RESILIENT LANDSCAPE VISION

for the Calabazas Creek, San Tomas Aquino Creek, and Pond A8 Area

BAYLAND-CREEK RECONNECTION OPPORTUNITES

A PRODUCT OF **HEALTHY WATERSHEDS ▪ RESILIENT BAYLANDS**

SFEI AQUATIC SCIENCE CENTER
SAN FRANCISCO ESTUARY INSTITUTE & THE AQUATIC SCIENCE CENTER

RESILIENT LANDSCAPE VISION

for the Calabazas Creek, San Tomas Aquino Creek, and Pond A8 Area

BAYLAND-CREEK RECONNECTION OPPORTUNITES

SFEI AQUATIC SCIENCE CENTER
SAN FRANCISCO ESTUARY INSTITUTE & THE AQUATIC SCIENCE CENTER

PRIMARY AUTHORS
Katie McKnight
Scott Dusterhoff
Robin Grossinger

DESIGN AND LAYOUT
Ruth Askevold
Katie McKnight

PREPARED BY San Francisco Estuary Institute-Aquatic Science Center

IN COOPERATION WITH
Santa Clara Valley Water District
South Bay Salt Ponds Restoration Project

FUNDED BY San Francisco Bay Water Quality Improvement Fund, EPA Region IX

A PRODUCT OF **HEALTHY WATERSHEDS • RESILIENT BAYLANDS**

MAY 2018

SAN FRANCISCO ESTUARY INSTITUTE PUBLICATION #870

SUGGESTED CITATION

San Francisco Estuary Institute-Aquatic Science Center. 2018. *Resilient Landscape Vision for the Calabazas Creek, San Tomas Aquino Creek, and Pond A8 Area: Bayland-Creek Reconnection Opportunites.* A SFEI-ASC Resilient Landscape Program report developed in cooperation with the *Healthy Watersheds, Resilient Baylands* Design Advisory Team, Santa Clara Valley Water District, and South Bay Salt Ponds Restoration Project, Publication #870, San Francisco Estuary Institute-Aquatic Science Center, Richmond, CA.

Version 1.0 (May 2018)

REPORT AVAILABILITY

Report is available at hwrb.sfei.org

COVER CREDITS

Front and back cover, imagery courtesy of Google Earth.

CONTENTS

OVERVIEW

This report proposes a multi-faceted redesign of the South San Francisco Bay shoreline at the interface with Calabazas and San Tomas Aquino creeks. Recognizing the opportunities presented by changing land use and new challenges, such as accelerated sea-level rise, we explore in this report a reconfigured shoreline that could improve ecosystem health and resilience, reduce maintenance costs, and protect surrounding infrastructure.

The San Francisco Estuary Institute, Santa Clara Valley Water District, and South Bay Salt Pond Restoration Project worked with technical advisors and a group of stakeholders to explore a range of opportunities for integrating flood risk management with habitat restoration, culminating in a Resilient Landscape Vision divided into short-term and long-term measures. The Vision focuses on breaching a levee protecting a historical commercial salt pond (Pond A8) and allowing Calabazas and San Tomas Aquino creeks to drain directly into the pond. The benefits that could be achieved by implementing this creek-bayland reconnection include:

- promoting channel scour and potentially increasing flood conveyance capacity
- allowing sediment delivery that will help with tidal marsh restoration in Pond A8
- creating a pathway for marsh migration adjacent to the lower reaches of the creeks as sea level rises
- improving ecosystem functioning and resilience through the creation of estuarine-terrestrial transition zones

The next steps for implementing the Vision measures include conducting feasibility analyses, garnering regulatory agency support, assessing benefit-cost relationships of proposed elements, and collaboration with local stakeholders. Upon implementation, Calabazas and San Tomas Aquino creeks could be the first creeks in San Francisco Bay to be realigned to discharge directly into their historical tidal marshlands— a case study that could be used to inform future reconnection projects in similar landscapes around the Bay and guide responsive policies to climate change challenges.

This work is an element of the EPA-funded *Healthy Watersheds, Resilient Baylands* project, which seeks to help reestablish landscape functions by working with nature to improve water quality, create habitat, provide flood protection to threatened communities, and reduce maintenance costs.

San Tomas Aquino Creek and Harvey Marsh. (photograph by Katie McKnight, SFEI)

INTRODUCTION

Over the past 150 years, lower Calabazas and San Tomas Aquino creeks and their attending baylands have been heavily modified for flood control and development. Most of the tidal marshes were leveed and converted to salt ponds in the mid-to-late 19th or early 20th century, and levees were also built on the banks of Calabazas and San Tomas Aquino to contain flood waters. Over time, the historical habitats on the valley floor were converted to agricultural, residential, and industrial uses, leading to a highly modified landscape. These changes have caused impacts to wildlife, high maintenance costs, and an overall decreased resilience to sea-level rise due to loss of baylands and reduction in sediment supply. In an effort to rethink the way we manage the interconnected Calabazas-San Tomas Aquino creeks-baylands system, the Santa Clara Valley Water District (District) is seeking new management approaches to restore and support natural processes and ecosystem functions while decreasing maintenance needs, improving flood conveyance and water quality, and supporting tidal marsh adaptation with sea-level rise. At the same time, the South Bay Salt Pond Restoration Project (SBSPRP) is interested in reconnecting creeks to nearby restored tidal marshes, a key recommendation of the Bayland Goals (2016) report.

To integrate and advance these goals, this report outlines a multi-benefit landscape vision to reconnect Calabazas and San Tomas Aquino creeks to Pond A8 to benefit both flood management and wetland habitat restoration. This Vision is an element of the EPA-funded project *Healthy Watersheds, Resilient Baylands*, which aims to integrate watershed planning and redevelopment with baylands restoration to create healthier and more resilient aquatic systems and communities. This Vision is the first step in exploring the potential that exists for multi-benefit design solutions around the Bay to reintegrate natural processes at this complex location for the benefit of people and wildlife.

Pond A8 shoreline.
(photograph by Katie McKnight, SFEI)

Developing the Resilient Landscape Vision involved three main steps. First, the San Francisco Estuary Institute (SFEI) created a conceptual understanding of the historical and contemporary physical and ecological landscape processes and considered the likely key impacts of future climate change. Second, SFEI, the District, and SBSPRP hosted a landscape visioning workshop in June 2017 that brought together local scientists and stakeholders with a Design Advisory Team (DAT) made up of regional scientists with engineering and regulatory expertise. The goal of the workshop was to identify opportunities for improving the delivery of freshwater and sediment out of the creeks and into Pond A8 and to discuss how the proposed reconnection could affect flood risk management, habitat, and water quality conditions. The workshop focused on Pond A8 and A8S, the downstream reaches of Calabazas and San Tomas Aquino creeks (between A8S and Highway 237), the capped landfill under America Center to the east, and Sunnyvale Baylands Park to the west (henceforth referred to as the "study area", see map on pg. 6). Third, the concepts discussed during the workshop were translated into a vision for a landscape more resilient to climate change that is divided into two phases: Phase 1, which could be implemented over the next decade, and Phase 2, which would be implemented later.

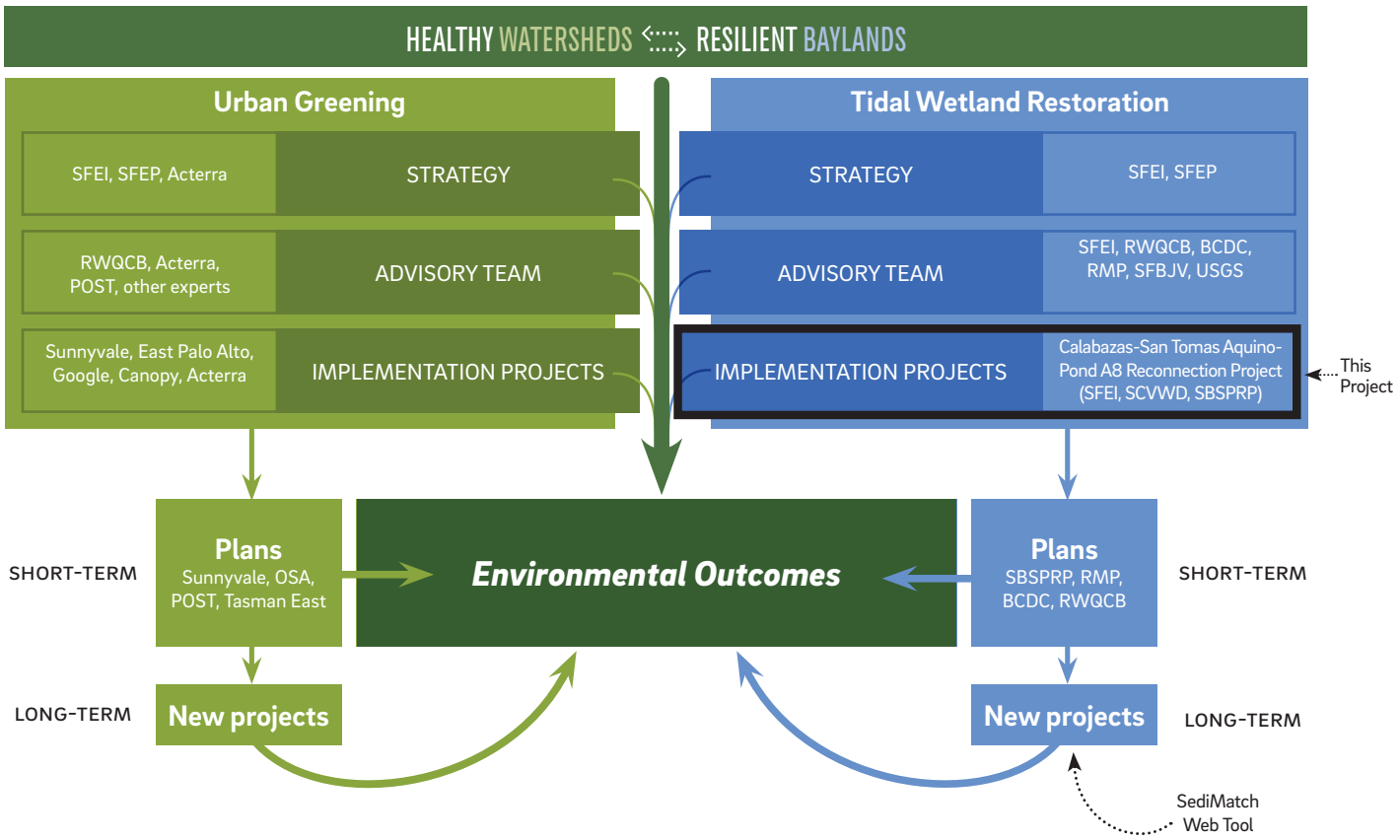
This Vision aims to support the District's and SBSPRP's ongoing planning processes aimed at fostering baylands that are more resilient to climate change and creating more ecosystem-friendly flood risk management measures. The project would result in sediment and freshwater delivery directly to the restored Pond A8, implemention of the Bayland Goals Science Update recommendations for increasing climate change resilience, as well as upland-wetland transition zone restoration. Feasibility studies, further modeling, engineering design, and permitting will be needed to refine these ideas into implementable projects.

HEALTHY WATERSHEDS, RESILIENT BAYLANDS PROJECT

Many of the creeks that drain to San Francisco Bay have been significantly altered from their natural form over the past 150 years. Habitat loss, water quality degradation, land subsidence, in-channel sedimentation, and nuisance flooding are some of the challenges watershed managers face in these highly urbanized watersheds. In addition, climate change presents long-term challenges for both flood risk management and habitat protection in watersheds and downstream tidal marshes and mudflats. To keep pace with sea-level rise, existing and restored baylands will need adequate supplies of sediment, elevating the need to understand and maximize projected future sediment delivery under different climatic and land management scenarios. The opportunity now exists to develop and implement science-based land management approaches because cities, flood protection agencies, the private sector, and other organizations are transforming landscapes as they replace aging infrastructure and prepare for sea-level rise and other impacts from climate change. While these site-level opportunities exist and recent plans have called for such multi-benefit "watersheds-to-the-Bay approaches," implementation is currently hindered by the lack of technical guidance, multi-partner coordination, and successful demonstration examples.

The *Healthy Watersheds, Resilient Baylands* project seeks to help reestablish landscape functions by working with nature to improve water quality, create habitat, provide flood protection to threatened communities, and reduce maintenance costs. The project offers an integrated approach to designing and implementing urban greening, wetland restoration, and water quality improvements within a set of representative urban watershed-bayland systems. This model of coordinated, multi-benefit projects is critical to achieving significant and lasting environmental outcomes in complex, interconnected systems with many jurisdictions and stakeholders. The most efficient way to invest in the innovations needed in our watersheds will be through coordinated expenditures by local flood control agencies, cities, private corporations, and others. This project takes a first step towards leveraging those financial resources to accomplish demonstrable environmental benefits.

Healthy Watersheds, Resilient Baylands focuses on providing support for two categories of management actions: urban greening and tidal wetlands restoration. The project includes development of a Multi-Benefit Urban Greening Strategy that will incorporate ecological benefits into the Low Impact Development (LID) planning process and take advantage of a broader array of urban greening activities with hydrological benefit. It also includes the development of a Sediment Strategy that will synthesize sediment need and availability data to maximize the value of limited sediment supplies in the design of tidal restoration projects for resilience to sea-level rise. The two strategies are being applied to a series of innovative implementation projects along the South Bay shoreline and in the cities of Sunnyvale, Mountain View, and East Palo Alto. The project also includes further development of SediMatch, an innovative online marketplace for matching those that need sediment for bayland restoration projects with those that have sediment available (e.g., the dredging community). Once completed, the outputs from *Healthy Watersheds, Resilient Baylands* will be valuable tools for helping our local landscapes thrive into the future and provide benefits for both people and wildlife.

