate in Reach 8 and the City of San Francisco's floodwall in Reach 10. The shoreline elevation at this location is less than 9 feet NAVD88, which is below both the mid-level and high-end scenario flood levels. Although Reach 9 lies within the boundary of the City, a collaboration with the San Francisco Airport would be necessary to implement any mitigations.

Figure 3-11. San Francisco Airport Shoreline from Bayfront Park

3.4.10 Reach 10—San Francisco Airport Floodwall

The Airport has flood protection around much of its property, as discussed in Chapter 1. The existing floodwall begins about 150 feet northeast of the Highline Canal Tide Gate and is within the City boundary, but its elevation is unknown. As discussed in Chapter 1, the Airport's Shoreline Protection Program is an ongoing effort aimed at providing a consistent level of flood protection to Airport property of 13 feet NAVD88.

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4. REGIONAL MITIGATION STRATEGIES

The ultimate goal of this Assessment is to identify mitigation measures that the City can take to prepare for and adapt to future sea level rise. The primary objective of this Chapter is to identify those mitigation options that support the regional collaboration to protect the OLU.

4.1 Introduction

One of the key questions for the region as a whole is whether or not to try to "hold the line" in protecting existing development and maintaining the existing coastline. The decision to hold the line has the lowest impact on existing development but acknowledges that low-lying developments will be at greater risk in the future. Alternately, some jurisdictions may elect to allow for the Bay to inundate areas that are now dry in favor of a more environmentally friendly approach.

The conceptual regional alternatives recommended for future analysis in this chapter include primarily structural mitigation options to increase the height of the shoreline within the City and connect to shoreline protections in adjacent communities. Such options may take years to realize, which is why this Assessment is an important first step. Chapter 5 discusses local non-shoreline mitigation strategies in the City, such as drainage improvements and regulatory updates to protect future development. Options to further integrate planning and funding of both local and regional mitigation strategies are discussed in Chapter 6. Local planning and funding strategies represent opportunities for near-term steps toward implementation that could occur simultaneously as the City makes progress toward regional shoreline solutions.

This chapter discusses the identification, screening, and recommendation of regional alternatives for a continuously protected shoreline that can connect to similar protections of neighboring regional partners. The need for a regional solution is clear: a continuous and connected set of elevated shoreline protections from high ground to high ground throughout the OLU would protect the City from sea level rise and eliminate the need for each individual community or parcel to pursue separate mitigations.

There are approximately 1,300 feet (0.25 miles) of total continuous shoreline in the City that can be protected in reaches, as discussed in Chapter 3. Of this shoreline, only the Highline Canal tide gate structure is wholly owned by the City. The majority of the City's shoreline is adjacent to Bayfront Park, which is owned by the Airport. Additionally, the Cowan Canal tide gate is co-owned by the City of Millbrae and the City of Burlingame. Close collaboration with all regional partners, especially the Airport and the City of Burlingame who own neighboring shorelines, will be essential in identifying viable alternatives.

4.2 Regional Mitigation Options

A variety of shoreline adaptations have been pursued by communities around the Bay Area since the area was first settled in the 1800s. A significant amount of land that is now developed along the shoreline has been reclaimed from the Bay using dredging and fill, dikes, levees and other shoreline revetments. To the north of the City, the Airport began to expand into the Bay on fill in the 1930s (Airport, 2019) and has been protected by different shoreline protections consisting of dikes, sheet pile walls, and concrete walls of varying ages, installed or upgraded over the last 30 years (Airport, 2019). To the south, the City of Burlingame also has a variety of shoreline hardening, including berms and concrete walls (City of Burlingame, 2019). Berms, floodwalls, and sheet piles are all options that can be considered within the City. As discussed in Chapter 2, guidance and input from regional partners in the Bay Area was considered when identifying and screening other mitigation options.

4.2.1 Identification of Potential Options

The SFEI Atlas (SFEI, 2019) provides a review of historical approaches to shoreline protections and an analysis of the appropriateness of "natural," "nature-based," "structural," and "non-structural" measures around the Bay.

Natural and nature-based shoreline solutions listed in the Atlas include the following:

- Nearshore reefs
- Submerged aquatic vegetation
- Mudflat augmentation
- Beach creation
- Tidal marshes
- Polder management
- Ecotone levees

Structural solutions in the Atlas included the following:

- Floodwalls, seawalls or bulkheads
- Levees, dikes and berms

Non-structural solutions involve changes in land use and regulation of development. Since these options do not adequately contribute to a regional solution by physically protecting the shoreline, and since they could only be executed via the City updating its regulations, they are discussed in Chapter 5. Each of the potential natural, nature-based, and structural shoreline mitigations is discussed in more detail below.

While the Atlas focuses on highlighting nature-based solutions, it acknowledges the limitations of such options to appropriate habitats and describes optimal applications for each potential mitigation option. A discussion of each shoreline option and the criteria for selecting viable alternative mitigations for the City's shoreline is outlined below.

4.2.2 Screening of Potential Options

As discussed in Chapter 2, initial screening of mitigation options was performed based on criteria developed in collaboration with regional partners. These criteria include the following:

- **Adequate Protection from Sea Level Rise—**Any recommended options should provide protection from a rise in sea levels to an elevation of 16.6 feet NAVD88, based on the expected increase in tidal elevation, as discussed in Chapter 1.
- **Suitable Physical Environment—**Adaptations should be suitable to the physical conditions at the City's shoreline.
- **Available Space—**Adaptations should have sufficient physical space for construction, operation and maintenance. While placement of environmentally acceptable fill into the Bay could provide additional space, permitting for such actions can be difficult to obtain, and could entangle potential projects in a lengthy process of approvals.
- **Alignment with Partner Goals—**Mitigation options should move the region toward a unified shoreline solution by providing a similar level of protection as solutions considered by regional partners, physically connecting the shoreline, and avoiding negative impacts on other regional partners.

There are many other criteria that will end up driving the final suite of mitigation options. Among these are cost, environmental permitting constraints, and structural or geotechnical feasibility. Although these are important considerations, the level of design detail available during the Assessment was insufficient to eliminate options based upon them. Additional challenges and benefits, such as the ability to integrate community benefits like recreation and shoreline access, preserve views, provide environmental benefits, or provide adaptive capacity are also discussed in this section, but similarly were not used to eliminate potential mitigation option.

Mitigation options suitable for one reach may not be suitable for another reach due to their unique individual characteristics. Therefore, the viability of each mitigation option is discussed for each reach below.

Wave action and erosion are not major concerns along the City's shore, although erosion protection should be included in any potential mitigation design. The San Francisco Bay at the City is relatively sheltered from wave runup, and thus wind-waves are unlikely to exceed 6 inches in height. The shoreline experiences a tidal fluctuation of just over 2 feet (SFEI, 2019), with tidal mudflats appearing at low tide.

Nearshore Reefs

Nearshore reefs are best suited to shallow water in areas of low wave action, near mudflats. Artificially created reefs have the ability to reduce wave transmission both directly and indirectly by trapping sediment and stabilizing substrate so that the bed elevation increases, and subsequently, attenuates waves. The pros and cons of nearshore reefs are listed by screening criteria below.

- **Adequate Protection from Sea Level Rise**—Wave action is not a major concern for the City, and nearshore reefs do not block sea level rise.
- **Suitable Physical Environment**—The Bay at the City's shoreline is characterized by a significant area of mudflats, with low wave action, making nearshore reefs viable offshore. However, SFEI did not recommend nearshore reefs for the City's shoreline, likely due to the extensive existing mudflats that perform a similar function in reduction of wave heights.
- **Available Space**—Nearshore reefs would be placed in the Bay. While space exists, permitting would be required to develop and maintain nearshore reefs.
- **Alignment with Partner Goals**—Nearshore reefs would not provide adequate protection from sea level rise.

Submerged Aquatic Vegetation

Submerged aquatic vegetation refers to underwater flowering plants, such as eelgrass, and can contribute to trapping sediment and slowing shoreline erosion. Such vegetation requires low currents, bed depths less than 6 feet below the water surface, higher salinity, low turbidity, and low wave action. The pros and cons of submerged aquatic vegetation are listed by screening criteria below.

- **Adequate Protection from Sea Level Rise**—Shoreline erosion is not a concern for the City, and submerged aquatic vegetation would not block sea level rise.
- **Suitable Physical Environment**—The Bay at the City's shoreline is characterized by a significant area of mudflats, with low wave action, making eelgrass viable offshore.
- **Available Space**—Submerged aquatic vegetation would be placed in the Bay. While space exists, permitting would be required to develop and maintain such vegetation.
- **Alignment with Partner Goals**—Submerged aquatic vegetation does not provide adequate protection from sea level rise and may draw birds who feed on sheltering fish. Habitat enhancements that encourage birds may create a safety hazard for air traffic at the Airport and therefore do not align with the goals of this regional partner.

Although submerged aquatic vegetation does not meet the City's immediate need for protection against sea level rise, it could be considered as a supplementary option to complement the eventual preferred mitigation alternative, since the City's Bayshore appears to be suitable habitat.

Mudflat Augmentation

Existing mudflats may be enlarged with the direct or indirect placement of fine sediment to increase bed elevation relative to the tides. Mudflat augmentation can help the shoreline by decreasing wave energy and thereby limiting erosion. The pros and cons of mudflat augmentation are listed by screening criteria below.

- **Adequate Protection from Sea Level Rise**—Shoreline erosion is not a concern for the City, and existing mudflats may continue to accrete naturally, due to the sheltering effect of the Airport.

- **Suitable Physical Environment—**The Bay at the City's shoreline is characterized by a significant area of existing mudflats and thus, is clearly suitable.
- **Available Space—**The City already has over half a mile of mudflats offshore that could be extended further into the Bay.
- **Alignment with Partner Goals—**Mudflat augmentation does not provide adequate protection from sea level rise.

Beach Creation

Typically, coarse beaches may occur naturally or be constructed of sand, shell, gravel, or cobble, and comprise a supratidal beach berm and a beach face. The lowest portion of a beach is often characterized by a low tide terrace and transition to tidal flat. A low tide terrace limits the duration that a beach is exposed to waves and can dissipate wave energy. The pros and cons of beach creation are listed by screening criteria below.

- **Adequate Protection from Sea Level Rise—**A supratidal berm is the only feature of a created beach that would provide protection from sea level rise. Such a berm could be considered for lower levels of rise, but given the existing shoreline elevations of 9 to 10 feet NAVD88, it would not be feasible to naturally achieve the heights needed to provide protection up to 16.6 feet NAVD88.
- **Suitable Physical Environment—**The Bay at the City's shoreline is characterized by a significant area of existing mudflats and SFEI's analysis suggests that it would be suitable for a beach.
- **Available Space—**The location identified by SFEI for a beach habitat is currently occupied by the City's nearshore wastewater outfall, which might be impacted by placement of a beach.
- **Alignment with Partner Goals—**A beach berm would not provide adequate long-term protection from sea level rise and may draw birds and other wildlife. Habitat enhancements that encourage birds may create a safety hazard for air traffic at the Airport and therefore do not align with the goals of this regional partner.

Tidal Marshes

Tidal marshes, can mitigate flood risk due to waves and currents through shoaling and friction effects. Marshes reduce wave runup enabling landward structural solutions to be lower and reducing maintenance costs. The pros and cons of tidal marshes are listed by screening criteria below.

- **Adequate Protection from Sea Level Rise—**Shoreline erosion is not a concern for the City, and tidal marshes do not protect to the level required.
- **Suitable Physical Environment—**The City's shoreline has a small existing area of wetland. SFEI has also identified inland developed areas suitable for the creation of new wetlands.
- **Available Space—**Conversion of developed land uses to expand wetlands could occur on a parcel-by-parcel basis, though not likely on a regional scale.

- **Alignment with Partner Goals—**Wetlands do not provide adequate long-term protection from sea level rise and may draw birds and other wildlife. Habitat enhancements that encourage birds may create a safety hazard for air traffic at the Airport and therefore do not align with the goals of this regional partner.

Polder Management

Polders are low-lying areas of land that are protected from inundation by shoreline structures. Polders are typically reclaimed historical marshes and mudflats. The low-lying nature of polders means that they often accumulate runoff that needs to be pumped into the Bay. SFEI recommends mitigating land subsidence in poldered areas, maintaining shoreline protections where needed, and considering breaching shoreline protections to allow natural recharge of sediments to create wetlands. The pros and cons of managing polders are listed by screening criteria below.

