Attachment 4:
Marin Shoreline Sea Level Rise Vulnerability Assessment

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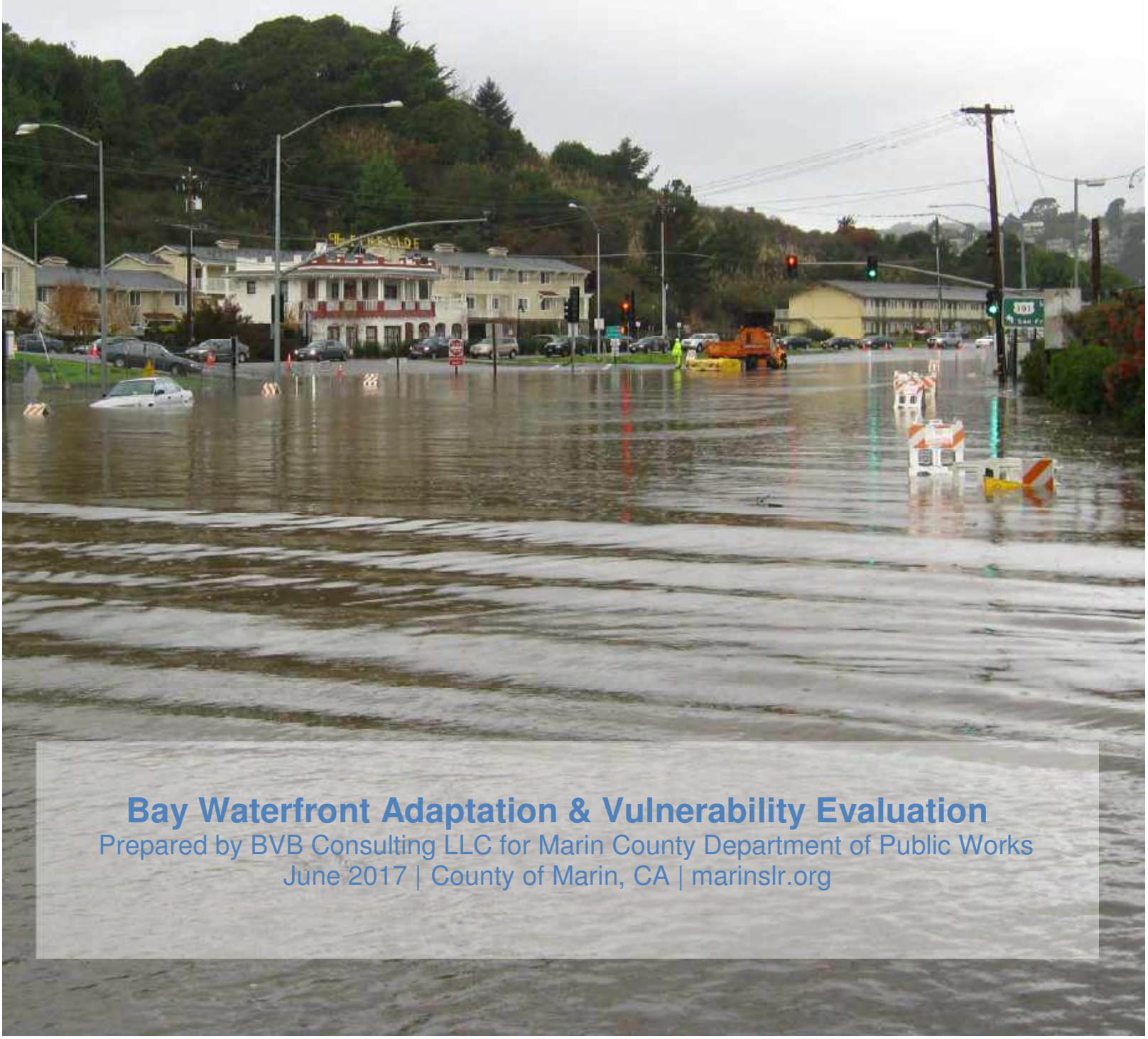
Marin Shoreline Sea Level Rise Vulnerability Assessment



Bay Waterfront Adaptation & Vulnerability Evaluation

Prepared by BVB Consulting LLC for Marin County Department of Public Works

June 2017 | County of Marin, CA | marinslr.org

Marin Shoreline Sea Level Rise Vulnerability Assessment

Bay Waterfront Adaptation & Vulnerability Evaluation (BayWAVE)

With special thanks to the California State Coastal Conservancy's Climate Ready Grant Program