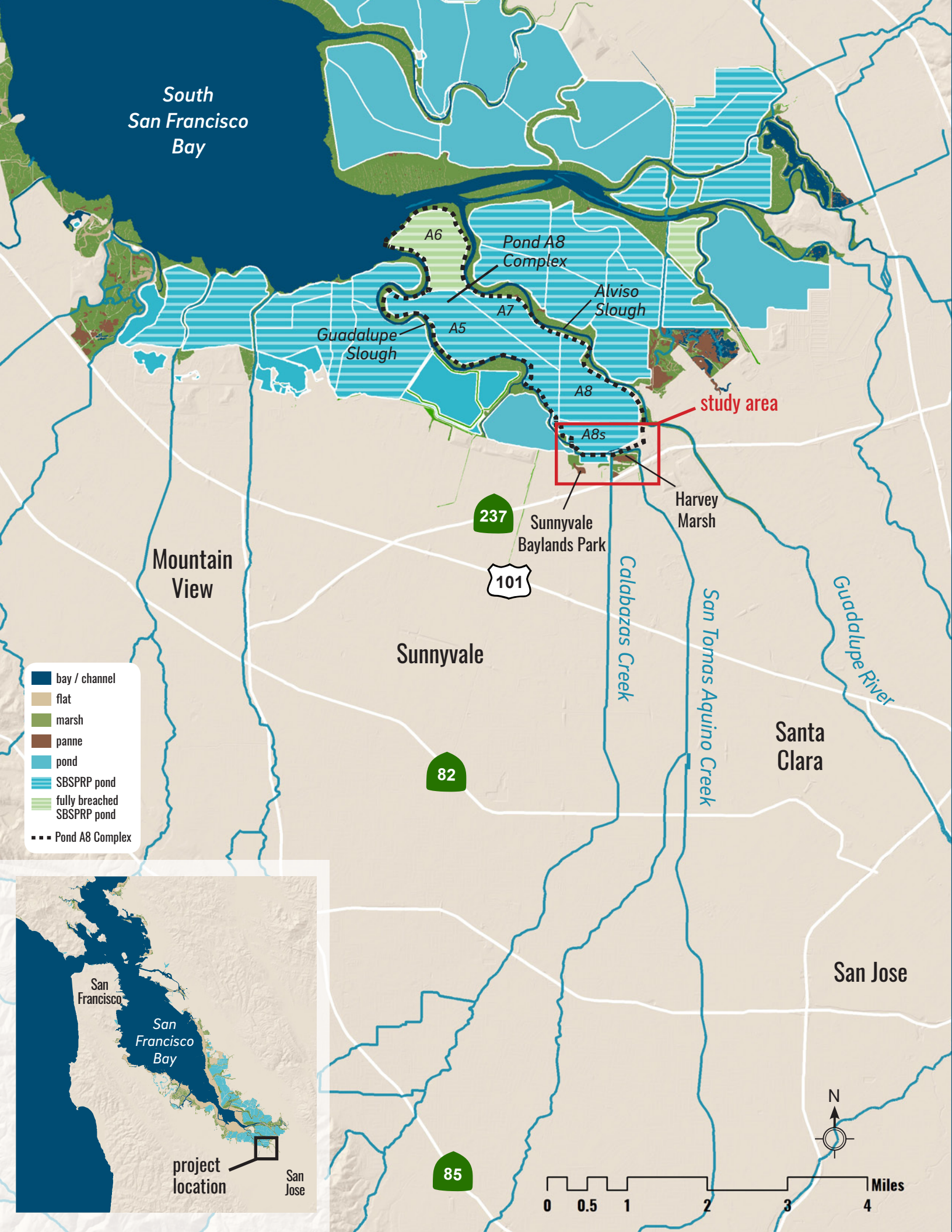


Project Partners:

Bay Conservation and Development Commission (BCDC)
San Francisco Bay Joint Venture (SFBJV)
San Francisco Estuary Institute (SFEI)
San Francisco Estuary Partnership (SFEP)
Santa Clara Valley Open Space Authority (OSA)
Santa Clara Valley Water District (SCVWD)
South Bay Salt Pond Restoration Project (SBSPRP)
Peninsula Open Space Trust (POST)
Regional Monitoring Program (RMP)
Regional Water Quality Control Board (RWQCB)
U.S. Geological Survey (USGS)

Structure of the *Healthy Watersheds, Resilient Baylands* project.

Additional project information: hwrb.sfei.org


South San Francisco Bay
A6
Pond A8 Complex
A7
Alviso Slough
A5
Guadalupe Slough
A8
A8s
study area
Harvey Marsh
237
Sunnyvale Baylands Park
101
Mountain View
Sunnyvale
Calabazas Creek
San Tomas Aquino Creek
Guadalupe River
Santa Clara
82
San Jose
85
bay / channel
flat
marsh
panne
pond
SBSPRP pond
fully breached SBSPRP pond
Pond A8 Complex
San Francisco
San Francisco Bay
project location
San Jose
N
0
0.5
1
2
3
4
Miles

CALABAZAS-SAN TOMAS AQUINO-POND A8 RECONNECTION PROJECT

Calabazas and San Tomas Aquino creeks flow through Silicon Valley before entering Guadalupe Slough just west of the neighborhood of Alviso in San Jose, CA. At their confluence with the Bay, the creeks are currently contained within levees and flow past Harvey Marsh and Sunnyvale Baylands Park and a 1440-acre complex of leveed salt ponds known as Ponds A8, A8S, A7, and A5 (collectively known as Pond A8) to the north.

Over the past 150 years, this landscape has undergone considerable change. Historically, floodwaters from these creeks and other creeks in the area spread onto the alluvial plain and tidal marsh plain. Beginning in the 1850s, the lower portions of the watersheds were reclaimed for agriculture and development, the creeks were realigned, and levees were built along the banks to help contain flood flows. In the early 20th century, levees were built around the tidal marsh downstream from these creeks and the marsh was converted to commercial salt ponds. In the latter part of the 20th century, the increased need for protecting developed areas adjacent to the creeks from flooding led to channel extension, straightening, widening, and the construction of engineered flood control levees. As a result of disconnecting these creeks from their floodplain and engineering large channel sizes for flood control measures, the lower portions of the creeks now tend to fill in and accumulate excess fine sediment that needs to be regularly removed by the District to maintain flood conveyance. Over the past two decades, the District has removed over 250,000 cubic yards of sediment from the creeks, with recently-removed sediment being placed in Pond A8 to support restoration activities. In addition, the historical tidal marsh habitat adjacent to the creek has been reclaimed and the diked areas that were once tidal marsh around the creeks have subsided several feet.

Sediment removal from San Tomas Aquino Creek between Highway 237 and Old Mountain View-Alviso Road. (photograph courtesy of Feliciano Aguilar, SCVWD)

Repetitive desilting on Calabazas and San Tomas Aquino creeks to convey floodwaters has led to high maintenance costs, with the total recorded sediment removal cost between 2001 and 2016 approximately $3,750,000 and $7,400,000 for Calabazas and San Tomas Aquino creeks respectively (E. Gabrielsen, personal communication). The District is seeking a new approach to flood risk management along the lower reaches of Calabazas and San Tomas Aquino creeks that is more ecologically resilient and economically viable than the current desilting practices. At the same time, the SBSPRP is slated to restore Pond A8 to full tidal action (pending resolution of historical mercury contamination issues), with the ultimate goal of trapping enough sediment to convert the salt pond back into a tidal marsh. To help meet their respective needs, the District and SBSPRP have partnered to explore the feasibility of reconnecting both creeks to Pond A8. This reconnection could help alleviate flooding issues by reducing backwater effects associated with an engineered turn and increase sediment exports by the creeks from the resulting larger flow velocities during high discharge events. The reconnection would also deliver much-needed sediment and freshwater to a large tidal marsh restoration project. Overall, this proposed reconnection could have significant benefits for wildlife and people, reduce maintenance costs and flood risks, and create a more resilient bayland-fluvial system able to adapt to rising sea levels and increased storm frequencies associated with a changing climate.

Landscape changes have created an array of challenges and opportunities associated with channel management:

EXISTING CHALLENGES

- Transportation and transmission infrastructure within and adjacent to the site that will need to be protected from flooding and erosion
- Capped landfill that currently underlies America Center, a business park complex adjacent to the site, will need to be protected from erosion
- Excess sediment accumulation in the lower reaches of both creeks that reduces flood capacity
- High maintenance costs and regulatory restrictions associated with continued desilting
- Increased flooding risks in the lower reaches of both creeks associated with a changing climate (e.g., sea-level rise and increased frequency of large storms)
- Maintaining public access to the Bay Trail and other amenities

OPPORTUNITIES

- Providing freshwater and sediment to restored tidal wetlands
- Increasing flood conveyance and decreasing sediment accumulation in the creeks
- Creating tidal marsh habitat along a fresh-brackish marsh gradient
- Constructing ecotone slopes that reduce erosion of capped landfill and provide upland-wetland transition habitats and space for tidal marsh to migrate as sea level rises
- Incorporating treated wastewater into habitat creation and support
- Realigning and reducing levee height for improving hydrologic and wildlife connectivity
- Reducing maintenance costs for levees and channels

(Above) **Current 90-degree turn on San Tomas Aquino Creek through Harvey Marsh.** (photograph by Katie McKnight, SFEI)

(Below) **San Tomas Aquino Creek and Harvey Marsh during a storm event and high tide in February 2017.** (photograph courtesy of Errol Gabrielsen, SCVWD)

THE PROCESS FOR DEVELOPING A RESILIENT LANDSCAPE VISION

Step 1
Pre-Workshop

UNDERSTANDING LANDSCAPE PROCESSES

Understanding the fundamental landscape processes that shape and sustain the baylands in South San Francisco Bay is the first step in identifying management approaches that foster healthy and resilient future landscapes. Through the use of historical maps and prior historical ecology studies for this region (in particular *Historical Vegetation and Drainage Patterns of Western Santa Clara Valley* [SFEI 2010]), SFEI reconstructed the historical (mid-19th century) landscape around lower Calabazas and San Tomas Aquino creeks and the adjacent baylands and identified major changes to landscape features and processes.

Step 2
At Workshop

VISION WORKSHOP

In June 2017, SFEI, the District, and SBSPRP hosted a landscape visioning workshop at the San Jose-Santa Clara Regional Wastewater Facility in San Jose, CA. The goal of the workshop was to develop an integrative conceptual plan for connecting Calabazas and San Tomas Aquino creeks in a manner that could support flood risk management and tidal wetland habitat restoration while maintaining other key land uses (e.g., recreation and transportation). A Design Advisory Team (DAT) consisting of scientists and engineers with expertise in hydrology, ecology, geomorphology, water quality, sediment dynamics, and fluvial and tidal engineering was recruited to identify opportunities for improving the delivery of freshwater and sediment from the creeks to Pond A8, and to discuss how directly connecting the creeks to Pond A8 could affect flood management and habitat conditions. The workshop also included organizations involved in local flood risk management, baylands management, public space management, private land mangment, recreation, transportation, and permitting. The workshop was facilitated by Andy Gunther of the Bay Area Ecosystems Climate Change Consortium (BAECCC).

The workshop began with a presentation by SFEI describing the evolution of the landscape over the past 150 years, current management issues, and potential future management challenges

Calabazas Creek-San Tomas Aquino Creek-Pond A8 Vision Workshop. (photographs by April Robinson (left) and Katie McKnight (right), SFEI)

associated with increased sea level and increased storm frequency. John Bourgeois of the SBSPRP then presented information related to Pond A8 restoration, including recent mercury monitoring, long-term plans for restoring the pond to tidal action, and proposed restoration actions (e.g., constructing ecotone levees). Next, District staff gave a presentation on the history of flood control issues along the lower reaches of Calabazas and San Tomas Aquino creeks, current flood management practices, and considerations for an updated flood management approach. Deltares, a research institute based in the Netherlands, presented initial sediment transport modeling results illustrating the effects of a simple creek reconnection scenario on in-channel sediment accumulation and sediment deposition and creek delta building in Pond A8. During the workshop field trip, participants viewed Harvey Marsh near the 90-degree bend of San Tomas Aquino Creek and the southern edge of Pond A8. After considering the information presented, the DAT provided expert advice on future management strategies including both short- and long-term opportunities for establishing a more functional system at this baylands-creek interface.

Step 3
Post-Workshop

DEVELOPING THE VISION

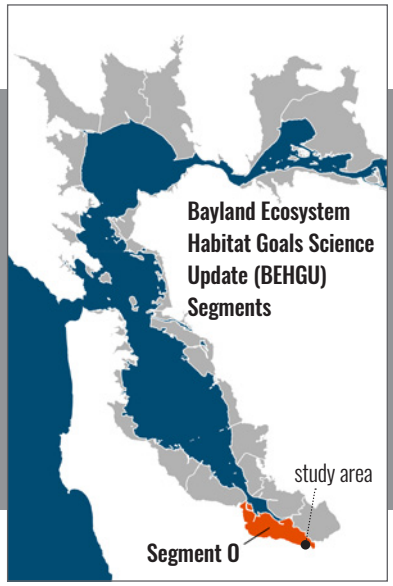
The ideas developed during the workshop were synthesized into high-level landscape-scale measures aimed at restoring and supporting natural processes and ecosystem functions over the long-term, while decreasing the need for repeated and costly maintenance, improving flood protection and water quality, and enhancing conditions for tidal marsh adaptation to sea-level rise. The landscape visioning process followed SFEI's existing Landscape Resilience Framework (Beller et al. 2015), which defines landscape resilience as "the ability of a landscape to sustain desired ecological functions, robust native biodiversity, and critical landscape processes over time, under changing conditions, and despite multiple stressors and uncertainties." This framework sets the foundation for this vision by outlining the fundamental drivers of ecological resilience to support healthy ecosystems that successfully adapt and thrive in the face of climate change and other challenges. The vision also applies recommendations of the Bayland Ecosystem Habitat Goals Science Update (2016) for *Segment O*, which emphasizes the need to restore creek-bayland connections and complete tidal wetland systems, establish transition zones for tidal wetlands to migrate with sea-level rise, and restore tidal wetlands as soon as possible.

Field visit during the Vision Workshop. (photograph by Katie McKnight, SFEI)

Interactive Map of BEHGU Segments: **Resilience.sfei.org**

RECOMMENDED ACTIONS FROM THE BAYLAND ECOSYSTEM HABITAT GOALS SCIENCE UPDATE:

- Restore large marsh areas before 2030
- Create a continuous marsh corridor along the shoreline
- Increase sediment supply to the baylands
- Enhance and restore natural transition zones
- Reestablish native vegetation and enhance riparian corridors



HISTORICAL CHANGE

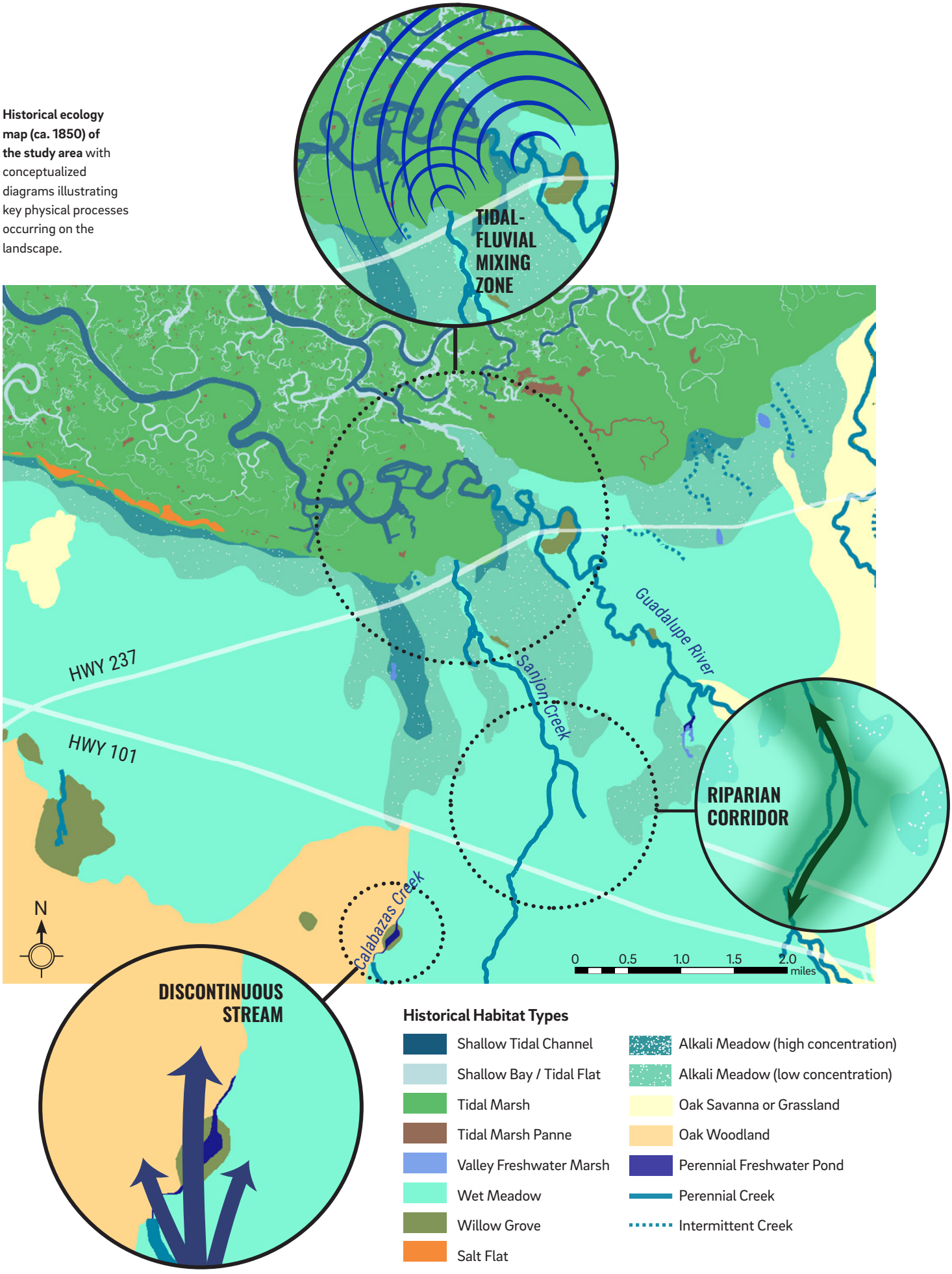
Historical accounts of the Santa Clara Valley from the early 1800s describe the region as having fertile soils, artesian water, sheltering oaks, and a temperate climate, making it what was considered to be one of the most beautiful and productive places in California (Beller et al. 2010). Within the lower reaches of Calabazas and San Tomas Aquino creeks and the adjacent baylands, dramatic alterations to the landscape over the past 150 years have caused considerable changes to tidal and fluvial process and the resulting landscape features and habitat conditions.