- **Adequate Protection from Sea Level Rise—**Polders do not provide protection from sea level rise but rely on shoreline protections to protect development. Breaching of elevated shoreline features would reduce protection and maintaining existing shorelines does not mitigate sea level rise.
- **Suitable Physical Environment—**The City has significant areas that are low-lying and protected by the shoreline but are not specifically identified as polders. Fill of low-lying undeveloped land could damage the environmental benefits of existing inland wetlands but could be applicable on a parcel-by-parcel basis, as discussed in Chapter 5, to elevate structures as redevelopment occurs.
- **Available Space—**Filling significant areas of land, either developed or undeveloped within the City is not considered a feasible option, as this would require either filling parks or wetlands (i.e., undeveloped areas) or valuable developed assets (developed areas). Along Lomita Canal, west of the Airport, and in certain areas west of Old Bayshore Highway, the City has low-lying areas that should be managed for future subsidence.
- **Alignment with Partner Goals—**Managing polders is not expected to have an impact on partners but does not meet the goal of a continuous protected shoreline.

Ecotone Levees

Ecotone levees are long earthen structures with gentle slopes and a length to height ratio of 20:1 or gentler; they typically lie between shoreline structures and Bay wetlands. Ecotone levees can provide transition zone habitat when properly vegetated, resulting in wave attenuation. They also allow marshes to migrate upslope with sea level rise. The pros and cons of ecotone levees are listed by screening criteria below.

- **Adequate Protection from Sea Level Rise—**Ecotone levees do not provide significant protection from sea level rise but rely on other shoreline structures to provide protection.
- **Suitable Physical Environment—**SFEI has identified a portion of the Airport property adjoining the City suitable for ecotone levee habitat, and this area extends into the City slightly.

- **Available Space—**The location identified by SFEI for a beach habitat within the City is currently occupied by the City's nearshore wastewater outfall, which might be impacted by regrading to achieve an ecotone levee.
- **Alignment with Partner Goals—**Transition zone habitat does not provide long-term protection from sea level rise and would draw birds and other wildlife. Habitat enhancements that encourage birds may create a safety hazard for air traffic at the Airport and therefore do not align with the goals of this regional partner.

Floodwalls, Seawalls and Bulkheads

Floodwalls are vertical barriers typically constructed of solid concrete that provide protection from flooding. They can be constructed at an individual site scale or regionally. There are a variety of construction types, but the majority are T-walls and I-walls, so named for their cross-sectional shapes, with T-walls having a foundational footing not present in I-walls. This footing can reduce the tendency of floodwalls to topple. In general, I-walls are used when the exposed wall height is less than 10 feet. I-walls are often constructed of sheet piles, which are commonly used around the Bay and are typically braced in coastal situations (U.S. Army Corps of Engineers [USACE], 1989). Sheet piles are sections of sheet materials, often vinyl or steel, that are driven into the ground. T-walls are generally used when the heights required for flood protection become larger than an I-wall can safely handle (U.S. Department of the Interior Bureau of Reclamation [Reclamation], 2012). With poor foundation conditions, T-wall footings are often anchored with pilings for greater stability. Flood walls require an easement sufficient to accommodate the construction of any footing and allow for routine inspection and maintenance. Along a shoreline, protection of the foundation and dissipation of wave action, such as through placement of large, angular rock riprap, would be required.

Similar to floodwalls, seawalls are large structures designed to protect upland areas from coastal flooding, especially in high-wave energy environments. They may be constructed of rock, concrete slab, concrete mattresses asphalt or gabions. Primary functions include wave energy dissipation and the prevention of shoreline erosion. Seawalls may add height to the shoreline or simply provide armoring (or further prevention of erosion through installation of physical structures) along the existing shoreline. Common designs include curved, stepped, vertical sheet pile, or large stone revetment. Heavily armored levees along the shoreline are often termed seawalls as well.

Bulkheads are vertical retaining structures built to stabilize the existing shoreline and limit shoreline erosion. The terms bulkhead and seawall are often used interchangeably. However, a bulkhead is primarily intended to retain the shoreline, while a seawall is generally intended to dissipate wave energy and prevent inland flooding. Bulkheads are not typically designed to resist waves and surge and can fail after overtopping saturates landward soil. Bulkheads are best suited to sites with already hardened shorelines to improve waterfront access and maritime use. Bulkheads are, by design, narrow and space-efficient, but are unsuitable for high-wave-energy environments. The pros and cons of floodwalls, seawalls and bulkheads are listed by screening criteria below.

- **Adequate Protection from Sea Level Rise**—Floodwalls and seawalls could provide adequate protection from sea level rise. A seawall or braced floodwall may be considered for shoreline protection, though bulkheads would not provide sufficient elevation to protect against sea level rise.
- **Suitable Physical Environment**—Floodwalls, seawalls, and bulkheads are suitable for the built environment of the City's shoreline.
- **Available Space**—The available space required to place a floodwall, seawall, or bulkhead is significantly lower than that of other solutions, such as levees.
- **Alignment with Partner Goals**—Since floodwalls and seawalls can be constructed to a required design height and do not augment habitat, they meet partner goals for regional flood protection. Bulkheads are typically not designed to add height to the shoreline and are thus unsuitable.
- **Other Considerations**—As with other options that increase shoreline heights, gravity drainage may be impeded and areas behind the higher shoreline may require new or expanded pump stations to remove groundwater or stormwater. Bulkheads and vertical or curved designs of floodwalls and seawalls can reflect waves and erode the shoreline on the water side. Also, such solutions may impede shoreline access for recreation and block views.

Levees and Berms

Levees are earthen structures built to reduce flood risk. Levees are common water control structures used around the Bay and along major waterways feeding into the Bay. If a levee were selected as an option, it would be located along the Bayshore. Levees are vulnerable to erosion and must be constructed with geotechnical specification of materials and geometry to prevent overtopping, seepage, instability, and erosion. Slopes may be vegetated but are often protected from erosion by riprap revetment in areas subject to scour. Due to the typical slope of these embankments (typically a minimum of 2:1 vertical, and often more gradual), levees can require wide easements from toe to toe. Two options discussed by SFEI in the Atlas are similar to levees: superlevees and land elevation.

Superlevees are extremely tall and wide levees constructed to accommodate other functions besides flood protection on their crowns. These other uses may include the placement of buildings, roadways for transportation, or installing recreational amenities. If a superlevee were selected as an option, it would likely be located along the Bayshore, but would incorporate various transportation and development alignments through the City.

Land elevation can typically be accomplished through the placement of fill on individual sites, as discussed in Chapter 5, or on a larger scale. As a regional strategy, at a minimum, land elevation would act as a superlevee. Individual site elevation could take place as new development, or when redevelopment occurs. If done properly, land elevation might also bring noncompliant structures into compliance with the NFIP. However, placing large quantities of fill can lead to compaction and subsidence, as well as disturbance to adjacent unfilled areas, especially on Bay soils. Additionally, construction would cause significant disruption to existing land uses, and would likely require temporary or permanent relocation. The pros and cons of levees, dikes and berms are listed by screening criteria below.

- **Adequate Protection from Sea Level Rise**—Levees, including superlevees or land elevation can remove areas from the floodplain, but would require easements for construction and maintenance. For superlevees or land elevation, developed parcels would need to be redeveloped to achieve a continuous line of protection required for regional protection.
- **Suitable Physical Environment**—Levees, superlevees and land elevation may be suitable for the City's shoreline, where sufficient space exits, or where infrastructure land owners, such as Caltrans, elect to raise contiguous infrastructure parallel to the shore.
- **Available Space**—While it may be possible to identify an alignment that can accommodate a levee, particularly a lower levee that meets interim protection goals, with a vision to adding a floodwall on top at a later time, there is no currently undeveloped space to place a continuous line of protection for placement of a superlevee or land elevation option.
- **Alignment with Partner Goals**—As long as levees are not planted for habitat enhancements that encourage birds, they are not expected to create a safety hazard for the Airport air traffic and thus should meet all partner goals.
- **Other Considerations**—As with other options that increase shoreline heights, gravity drainage may be impeded and areas behind the higher shoreline may require new or expanded pump stations to remove groundwater or stormwater. Also, such solutions may impede shoreline access for recreation and block views.

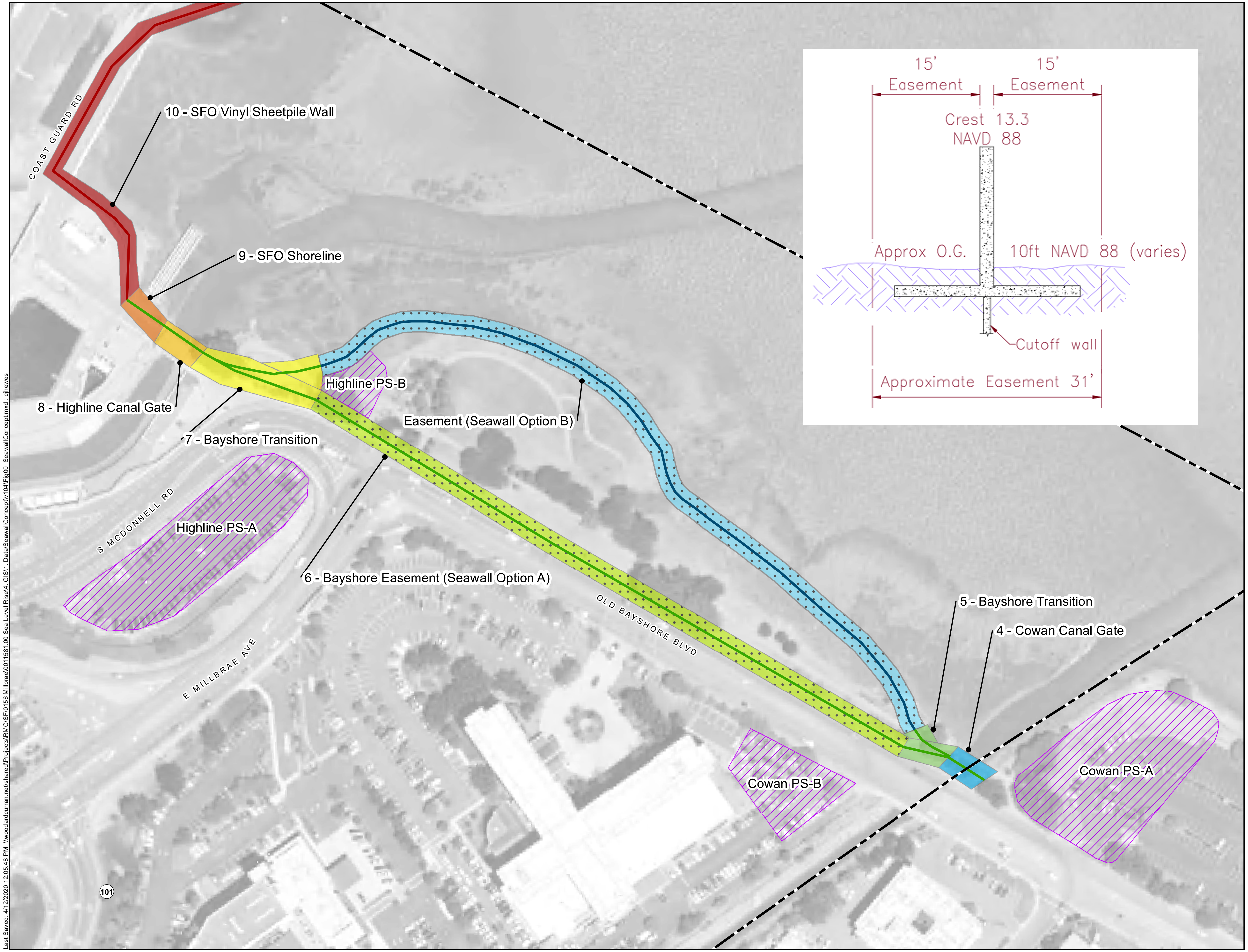
4.3 Summary of Feasible Options

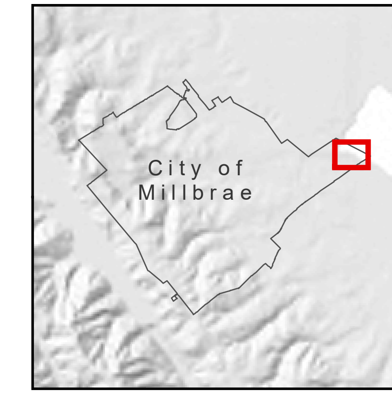
Based on the initial screening, floodwalls, seawalls and levees were selected as feasible options to address regional mitigation needs. Feasible mitigation options were grouped into three regional alternatives as follows:

- **Alternative 1**—A floodwall and seawall combination with a protection elevation of 16.6 feet NAVD88, as shown on Figure 4-1.
- **Alternative 2**—A floodwall and levee combination with a protection elevation of 16.6 feet NAVD88, as shown on Figure 4-2.
- **Alternative 3**—A floodwall and levee combination that represents a variation of Alternative 2 comprised of a levee segment through Bayfront Park with an interim protection elevation of 13.3 feet NAVD88, allowing for adaptive management to increase levee height with the addition of a floodwall on top of the levee, as needed.