Prepared by BVB Consulting for Marin County Department of Public Works

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List of Acronyms

BayWAVE	Bay Waterfront Adaptation and Vulnerability Evaluation
MHHW	Mean Higher High Water
GGBHTD	Golden Gate Bridge, Highway and Transportation District
GGT	Golden Gate Transit
GGF	Golden Gate Ferry
C-SMART	Collaboration: Sea-Level Marin Adaptation Response Team
OWTS	On-site Wastewater Treatment System
CDA	Community Development Agency
DPW	Department of Public Works
NMWD	North Marin Water District
MMWD	Marin Municipal Water District
PG&E	Pacific Gas and Electric
SASM	Sewerage Agency of Southern Marin
NSD	Novato Sanitary District
USFWS	United States Fish and Wildlife Service
CADFW	California Department of Fish and Wildlife
LGVSD	Las Gallinas Valley Sanitary District
CMSA	Central Marin Sanitation Agency
LHMP	Local Hazard Mitigation Plan

EXECUTIVE SUMMARY

Executive Summary

Sea level in the San Francisco Bay Area has risen eight inches in the past century, and could rise up to 70 inches by the end of the century.[1, 2] Marin's bay shoreline is vulnerable to sea level rise and intensifying storm patterns. The third National Climate Assessment cites strong evidence that the cost of doing nothing exceeds the costs associated with adapting to sea level rise by 4 to 10 times.[3] Therefore, it is critical the County of Marin, incorporated jurisdictions, and special districts plan and prepare for the impacts of sea level rise to ensure a resilient county for present and future generations.

The County of Marin Department of Public Works and Community Development Agency are the project leads for the Bay Waterfront Adaptation & Vulnerability Evaluation (BayWAVE) program. The program began in September 2015 with funding from County of Marin and additional financial support from the California Coastal Conservancy.

Several committees support the BayWAVE process. The Executive Steering Committee consists of County of Marin and local jurisdiction representatives. The Technical Advisory Committee includes staff from local, state, and federal agencies. Lastly, the Policy Committee includes elected officials from the participating jurisdictions. These committees serve as the beginning of the program's goals to establish an efficient shared learning process and community messaging, and create a collaborative environment for preparing for sea level rise for all shoreline communities, and others inland, that could face the impacts of sea level rise in the coming decades. This effort may also support these communities in collaborating with and benefiting from the larger Bay Area region efforts underway.

The Vulnerability Assessment is an initial effort to identify the risks and exposure from sea level rise. Future tasks could include development of an adaptation report and may occur at different jurisdictions: local municipalities, service districts, and County of Marin could update general plans, master plans, capital improvement plans, hazard mitigation plans, and other relevant plans and procedures in the near future. While this effort focuses on sea level rise, Marin County experiences flooding from creeks, tides, and stormwater. Planning for solutions should evaluate the combined impacts of flooding to best prepare for a range of conditions.

This effort is part of an ongoing scientific and public process to understand and prepare for sea level rise along the shoreline This Vulnerability Assessment seeks to provide context and estimates of the physical and fiscal impacts across the County of Marin's bayside shoreline over the coming decades. These data highlight the complexity of the potential impacts and the need for concerted and individual actions in the face of rising tides. The data can be used to prioritize efforts, seek funding, and shape policy and development discussions that will guide the plans mentioned above.

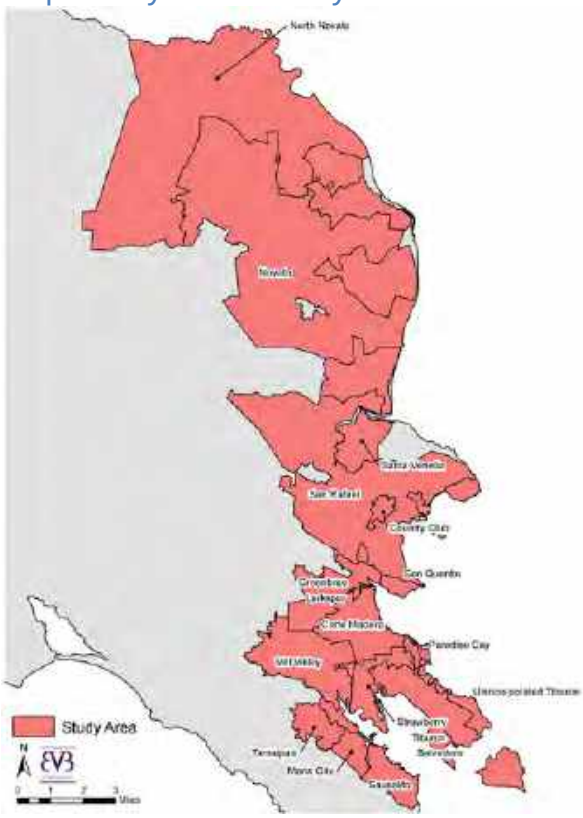
This document presents asset profiles describing the potential consequences of a no-action, or business as usual political environment, especially for existing development. Asset profiles present potential consequences for parcels and buildings, transportation networks, utilities, working lands, natural resources, recreational assets, emergency services, and cultural resources. Vulnerable assets are also presented by jurisdiction in community profiles to enable local professionals, officials, and residents to engage is local discussions and relate to their neighbors. The following exposed and vulnerable communities have community profiles and make up the 85,840 acre study area shown in Map 1.