HISTORICAL PROCESSES & FEATURES

In the mid-19th century, Calabazas and San Tomas Aquino creeks flowed from the Santa Cruz Mountains across the valley towards the extensive tidal marsh and mudflats that bordered the lower valley. Tidal action transported fine sediment onto the marshlands during flood tides and scoured an expansive network of tidal channels during ebb tides. Salt pannes existed around the edge of the tidal marsh, and are features associated with little direct freshwater inundation (unless seasonally inundated as a result of emerging groundwater and/or channelized runoff) and areas of high marsh plain removed from frequent tidal flooding (Beller et al. 2010). These salt pannes likely existed on the western edge of the study area away from the mouths of streams that maintained direct connections to the Bay, such as Guadalupe River. An expansive tidal-terrestrial transition zone (hereafter, the "transition zone"; the gradient between intertidal areas and upland terrestrial and/or fluvial environments) occupied the broad interface between high marsh and the large expanses of wet meadow and alkali meadow on the valley floor (Beller et al. 2013). Differences in landscape features (e.g., slope, fluvial influence, tidal inundation dynamics, groundwater levels, soil type) resulted in natural variations in the physical dimensions and habitat composition of the historical transition zone. The transition zone provided valuable ecosystem functions for feeding and breeding and allowed species to migrate around the marsh edge and between low-lying and upland habitats, providing high-tide and storm refuge for many marsh wildlife (Beller et al. 2013).

Calabazas and San Tomas Aquino creeks were both discontinuous streams typical to Santa Clara Valley, transitioning from more well-defined meandering channels at higher elevations on the alluvial plain, to shallower distributaries around the 100–200 foot elevation contour, which lost definition well before reaching the Bay. Historically, Calabazas Creek sank into the alluvium in the oak savanna around today's Stevens Creek Boulevard, near Cupertino High School. Flows from Calabazas Creek traveled subsurface before reemerging as a series of shallow sloughs that eventually supported the wet meadows that covered the low-lying areas of the valley floor and ultimately draining to the baylands. San Tomas Aquino Creek also disappeared underground in the oak savanna high on the alluvial plain, terminating far from the Bay. Historical maps show a series of disconnected distributary channels flowing north of San Tomas Aquino's terminus, which connected wet season flows to Sanjon Creek (known as lower San Tomas Aquino Creek today). Sanjon Creek was likely a relatively small, shallow watercourse that received flood flows from the creeks and drained directly into the baylands (Beller et al. 2010).

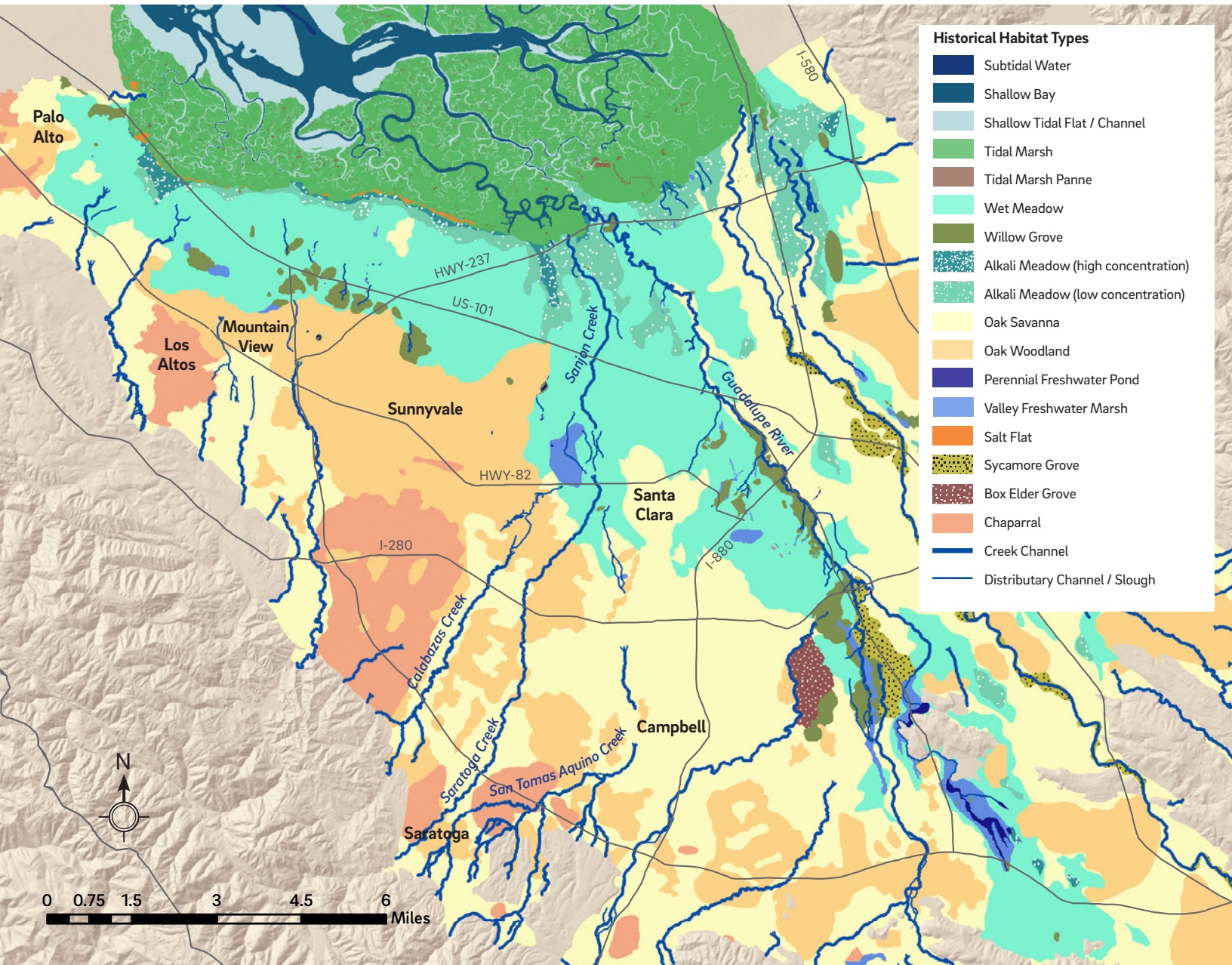
Historical ecology map (ca. 1850) of the study area with conceptualized diagrams illustrating key physical processes occurring on the landscape.



During large storm events, episodic pulses of sediment would have caused the distributary channels on both Calabazas and San Tomas Aquino creeks to be unstable, filling with sediment and carving out new channels on the valley floor. Sanjon Creek likely received flows from Calabazas, San Tomas Aquino, and Saratoga (located between Calabazas and San Tomas Aquino) creeks during periods of large flows (Beller et al. 2010), depositing pulses of freshwater, nutrients and sediment that sustained marsh development.

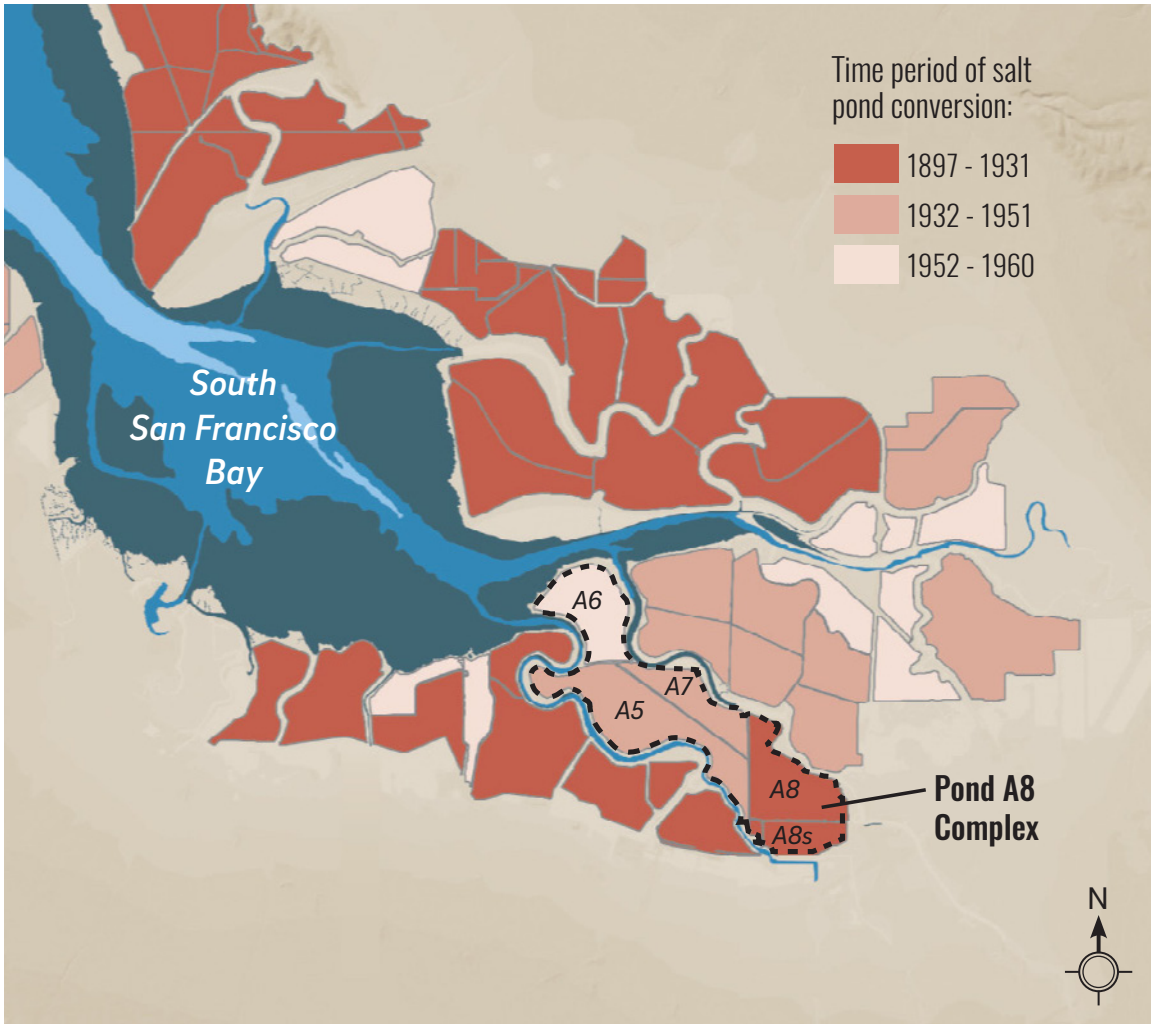
The nearby Guadalupe River, which maintained a direct connection to the tidal marsh and Bay year-round, contributed major flows of freshwater, nutrients, and sediment to the surrounding baylands. Regular freshwater influence from Guadalupe River likely reduced tidal channel density, sinuosity, and panne abundance, and increased average panne size in this zone (Beller et al. 2013, Grossinger 1995) compared to transition zones with little freshwater influence. Willow groves and other riparian habitats existed along the banks of these streams and likely acted as an important upland wildlife corridor connecting diverse habitats across the valley floor. Oak savanna and oak woodland habitats were common higher up on the valley floor in areas with more coarse gravel loam soils, and bordering the wet meadow habitats.