Although most natural or nature-based solutions were deemed infeasible due to either unsuitable environmental conditions, negative impacts to regional partners, or a failure to achieve sufficient vertical protection, the option to incorporate nearshore reefs should be considered in future studies. The incorporation of nearshore reefs could complement the design of a larger flood control project along the Bayshore. However, the amount of benefit expected is unclear, since the City already has extensive mudflats that accomplish similar wave attenuation and erosion reduction goals.

As discussed in Chapter 3 and shown on Figure 3-5, the City's shoreline is composed of seven reaches, distinguished based on ownership and design considerations. Reaches 4 through 10 constitute the shoreline where regional mitigation strategies are appropriate. Feasible options for each reach are discussed in this section, with a view to necessary easements, permitting, and design considerations for each.





N
0 50 100
Scale in Feet

Legend

- City of Millbrae
- Existing vinyl sheetpile wall
- Seawall Option A
- Seawall Option B
- 4 - Cowan Canal Gate
- 5 - Bayshore Transition
- 6 - Bayshore Easement (Seawall Option A)
- 7 - Bayshore Transition
- 8 - Highline Canal Gate
- 9 - SFO Shoreline
- 10 - SFO Vinyl Sheetpile Wall
- Easement (Seawall Option B)
- Pump Station Location Options

MILLBRAE CLIMATE READY SAN MATEO COUNTY WEST YOST ASSOCIATES

Figure 4-1

Seawall-Based Shoreline Adaptation Concept

City of Millbrae
Sea Level Rise Adaptation Assessment

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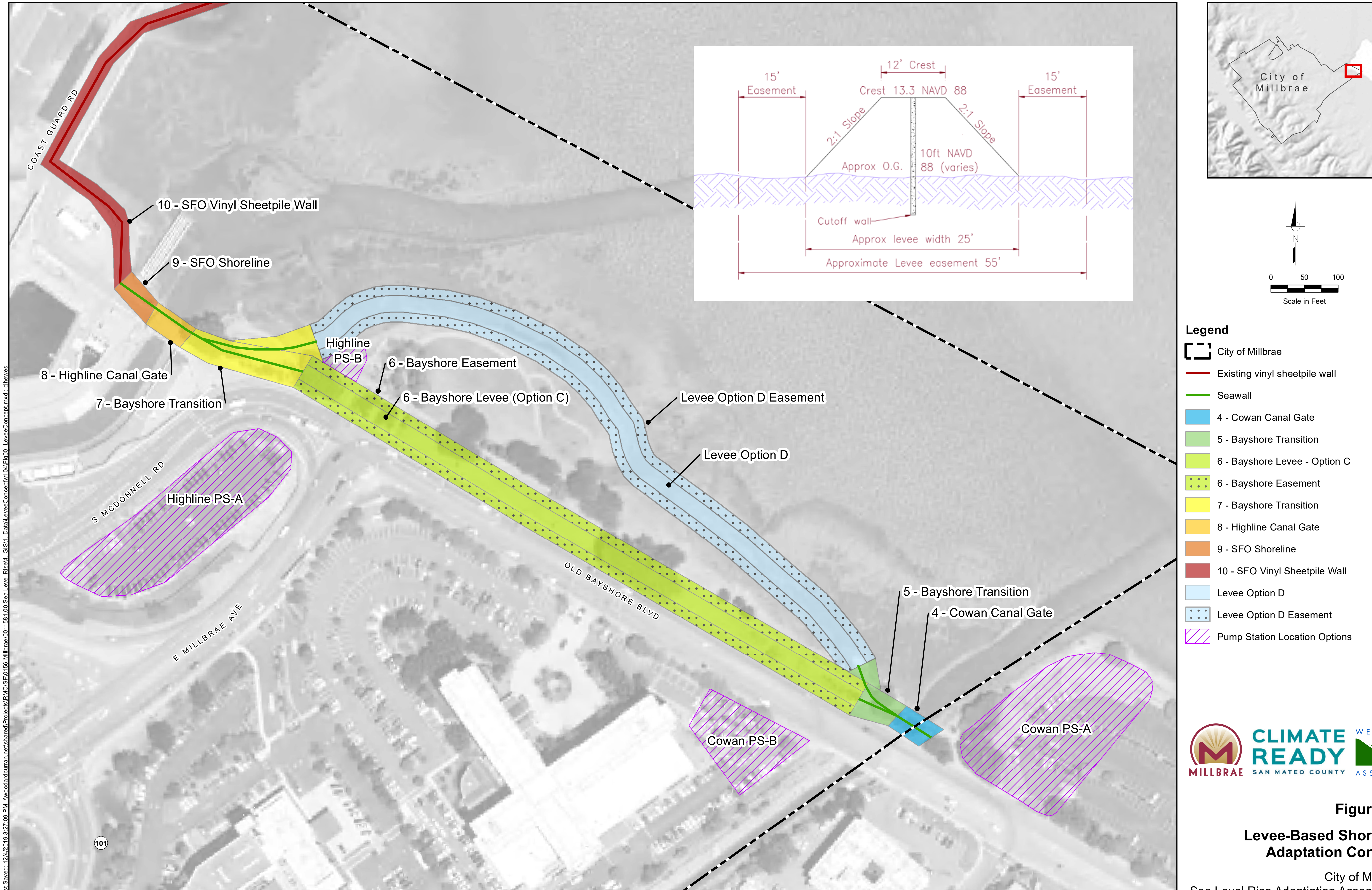

Figure 4-2

Levee-Based Shoreline Adaptation Concept

City of Millbrae
Sea Level Rise Adaptiation Assessment

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4.3.1 Mitigation Options for Reaches 4 and 8

Reach 4 represents the 20-foot-long Cowan Canal tide gate structure jointly owned by the cities of Millbrae and Burlingame, and running under the Old Bayshore Highway. Reach 8 represents the 30-foot long the Highline Canal tide gate structure, owned solely by the City and topped by an approximately 25-foot wide access road. Crest elevations of the Cowan Canal tide gate and the Highline Canal tide gate are 8 feet NAVD88 and 9 feet NAVD, respectively. For both reaches, potential mitigation options are limited by the width of the gate structures and the need to preserve access. In both cases a floodwall addition to the gate structure may be the only way to increase existing gate height to tie-in to new flood protection structures on neighboring reaches. A full gate structure replacement may also be an option, particularly with existing performance issues at the Highline Canal tide gate. Additional height required to provide protection from sea level rise at the Cowan Canal tide gate and the Highline Canal tide gate are 8.6 feet and 7.6 feet, respectively.

4.3.2 Mitigation Options for Reaches 5 Through 7

Reaches 5 through 7 represent the Bayshore, the shoreline between Cowan Canal tide gate and Highline tide gate, and could follow one of two potential alignments. The first alignment option runs through Bayfront Park, which is owned by the Airport. Bayfront Park varies in width from approximately 40 feet to over 200 feet. The second alignment runs along the western edge of the Old Bayshore Highway, just west of Bayfront Park and is owned by the City, but is severely width-constrained by existing infrastructure.

Bayfront Park has sufficient space to accommodate either a levee or a seawall in Reach 6, with a transition to the tide gate structures most likely needed in Reaches 5 and 7 only if the levee option is selected for Reach 6, as shown on Figure 4-1. Such a transition is typically accomplished by a gradual decrease in the levee’s size, with an overlapping landward floodwall through the reach, ending where the levee reaches its full height. It is expected that a seawall could connect directly to the tide gate structures without a transition in Reaches 5 and 7, as shown on Figure 4-2.

An alignment within Bayfront Park would allow for a greater range of potential mitigation options than an alignment along Old Bayshore Highway. The existing portion of Old Bayshore Highway available for mitigation is approximately 8 feet wide in total and is currently occupied by sidewalks on both sides of the roadway. Since it is assumed that a floodwall would require at least 15 feet of easement width, a re-design of Old Bayshore Highway and/or a small easement on the Bayfront Park property would be needed to accommodate a floodwall along Old Bayshore Highway.

4.3.3 Mitigation Options for Reaches 9 and 10

Reaches 9 and 10 are on the Airport property and the Airport has plans to address sea level rise in these locations, as described in their Shoreline Protection Plan. In the Shoreline Protection Plan, Reach 10 is part of the Airport’s Reach 14, where an existing vinyl sheet pile wall would be raised to a height of 13 feet NAVD88 and fortified against erosion. This proposed mitigation should align with either the Levee Concept or the Floodwall concept along the Bayshore.

Reach 9, located between the Highline Canal tide gate and the Reach 10 floodwall, currently has no shoreline flood protection measures in place. Reach 9 would be addressed in the Shoreline Protection Plan's Reach 15 mitigations that extend east along the northern bank of Highline Canal at the Airport's property line. The proposed mitigation at this location is a new sheet pile wall, currently shown aligned with the landward toe of the existing Highline Canal embankment. While a shoreline vinyl sheet pile wall is consistent with the City's Levee Concept and Floodwall Concept, the approach to mitigation along Highline Canal could benefit from further collaboration between the Airport and the City. This portion of the Shoreline Protection Plan is further discussed in Chapter 5, since the canal embankments are considered local infrastructure.

4.4 Planning and Design Considerations

This section identifies potential permitting, planning and design considerations for each of the three regional mitigation alternatives.

4.4.1 Impacts to Drainage

All three regional mitigation strategies focus around raising the shoreline to prevent incursion from the Bay. Elevated shorelines trap runoff and can cause fluvial flooding. This type of flooding will increase as sea levels rise, since higher Bay levels would mean the tide gates on Highline and Cowan Canals would be closed more often. To move runoff to the Bay during storm events, a substantial pump station would be needed at the mouth of each canal. Without pumping, there would be insufficient storage in the City's drainage canals during storms to contain excess runoff. Even with pumping, canal improvements are recommended, and are further discussed in Chapter 5.

Locations for these pump stations have not yet been identified, but there are a couple of options to consider for the Highline Canal pump station. The first is a parking lot, owned by the Airport, adjacent to the mouth of Highline Canal. This property is a lower value use and might be relocated elsewhere within the City to facilitate construction of a pump station and possible realignment of South McDonnel Road, which runs along the south side of the canal. The second option would be to place a pump station behind a shoreline protection feature within the existing Bayfront Park. Since this is also currently the Airport property, and is more space-constrained, it would likely be a less desirable location. Similarly, at Cowan Canal, there is an existing parking lot on private property at the Westin San Francisco Airport adjacent to the mouth of the canal on the north side. As it would be in the property owner's interest to protect the hotel, it might be possible for the City to acquire the necessary space for a pump station at that location. Alternately, similar to the Bayfront Park option at Highline Canal, a pump station might be located in the park behind a shoreline protection on the City of Burlingame side of the existing outfall.

4.4.2 Recreational Preservation

Due to the presence of the existing Bayfront Park and the Bay Trail, there are significant shoreline recreational opportunities along the City's existing shoreline. The City has opportunities to preserve and enhance recreational opportunities along the shoreline with each regional shoreline alternative. Under Alternative 2 or Alternative 3, where a levee would be constructed through Bayfront Park, a portion of park could be preserved by following a more easterly alignment. In addition, the Bay Trail could be placed along a very similar alignment to its present one, by placing the trail on top of the levee.

Under Alternative 1, where a seawall would be constructed, various designs are possible. For a more vertical seawall, an elevated landward walkway could be constructed to allow the Bay Trail to retain a similar alignment to the present one.

4.4.3 Aesthetics

The construction of a new elevated shoreline from any of the alternatives could potentially impact land and water views of San Francisco Bay or degrade the visual character of the Bay. Although views from most of the City would not be impacted, views in areas near the shoreline would be obstructed. As much as possible, it is important to provide mitigation of negative impacts to views. Whether a floodwall or levee alignment is chosen through Reaches 5 to 7, opportunities exist to make structures more visually appealing. Floodwalls can be used as community art space with murals that celebrate the unique character of the City or the Bay either directly painted on the floodwall or on the landward walkway. Levees can be planted with low-lying vegetation with minimal root structure to increase aesthetics.