[1] Sea-Level Rise for the Coasts of California, Oregon and Washington: Past, Present and Future. National Research Council (NRC), 2012.

[2] Rising sea levels of 1.8 meter in worst-case scenario, researchers calculate. Science Daily Online News. University of Copenhagen. Oct. 14, 2014. http://www.sciencedaily.com/releases/2014/10/141014085902.htm Original published in the journal Environmental Research Letters.

[3] Moser, S. C., M. A. Davidson, P. Kirshen, P. Mulvaney, J. F. Murley, J. E. Neumann, L. Petes, and D. Reed, 2014: Ch. 25: *Coastal Zone Development and Ecosystems. Climate Change Impacts in the United States: The Third National Climate Assessment*, J. M. Melillo, Terese (T.C.) Richmond, and G. W. Yohe, Eds., US Global Change Research Program, , 579-618. doi:10.7930/J0MS3QNW. http://nca2014.globalchange.gov/report/regions/coasts

Map 1. BayWAVE Study Area



- Municipalities
  - Belvedere
  - Corte Madera
  - Larkspur
  - Mill Valley
  - Novato
  - San Rafael
  - Sausalito
  - Tiburon
- Unincorporated Jurisdictions
  - Almonte
  - Bayside Acres
  - Bel Marin Keys
  - Black Point
  - California Park
  - Country Club
  - Greenbrae
  - Kentfield
  - Marin City
  - North Novato
  - Paradise Cay
  - Point San Pedro
  - San Quentin
  - Santa Venetia
  - St. Vincent's
  - Strawberry
  - Tamalpais Valley
  - Unincorporated Tiburon
  - Waldo Point Harbor

Each profile details key issues and geographic locations. Asset profiles include economic, environmental, equity, and management considerations related to sea level rise vulnerability. Each profile can be read independently of the others, enabling asset managers to focus on their professional area, and community members, elected officials, and others to read the analysis for a community as a whole.

Methods

Table 1 shows the range of sea level rise projections for California adopted by the National Research Council in 2012. Given the uncertainty in the magnitude and timing of future sea level rise, this Assessment uses a scenario based approach to assess a range of potential sea level rise impacts. The scenarios selected for this Vulnerability Assessment are derived from the United States Geological Survey (USGS) Coastal Storm Modeling System (CoSMoS) that combines global climate and wave models with projected sea level rise to identify areas that could be flooded across 10 different sea levels (ranging from 0 to 200 inches) and 4 storm severities (none, annual, 20-, 100-year storm surges) to total 40 possible combinations. All of these scenarios are viewable on the Our Coast Our Future (OCOF) Flood Map website.

One limitation of the model and every sea level rise model available at this time is the failure to combine sea level rise, stormwater drainage, and creeks. The model displays the impacts of flooding from the bay overtopping the shoreline edge and flooding low-lying areas. However, in Marin areas experience the impacts of high tides that coincide with storms, which result in water coming from the hills and the bay. Additionally, underground or low-lying drainage pipes and channels allow water to flood areas where the shoreline edge is sufficiently elevated to prevent direct overtopping. These vulnerabilities are described in the text, but tables and maps show sea level rise as presented in the CoSMoS model.

EXECUTIVE SUMMARY

The findings of this assessment are based on three sea levels and each sea level combined with a 100-year storm surge as shown in Table 2. Scenarios 1 and 2 represent the near-term, and correspond to the 2030 NRC projected sea level range. Scenarios 3 and 4 represent the medium-term and are within the 2050 NRC range. Scenarios 5 and 6 represent the long-term and correspond to the 2100 NRC range. Figure 3 presents another view of the BayWAVE scenario where the red lengths represent tidal flooding in sea level rise scenarios 1, 3, and 5, and the blue lengths represent the addition storm surge water level associated with scenarios 2, 4, and 6. Together these bands show the potential flooding in the near-, medium-, and long-terms.