Historical habitats in west Santa Clara Valley prior to significant Euro-American modification. (Beller et al. 2010)

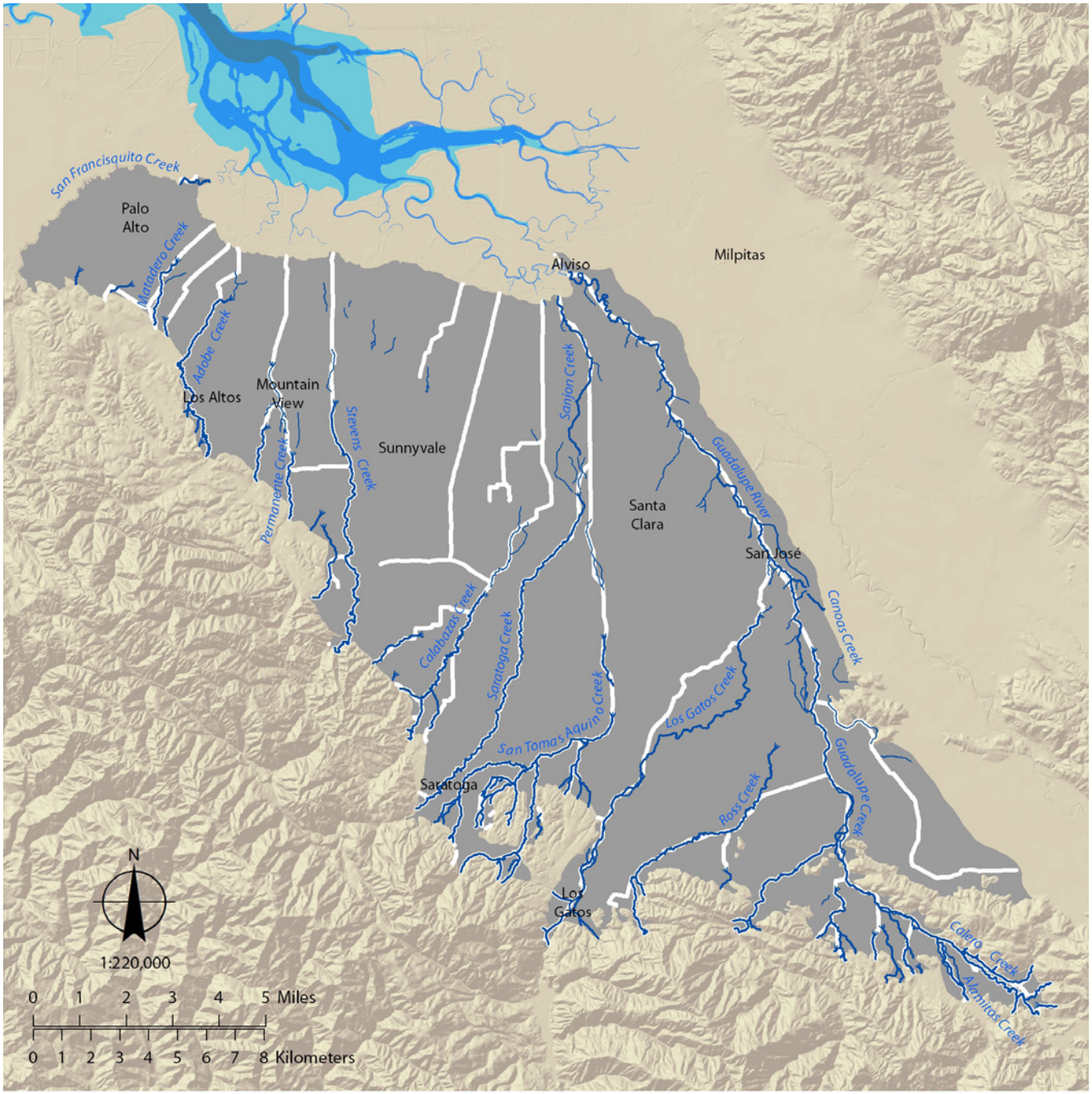


CURRENT PROCESSES & FEATURES

Europeans settled in the Santa Clara Valley as early as 1777, leading to significant landscape modifications by the early to mid-1800s (Beller et al. 2010). From the 1850s to the 1950s, the diking of tidal marshes became common practice in the South Bay to make ponds for salt production (Grossinger and Askevold 2005). The creation of leveed salt ponds from tidal marsh cut off sediment and nutrient delivery, and led to considerable baylands subsidence. In the adjacent lowlands, some channels were straightened to accommodate development and to improve flood management (Beller et al. 2010). The historically more discontinuous channels of Calabazas and San Tomas Aquino creeks were converted to continuous channels, taking freshwater out to the Bay, bypassing the salt ponds and marshes, and altering the transport of water across the valley floor (Beller et al. 2010). The construction of stormdrain networks and engineered channels further increased the connectivity of the watersheds far beyond historical conditions. In some cases, entirely new channels were created (e.g., Sunnyvale East and West). As a result of the widespread increase in channel connectivity, floodwaters during the rainy season that would have supported seasonal wetlands or recharged groundwater were disconnected from the floodplain and diverted directly to the Bay. In addition, Calabazas and San Tomas Aquino (formerly Sanjon) creeks likely decreased in sinuosity as they were straightened and realigned (Beller et al. 2010).



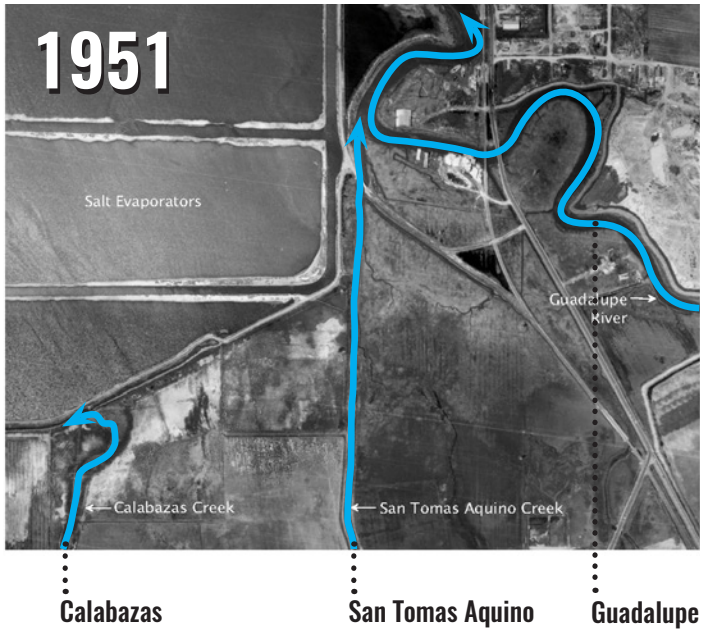
History of tidal marsh conversion to salt ponds in South San Francisco Bay. (courtesy of Oakland Museum of California, Grossinger and Askevold 2005)

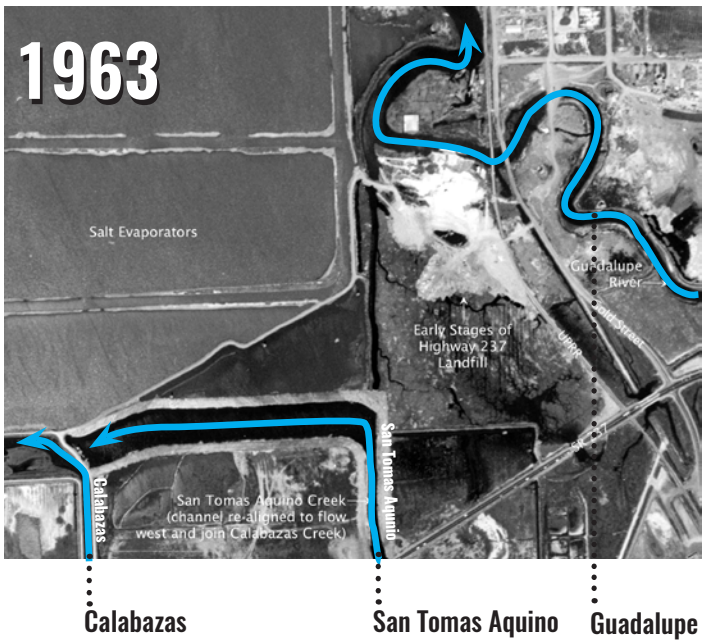


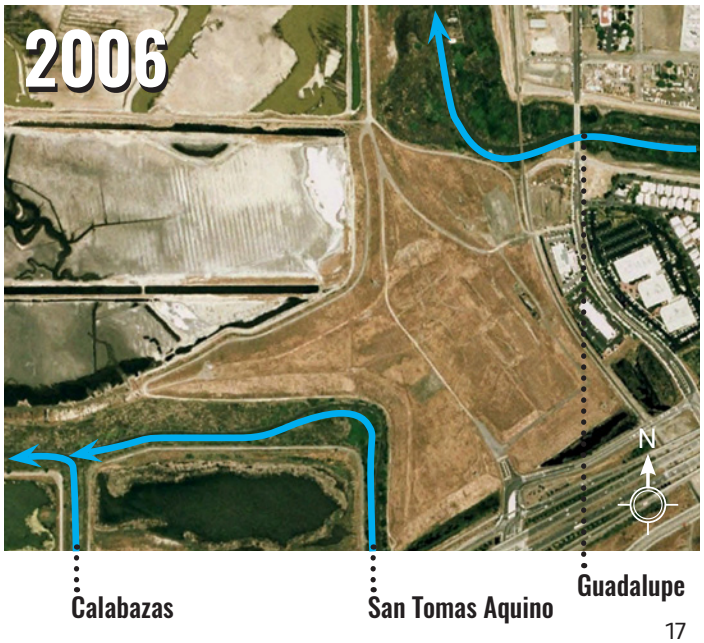
(above)
Historical drainage network with historical creek names (in blue, ca. 1800) and modern drainage network (in white, 2007) in western Santa Clara Valley. (Beller et al. 2010)

(top and middle right)
Historical alignments of Calabazas, San Tomas Aquino, and Guadalupe creeks near the boundary of Highway 237 landfill. (maps courtesy of Crawford Consulting, Inc.)

(bottom right)
Present-day alignments of Calabazas, San Tomas Aquino and Guadalupe Creeks. (courtesy of Google Earth)







Widespread development and continued channel straightening increased the need for flood management and channel dredging by the middle of the 20th century. By the 1950s, Calabazas and San Tomas Aquino creeks were diverted around the baylands, a departure from the historical surficial connections via Sanjon Creek. By 1951, Calabazas Creek had been diverted to the west while San Tomas Aquino Creek had been extended north into Guadalupe River (Crawford Consulting 2002). By 1963, the creation of a landfill adjacent to the southeastern edge of Pond A8S resulted in the loss of existing tidal marsh and the realignment of San Tomas Aquino Creek away from Guadalupe River to flow west and join Calabazas Creek (Crawford Consulting 2002). The realigned channel formed a 90-degree bend on San Tomas Aquino Creek, an unnatural turn that still exacerbates sedimentation and flood conveyance challenges today. By 1963, Calabazas and San Tomas Aquino creeks were widened and constricted by levees and, over time, the stream bed aggraded due to fluvial and tidal sedimentation. Today, Calabazas and San Tomas Aquino creeks have moderate average annual sediment loads: approximately 14,000 tons/yr and 29,000 tons/yr respectively (as calculated from records for water years 1957 to 2013) (SFEI-ASC 2016). Sediment accumulates in the lower reaches of these channels, requiring regular removal to maintain flood capacity.

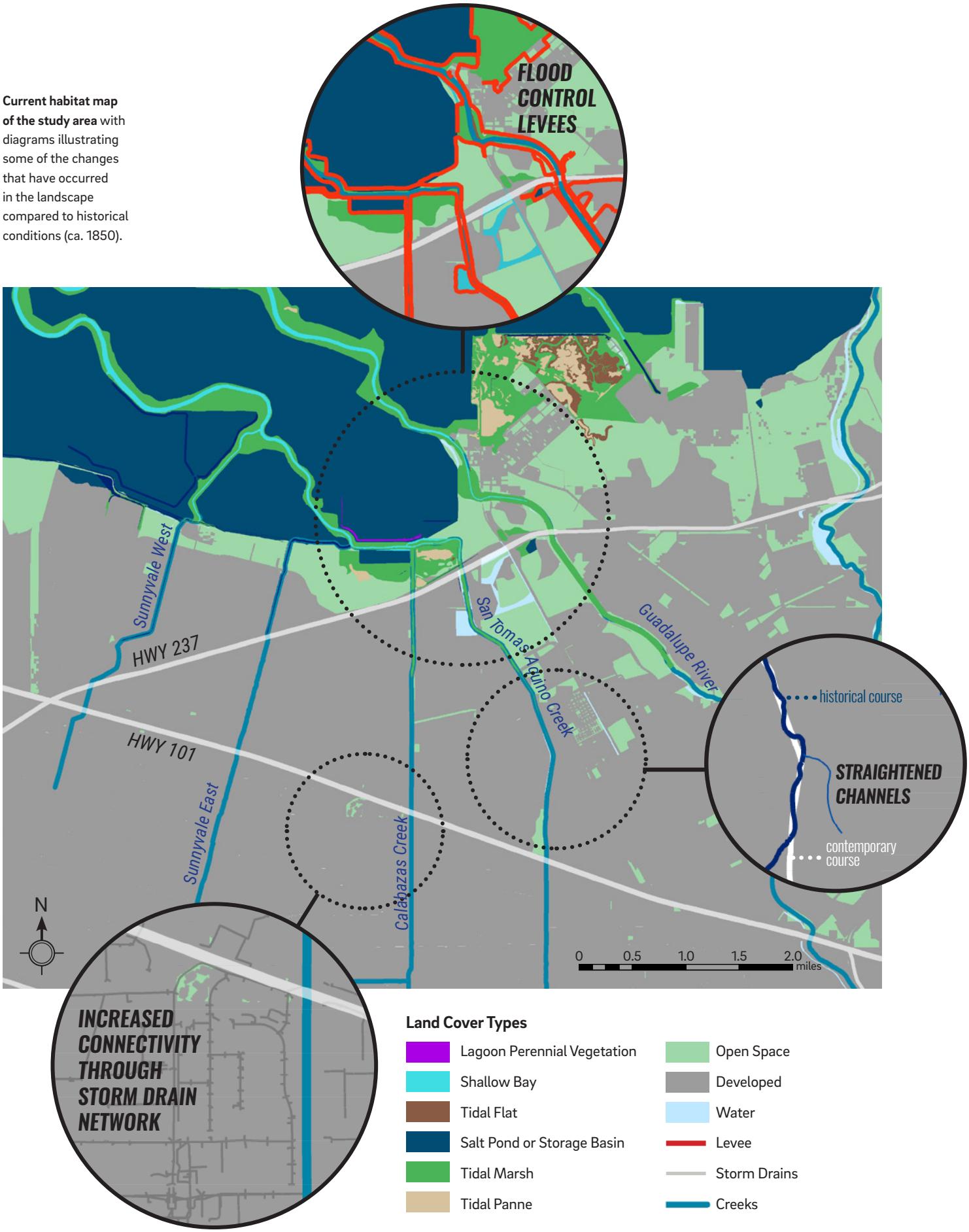
Once-coherent habitat mosaics within the Calabazas-San Tomas Aquino baylands that supported suites of native species and communities have also changed substantially following Euro-American colonization (Robinson et al. 2015). The majority of upland transition zone habitats have been lost to agriculture and development, and the small fragments that remain exist as transitions between the upper limits of tidal marsh and the steep slope of artificial levees (Beller et al 2013). Because of this,

transition zone habitats are considered a conservation and restoration priority and offer additional benefits as critical accommodation space for marsh migration and flood abatement as sea level rises (Beller et al. 2015, Bayland Goals 2016). The vast majority of alkali and freshwater meadows in the region were drained and converted for agriculture and, later, industrial uses and housing. Upstream of the baylands, former oak savannas and woodlands were lost to large-scale clearing for agriculture and development.

Habitat restoration efforts progressed by the early 2000s. These efforts seek to preserve the remaining fragments of historical habitats, restore portions that were lost, and implement management strategies with multiple benefits to address modern flood risk management challenges. The current tidal marsh areas within the study site are confined to the deposited silts of sedimented areas between levees, Sunnyvale Baylands Seasonal Wetland Preserve, and Harvey Marsh, a CalTrans mitigation project. Additional open space exists atop the capped landfill and in adjacent open spaces, mostly in the form of urban parks.

Study area of Calabazas Creek, San Tomas Aquino Creek, and Pond A8 interface and adjacent land uses.
(basemap courtesy of Google Earth Pro)

Current habitat map of the study area with diagrams illustrating some of the changes that have occurred in the landscape compared to historical conditions (ca. 1850).



FUTURE CONDITIONS

The factors affecting flooding within lower Calabazas and San Tomas Aquino creeks, as well as the factors affecting physical and ecological processes within Pond A8 and the adjacent landscape, are dynamic. Regional climatic changes coupled with changes in physical landscape characteristics and processes have the potential to cause serious infrastructure damage during storm events and result in costly maintenance. Here, we consider several features and processes that are expected to change in the coming decades and their possible effects on the physical and ecological conditions of the Calabazas-San Tomas Aquino-Pond A8 landscape.