4.4.4 Flood Insurance Implications

Although not the object of this Assessment, opportunities exist to design and construct any of the regional alternatives for accreditation through the NFIP. An elevated shoreline could be a component in a larger strategy to remove structures from the floodplain with its requirement to carry flood insurance on federally backed mortgages. Levee systems must meet and continue to meet particular minimum design, operation, and maintenance requirements described in the Code of Federal Regulations to be mapped on a FIRM as providing protection from the 100-year flood (FEMA, 2019). FEMA may require a specific protection elevation and additional freeboard, among other things.

4.4.5 Permitting Considerations

Prior to construction of any shoreline protection measures, CEQA requires investigation and documentation of sensitive habitats and species that could be impacted by construction activities. If significant environmental impacts are identified, an Environmental Impact Report must be prepared to discuss measures to mitigate environmental impacts. Table 4-1 lists the local, state, and federal agencies that may need to be engaged to acquire appropriate permits.

Table 4-1. Permitting Agencies Listed by Jurisdiction.

Jurisdiction	Agency
Local	San Francisco Bay Conservation and Development Commission (BCDC) Regional Water Quality Control Board (RWQCB)
State	California Environmental Quality Act (CEQA) California Department of Fish and Wildlife (CDFW)
Federal	USACE: Section 10 permit

Table 4-1. Permitting Agencies Listed by Jurisdiction.

Jurisdiction	Agency
	USACE: Section 404 permit U.S. Fish and Wildlife Service (USFWS) National Marine Fisheries Service NMFS

4.4.6 Adaptive Management

Adaptive management is the ability to adjust decision-making and to provide redundancies in the face of uncertain future conditions. In the case of sea level rise, where human action over time is unpredictable, but has significant bearing on outcomes, adaptive management is particularly important to consider. One strategy to provide adaptive management is addressed in Alternative 3, where a lower level of interim flood protection can be provided with lower project impacts and costs. Then, additional protection could be added as sea levels rise, and certainty about eventual outcomes improves.

Further adaptive management can be achieved through supplementing regional shoreline mitigations with local adaptations. Such mitigations would include strengthening and raising canal embankments, adding redundancy and capacity to existing pump stations and drainage systems throughout the lower elevations of the City, and increasing runoff capture and infiltration to reduce pressure on the drainage system. Such strategies are discussed more fully in Chapter 5.

4.5 Cost Estimates

Foster City's efforts to prepare for and address sea level rise were presented in their 2015 *Levee Protection Planning Study* (Foster City, 2015). The *Levee Protection Planning Study* estimated costs for a range of alternatives including raising levees and constructing structural floodwalls. These cost estimates were based on existing information from local jurisdictions such as the City of San Mateo, the Airport, and Redwood City that had previously completed significant levee improvements. Costs for floodwalls also factor in 6 inches of potential settlement expected to occur during construction of a deep foundation. Earthen levee cost estimates assume a top width of 12 feet.

Based on the cost estimates provided in the *Levee Protection Planning Study*, Table 4-2 presents estimated costs for adding height under three design scenarios as follows:

- Conventional earthen levee
- Lightweight fill earthen levee
- Structural floodwall

Total costs have been adjusted to 2020 dollars and are presented for an assumed 1,300-foot structure, representing an alignment close to the shoreline that would preserve more of Bayfront Park. With an average existing shoreline elevation of 9 feet NAVD88, a structural solution would need to be nearly 6 feet high to exceed the mid-level sea level rise scenario and 8 feet high to exceed the high-end sea level rise scenario. Cost estimates for a shoreline solution of entirely conventional levee would be $4.9 or

$6.5 million dollars to achieve a mid-level or high-end level of protection, respectively. Compared with the cost estimate to construct a similar lightweight levee of $3.9 or $5.2 million respectively, the lightweight levee is a significantly lower cost option. For lower levels of protection, a full-length floodwall at $4.7 million is the least expensive option; for the high-end scenario, a full-length floodwall is estimated to cost $6.3 million.

Table 4-2. Unit Cost and Total Cost of Levees and Floodwalls.

Height (feet)	Earthen Levee ($/lf)	Conventional Levee Cost (dollars)	Lightweight Earthen Levee ($/lf)	Lightweight Levee Cost (dollars)	Flood wall ($/lf)	Floodwall Cost (dollars)	Data Origin
1	811	1,054,939	1,391	1,808,468	696	904,234	Foster City, 2015
2	1,391	1,808,468	1,971	2,561,996	1,275	1,657,762	
3	2,087	2,712,701	2,434	3,164,818	1,739	2,260,584	
4	2,666	3,466,229	2,898	3,767,641	2,434	3,164,818	
5	3,130	4,069,052	3,362	4,370,463	3,130	4,069,052	
6	3,791	4,928,074	3,014	3,918,346	3,663	4,762,298	Estimated Based on Trendline
7	4,382	5,696,673	3,501	4,551,310	4,266	5,545,967	
8	4,973	6,465,272	3,988	5,184,274	4,869	6,329,636	

Each feasible alternatives proposed by this Assessment is composed of more than one type of structure. Therefore, costs to implement the City's preferred alternative will likely vary, but can provide order-of-magnitude information to facilitate future decision-making. Costs for both levees and floodwalls can vary with height, length, and width, soil condition, and market prices of materials required at the time of construction.

4.6 Conclusions

Three preliminary regional alternatives meet City and partner goals for shoreline flood protection. Alternative 1 presents a floodwall and seawall combination along the shoreline or along the eastern edge of Old Bayshore Highway. Alternative 2 presents a floodwall and levee combination along the same alignments. Alternative 3 offers a variation of Alternative 2 at a lower level of protection to allow for future adaptive management and a lower initial cost.

Such solutions on a regional scale could protect both the City and the OLU from sea level rise. In addition, working collaboratively with regional partners can reduce individual planning and implementation costs in the long run. The need for individual community or parcel scale mitigations will be reduced, and each protected community can take a share in a single large-scale solution. This chapter presented feasible shoreline mitigation measures, initial screening criteria and, based on these criteria, identified three alternatives for the City to contribute to the regional solution to sea level rise.

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5. LOCAL MITIGATION STRATEGIES

This chapter highlights local sea level rise mitigation strategies the City can undertake to support regional solutions discussed in Chapter 4, improve capacity of the existing drainage system, and reduce risks to individual properties in the City.

5.1 Introduction

The benefit of local mitigation is that it generally falls within the City's power to fund and implement, making near-term implementation possible. In addition, local mitigation can protect some of the City's most vulnerable assets if a regional solution does not materialize, providing this some adaptive capacity based on this Assessment.

The conceptual local mitigation alternatives recommended for future analysis fall into one of four following categories of work:

- Capital improvement projects that can reduce both existing and future potential for flooding
- Runoff reduction measures that can increase infiltration and reduce pressure on the downstream drainage system
- Local components of regional projects
- Asset-specific mitigations that can protect individual sites from sea level rise, if a regional solution cannot be implemented in time

This chapter describes the identification, screening, and recommendation of local alternatives. Information was derived from previously prepared planning documents, and coordination and communication with regional partners on components necessary to support those projects. Additional local opportunities to reduce risk are also discussed in Chapter 6, which outlines local regulatory and development standards updates that could be considered while gradually improving resilience of the City's low-lying areas.

5.2 Identification of Local Mitigation Alternatives

As discussed in Chapter 4, the SFEI Atlas recommends a variety of potential mitigation alternatives for local jurisdictions to consider. Some of the potential solutions recommended include the following:

- Elevated lands
- Managed retreat
- Building code updates and retrofits

Additional guidance about potential mitigation alternatives also comes from the City's recently prepared *Storm Drain Master Plan* (City, 2018), which identified 10 specific drainage infrastructure improvement projects and eight general drainage improvement recommendations. These projects have the potential to decrease surcharges of the local drainage system and reduce combined flooding.

According to the *Storm Drain Master Plan,* the projects most likely to reduce flood risk due to increased precipitation under climate change or combined flooding due to rising sea levels include the following:

- Reconfiguration of Landing Lane Bowl
- Reoperation of Hillcrest Pump Station
- Increased Highline Canal inlet capacity
- Downtown capacity increases
- Flood risk reduction along Tioga Drive
- Flood risk reduction along Helen Drive
- Capacity increases along Center Street
- Canal improvements and repair of Highline Canal tide gate
- Airport lift station improvements
- Improvement of Lomita Canal

Finally, the City's recently completed *Green Infrastructure Plan* (City, 2019), proposes projects to alleviate existing flood potential and watershed runoff. Although these types of projects will not reduce sea level rise inundation, they do have the potential to reduce impacts from increased rainfall runoff due to climate change and the impacts of combined flooding.

5.3 Screening of Local Mitigation Alternatives

Unlike the selection process for regional mitigation alternatives described in Chapter 4, local options were not screened. Some parcels, zones, or projects may be more suitable than others for a particular mitigation. However, criteria were identified that the City can use to evaluate each approach to risk reduction. These criteria include the following:

- **Consistency with Existing Planning and Design Criteria—**Any mitigations should not violate existing City, state or federal codes or practical engineering and design standards.
- **Ability to Provide Adequate Protection—**Any mitigations should be able to provide an appropriate level of protection from sea level rise, as discussed in Chapter 1.
- **Suitable Physical Environment—**Adaptations should be suitable to the physical conditions of each development site.
- **Available Space—**Each adaptation option should have sufficient physical space for construction, operation and maintenance.

The appropriateness of each potential mitigation alternative is discussed below.

5.4 Summary of Local Mitigation Alternatives

The following sections summarize local flood reduction and sea level rise mitigation alternatives, and discuss, where appropriate, the screening that should be used to apply each solution within the constraints of each development site or project.

5.4.1 Elevated Lands

One local mitigation alternative proposed by SFEI is to elevate land under new developments and redevelopments with fill. Construction above a design flood elevation would lift future development and critical assets out of inundation areas. Elevating parcels as they are developed could offer near-term protection on a parcel-by-parcel basis but can have negative impacts on the community as a whole. Floodwaters that are displaced from one parcel can exacerbate problems for neighboring properties. Additionally, there can be access, drainage, regulatory and aesthetic concerns.

Much of the City within the mid-level and high-end inundation areas is significantly below the elevations of the mid-level and high-end scenarios and thus, the amount of fill needed would be prohibitive. Elevating land is most feasible in the case of a super levee, as discussed in Chapter 4, which can provide protection to a large area of the City, without disrupting other land uses. Additionally, in areas along the margins of the inundation area, where the amount of fill required would be less, this may be a more appropriate approach to reducing flood hazards.

5.4.2 Managed Retreat

Managed retreat involves controlled, intentional flooding of vulnerable low-lying areas. The City could provide tax credits for relocating flood-prone properties, offer tax incentives to property owners in exchange for maintaining land as open space, or create conservation easements. This mitigation alternative typically works in areas where land is of lower value because it is cheaper than paying for soft or hard shoreline protection measures. The abandoned land could be converted into salt marshes as it is reclaimed by the sea. Managed retreat could be accomplished through the City purchasing properties over time or creating an incentive for existing development to relocate.

However, with such a significant portion of the City, including much of its business and industry in the inundation area, managed retreat would likely be cost prohibitive, except on a very small scale. Costs would stem from both the cost to implement a project, and long-term loss of tax revenue from developed parcels.

5.4.3 Building Code Updates and Retrofits

Building code updates are a relatively easy-to-implement local mitigation alternative. As new development and redevelopment occur with enhanced flood protection, risk is gradually reduced. Among other standards, the floodplain management portion of the building code generally requires a building's lowest floor to be elevated or floodproofed above a specified flood elevation. Though typically triggered by code requirements, retrofits can be accomplished on any structure. Typical retrofits include elevation of the lowest floor or the use of flood-proof building materials below the expected flood elevation. Updates to building codes and retrofitting during redevelopment are most effective against intermittent flooding, rather than long-term sea level rise. Although they can reduce risk to structures in the near-term, if surrounding roadways and utilities are inundated by long-term sea level rise, flood-proof structures will still be lost.

The City's building code already includes provisions to protect development against flooding up to an elevation of 12 feet NAVD88, 2 feet in excess of the minimum federal requirement. To decrease near-term flood risk, the City could increase the level of protection required and/or expand the area where existing floodplain management standards are applied. Updated building codes would further reduce flood risk to new development and existing development undergoing substantial improvements.