SEA-LEVEL RISE

Over the past century, mean tide elevation in San Francisco Bay increased by over 220 mm (8.7 in) (Flick et al. 1999). Future sea-level rise projections for the Bay vary considerably as a function of modeled carbon dioxide emission and associated air temperature scenarios. Recent analyses show a minimum of approximately 0.2 m (0.7 ft) and a maximum of approximately 1.5 m (4.9 ft) of sea-level rise at the NOAA San Francisco gage by 2100 (USACE 2013), with the value most likely being between 0.3 and 1 m (1.0 and 3.4 ft) (Griggs et al. 2017). The amount of sea-level rise is uncertain. Increases in deep ocean warming and the destabilization of the Greenland and Antarctic ice sheets could greatly accelerate the amount of sea-level rise by the end of the century (DeConto and Pollard 2016). Increasing sea level will cause the head of tide (i.e., the inland tidal inundation extent during mean higher high water [MHHW]) to migrate inland in both Calabazas and San Tomas Aquino creeks, causing shifts in vegetation assemblages and the potential for an increase in local tidal sediment deposition in the expanding tidal reach.

FLOOD EVENTS

Climate change is likely to affect the frequency and intensity of storm events leading to flooding and shoreline erosion. Over the past several decades, the frequency of extreme precipitation events in the Bay Area has increased by approximately 5% to 20% compared to the previous decades (Russo et al. 2013). In the future, increases in river flooding in the region will likely track extreme precipitation events (Prein et al. 2017, Flint and Flint 2012) and could be exacerbated when peak flood discharge coincides with high Bay water levels (Dettinger 2011). More frequent large floods coming out of the Calabazas Creek and San Tomas Aquino Creek watersheds would increase the potential for channel erosion and put levees and flood infrastructure protecting floodplain development at risk.

SEDIMENT SUPPLY

In the coming decades, the supply of contributing watershed and tidal sediment delivered to the lower reaches of Calabazas and San Tomas Aquino creeks will also likely be different as a result of a changing climate. A future with more extreme precipitation events could result in higher average annual watershed sediment loads over the long term. Recent modeling suggests that summers in the Bay Area will be longer and hotter (Flint and Flint 2012), which could cause

changes in vegetation assemblages that would further increase runoff and sediment delivery during storm events. On the tidal side, sediment supply in much of San Francisco Bay has been on the decline since the turn of the 21st century due in large part to the depletion of an erodible sediment pool in the Bay that was a result of 19th century hydraulic mining in the Sierra Nevada (Schoellhamer 2011). It is currently unclear how future changes to precipitation patterns and flow to the Bay from the Delta and surrounding watersheds could affect Bay sediment supply. However, a combination of high watershed and tidal sediment supply in the future could cause increased sediment deposition in the lower reaches of Calabazas and San Tomas Aquino creeks, which would add to future flooding concerns.

SHORELINE MANAGEMENT

There are several projects underway that will impact the physical and ecological functioning of the South Bay. Over the next several decades, the SBSPRP aims to restore much of the 15,000-acre commercial salt pond complex that lines the South Bay shoreline to tidal marsh and managed pond habitat. This includes the Pond A8 complex and the adjoining Pond A6 to the north. This effort will restore habitat for an array of native wildlife such as shorebirds and waterfowl. In conjunction with the larger SBSPRP, the South San Francisco Bay Shoreline Project is currently examining the feasibility of options for managing flood risk along the South Bay shoreline that incorporates salt pond restoration and expanded public access. In March 2016, the Santa Clara Valley Water District Board approved the first phase of the project, which includes building an ecotone levee (i.e., low gradient levee that provides a gradient of tidal to upland habitats) to protect Alviso. This new levee could provide habitat for a variety of threatened and endangered species, such as Ridgway's rails, black rails and the salt marsh harvest mouse, and provide space for inland marsh migration as sea level rises.

(left to right)
Salt marsh harvest mouse. (photo courtesy of USGS)
Ridgway's Rail. (photo courtesy of Becky Matsubara CC 2.0)

PRELIMINARY SCENARIO MODELING

As a first step in assessing the potential benefits associated with connecting Calabazas and San Tomas Aquino creeks to Pond A8, Deltares conducted preliminary hydro- and morphodynamic modeling of simple reconnection scenarios. The modeling assessed the impact of connecting the creeks to Pond A8 through levee breaches on flow velocity, sediment transport rates, and sediment deposition/erosion characteristics within the lower reaches of both creeks and within Pond A8. The modeling effort explored two breaching scenarios: (A) connecting Calabazas and San Tomas Aquino creeks to Pond A8 through a single breach directly north of the confluence of both creeks; and (B) the Scenario A breach plus a second levee breach 600 m further upstream where San Tomas Aquino Creek sharply turns to the west. The model results are intended to show general flow, sediment transport, and sediment deposition dynamics in both the channels and Pond A8 associated with levee breaches. Subsequent efforts can use the same morphodynamic model for assessing the feasibility of various design scenarios.

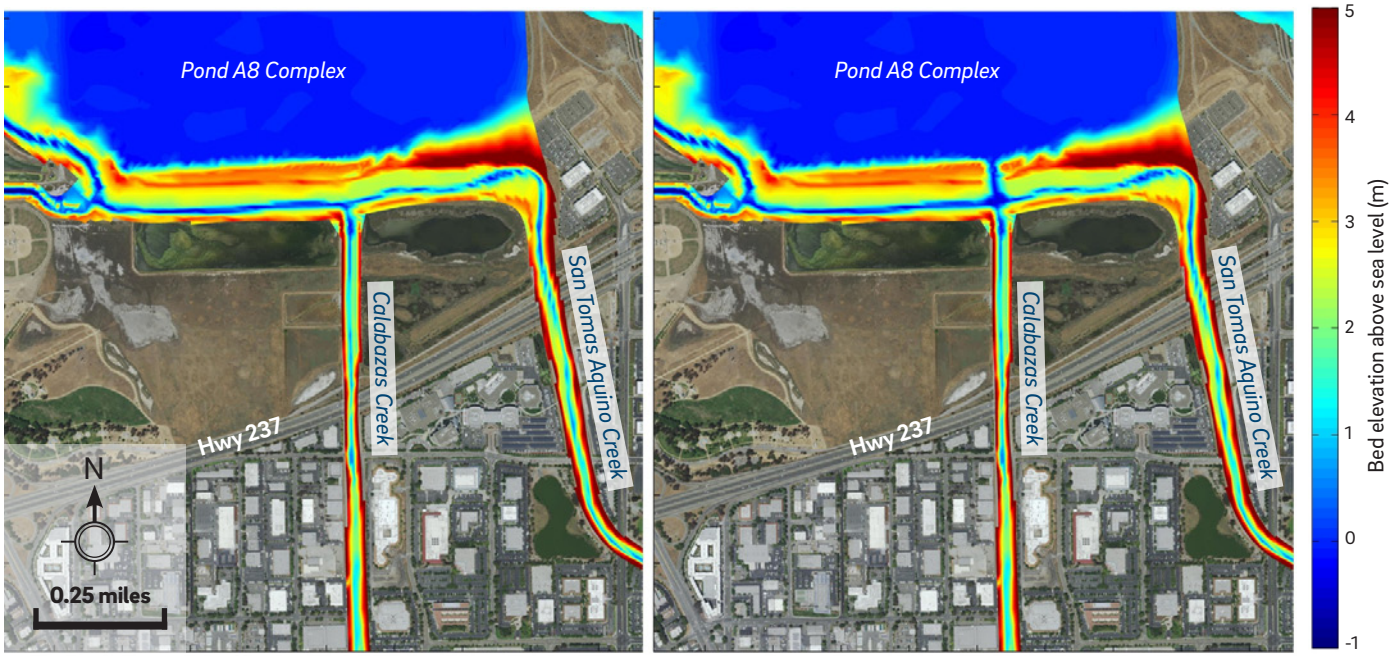
Here we provide a general overview of the modeling approach and results from the single breach near the mouth of Calabazas Creek (Scenario A), which is considered a likely breach configuration. More detailed information about the modeling effort is provided in Röbke & van der Wegen (2018).

APPROACH

Deltares modeled flow and sediment dynamics using an existing Delft3D Flexible Mesh morphodynamic model of South San San Francisco Bay (Rey 2015) that was modified to include Calabazas and San Tomas Aquino creeks downstream of Highway 101. The ground surface elevation used in the model came from the 2010 USGS LiDAR dataset and USGS bathymetric survey data (Foxgrover et al. 2014). The levee breach was simulated by lowering the surface elevation of a 40-m section of the Pond A8 levee next to the confluence of Calabazas and San Tomas Aquino creeks several meters to match the adjacent creek bed elevation. Under this condition, Pond A8 was also connected to the tide at two levee breach points on Alviso Slough and Guadalupe Slough, respectively.

The model was run for existing conditions and levee breach conditions for 5.5 years (October 2011 to March 2017) to examine sediment deposition/erosion patterns and amounts after several high flows, including large flood pulses during three rainfall events in January 2017. Tidal elevations were derived from water levels recorded by NOAA at Coyote Creek station during the simulated period (station ID: 9414575). Discharge boundary conditions for the upstream boundaries of the creeks were derived from measurements recorded by the Santa Clara Valley Water District. Gage stations used to derive the discharge boundary conditions for the creeks in the study area included Sunnyvale East Channel at Highway 101 (station number 74), Calabazas Creek at Wilcox School (station number 26.1), San Tomas Aquino Creek at Mission College Boulevard (station number 28), Guadalupe River at Highway 101 (station number 109), and Coyote Creek at Highway 237 (station number 97) (see Röbke & van der Wegen 2018). Sediment loads from Calabazas and San Tomas Aquino creeks were calculated using streamflows and a suspended sediment rating curve derived from sediment concentration data collected at the Guadalupe and Coyote Creek USGS ws.

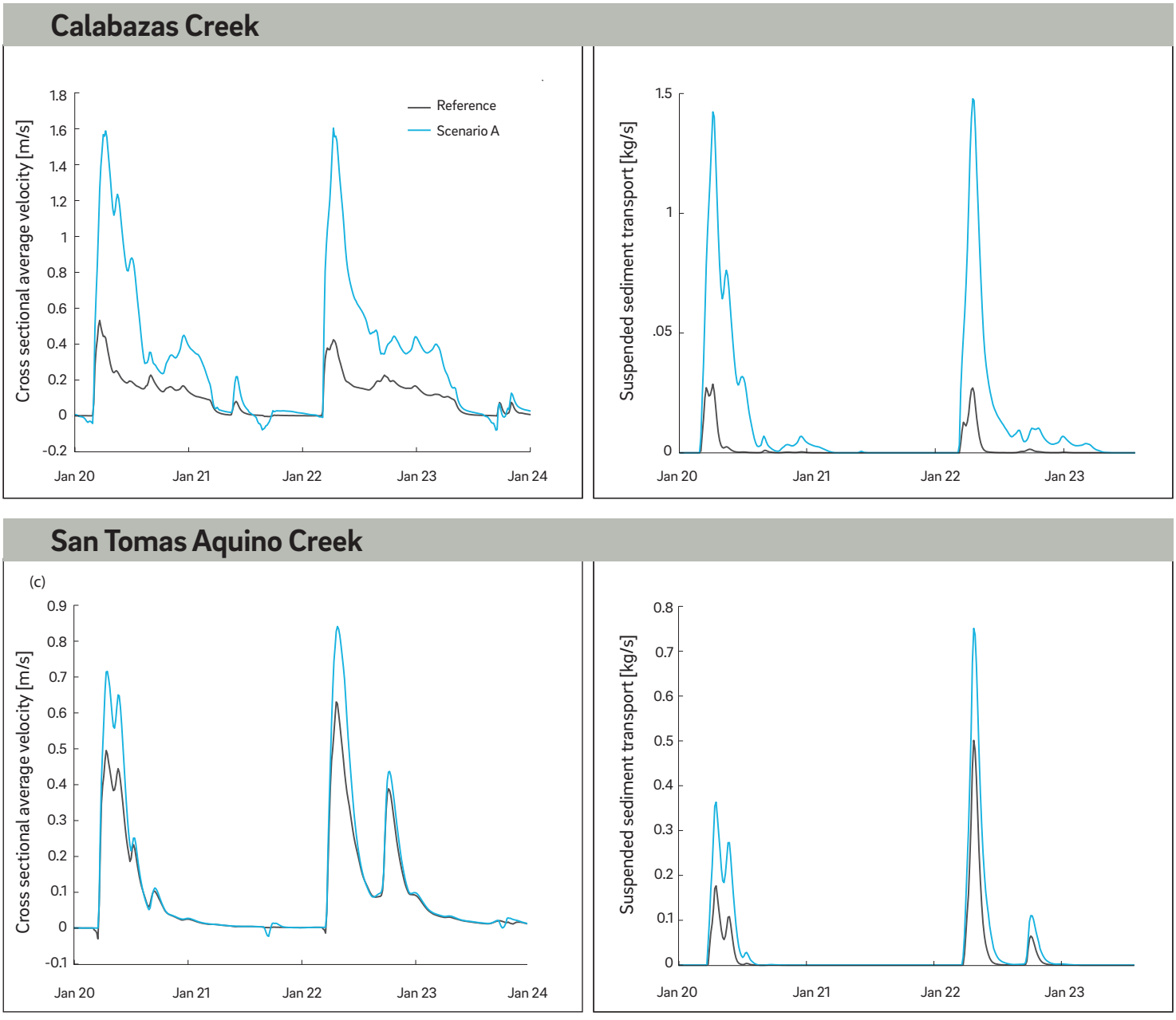
Breach locations in the Pond A8 Complex.
(basemap courtesy of Google Earth Pro)



Bed elevations in Pond 8A and the downstream areas of Calabazas and San Tomas Aquino creeks in the Reference case (left) and single breaching scenario, Scenario A (right) (Röbke & van der Wegen 2018).

RESULTS

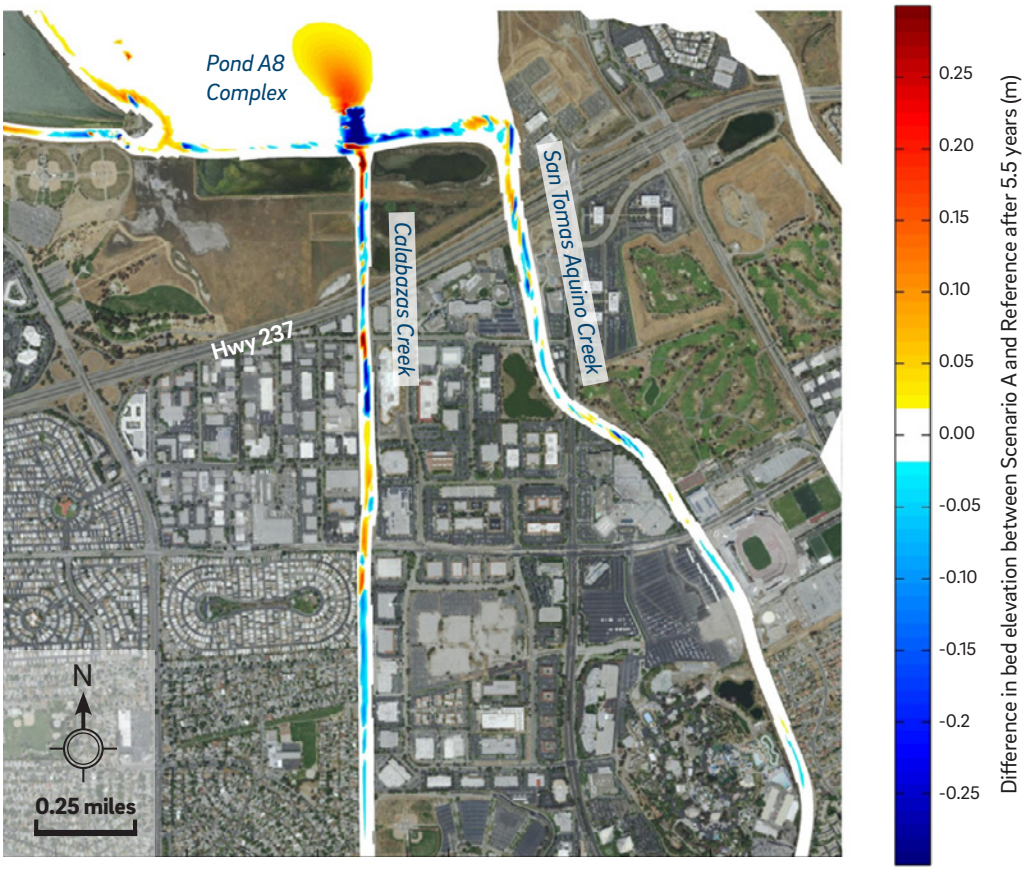
The modeling shows that the levee breach would cause an increase in creek flow velocity and associated sediment transport from the creeks to Pond A8 during flood pulses, but that the relative increase for the two creeks would be quite different. Focusing on flood pulses that occurred on January 20, 22 and 23, 2017, the modeling showed that the levee breach would cause daily peak flow velocity and suspended sediment transport rate for lower Calabazas Creek just upstream of the breach to increase by a factor of 3 and 7, respectively. The modeling also showed that for those same flood pulses, the daily peak flow velocity and suspended sediment transport rate in lower San Tomas



Depth averaged flow velocities (top left) and suspended sediment transport rates (top right) simulated on Calabazas Creek in the reference case (gray) and the single breaching scenario (blue). **Depth averaged flow velocities (bottom left) and suspended sediment transport rates (bottom right) simulated on San Tomas Aquino Creek** in the reference case (gray) and the single breaching scenario (blue). Flow velocities and sediment transport rates are shown for three high-river discharge events in January 2017. (Figures modified by those provided in Röbke & van der Wegen (2018))

Aquino Creek near the breach would increase by approximately a factor of 1.4 and 2 respectively, suggesting that Calabazas could provide more sediment to Pond A8 over the long-term.

The changes to flow and sediment transport dynamics caused by a levee breach are expected to cause net sediment erosion of the beds of both creeks and increased sediment deposition in Pond A8. The modeling shows that when considering tidal and fluvial conditions over the past 5.5 years, the overall bed elevation of both Calabazas Creek and San Tomas Aquino Creek would be expected to lower with a levee breach, with some local areas of increased sediment deposition. This net lowering of the bed would be caused by increased sediment transport rates to Pond A8 during flood events and by increased tidal prism associated with the breach causing scouring of the bed during daily tides. The increased sediment transport from the creeks out to Pond A8 over the 5.5 year period resulted in the formation of a delta next to the breach with a maximum height of approximately 25 cm (9.8 in) above the Pond A8 bed.



Modeled bed elevation difference between Reference (i.e. existing) conditions and Scenario A (single breach). Blue colors indicate increased erosion/less deposition in the scenarios compared to the reference case at the end of the simulations after 5.5 years, while yellow to red colors mark less erosion/increased deposition in the scenarios compared to the reference case. Note that the dark blue colors directly south of the sediment fan are related to the implementation of the breach in the model. (figure courtesy of Röbke & van der Wegen (2018))

Vision for Improving Landscape Functionality & Resilience

The primary goals of the developed Vision are to help address the current and future challenges faced by the District by reducing costly periodic dredging and improving flood conveyance while working towards the wetland restoration objectives of the SBSPRP. The proposed creek-bayland reconnection that is central to the Vision would allow sediment delivery to facilitate tidal marsh restoration, create a pathway for marsh migration with sea-level rise, reduce the risk of landfill erosion and associated water quality impacts, and improve ecosystem functioning and resilience through the creation of estuarine-terrestrial transition zones irrigated with treated wastewater. The Vision presented here is divided into two phases: Phase 1 (near-term) and Phase 2 (long-term). Phase 1 measures could be implemented in the next decade while Phase 2 measures could be pursued over a longer planning horizon in response to rising sea level. Implementation of components of this Vision will require feasibility studies, more detailed numerical modeling, engineering design, integration with existing planning efforts in the study region, support from regulatory agencies, and adequate funding.

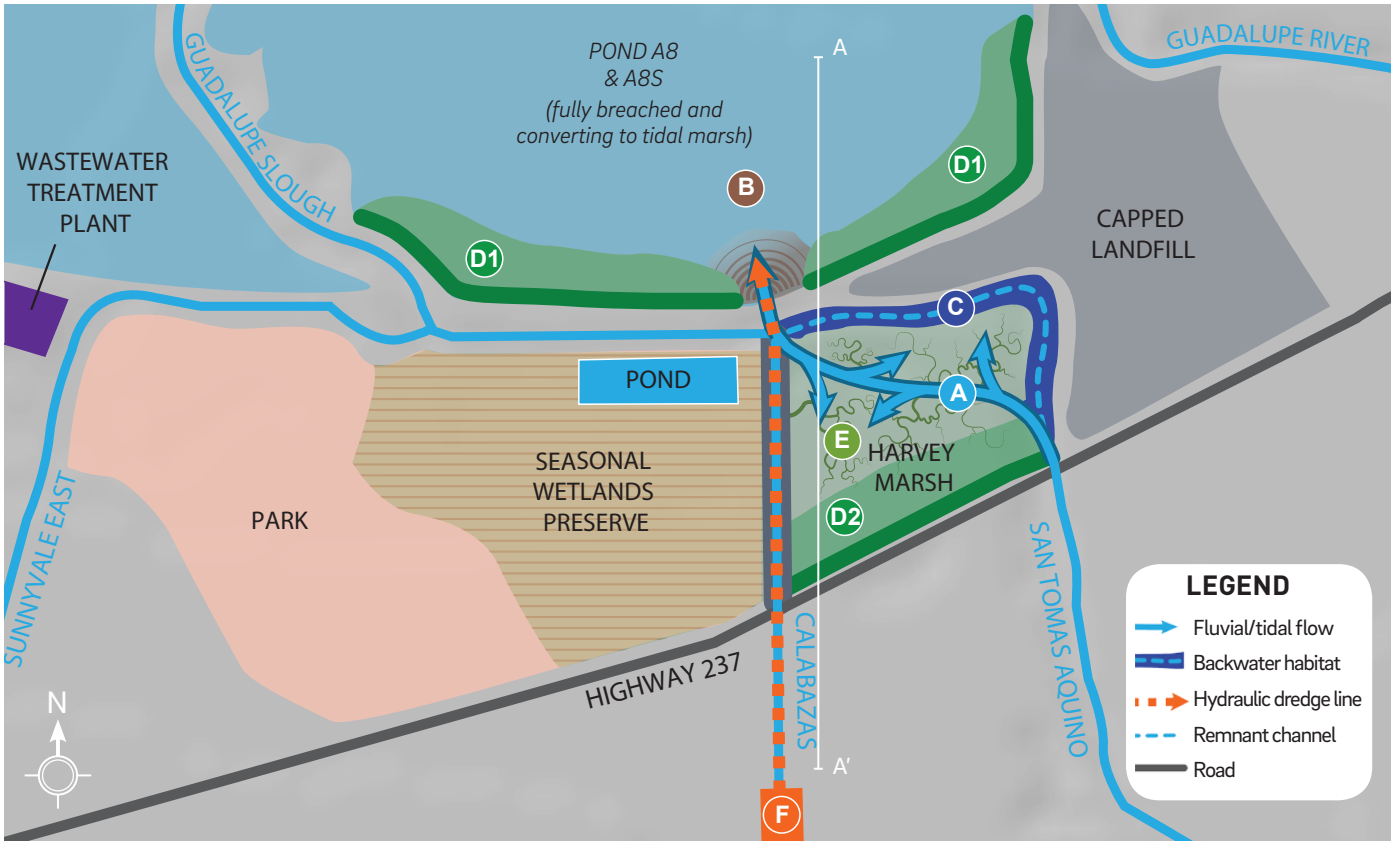
The resilient landscape Vision for the Calabazas Creek-San Tomas Aquino Creek-Pond A8 area involves connecting the creeks directly into Pond A8 through a wide breach rather than flowing around the pond's perimeter to drain to the Bay. The portion of levees constraining San Tomas Aquino Creek within Harvey Marsh would be removed or reduced, eliminating the 90-degree bend in San Tomas Aquino Creek and creating a broad brackish marsh area. The remnant channel on San Tomas Aquino Creek would be left intact after the realignment to act as backwater habitat for fish. While sediment delivery from Calabazas and San Tomas Aquino creeks is not enormous, it is relatively high for their watershed size, and is likely to be an increasingly important source as Bay sediment supplies decline. Over several years, sediment delivery through the new breach would form a proto-delta (or initial delta) directly north of the breach that acts as a promontory to attenuate wave energy, trap sediment, elevate subsided baylands, and create brackish-freshwater habitat. The implementation of a hydraulic slurry system on Calabazas Creek would augment sediment delivery from the lower reach of the creek into Pond A8. This type of sediment management system would improve in-channel flood conveyance while reducing the need for repeated and costly dredging. The Vision also includes a broad ecotone slope, constructed from excavated creek sediment, to protect the landfill from erosion (a current threat to water quality) when Pond A8 is fully tidal, and an additional ecotone slope to protect Highway 237 from erosion. The ecotone slopes would be planted with wet meadow and valley terrestrial

species currently excluded from the transition zone which would enhance habitat quality and promote landscape connectivity to adjacent upland areas. The longer-term vision considers some larger actions that may be necessary as sea level rises further and larger infrastructure changes are incorporated. Portions along the levee on Calabazas Creek would be lowered to create notches that allow freshwater and sediment to spill over the levee during high flow events. The notches would allow fringing marsh habitats to develop between Highway 237 and Pond A8 while still directing the majority of creek flow and sediment into Pond A8. Tertiary treated wastewater from the Sunnyvale Wastewater Treatment Plant would be used to irrigate the ecotone slope adjacent to Baylands Park and Highway 237, creating favorable conditions for halophytic native vegetation and minimizing the need for maintenance. Recreational access could be incorporated into this Vision by creating a pedestrian and biking trail along the upland edge of the southernmost ecotone slope, adjacent to Baylands Park and Highway 237, with opportunities for educational signage explaining the long-term benefits of the baylands-creek reconnection project.

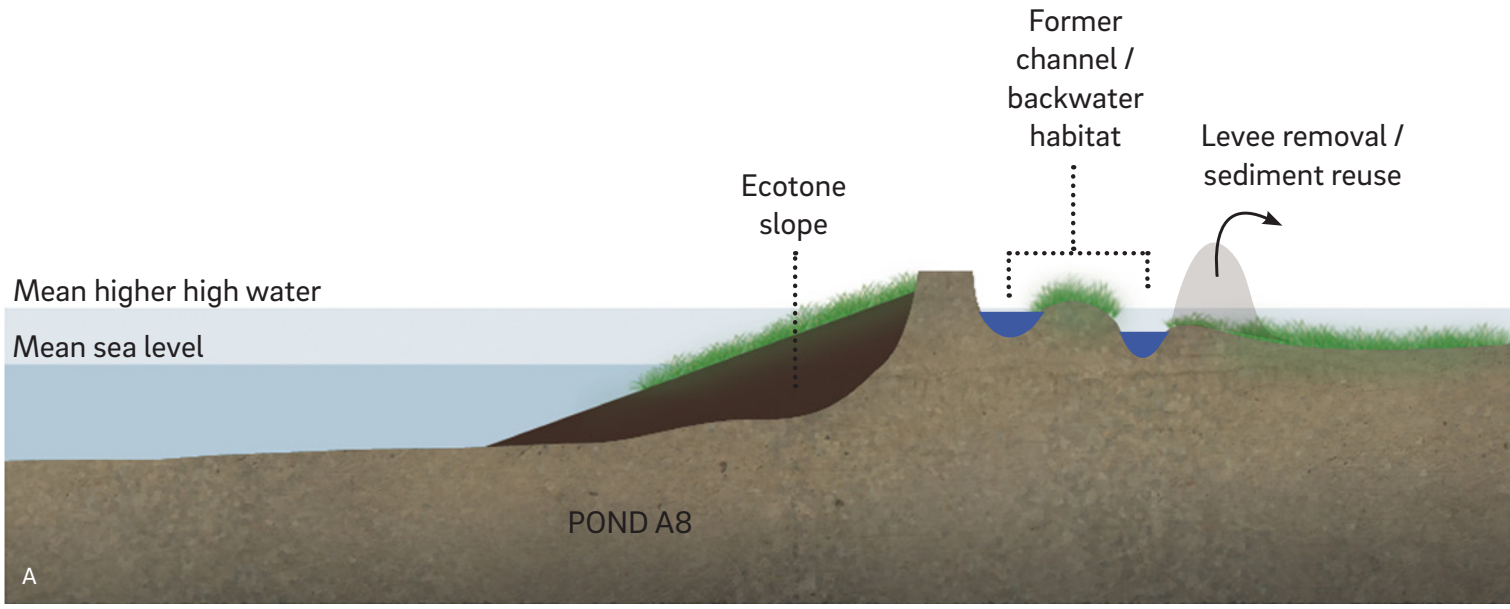
The components of the Vision outlined here are conceptual, highlighting opportunities to increase the ecological resilience of the landscape through multi-benefit management of the Calabazas-San Tomas Aquino creek-bayland interface. In order to move from measures to on-the-ground implementation, current constraints will need to be explored in more detail and additional stakeholders need to be involved in the planning process (e.g., city and county officials, stakeholders from the adjacent landfill and park). In addition, there will need to be close coordination with regulatory agencies to address potential permitting challenges. Ultimately, this Vision will also need to be tied into the management goals for the marshes in the local area, the upland areas draining to the study area, as well as management goals for the subtidal habitats bayward of the study area. Additionally, other land uses that are not explicitly covered in the Vision currently, such as recreational access, will need to be incorporated.

(top to bottom)
Confluence of Calabazas and San Tomas Aquino creeks; Highway 237 bridges over San Tomas Aquino Creek; 90-degree alignment of San Tomas Aquino Creek. (satellite imagery courtesy of Google Earth Pro)

PHASE 1: SHORT-TERM VISION



Short-term vision for Calabazas Creek, San Tomas Aquino Creek, and Pond A8 area.



Conceptual east-facing section through Pond A8 and Harvey Marsh *(note: not to scale)*.