5.4.4 Storm Drainage Improvements

A suite of capital improvement projects were recommended in the *Storm Drain Master Plan* (City, 2018). The projects were conceptually designed to meet the City's 10- and 100-year drainage design criteria, with the exception of providing sufficient freeboard in open channels during a 100-year, 24-hour event. The City's storm drain system was not designed for a 100-year, 24-hour storm. Therefore, during such large events, significant street flow is expected throughout the City. The proposed improvements address areas with excessive flood depths during these types of events and can help alleviate flooding from more intense storms as climate change progresses. They do not address long-term inundation from future sea level rise but can provide a complementary reduction in combined flooding. The *Storm Drain Master Plan* noted that future sea level rise will require increases in channel height to contain the storage in the low-lying parts of the system that will occur with higher sea levels. Mitigation alternatives to address open channel capacity are discussed later in this chapter.

Reconfiguration of Landing Lane Bowl

Improvements are needed at the Landing Lane Bowl that feeds into Lomita Canal to increase hydraulic capacity. The recommended improvements include replacing the trash capture devices and the low flow weir to maximize conveyance through Landing Lane Bowl under the tracks. It may be necessary to identify an alternate design or location for trash capture in the future. This improvement will reduce backup in upstream drainage systems but should be coupled with vegetation removal in Lomita Canal to achieve optimum results. It is assumed that vegetation control will be managed by Airport maintenance staff.

Reoperation of Hillcrest Pump Station

This project includes two components: reoperation of the Hillcrest Pump Station to make use of both pumps during high flow storm events and adding a discharge line that crosses the tracks. The increased discharge will require upgrading the downstream conveyance to Highline Canal by adding a second, parallel 66-inch line on the east side of the Bay Area Regional Transit (BART) tracks. The 66-inch line also alleviates existing performance issues upstream. Since both pumps are already in place, the bulk of the cost of this improvement is in the additional discharge and new large diameter line. The City may also consider a third pump as back up for large storm events, particularly when considering future climate change.

Increased Highline Canal Inlet Capacity

This project increases the conveyance under the BART tracks at the head of the 33-inch line under the Highline Canal that leads to the Airport Pump Station. This location is currently a hydraulic constriction, according to available drawings that indicate the line is 18 inches in diameter. In the improvements modeling, the size of the line was increased to 2.5 feet to achieve the design criteria. This was recommended, as opposed to adding a parallel line, as the additional width needed to install a line parallel could create the potential for utility conflicts.

Downtown Capacity Increases

A suite of project components were proposed in the *Storm Drain Master Plan* (City, 2018) to achieve a reduction in flood depths for three locations, as well as high velocity flows along Tioga Drive. The proposed improvements also contribute to the improvement of widespread shallow flooding throughout downtown. Improvements include the following:

- Increasing pipe diameters all the way from Tioga Drive to Magnolia by 0.5- to 1-foot in diameter, depending on location.
- Relocating the connection of this line to the line in Taylor Boulevard to allow additional parallel facilities to be added within street rights of way. This improvement includes capping the upstream end of the existing 4-foot diameter segment of storm drain.
- Increasing pipe size just before the Taylor Boulevard line empties into the box culvert under Broadway to accommodate the additional flow.

The cost and difficulty of implementing this project is not fully understood at this time. The preliminary alignment selected for the new right of way was chosen to make use of City streets, but the extent of conflict with existing utilities is unknown and may impact the practicality of implementing this improvement.

Food Risk Reduction Along Tioga Drive

The improvement projects proposed along Tioga Drive were conceptually designed to alleviate flood hazard, where velocities are expected to be up to 14 feet per second during a 100-year, 24-hour event. The 6-inch increase to the existing 30- and 36-inch lines increase capacity to carry high flows underground, rather than in the street. Achieving the recommended amount of cover over the new pipe installations should be undertaken with care, as preliminary analysis suggests that there is less than 2 feet of cover available. It is reasonable to assume that adjustments in new pipe inverts can be made to obtain sufficient cover.

Flood Risk Reduction Along Helen Drive

Increased pipe sizes along Helen Drive were proposed to reduce flood hazards, where velocities during ae 100-year event are expected to be as high as 10.6 feet per second under the existing condition. While the improvements do not eliminate street flooding during a 100-year, 24-hour event, the flood hazard is expected to decrease significantly.

Capacity Increases Along Center Street

The improvement recommended along Center Street was proposed because the existing condition 100-year, 24-hour model indicated a large amount of overflow. It is likely that overland flow would distribute through surrounding streets but could be alleviated with a 6-inch increase in diameter. For this proposed improvement, less than 2 feet of cover is available at both the upstream and downstream ends of the segment and care should be used in design to address this issue. Prior to the implementation of this improvement, the connection of this system with Center Street should be verified. During field investigations, the City indicated it does not connect to the 42-inch line from Greenhills Park, but it is possible that a connection exists that could not be located.

Canal Improvements

Open channels that drain the City, including those at Highline and Cowan canals have insufficient freeboard to contain large amounts of runoff under existing conditions. In the near-term, the City can undertake improvements to the canals to prevent seepage and backflow from the Bay and initiate projects in support of the longer-term regional shoreline solution.

Existing Capacity Improvements

Embankments along Highline and Cowan canals may also be exceeded under the current 100-year extreme tide elevation of 10.28 feet NAVD88 (AECOM, 2016). There is also existing seepage along the north bank of Highline Canal. Capacities would be further impacted under sea level rise scenarios that reduce the ability of these channels to discharge to the Bay. Should a large storm event occur at the same time as an extreme high tide, as modeled during the development of the *Storm Drain Master Plan* (City, 2018), this situation would be exacerbated.

As discussed in Chapter 3, minimum crest elevations of the Cowan and the Highline canal embankments are 7 feet and 6 feet NAVD88, respectively. To attain crest elevations of 13.3 feet and 16.6 feet to meet the mid-level and high-end sea level rise planning elevations, up to an additional 8 to 11 feet of height would need to be added to canal embankments. Existing rights of way are insufficient to accommodate higher (and therefore wider) earthen embankments. Therefore, a floodwall solution would be necessary. Concurrent improvements of the existing embankments and possibly the foundations could also be recommended to address performance issues, if recommended by a geotechnical analysis.

Further, as an interim flood reduction measure, the City plans to repair the Highline Canal tide gates. Currently, water from the Bay is prevented from entering the Highline Canal by twin box culverts (near South McDonnell Road), each 15 feet wide by 15 feet tall, with large flap gates. Flap gates allow water to flow from the City to the Bay but prevent back flow from the Bay to the City. However, these flap gates sometimes do not close completely because mud accumulates below the gates and prevents the gates from sealing shut. The annual operations and maintenance cost of the tide gate is approximately $250,000. The tide gate could be replaced at a cost of about $1.5 million.

Future Capacity Improvements to Address Climate Change

In addition, as discussed in Chapter 4, it may eventually be necessary to seal the tide gates on Highline and Cowan canals as sea levels rise to prevent backflow and overtopping of canal embankments. This would result in the necessity for new pump stations to move runoff from the canals to the Bay. These pump stations would be part of a regional solution but resolve local drainage issues. The pump station serving Highline Canal could be constructed by the City alone. The new pump station on Cowan Canal would likely be a collaboration between the City and Burlingame, who share the canal.

Airport Lift Station Improvements

The City-owned side of Airport Pump Station moves runoff from Lomita Canal into Highline Canal, where the discharge gravity flows to the Bay. A separate portion of the pump station is owned by the Airport and is used to move runoff from the Airport to Highline Canal. Flooding has occurred in the past in the Aviador Area, adjacent to Lomita Canal during a failure at the Airport Lift Station. Currently, the Airport Lift Station relies on a single 125-horsepower pump. Adding a redundant pump could increase the resiliency of this pump station, as well as add future capacity, if needed. The existing Airport Lift Station modifications to the wet well and a separate discharge pipeline would be required to accommodate the addition of a second pump to the City’s side of the pump station. Although the cost to improve the City’s side of the pump station would be borne by the City, coordination would need to take place with the Airport, due to their interest in the pump station.

Improvement of Lomita Canal

Lomita Canal is the main drainage channel that receives runoff from the northern portion of the City and is maintained by Airport staff. There has been a history of flooding in the vicinity of Landing Lane. The *Storm Drain Master Plan* (City, 2018) modeled the impacts of an excess of vegetation in the Lomita Canal and noted hydraulic impacts. Maintenance of the channel has been hampered by difficulty in obtaining permits to use equipment in the channel, where endangered species are present at times. Excess vegetation causes a backwater condition in the upper portion of Lomita Canal that impairs drainage of the City at the Landing Lane Bowl. However, the City has recently installed a trash capture device in the Landing Lane Bowl that may also create a hydraulic impact at lower flows. Removing vegetation would support additional storage and hydraulic conveyance in the channel that will also improve the function of the Airport Pump Station.

5.4.5 Green Infrastructure Runoff Reduction Measures

Climate change is expected to change precipitation intensity, resulting in more frequent and larger flood events. One mitigation measure that can be undertaken is implementation and expansion of the City's recently completed *Green Infrastructure Plan* (City, 2019). Green infrastructure can include rain gardens, bioswales, cisterns or rainwater harvesting, permeable pavement, creek daylighting, green roofs, urban forestry and more. Green infrastructure captures stormwater runoff, allowing it to either enter a downstream storm drain at a slower rate, or infiltrate into the soil. Projects can be placed on individual development sites as redevelopment occurs or can be larger projects that capture runoff from multiple properties. Some green infrastructure alternatives are described below.

Green Streets

Green street projects offer multiple benefits to the City, including pedestrian and traffic safety components and water quality enhancement. These projects typically incorporate curb extensions to shorten pedestrian crossing distances, calm traffic, and provide space to infiltrate stormwater runoff through integrated bioretention areas. Current plans for green streets projects include projects at the following locations:

- **El Camino Real—**Along with other improvements, the El Camino Specific Plan would provide infiltration of runoff into landscaped elements placed along the right of way.
- **San Anselmo—**Along with other improvements, the project would provide infiltration of runoff into landscaped elements placed along the right of way on San Anselmo Avenue from the San Bruno City limit to Landing Lane.
- **Laurel Avenue and Richmond Drive—**Bioretention areas will be incorporated within new curb extensions and will treat stormwater runoff from surrounding impervious surfaces.
- **Taylor Middle School—**At the intersection of Taylor Boulevard and Almenar Street, the City proposes to add biofiltration as part of a larger traffic safety project.

Low Impact Development

Current plans for low impact development include projects at the following locations:

- **Millbrae Serra Station Development—**Tree well and a green roof would reduce site runoff as well as providing water quality benefits.
- **The Gateway at Millbrae Station—**Bioretention areas will infiltrate stormwater through engineered soils and pervious pavers.
- **480 El Camino Redevelopment—**Flow-through planters, bioretention areas, and infiltration basins will treat and infiltrate stormwater runoff.

These projects offer multiple benefits to the City, including pedestrian and traffic safety components and water quality enhancement, but the ability to add storage to the watershed and reduce runoff makes them an ideal component of climate change adaptation.

Expansion of the Green Infrastructure Plan

There may be opportunities to expand the current *Green Infrastructure Plan* to identify additional locations to create detention and infiltration areas. These opportunities could include park sites, permeable pavement projects, or further green streets projects as described below.

Park Sites

Part of the existing *Green Infrastructure Plan*, the 104-acre Green Hills Country Club golf course has existing on-site retention ponds that naturally infiltrate water. Although the facility is privately owned, a partnership with the City could increase the capacity of green infrastructure on the property, if these features were designed to add value to the existing use. An additional benefit of this opportunity would be to design the retention to meet the goals of the current Municipal Regional Stormwater National Pollutant Discharge Elimination System (NPDES) Permit.

The City has 13 parks. Those in the upper portions of the watershed offer the greatest potential to reduce strain on the drainage system, as they benefit all pipelines downstream of their location. Upper watershed parks (i.e., west of El Camino Real) that drain to the City's storm drainage system include the following:

- Central Park
- Meadows Park
- Mills Estate Park
- Green Hills Park
- Spur Trail Phase I
- Josephine Waugh Soroptimist Park
- Rotary Park
- Bill Mitchell Lions Park
- Spur Trail Phase II
- Mosta Grove

With further study, it is likely that additional locations at these parks could be identified for retention or infiltration gallery placements to increase downstream drainage capacities to adapt to increased precipitation intensity under climate change. Additionally, there are private parks that could provide similar opportunities, with a greater level of planning required to retrofit these sites.

Permeable Pavement and Green Streets

Because the public right of way is owned by the City, street locations are ideally suited to adding to the existing *Green Infrastructure Plan*. As streets are repaved, or infrastructure is replaced, features to capture and treat stormwater can be added. While it is beyond the scope of this Assessment to identify optimal locations, the City anticipates regularly adding to its *Green Infrastructure Plan* in the future, as it is considered a living document. This will allow the City to increase stormwater capture over time and increase the resiliency of its drainage systems.

5.5 Conclusions

Local mitigation strategies offer opportunities to enhance adaptive management, reduce flood risk, and support regional solutions to sea level rise. They offer near-term steps the City can take in conjunction with ongoing efforts to identify and implement regional solutions. Chapter 6 addresses additional recommendations to integrate local and regional solutions and to address planning and funding for these projects.

6. ASSESSMENT RECOMMENDATIONS

This chapter outlines some of the necessary next steps for refining and selecting shoreline mitigations and highlights additional information that will be needed to move these options forward. This chapter also provides general recommendations for next steps in overall coordination, planning, funding, and engagement activities.

6.1 Introduction

This Assessment has identified numerous opportunities for the City to prepare for future sea level rise. By understanding the threats the City faces from sea level rise, the City and the region can collectively begin to take action to reduce risk. The City’s primary goal is to implement a regional project that can protect both the City and its partners in the OLU. However, adaptation to climate change can take place on multiple fronts concurrently, yielding multiple benefits and local and regional levels. The City can continue to participate in efforts to reduce its climate footprint, increase smart redevelopment, and expand local and regional conversations around adaptation while advancing the regional solution.

6.2 Planning Recommendations and Next Steps

This section presents some recommendations for next steps in local and shoreline planning, and discusses integration of this Assessment’s findings into other local plans to maximize its usefulness and encourage cohesion across current and future planning tools. Consequently, this section describes opportunities to enhance future sea level rise planning. As available information and understanding of climate change continues to improve, this Assessment and other regional studies should be updated to reflect further adaptation options, integrating the best available state of science and changes in local and regional planning needs.

6.2.1 Shoreline Solution Planning

If the City selects a mid-level increase in sea levels as an interim planning target, the shoreline would need to increase in height from 1 to 5 feet. Key components of the shoreline solution that would be driven by the City would include improvements at Highline Canal tide gate (Reach 8), and implementation of a levee or seawall across the Bayshore (Reaches 5, 6, and 7). The City can choose from a variety of configurations through the Bayshore to accomplish this. Options discussed in Chapter 4 include construction of a conventional or lightweight levee, a seawall, or a levee with a floodwall added as sea levels rise. A supplementary design feature of the selected alternative could be incorporation of eelgrass offshore in the existing area of mudflats. The alignment followed may parallel the Old Bayshore Highway or follow the shoreline more closely through Bayfront Park to preserve land and recreational opportunities.

With multiple adaptation options, further work will be required to select a feasible alternative. The following engineering efforts are anticipated to better understand the full range of benefits, costs, and impacts of each option:

- Finalizing design requirements
- Collecting data collection
- Refining alternatives
- Performing feasibility studies

Finalizing design requirements will occur in collaboration with regional partners as discussed in the Section 6.4. One of the first decisions the City and the region should make is whether future improvements should be designed to remove the City from the floodplain shown on FEMA's FIRMs. Levees, seawalls, and floodwalls designed to stop flooding to a FEMA standard will require additional freeboard and analyses as part of design. One implication of this decision is that the requirement for protected structures to carry flood insurance would be waived, and premiums for optional coverage would be more affordable. However, the additional design considerations would increase the cost to implement protections from sea level rise and/or combined flooding.

Although extensive additional data will be needed to design and construct adaptations, two main types of data will be needed in the near term to advance selection of feasible alternatives: shoreline survey data and geotechnical information. As mentioned in Chapter 3, shoreline survey data discussed in this Assessment have been taken from LiDAR surveys, and are therefore subject to vertical uncertainty. High-accuracy survey elevations should be collected along the potential shoreline alignments and along the crest of the embankments of Highline and Cowan canals. However, a land survey will also be needed to verify property lines, as available parcel data used in this Assessment were outdated in some areas.

The second type of data that will be needed is geotechnical information. An understanding of the current condition of both Highline and Cowan canal embankments will influence the potential local mitigations selected and, given existing seepage concerns, could significantly impact the potential cost. Additionally, a study of potential foundation conditions will be critical to identifying constraints in the design and ultimately the viability of any structural improvements, particularly along the shoreline.

6.2.2 Local Solution Planning

Locally, it will be important for the City to decide whether, and to what extent, to modify future development standards. The City is currently enforcing floodplain management regulations within the FEMA special flood hazard area correlating to an elevation of 10 feet NAVD88, as shown on the FIRM. The elevation to which redevelopment must protect structures is 12 feet NAVD88, according to the floodplain management ordinance, which provides this additional protection partially to reduce risks from sea level rise. However, a flood elevation of 12 feet would have a larger floodplain than a 10-foot flood elevation. Considering that the City anticipates sea levels of up to 16.6 feet NAVD88 a possibility, both development standards and local flood hazard mapping could be updated to proactively reflect the anticipated risk. Such a decision would not necessarily impact flood insurance rates but would reduce overall risk.

Not only is the alignment of standards helpful in conveying risk to the public, but it can support decision-making since benefits and costs of flood risk reduction would be computed on the same basis.

Understanding the magnitude and footprint of potential benefits can help the City to obtain funding for implementations, as discussed in Section 6.3.

The City's *Green Infrastructure* and *Storm Drain Master* plans prioritize of many local projects that the City can fund and implement concurrent with other efforts. Allocating funding toward these projects in the annual budget will ensure progress is made toward local sea level rise adaptation. The City can also continue to revise and update these studies periodically to add further projects and expand their impact, as discussed in Chapter 5.

6.2.3 Plan Integration

To increase the effectiveness of this Assessment, and facilitate integration into overall City planning and funding, the City should incorporate Assessment findings into future updates of several other documents and processes. These include the annual budget development and capital improvement planning process, the *Green Infrastructure Plan* (City, 2019), the *Storm Drain Master Plan* (City, 2018), the in-progress *Draft Climate Action Plan*, the *Hazard Mitigation Plan* (County, 2016), and the *General Plan* (City, 1998).[1]

Annual Budget and Capital Improvement Plan Updates

Appropriations for planned capital projects must be included in the City's annual budget. Budget for new and upgraded infrastructure is allocated based on priorities identified in the Public Works Department's Capital Improvement Program and approval by the City Council. Local projects identified in Chapter 5 and detailed and prioritized in the *Storm Drain Master Plan* and *Green Infrastructure Plan* should be incrementally funded each budget cycle. As funding is obtained, as discussed in Section 6.3, additional priorities can be identified.

Storm Drain Master Plan and Green Infrastructure Plan Updates

As discussed in Chapter 4, updates should be made to the *Storm Drain Master Plan* and the *Green Infrastructure Plan* as the City makes progress in implementing projects that it has identified. These plans identify projects to increase watershed storage of runoff and capacity of the drainage system. Updates should reflect additional portions of the drainage system that can benefit from improved capacity and runoff capture. Adaptive management of these plans will compound the benefits to the City, offsetting the impacts of climate change that will occur over time.

[1] City of Millbrae General Plan adopted in 1998. Since then several updates have been made to specific plan Elements. However, a full update for 2040 is currently underway (see https://www.ci.millbrae.ca.us/departments-services/community-development/general-plan-update)

Climate Action Plan

The City developed a *Draft Climate Action Plan* in 2018 and has adopted and implemented a number of policies, programs and projects to address the reduction of greenhouse gas emissions and related efforts to improve sustainability. The City adopted the U.S. Mayor's Climate Protection Agreement in 2007 and has participated in the International Council for Local Environmental Initiatives Cities for Climate Protection Campaign and Countywide regionally integrated climate action planning. In 2009, the City established specific greenhouse gas emissions reduction goals for municipal operations and City emissions sources. In addition to reducing emissions, the City can include plans to create a more resilient community through adaptation of physical infrastructure in future *Climate Action Plans*.

Hazard Mitigation Plan Updates

The San Mateo County *Hazard Mitigation Plan* was updated in 2016. The City of Millbrae participated in the planning process and the *Local Hazard Mitigation Plan* was prepared as an annex to the County plan. This document focuses on reducing risks to the community from a variety of hazards and includes actions to prepare for climate change. Future updates of the local and County plans should incorporate the findings of this Assessment and include actions toward both local and regional adaptations.

General Plan Updates

The City has begun a multi-year process to update the *General Plan*, which was last adopted in 1998. The *General Plan* will guide decision-making for land use, transportation, infrastructure, community design, environmental issues, and other important topics that impact the community. The results of this Assessment and subsequent decisions about future development standards should be reflected in the *General Plan* update. Relevant policies that should be updated include the following:

- Policy S1.1, Location of A Future Development
- Policy S1.8, Reforestation
- Policy S1.12, Ordinances and Codes
- Policy S1.17, Drainage Channels, Hydraulic Pumps and Conduits
- Policy S1.18, Hazards
- Policy S1.19, Rise in Sea level
- Policy S2.2, Emergency Services Facilities
- Policy S2.3, Hazardous Awareness

6.2.4 Plan Adaptation

This Assessment provides baseline information about potential impacts to the City, its residents, and its infrastructure and recommends potential adaptations, based on available information. However, as additional information becomes available, this Assessment and other planning documents should be adjusted. There are several areas where future advances are expected to inform decision-making including revised estimates of climate change, improved understanding of combined flood risks, subsidence, and rising groundwater. These topics are discussed in further detail below.

Revised Climate Change Estimates

Climate change is driven by human behavior and thus, can be unpredictable. As time passes, understanding of the expected future rate of climate change, and thus, sea level rise estimates, will improve. Climate change and climate impact modeling is also improving rapidly. Although the City and the County have selected the mid-level and high-end scenario flood elevations of 13.3 and 16.6 feet NAVD88 for the purposes of this Assessment, the City and the region may ultimately elect to plan to a different elevation in the future and should consider the latest climate science as it becomes available.

Combined Flooding

To some extent, the impacts of combined flooding may be mitigated by providing extra storage in the City's drainage system, but additional capacity will be required to address increased future flows, particularly in the City's lower-lying areas. Further, the existing capacity of City pump stations is likely to be exceeded as flows increase and must be lifted higher to drain to a higher Bay. Some discussion of potential adaptive actions is provided in Chapter 5, based on modeling of the existing drainage system. However, more work will be needed to understand changes in precipitation and the magnitude of combined flooding due to climate change, and the impacts on the City's infrastructure. The County is currently preparing a study of combined flooding and the findings should be used to support future storm drain master planning and development standards.

Subsidence

Local land subsidence has not historically been a concern for the City, but a recent study (Shirzaei and Bürgmann, 2018) has indicated that subsidence in the Bay Area, including the area around Millbrae is accelerating the rate of sea level rise. This subsidence has generally not been accounted for in sea level rise predictions developed to date. Areas with significant fill can be more impacted, with fill consolidating over time. While the City is largely located on better soils, this is an area recommended for further regional and local study to improve hazard mapping and influence decisions on eventual heights of adaptations.

Rising Groundwater

As sea levels rise, low-lying areas may be vulnerable to groundwater inundation or localized flooding due to a rising groundwater table (Plane and Hill, 2017). It is possible, with sufficient sea level rise for groundwater to break out above the land surface creating impacts behind shoreline protections. Such breakout could create or expand wetlands, reduce drainage capacity, and inundate low-lying areas. The potential for rising groundwater in the City is not well understood and additional modeling should be performed to quantify this risk to development along the shoreline.

6.3 Funding Recommendations and Next Steps

Limited funding presents a challenge to implementation of both local and regional adaptation strategies. Costs to implement local and shoreline adaptation strategies will be high and successful implementation will require a funding strategy that leverages available City budget to match federal, state, and local funding. This section presents an overview of the costs to implement sea level rise adaptations. Order of magnitude capital costs are provided where known, and a discussion of known and unknown additional costs is also included to highlight some next steps to achieve funding.

With a nearly $70 million cost to implement only a partial list of adaptations (not including new pump stations) as outlined in Table 6-1, the City and the region will need to prioritize expenditures and seek extensive outside funding. A single source of revenue is unlikely to cover all the various adaptations needed to meet the challenges of sea level rise. Instead, implementation will require a range of local, state, and federal funding sources.