A REALIGNED CALABAZAS & SAN TOMAS AQUINO CREEK

ACTIONS

- Create new San Tomas Aquino channel through Harvey Marsh
- Create a breach in the levee that separates Calabazas and San Tomas Aquino creeks from Pond A8
- Remove existing levees to expand wetland area in Harvey Marsh
- Design channels through Harvey Marsh to have a long hydraulic residence time

BENEFITS

- Allows freshwater and sediment to enter into Pond A8
- Creates more space for wetland habitat, which may be beneficial to the permitting process
- Harvey Marsh helps improve Bay water quality

B PROTO-DELTA IN POND A8

ACTIONS

- Use the combined breach scenario to form a proto-delta within Pond A8 (with the initial delta built farther into the pond than just inside the breach)
- Conduct modeling, including episodic events, to determine how active (e.g., ditch blocks, wave breaks, benched topography) or passive the approach should be to expand the proto-delta in Pond A8

BENEFITS

- Acts as a promontory that attenuates wave energy, traps sediment, elevates subsided baylands and helps prograde

C BEND IN CHANNEL / BACKWATER HABITAT

ACTIONS

- Leave the remnant reach of San Tomas Aquino (reach with 90-degree turn) intact after the realignment, with design attention given to the possibility of fish stranding

BENEFITS

- Creates lagoon-like backwater habitat for fish

D ECOTONE SLOPES

ACTIONS

- D1 Use local sediment to build wide, gently sloped levees to protect the access road and landfill east of the breach and the access road west of the breach
- Expand existing efforts by the SBSPRP for Phase 2 planned ecotone slope construction to include plantings
- D2 Use local sediment to build wide, gently sloped levees to protect Highway 237

BENEFITS

- Emulates a natural wide ecotone at a 1:30 slope
- Provides habitat for resident wildlife (e.g., high tide refugia)
- Protects roads against erosion
- Reuses excavated creek sediment
- Provides opportunity for marsh migration space

E TIDAL MARSH

ACTIONS

- Create tidal marsh through reconnecting baylands to tidal-fluvial influence

BENEFITS

- Reestablishes functioning marsh plain in historical baylands
- Increases edge habitat between marsh and Bay

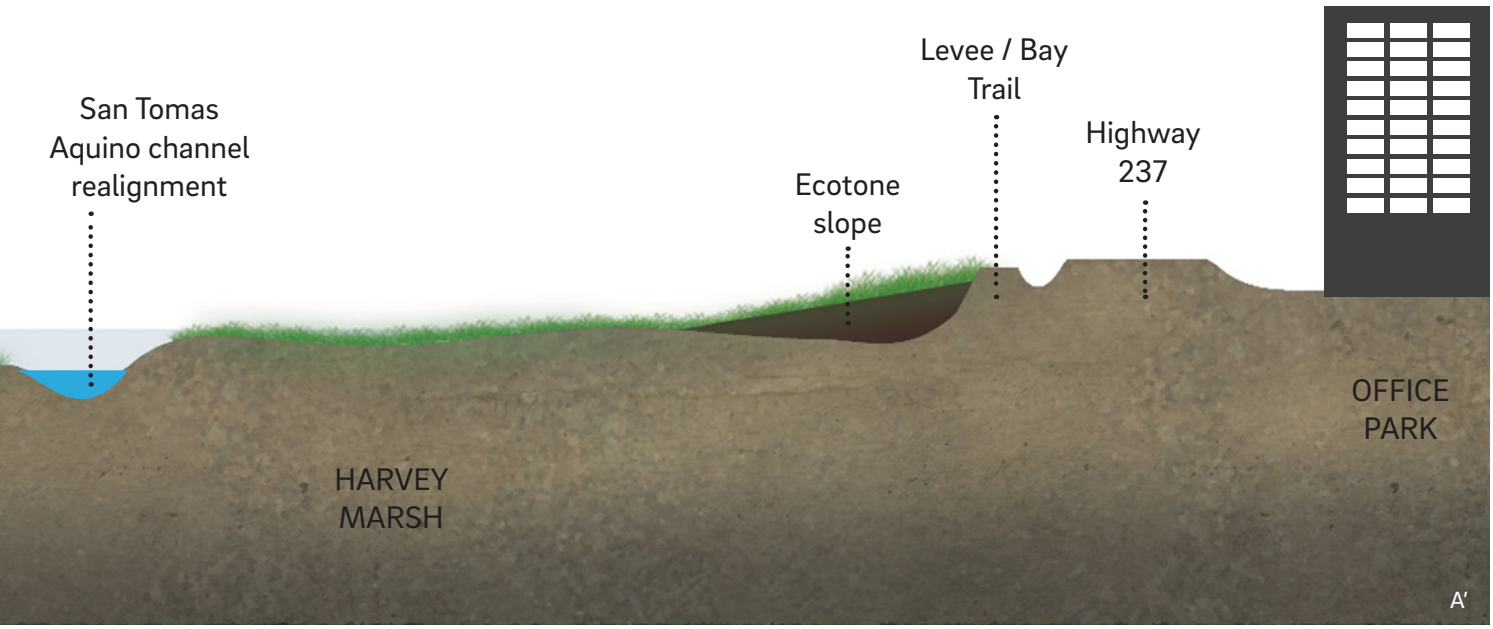
F SEDIMENT MANAGEMENT WITH HYDRAULIC SLURRY

ACTIONS

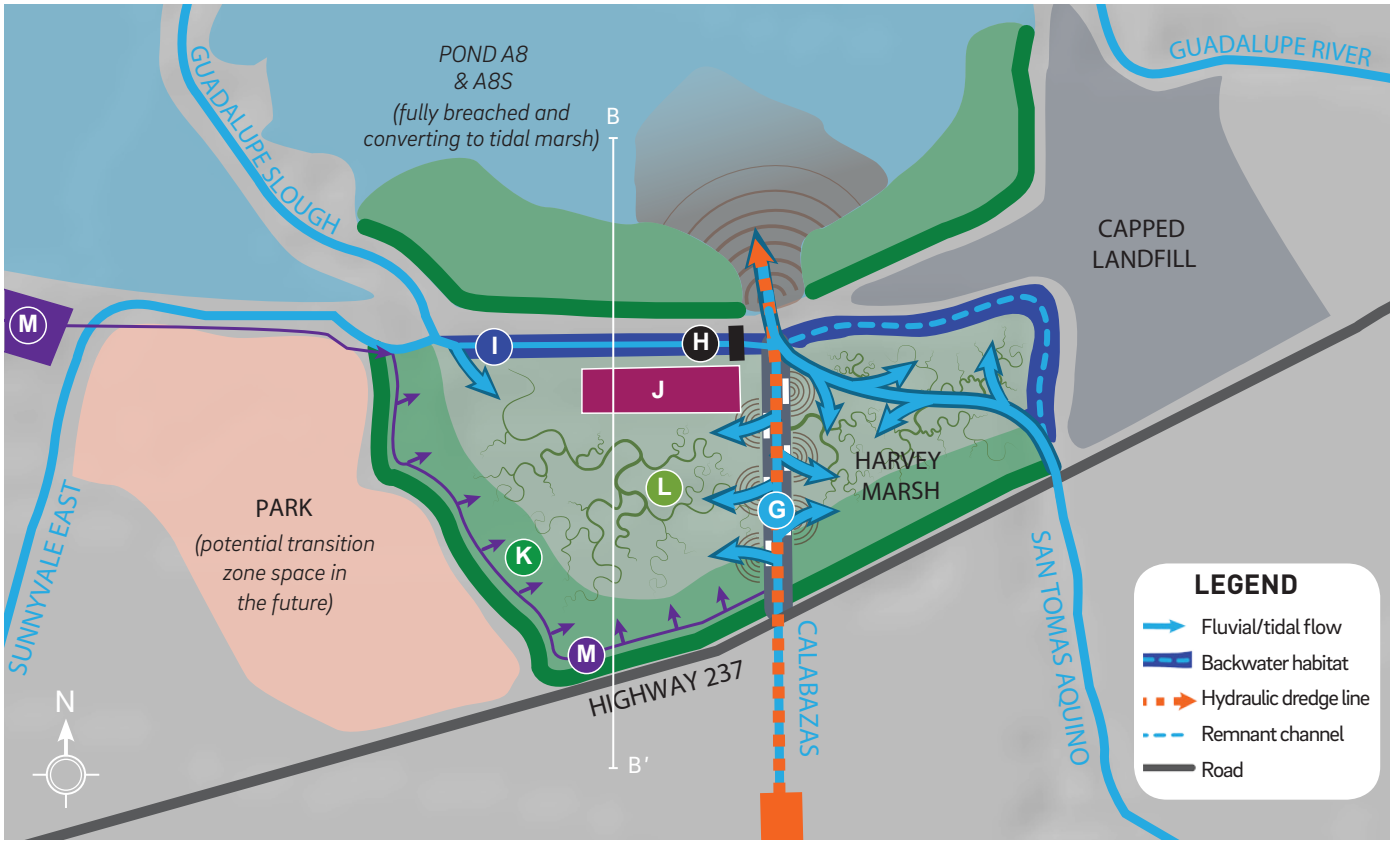
- Install a hydraulic slurry system on Calabazas Creek
- Implement booster pumps and a hydraulic slurry line using a cutter head dredge to create a permanent discharge point that slurries sediment from the lower reaches of the creek

BENEFITS

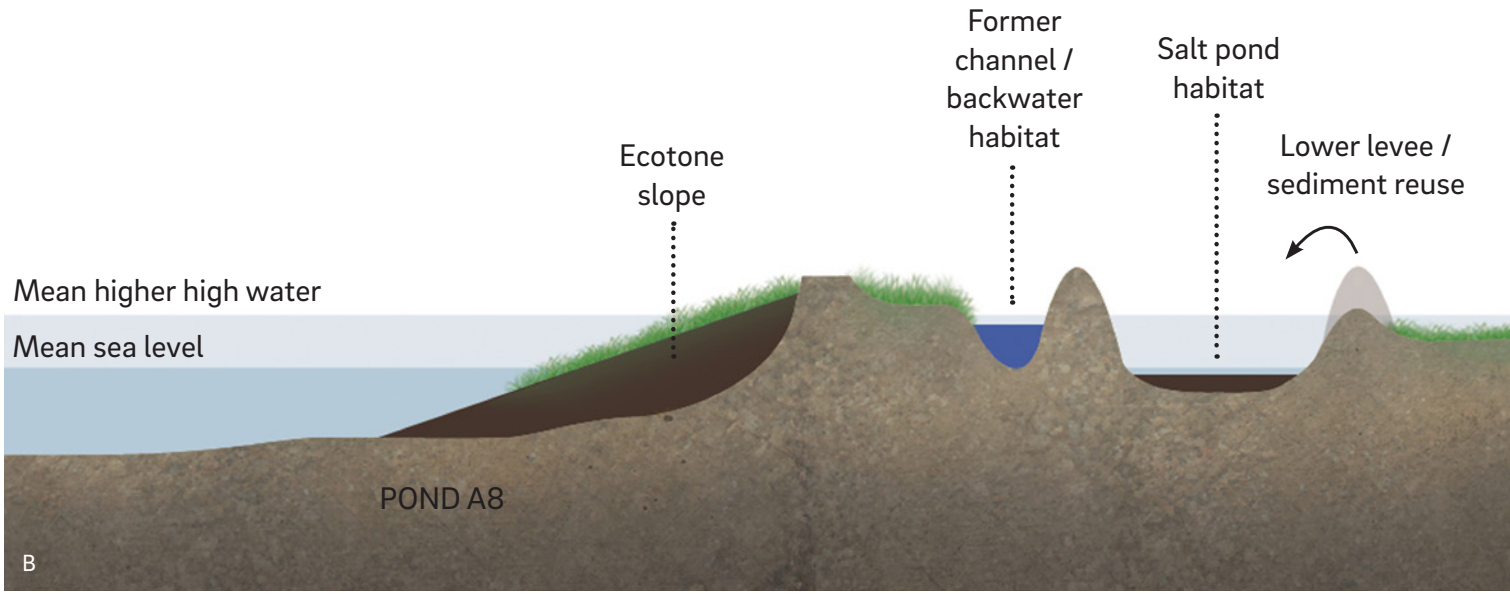
- Facilitates sediment transport and delta creation in Pond A8
- Improves in-channel flood conveyance
- Reduces need for repeated dredging



PHASE 2: LONG-TERM VISION



Long-term vision for Calabazas Creek, San Tomas Aquino Creek, and Pond A8 area.



Conceptual east-facing section through Pond A8 and Sunnyvale Baylands Seasonal Wetlands Preserve *(note: not to scale)*.

G RECONNECTED CALABAZAS CREEK

ACTIONS

- Create a series of notches in the current levees

BENEFITS

- Increases tidal prism and channel scour
- Allows freshwater and sediment to spill over during high flow events and create fringing marsh habitats between Highway 237 and Pond while still directing the majority of creek flow and sediment into Pond A8.

H BLOCKED OFF SLOUGH

ACTIONS

- Block off connection to Guadalupe Slough adjacent to Calabazas

BENEFITS

- Concentrates flow of sediment into Pond A8

I BREACH POINT & BACKWATER HABITAT

ACTIONS

- Create a breach point to connect Guadalupe Slough

BENEFITS

- Tidal action allows for sediment deposition
- Creates backwater habitat in former slough

J SALT POND HABITAT

ACTIONS

- Remove levees from the county-owned pond during the next capital improvement project

BENEFITS

- Creates salt pond habitat for native wildlife

K ECOTONE SLOPES ADJACENT TO HIGHWAY 237 & AT SUNNYVALE BAYLANDS PARK

ACTIONS

- Use local sediment to build wide, gently sloped levees to protect Highway 237 & Sunnyvale Baylands Park

BENEFITS

- Provides habitat for resident wildlife (e.g., high tide refugia)
- Protects highway against erosion and adjacent infrastructure from flooding
- Reuses excavated creek sediment
- Provides opportunity for marsh migration space and transition zone

L TIDAL MARSH

ACTIONS

- Create tidal marsh through reconnecting baylands to tidal-fluvial influence

BENEFITS

- Reestablishes functioning marsh plain in historical baylands
- Increases edge habitat between marsh and Bay

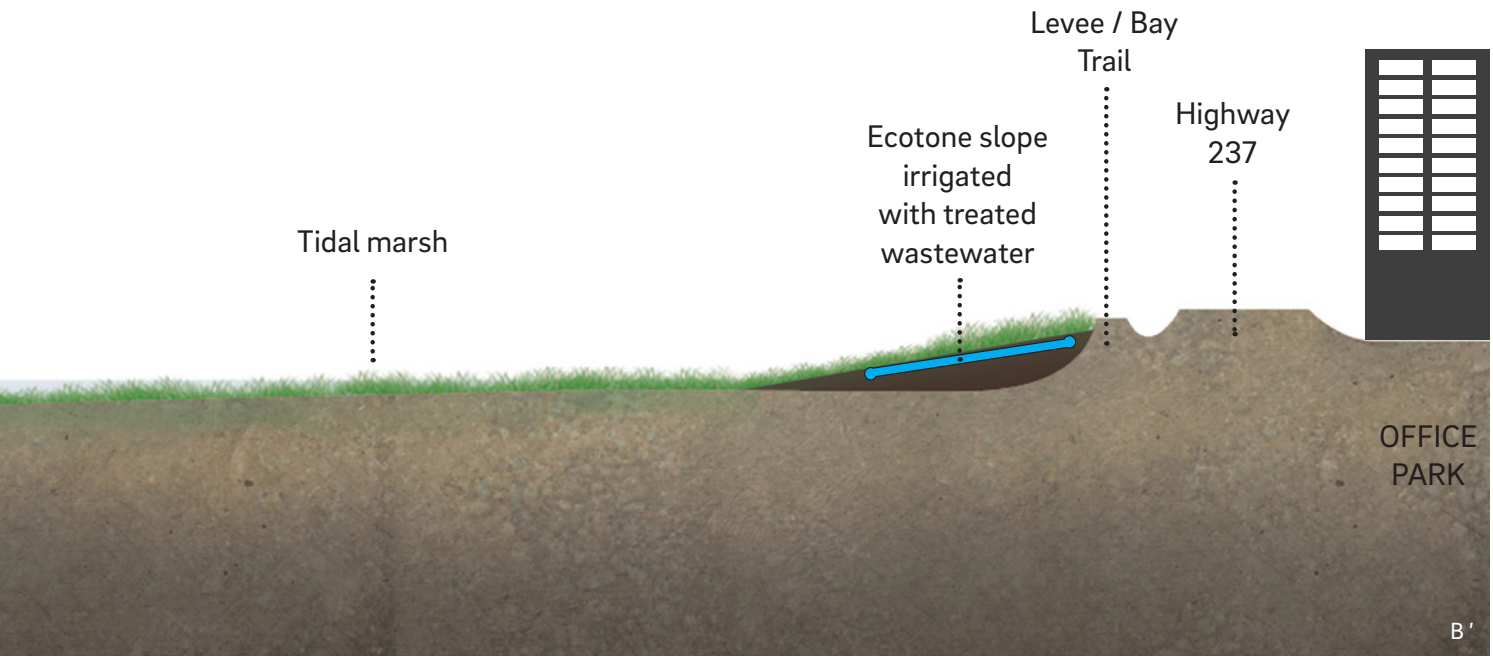
M TREATED WASTEWATER FOR ECOTONE SLOPE IRRIGATION

ACTIONS

- Use tertiary treated wastewater from the Sunnyvale Wastewater Treatment Plant to irrigate the ecotone slope adjacent to Highway 237

BENEFITS

- Creates an opportunity to maximize fresh/brackish water inputs, with potential benefits for more alkali meadow plant species



KNOWN CONSTRAINTS

This report explores the ecological and flood management benefits associated with connecting Calabazas and San Tomas Aquino creeks to Pond A8. The types of constraints that would need to be addressed include:

Existing infrastructure. Implementing these measures would require modification, relocation, or removal of existing infrastructure and restoration of relevant habitats. For example, to facilitate the breach that would connect Calabazas and San Tomas Aquino creeks to Pond A8, a transmission tower would need to be relocated. In addition, the San Francisco Bay Trail would need to be relocated from its current location on the levee along the west bank of Calabazas Creek and the levees around the pond in Sunnyvale Baylands Park to allow for these levees to be modified.

Integration with other plans. These measures will need to be assessed given other land-use plans for the area. For this Vision to be implemented, the US Army Corps of Engineers and the Regional Water Quality Control Board would need to approve a change in management approach for Harvey Marsh. Conversion of the land west of lower Calabazas Creek in Sunnyvale Baylands Park to a tidal marsh would need to consider the

PG&E transmission tower at the confluence of Calabazas Creek and Guadalupe Slough. (photograph courtesy of Errol Gabrielsen, SCVWD)

impact to current storm water retention needs. Additionally, the Vision calls for using treated wastewater from the Sunnyvale Wastewater Treatment Plant to irrigate the ecotone seepage slope protecting Highway 237. This would need to be coordinated with the Treatment Plant's future plans for the volume and fate of their treated effluent.

Permitting. The regulatory issues associated with discharging treated wastewater to seepage slopes or installing hydraulic sediment slurry infrastructure need to be resolved before implementation, which may take time because there are no projects like these permitted in San Francisco Bay. Alterations to Harvey Marsh will also require continuing to work with CalTrans and permitting agencies to address how these changes will affect existing mitigation commitments. Other permitting issues may be able to be resolved by early consultation with relevant regulatory agencies before submitting a permit application and receiving feedback from managers who have had to obtain permits for similar project designs.

Flood risk management benefits. Site-specific modeling will be important to ensure flood stages are not expected to increase with the breach and to assess the dominant controls on post-breach flood stages. Channels and associated floodplains at the fluvial-tidal interface need storage capacity for both tidal water (both daily tides and storm surges) and varying watershed flood flows.

Sediment availability and re-use. It will be important to consider the long-term availability of future sediment sources to ensure marsh sustainability given accelerated sea-level rise. For example, the episodic nature of watershed sediment delivery could be a major constraint for using this sediment to build and maintain habitats (i.e., the amount of sediment required in the short term could exceed the sediment delivered).

Field tour during workshop. (photograph by Katie McKnight, SFEI)

MOVING FORWARD

The Vision is intended to provide the District and SBSPRP a launching point for developing an integrated approach for supporting natural processes, and in turn, benefiting flood risk management and ecosystem functioning within the lower reaches of Calabazas Creek and San Tomas Aquino Creek, and ecosystem functioning within Pond A8 as it transitions to a tidal marsh. While this redesigned, multi-benefit landscape would require a first-of-its-kind major landscape retooling to connect creeks directly to a restored tidal marsh, it has the potential for diverse and synergistic benefits, including improved habitat conditions while assisting flood risk management, reduced sediment management costs, and increased Bay water quality.

The transition from the idealized Vision measures shown here to implemented projects will be complex, requiring detailed technical analyses, engineering design, and extensive collaboration among stakeholders. This would need to be viewed as a multi-decade process where components of the Vision are implemented in two phases based on factors such as available financial resources, site constraints, and project interdependence (i.e., some projects need to be implemented before others).

San Tomas Aquino Creek and Harvey Marsh.
(photograph by Scott Dusterhoff, SFEI)

NEXT STEPS:

Assessing the benefit-cost relationships. These Vision measures will be assessed using a benefit-cost analysis that looks at benefits and costs under the existing management approach (e.g., dredging that includes costs for infrastructure installation, channel dewatering, and sediment hauling and disposal) and under a scenario that incorporates the Vision measures. The benefit-cost analysis can be used to help identify projects to prioritize in the near-term. Recent benefit-cost analyses for multi-benefit Visions developed for lower Novato Creek and lower Walnut Creek, done by the San Francisco Estuary Partnership (SFEP) as part of the EPA-funded Flood Control 2.0 project, can be used for reference (see floodcontrol.sfei.org for more detail).

Conducting detailed technical analyses. The District, SBSPRP, and other local partners are excited by the prospect of connecting Calabazas and San Tomas Aquino creeks to Pond A8 provided there is a long-term net benefit to flood management and habitat support. Understanding the impacts to flooding and habitat associated with the Vision measures will require more detailed technical analysis, including hydraulic and sediment transport modeling, water quality modeling, and habitat assessments. As part of project alternatives and feasibility analyses, the District will be assessing the impact of these measures on flood stages, flood flow velocities, and sediment transport and deposition dynamics within the channels and Pond A8. The results will help guide the final design of the Pond A8 levee breach and the surrounding landscape features that will be created or restored as part of the project.

Assessing regulatory considerations. In addition to assessing the economic and technical considerations associated with the Vision measures, the permitting challenges will also need to be assessed. Concerns over potential mercury contamination will need to be addressed before permits for the pond breaches will be issued. There are also many aspects of the Vision that are novel and will require close coordination with regulatory agencies responsible for permitting during the early stages of the alternatives and feasibility analyses. Regulatory Analysis and Regulatory Guidance Reports developed by the San Francisco Bay Conservation and Development Commission (BCDC) as part of *Flood Control 2.0* can be used to help frame the coordination with regulators based on lessons learned from similar projects.

ACKNOWLEDGEMENTS

Many people were integral to the creation of the Calabazas-San Tomas Aquino-Pond A8 Vision and report. We would first like to thank the Design Advisory Team (DAT) whose ideas formed the foundation of this Vision and whose critical review greatly improved this report. The DAT includes Peter Baye (Ecological Consultant), Andy Collison (ESA), Maureen Downing-Kunz (USGS), Jeremy Lowe (SFEI), Steve Rottenborn (H.T. Harvey & Associates), and Dan Schlenk (UC Riverside). Andy Gunther (BAECCC) moderated the Vision development workshop and deserves many thanks, as does the San José-Santa Clara Regional Wastewater Facility for hosting the workshop, and Mark Wheeler for coordinating access for site visits. We would also like to thank John Bourgeois (South Bay Salt Ponds Restoration Project), Sara Duckler, Judy Nam, Errol Gabrielsen, Carole Foster, and Afshin Rouhani (Santa Clara Valley Water District) for being close partners in the development of this Vision throughout the entire process. Monica Gan (Caltrans) and Melody Tovar (City of Sunnyvale) also deserve many thanks for their participation in the Vision development. Conversations with Janelle Leeson and Frankie Malamud-Roam (USACE) and Derek Beauduy and Susan Glendening (SFBRWQCB) were very helpful in identifying key regulatory considerations during the Vision development process. Mick van der Wegen and Björn Röbke (Deltares) conducted the preliminary numerical modeling used to help develop the Vision, with support from Bruce Jaffe (USGS). Luisa Valiela (USEPA) provided very helpful review comments on an early draft of this report. This effort was possible largely through funding provided by the EPA Region IX's San Francisco Water Quality Improvement Fund as part of the *Healthy Watersheds, Resilient Baylands* project. The Santa Clara Valley Water District funded the numerical modeling and provided in-kind support.

Study area. (imagery courtesy of Google Earth Pro)

REFERENCES

Beller E, Robinson A, Grossinger R, Grenier L. 2015. *Landscape Resilience Framework: Operationalizing ecological resilience at the landscape scale.* Prepared for Google Ecology Program. A report of SFEI-ASC's Resilient Landscapes Program, Publication #752, San Francisco Estuary Institute, Richmond, CA.

Beller EE, Salomon MN, Grossinger RM. 2010. *Historical vegetation and drainage patterns of western Santa Clara Valley: a technical memorandum describing landscape ecology in Lower Peninsula, West Valley, and Guadalupe Watershed Management Areas.* SFEI contribution #622. Oakland, CA: San Francisco Estuary Institute.

Beller EE, Salomon MN, Grossinger RM. 2013. *An assessment of the South Bay historical tidal-terrestrial transition zone.* SFEI contribution #693. Richmond, CA: San Francisco Estuary Institute.

Crawford Consulting, Inc. 2002. *Boundary of Highway 237 Landfill along San Tomas Aquino Creek*, letter report prepared for Legacy Partners Commercial, Inc., July 17, 2002.

DeConto RM, Pollard D. 2016. *Contribution of Antarctica to past and future sea-level rise.* Nature 531(7596):591-597.

Dettinger M. 2011. *Climate change, atmospheric rivers, and floods in California - a multimodel analysis of storm frequency and magnitude changes.* Journal of American Water Resources Association 47(3):514-523.

Flick RE, Murray JF, Ewing LC. 1999. *Trends in U.S. tidal datum statistics and tide range: A data report atlas.* Scripps Institution of Oceanography, La Jolla, California.

Flint LE, Flint AL. 2012. *Downscaling future climate scenarios to fine scales for hydrologic and ecological modeling and analysis.* Ecological Processes 1(1):1.

Foxgrover AC, Finlayson DP, Jaffe BE, Fregoso TA. 2014. *Bathymetry and digital elevation models of Coyote Creek and Alviso Slough, South San Francisco Bay, California.* U.S. Geological Survey Open-File Report 2011-1315. doi: 10.3133/ofr20111315.

Goals Project. 2016. *The Baylands and Climate Change: What We Can Do. Baylands Ecosystem Habitat Goals Science Update 2016* prepared by the San Francisco Bay Area Wetlands Ecosystem Goals Project. California State Coastal Conservancy, Oakland, CA.

Griggs G, Árvai J, Cayan D, DeConto R, Fox J, Fricker HA, Kopp RE, Tebaldi C, Whiteman EA. 2017. *Rising Seas in California: An Update on Sea-Level Rise Science.* A report by the California Ocean Protection Council Science Advisory Team Working Group, California Ocean Science Trust, April 2017.

Grossinger RM. 1995. *Historical evidence of freshwater effects on the plan form of tidal marshlands in the Golden Gate Estuary.* University of California, Santa Cruz.

Grossinger R, Askevold R. 2005. *Baylands & Creeks of South San Francisco Bay.* A map by the San Francisco Estuary Institute, William Lettis & Associates, Inc., and the Oakland Museum of California. The Oakland Museum of California, Oakland, CA.

Rey C. 2015. *Mud dynamics in a tidal channel: The impact of opening salt ponds on channel deepening.* Master thesis WSE-HECEPD-15.08, UNESCO-IHE Institute for Water Education.

Robinson A, Beller E, Grossinger R, Grenier L. 2015. *Vision for a resilient Silicon Valley landscape*. Prepared for Google Ecology Program. A Report of SFEI-ASC's Resilient Landscapes Program, Publication #753, San Francisco Estuary Institute, Richmond, CA.

Röbke BR, van der Wegen M. 2018: *Calabazas-San Tomas Aquino Pond A8 reconnection: Preliminary scenario simulations*. Deltares Reports, 11200020-002.

Russo TA, Fisher AT, Winslow DM. 2013. *Regional and local increases in storm intensity in the San Francisco Bay Area, USA, between 1890 and 2010.* Journal of Geophysical Research: Atmospheres 118:3392-3401.

Prein AF, Rasmussen RM, Ikeda K, Liu C, Clark MP, Holland GJ. 2017. *The future intensification of hourly precipitation extremes.* Nature Climate Change 7(1):48–52.

Schoellhamer DH. 2011. *Sudden clearing of estuarine waters upon crossing the threshold from transport to supply regulation of sediment transport as an erodible sediment pool is depleted: San Francisco Bay, 1999.* Estuaries and Coasts 34(5):885-899.

SFEI-ASC (San Francisco Estuary Institute-Aquatic Science Center). 2016. *Changing Channels: Regional Information for Developing Multi-benefit Flood Control Channels at the Bay Interface.* A SFEI-ASC Resilient Landscapes Program report developed in cooperation with the Flood Control 2.0 Regional and National Science Advisors, Publication #801, San Francisco Estuary Institute-Aquatic Science Center, Richmond, CA.

USACE (United States Army Corps of Engineers). 2013. *Incorporating Sea Level Change in Civil Works Programs.* EM 1110-2-816231. December 2013.

Over the past 150 years, lower Calabazas and San Tomas Aquino creeks and their attending baylands have been heavily modified for flood control and development. Most of the tidal marshes were leveed and converted to salt ponds in the mid-to-late 19th or early 20th century, and levees were also built on the banks of Calabazas and San Tomas Aquino to contain flood waters. Over time, the historical habitats on the valley floor were converted to agricultural, residential, and industrial uses, leading to a highly modified landscape. These changes have caused impacts to wildlife, high maintenance costs, and an overall decreased resilience to sea-level rise due to loss of baylands and reduction in sediment supply. In an effort to rethink the way we manage the interconnected Calabazas-San Tomas Aquino creeks-baylands system, the Santa Clara Valley Water District is seeking new management approaches to restore and support natural processes and ecosystem functions while decreasing maintenance needs, improving flood conveyance and water quality, and supporting tidal marsh adaptation with sea-level rise. At the same time, the South Bay Salt Pond Restoration Project is interested in reconnecting creeks to nearby restored tidal marshes, a key recommendation of the Bayland Goals (2016) report.

To integrate and advance these goals, this report outlines a multi-benefit landscape vision to reconnect Calabazas and San Tomas Aquino creeks to Pond A8 to benefit both flood management and wetland habitat restoration. This Vision is an element of the EPA-funded project Healthy Watersheds, Resilient Baylands, *which aims to integrate watershed planning and redevelopment with baylands restoration to create healthier and more resilient aquatic systems and communities. This Vision is the first step in exploring the potential that exists for multi-benefit design solutions around the Bay to reintegrate natural processes at this complex location for the benefit of people and wildlife.*