Table 6-1. Summary of known costs for sea level rise adaptations.

Table 6-1. Summary of Known Costs for Sea Level Rise Adaptations.

Sea Level Rise Adaptation	Reach	Order of Magnitude Cost Estimate (dollars)
Shoreline raise to mid-level scenario using lightweight levee	5, 6 and 7	3,900,000
Highline Canal tide gate replacement and 4-foot raise[1]	8	1,646,069
Cowan Canal tide gate replacement and 5-foot raise[2]	4	1,687,802
Trunk drainage improvements from *Storm Drain Master Plan*	N/A	23,405,000
Green Infrastructure Plan implementation[3]	N/A	8,033,583
Average 5-foot floodwall on Cowan Canal[4]	3	11,200,000
Average 5-foot floodwall on Highline Canal[4]	1 and 2	20,126,000
	Total Costs	69,998,454

1. Gate replacement cost of $1.5 million from San Mateo County, 2017; floodwall raise costs from Foster City, 2015.
2. Assumes costs for gate replacement to be comparable to those for Highline Canal.
3. Millbrae, 2019 (Includes only Intermodal Station, Community Center, History Museum, Richmond Avenue, and San Anselmo project locations).
4. Foster City, 2015; does not include improvements to existing embankments to support a floodwall raise.

One of the benefits of preparing this Assessment is to communicate adaptation goals and options with the region. One of the next steps in advancing shoreline solutions is integrating this Assessment into a larger regional strategy including the following steps:

- Participate in the development of a regional Memorandum of Understanding reflecting a shared commitment to sea level rise adaptation, understanding the need for collaborative funding pursuits, and continued coordinative efforts with key stakeholders and major utilities

- Develop of a funding plan that will identify the best way to leverage available funding opportunities and/or participation in development of a regional funding plan
- Consider preparing a local fee study to determine whether residents would benefit from an assessment to implement flood risk reduction, including factors such as benefits over insurance costs and potential risks over the lifetime of mortgages

As the City and the region make progress toward adaptation, funding needs and opportunities will change. The City's approach to funding will need to be adapted as additional information becomes available and more awareness is brought to the need for sea level rise adaptation and funding opportunities are made available. One benefit of the City's participation in San Mateo's new Flood and Sea Level Rise Resiliency District is that the District can help facilitate these efforts.

6.4 Continued Engagement Recommendations and Next Steps

Continued engagement of the public, regulators, regional partners and other stakeholders will be critical to successful decision-making, and ultimately, implementation of actions for adaptation to climate change and sea level rise. Anticipated outreach efforts are described below.

6.4.1 Outreach to the Public

Garnering public support for adaptation will require ongoing engagement and education. The City routinely holds public meetings to announce important project milestones and seek public input on planning decisions. This kind of input can also be supported through ongoing public surveys, such as those discussed in Chapter 2 (see Section 2.3.4), which provided important public input on this Assessment. In addition, the City will need to regularly update the climate adaptation web page with relevant information on progress toward implementation and include social media postings similar to those conducted in support of this Assessment and discussed in Chapter 2. These efforts will keep adaptation in the public eye and foster continued dialogue and interest. Finally, the County is currently preparing a *Climate Ready Sea Level Rise Adaptation Toolkit*[1]. The toolkit is expected to be ready by February 2020 and can serve to synthesize existing and planned efforts throughout the County to aid in consistent messaging strategies.

6.4.2 Outreach to Permitting Agencies

As discussed in Chapter 4, there are a wide variety of agencies likely to seek input on the selection of adaptation alternatives. It will be in the City's interest to seek early input from regulators on permit requirements and preferences, including the BCDC, RWQCB, CDFW, USACE, USFWS, and NMFS.

[1] The Toolkit is still in progress. For more information on the Climate Ready San Mateo County Collaborative see https://climatereadysmc.org/

Early input from these agencies can facilitate implementation because alternatives can be formulated to minimize impacts and mitigations. At the same time, ongoing discussions with regulators can assist the City in identifying potential funding streams from each agency.

6.4.3 Outreach to Asset Owners

As discussed in Chapter 2, the City has made an effort to reach out to the owners of major utility assets within the potential mid-level and high-end inundation areas. In Chapter 3, this Assessment provides identification of additional assets that can guide future outreach to affected property owners and stakeholders. Further targeted outreach should focus on understanding the planning and decision-making processes used by transportation utilities including BART, Muni, and Caltrans to integrate their plans into the City's overall approach to adaptation and could be facilitated via a short workshop with representatives from these major utilities. It is also anticipated that further discussions with PG&E will be necessary, given the gas and electric corridors that run through the Bayshore areas.

6.4.4 Outreach to Regional Partners

The City has made extensive efforts to engage with regional partners throughout the OLU. Further outreach is needed to the cities of South San Francisco and San Bruno, who did not provide input to this Assessment. Additionally, ongoing coordination with all regional partners and especially with the Airport will be needed to develop a set of regional standards, priorities, and a memorandum of understanding to facilitate funding. One of the next steps in determining potential alignments of through Bayfront Park is to present alternatives to the Airport's land use and legal review teams to seek input on the potential to pursue these adaptations.

6.5 Conclusions

This Assessment has provided new insights into the local risks of mid-level and high-end sea level hazards that can be used to plan for adaptation and communicate with residents, property owners, and other stakeholders to encourage successful on-the-ground implementation and risk reduction. To preserve up to $380 million of property value and avoid the loss of up to $175 million in annual tax revenues, additional work is needed to continue planning, funding and coordinating both local and regional adaptation efforts. Actions for adaptation range from simple improvements that can be readily funded within the annual budget update to complex multi-agency and multi-year efforts. The City plans to continue its proactive approach to understanding and adapting to sea level rise, and to enable its vibrant downtown residential, commercial, industrial, and transportation development areas to continue to thrive into the future.

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APPENDIX A: COMMUNITY & STAKEHOLDER ONLINE SURVEY

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Raw Survey Scores

Relation to City of Millbrae	Sea Level Rise Concern	Other Flooding Concern	Keep Up with Sea Level Rise News	Views of Shoreline	Recreational Access to Bay	Enhancing/Creating Habitat Along Bay Shore	Cost of Shoreline Protection	Support Changes in Development	Consider Other Impacts?	Beyond levees, sea walls/sheet pilings, rocky/shell shorelines, or ecotone levees are there other shoreline solutions the City of Millbrae should consider?
Live in Millbrae west of El Camino	1	1	Yes	2	1	1	5	1	Yes	No
Own property in Millbrae	1	1	Yes	1	2	1	1	1	No	No
Live in Millbrae west of El Camino	1	1	Yes	5	5	5	5	1	No	No
Live in Millbrae east of El Camino	1	1	Yes	5	5	5	1	1	No	No
Live in Millbrae west of El Camino	2	2	No	5	5	3	5	4	No	No
Live in Millbrae west of El Camino	2	2	Yes	3	5	5	3	5	No	No
Live in Millbrae west of El Camino	2	1	No	3	3	3	4	3	No	No
Live in Millbrae west of El Camino	2	2	No	4	4	4	3	4	No	No
Live in Millbrae west of El Camino	3	2	No	5	5	5	3	5	No	Yes
Work close to Millbrae	4	3	Yes	5	5	4	3	5	Yes	Yes
Live in Millbrae east of El Camino	4	2	Yes	4	4	5	2	5	Yes	No
Live in Millbrae west of El Camino	4	2	Yes	3	3	3	3	3	No	No
Live in Millbrae west of El Camino	5	5	Yes	5	3	3	5	5	Yes	Yes
Live in Millbrae west of El Camino	5	4	Yes	3	3	3	4	4	Yes	Yes
Live in Millbrae west of El Camino	5	4	Yes	5	5	5	1	1	Yes	Yes
Live in Millbrae east of El Camino	5	4	Yes	1	1	3	3	5	Yes	No
Live in Millbrae west of El Camino	5	5	No	4	4	4	2	5	No	No
Average		2.470588235		3.705882353	3.705882353	3.647058824	3.117647059	3.411764706		

Weighted Survey Scores

Relation to City of Millbrae	Sea Level Rise Concern	Other Flooding Concern	Keep Up with Sea Level Rise News	Views of Shoreline	Recreational Access to Bay	Enhancing/Creating Habitat Along Bay Shore	Cost of Shoreline Protection	Support Changes in Development	Consider Other Impacts?	Beyond levees, sea walls/sheet pilings, rocky/shell shorelines, or ecotone levees are there other shoreline solutions the City of Millbrae should consider?
Live in Millbrae west of El Camino	1	0.5	Yes	1	0.5	0.5	2.5	0.5	Yes	No
Own property in Millbrae	1	0.5	Yes	0.5	1	0.5	0.5	0.5	No	No
Live in Millbrae west of El Camino	1	0.5	Yes	2.5	2.5	2.5	2.5	0.5	No	No
Live in Millbrae east of El Camino	1	0.5	Yes	2.5	2.5	2.5	0.5	0.5	No	No
Live in Millbrae west of El Camino	2	1.4	No	3.5	3.5	2.1	3.5	2.8	No	No
Live in Millbrae west of El Camino	2	1.4	Yes	2.1	3.5	3.5	2.1	3.5	No	No
Live in Millbrae west of El Camino	2	0.7	No	2.1	2.1	2.1	2.8	2.1	No	No
Live in Millbrae west of El Camino	2	1.4	No	2.8	2.8	2.8	2.1	2.8	No	No
Live in Millbrae west of El Camino	3	2	No	5	5	5	3	5	No	Yes
Work close to Millbrae	4	3.9	Yes	6.5	6.5	5.2	3.9	6.5	Yes	Yes
Live in Millbrae east of El Camino	4	2.6	Yes	5.2	5.2	6.5	2.6	6.5	Yes	No
Live in Millbrae west of El Camino	4	2.6	Yes	3.9	3.9	3.9	3.9	3.9	No	No
Live in Millbrae west of El Camino	5	7.5	Yes	7.5	4.5	4.5	7.5	7.5	Yes	Yes
Live in Millbrae west of El Camino	5	6	Yes	4.5	4.5	4.5	6	6	Yes	Yes
Live in Millbrae west of El Camino	5	6	Yes	7.5	7.5	7.5	1.5	1.5	Yes	Yes
Live in Millbrae east of El Camino	5	6	Yes	1.5	1.5	4.5	4.5	7.5	Yes	No
Live in Millbrae west of El Camino	5	7.5	No	6	6	6	3	7.5	No	No
Average		3		3.8	3.705882353	3.770588235	3.082352941	3.829411765		

Sea Level Rise Response	Weight
5	1.5
4	1.3
3	1
2	0.7
1	0.5

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APPENDIX B: ASSET VULERABILITY PROFILE FOR THE WATER POLLUTION CONTROL PLANT

ASSET VULNERABILITY PROFILE
CITY OF MILLBRAE WATER POLLUTION CONTROL PLANT

400 E Millbrae Avenue, Millbrae, CA 94030

VULNERABILITY SUMMARY

Millbrae's Water Pollution Control Plant (WPCP) is **highly vulnerable** to sea-level rise due to its low site elevations and its proximity to the shoreline. Inundation from sea-level rise might impact the WPCP's operative capacity, potentially leading to a partial or complete loss of service. Adaptive capacity of the WPCP is low because the plant does not have a gate valve to shut off influent flow from the collection system and it is the only plant that treats wastewater from the City of Millbrae. The WPCP would likely sustain temporary and permanent damages from floodwaters that could affect long term operations. Consequences of loss of operative capacity at the WPCP (i.e., water supply shutoffs, contamination of water bodies) could negatively impact the entire service area.

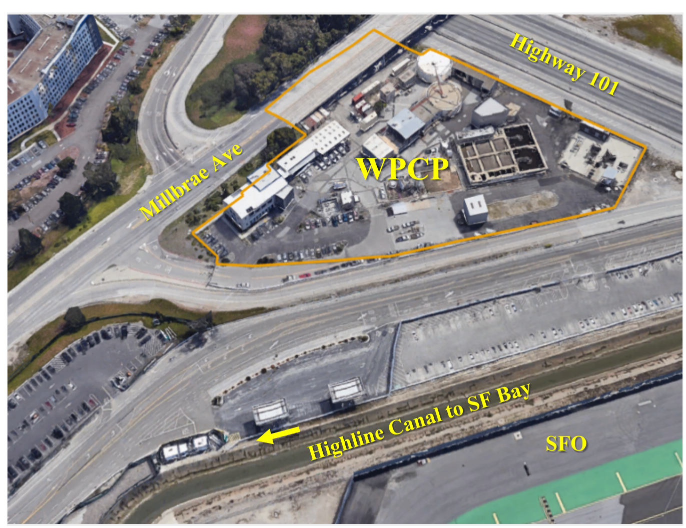
SENSITIVITY	EXPOSURE	ADAPTIVE CAPACITY	CONSEQUENCES
Moderate	*High*	*Low*	*High*

ASSET CHARACTERISTICS

The WPCP was built in 1952 and is located at 400 E Millbrae Avenue adjacent to Highway 101 and immediately south of San Francisco International Airport (SFO) in San Mateo County. The WPCP site is approximately 550 feet inland from and west of San Francisco Bay. Elevations on site range from 6.0 to 8.0 feet in the National Geodetic Vertical Database of 1988 (NAVD88). In addition to the risk of inundation from sea level rise, the WPCP is two to four feet below the existing 100-year flood elevation of 10 feet NAVD88 as shown on the Federal Emergency Management Agency's (FEMA's) Flood Insurance Rate Map (FIRM). The WPCP also lies between High Line Canal and Cowan Canal, which have existing seepage issues and the potential for overtopping during events more frequent than the 100-year storm event (1% flood).

The WPCP performs primary and secondary treatment of domestic and commercial wastewater collected from approximately 21,500 City residents. Plant discharge is distributed as chlorinated secondary effluent into the North Bayside System Unit force main, which shares power authority with the cities of Millbrae, Burlingame, South San Francisco, San Bruno, and the SFO. The Regional Water Quality Control Board, the State Water Resources Control Board, and the Environmental Protection Agency regulate the site.

Figure B-1 – Aerial View of WPCP Site and Surrounding Area



Asset Type	Wastewater Facility (Treatment Plant)
Asset Risk Class[1]	3
Landowner	City of Millbrae
Size	200,000 square-feet
Permitted Capacity	3.0 MGD (dry weather) 9.0 MGD (wet weather)
Level of Use	24/7 Operation
Year of Construction	1954
Year of Last Major Repair	2010
Insurance Valuation (2019)	$55 Million
Annual O&M Cost	$132,000[2]
Physical Condition	3.5 (Fair – Good)
Backup Power	Generator

Figure 2 – Aerial View of WPCP

The City of Millbrae Corporation Yard and Operations Center are also located on the property. The Corporation Yard extends underneath the Millbrae Avenue bridge over Highway 101.

Underground Facilities

The WPCP has the following major infrastructure below-grade and exposed to the atmosphere:

Infrastructure	Elevation (NAVD88)[1]
36" Influent Sewer Pipe and Headworks	-2.97 (*Top of Pipe/Channel*) = 9.72 FBG
Influent Pump Station and 1.2-MG Overflow FEQ Tanks	5.75 (Bottom of Slab) = 1.00 FBG
Blower Room for Aeration Tanks (Below Control House)	10.17 (*Ceiling*) = 0.75 FBG
Effluent Pumps	2.70 (*Centerline*) = 3.3 FBG
Sedimentation Tanks	15.25 (*Top of Wall*) = 8.5 FAG
Aeration Tanks	14.25 (*Top of Wall*) = 7.5 FAG
Secondary Clarifiers	14.25 (*Top of Wall*) = 6.25 FAG
Chlorine Contact Tank	14.25 (*Top of Wall*) = 8.25 FAG

[1] FBG = Feet Below Grade; FAB = Feet Above Grade

[1] American Society of Civil Engineers, 2015. 24-14 *Flood Resistant Design and Construction*.
[2] *Engineer's Project Summary Report, Millbrae Water Pollution Control Plant*. Kennedy Jenks. February 15, 2006.

Environmental Considerations

The WPCP site is fully developed and will have no additional environmental impacts. Special status plants, animals, and natural communities are unlikely to be present at the WPCP site.

ASSET SENSITIVITY

The WPCP is moderately sensitive to inundation. The WPCP has historically never been inundated from floodwaters; however, sea level rise ranging from two to three feet would likely inundate approximately 30 percent of the plant. Temporary flooding could disrupt or suspend treatment processes, leading to potential discharge of untreated effluent and contamination of water bodies. The weight of floodwaters could cause permanent structural damage to the WPCP. Structural damage to electrical control systems and/or loss of power supply would shut down all pump-driven processes. These damages and shut offs could result in release of untreated water to the surrounding environment with the potential to contaminate water bodies and water supplies.

Figure 3 – Effluent Pumps

The electrical switchboard and cogeneration turbine are the WPCP's most critical and essential components. The plant cannot function if the electrical equipment and/or power distribution system are damaged. Other vital components include pumps, particularly the influent pumps and effluent pumps, the headworks, the diesel fuel tank, and the standby generator. There is a drain located approximately 30 feet west downslope of the diesel fuel tank that would collect any spilled fuel and send it back to the WPCP headworks; however, the fuel tank is not equipped with any secondary containment at the source. Therefore, if floodwaters were to damage the fuel tank, it is likely that diesel could leak out onto the WPCP site and cause contamination.

SHORELINE VULNERABILITY

Shoreline Overtopping Analysis

For the shoreline overtopping analysis, both LiDAR data (Airport, 2018) cross sections and the Adapting to Rising Tides datasets (AECOM, 2016) were used to identify potential pathways of flooding to the WPCP. Millbrae Avenue is a potential flood pathway from the shoreline to the WPCP, but the first point of shoreline overtopping could come from overtopping of the Highline or Cowan Canals. Although the accuracy of the LiDAR data needs to be verified at the scale of canal embankments, the lowest crest elevations along both canals appear to be less than 8 feet NAVD88. In either sea-level rise scenario, with unrepaired tide gates on Highline Canal that often stick open or a large storm event without additional pumping capacity, the canals could easily overtop before the shoreline is overtopped. Figure 3-4 in Chapter 3 presents potential flood vulnerabilities based on the shoreline overtopping analysis.

Cross-Cutting Vulnerabilities

Inundation of the WPCP from floodwaters would likely have cascading impacts, including water supply shutoffs to reduce the amount of wastewater flowing into the Bay, since there is currently no way to stop inflow to the WPCP. Once inundated, the City's only option would be an emergency connection to an adjacent community's treatment facility, but no such connection is currently available, nor has such a connection been studied.

SEA LEVEL RISE EXPOSURE ANALYSIS

Exposure Discussion

The WPCP is highly exposed to impacts from sea-level rise. The WPCP has never been inundated from floodwaters, but it is subject to future inundation from sea-level rise because of low elevations and shoreline proximity. Currently, there is no barrier (i.e., berm, floodwall) to protect the WPCP site from floodwaters. Floodwaters would likely reach the WPCP from the Highline Canal South and the Cowan Canal North vulnerable reaches. If the Highline Canal Tide Gate remains unrepaired, it will likely be the first flood pathway to the WPCP.

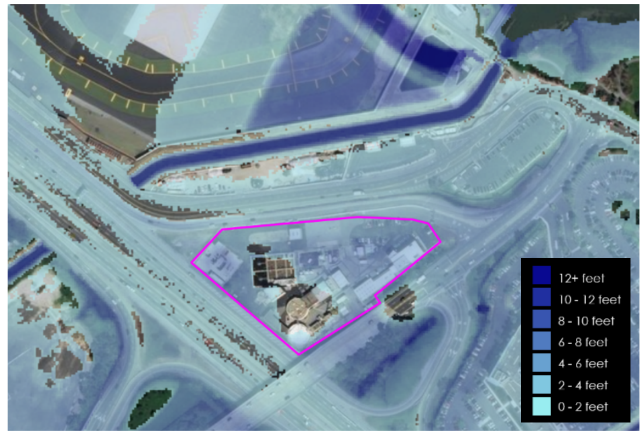
Water that gets on site would likely inundate much of the plant, including the influent and effluent pump stations. The WPCP is subject to moderate inundation during the baseline scenario (1% flood). Flooding at the WPCP could occur between 24-inches and 36-inches of total added water level. Figure B-4 shows project inundation areas and depths of flooding for the baseline, mid-level, and high-end sea level rise scenarios.

Exposure Analysis Results

Potential Inundation Depth (feet)		
Scenario	***Minimum***	***Maximum***
First Significant Impacts (*24-36 inches*)	0	5
Baseline *1% Flood*	0	6
Mid-Level *1% + 3.3 feet*	4	8
High-End *1% + 6.6 feet*	5	11

Figure B-4 – Inundation Exposure by Scenario

Baseline Scenario: *Asset under 0 to 6 feet of water*



Mid-Level Scenario: *Asset under 4 to 8 feet of water*

High-End Scenario: *Asset under 5 to 11 feet of water*

ADAPTIVE CAPACITY, CONSEQUENCES, AND POTENTIAL ADAPTATION

Adaptive Capacity

The WPCP has a few resiliency measures built in, but its overall adaptive capacity is low. It is the only wastewater treatment facility servicing the City of Millbrae and though it could mitigate effects from temporary or minor inundation; there is no alternate treatment facility to perform the same service long-term. It is equipped with a standby generator that can provide backup power for the entire plant in the occurrence of a utility power outage, but its use is only feasible if the power distribution system remains dry. If the power distribution system remains dry and the diesel tank is not damaged, the WPCP site has enough fuel storage to run the generator for approximately one to two days. The generator sits atop a concrete pad within an outdoor enclosure at an elevation just above 10 feet NAVD88, as it was designed to be protected from the existing 100-year flood elevation of 10 feet NAVD88. However, ventilation is provided around the base of the generator enclosure that would likely allow water to penetrate the enclosure if it exceeds 10 feet in elevation.

Figure 5 – Standby Generator Enclosure

There are also sump pumps in place to keep major equipment dry. Sump pumps are located, at minimum, before the aeration tank influent chamber, inside the blower room, and at the effluent pump station.

An effluent vault on site provides the WPCP with the option to direct treated flow to either the effluent pump station on site, which pumps to the joint use outfall line, or the emergency overflow "near shore outfall". The "near shore outfall" is currently inoperable and, if repaired, the WPCP must obtain approval from the Army Corps of Engineers prior to operating it. There is no built-in design mechanism (i.e., gate valve) at the influent of the plant, however, to stop the wastewater influent flow from the collection system.

Figure 6 – Highline Canal Tide Gate

Consequences

The consequences of inundation of the WPCP are high. Inundation from sea-level rise could significantly impact the City and water quality in the Bay. Direct damages to the WPCP from floodwaters may create a need for costly equipment repairs. Complete loss of service could negatively affect the entire sanitary collection system including the gravity mains, force mains, and lift and pump stations that convey wastewater from the City's 21,500 customers to the plant. As discussed above, the WPCP could lose service altogether if the standby generator enclosure flooded. If the WPCP lost service, overflows at the plant would likely occur, as plant operators can only utilize the 1.2-MG overflow tank for temporary storage.

Additional Important Information

There are operators on site at the WPCP seven days per week between the hours of 7:30 am and 3:30 pm. There are three operators on site on weekdays and only one operator on site on weekends. Currently, there is an ongoing Supervisory Control and Data Acquisition (SCADA) project to improve control of pumps at the plant.

Although the WPCP has never been inundated from floodwaters, the plant was inundated in 2017 due to a Pacific Gas and Electric (PG&E) power outage. When the power came back on, the pumps did not turn on. The grit pumps were flooded, and the SCADA system did not automatically start the influent pumps. This issue was resolved by a updating the SCADA system software and draining the plant. One pump had to be rebuilt as a result of this flood event, costing the City approximately $100,000. The equalization tank did not sustain damages because the built-in seismic valves automatically shut off the influent wastewater.

Asset-Specific Adaptation

Local adaptation could include measures inside the plant itself such as elevating water- or salt-sensitive equipment (i.e., electrical systems) or floodproofing individual critical structures. Much of the WPCP's critical components are located below the 100-year flood elevation of 10 feet NAVD88, so raising essential facilities is a less feasible option. Floodproofing individual structures can prevent water penetration during smaller storm events; however, weight of the floodwaters will likely be significant enough to cause structural damage, thus breaching buildings and still allowing floodwaters in.

If no other regional solution can be implemented to protect the City and the Region from floodwaters, the City could consider construction of a floodwall around the site. This long-term adaptation measure would fully protect the site perimeter and is discussed and conceptually presented in Chapter 5.

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