Vulnerability is based on an asset's exposure, sensitivity, and adaptive capacity to rising bay waters and storm surge threats. If an exposed asset is moderately or highly sensitive to sea level rise impacts, with low to no adaptive capacity, the asset is considered vulnerable. Vulnerable assets may be vulnerable to flooding and/or increased rates of subsidence over the coming decades. Extensive geographic mapping was conducted overlapping layers of assets from MarinMap and sea level rise extent and flood depth layers to determine exposure. To ascertain sensitivity and adaptive capacity, the project team interviewed 115 asset managers, for example, the heads of public works departments, using the *BayWAVE Asset Vulnerability Assessment Tool* to assess more than 350 built and natural resource assets. The interview results were combined with the geographic data to develop the Vulnerability Assessment.

Table 1. Sea Level Rise Projections for San Francisco, CA Region

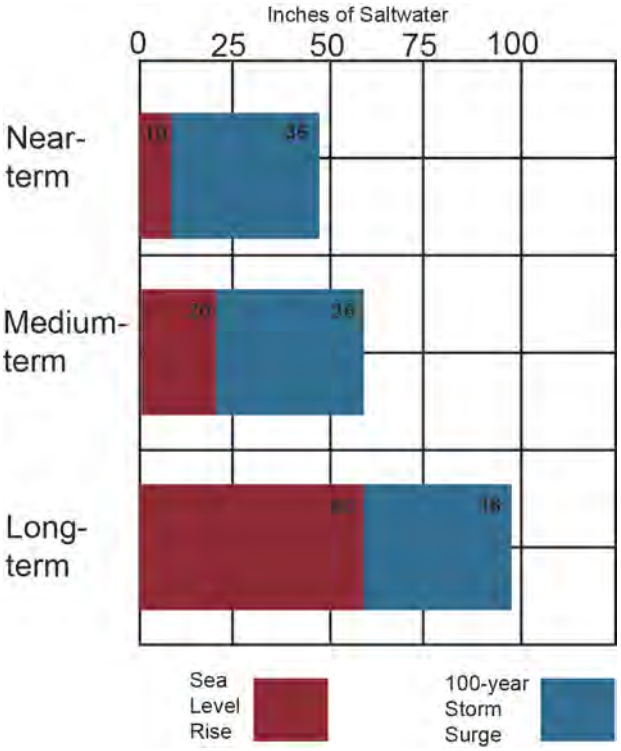
Time Period	Projected Range
by 2030	1.6 – 11.8 inches
by 2050	4.7 – 24 inches
by 2100	16.6 – 65.8 inches

Source: NRC 2012

Table 2. BayWAVE Sea Level Rise Scenarios

Scenario 1	10 inches
Scenario 2	10 inches+100-year storm surge
Scenario 3	20 inches
Scenario 4	20 inches+100-year storm surge
Scenario 5	60 inches
Scenario 6	60 inches+100-year storm surge

Figure 3. BayWAVE Scenarios Associated Water Levels



15-year Expectations

Sea level rise flooding could reduce useable living space and adversely affect tourism, transportation, and natural attractions and resources within 15 years. The first threats are to buildings, roads, and original utility systems along the shoreline. Disruptive flooding to the road and utility networks could have regional ripple effects for extended periods of time. In the near-term, San Rafael and Southern Marin shoreline communities are most at risk to tidal and storm surge flooding.

EXECUTIVE SUMMARY

In this near-term timeframe, tidal flooding at 10 inches of sea level rise (MHHW) could reach 5,000 acres, 1,300 parcels, and 700 buildings, potentially impacting tens of thousands of residents, employees, and visitors. Regular tidal flooding could adversely impact San Rafael east of US Highway 101, bayfront Belvedere and Tiburon, Greenbrae Boardwalk, Waldo Point, and Paradise Cay.

With an additional 100-year storm surge, the previously impacted acres, parcels, and buildings could face tidal and storm surge flooding. An additional 3,000 acres, 2,500 parcels, and 3,800 buildings could anticipate storm surge flooding. These figures amount to six percent of parcels and buildings in the study area. Storm surge flooding, could impact North Novato at Gnoss Field, Black Point on the Petaluma River, lower Santa Venetia, Belvedere around the lagoon, bayfront Corte Madera, bayfront Mill Valley, Marinship in Sausalito, Tamalpais, and Almonte, in addition to the communities vulnerable to tidal flooding.

Eight miles of road could expect tidal flooding. Many of these flooded areas already experience seasonal and king tide flooding. These are:

- Manzanita, Almonte
- Miller Avenue in Mill Valley,
- the Marinship area in Sausalito,
- US Highway 101 in Marin City, Corte Madera, Larkspur, and
- State Route 37 in Novato.

This is expected to worsen in severity and become increasingly frequent. Tidal flooding would reach the Canal area of San Rafael, spreading to I-580. Several roads in Santa Venetia, Tamalpais, Belvedere, Mill Valley, Marin Lagoon of San Rafael, and bayfront Corte Madera and Larkspur would begin to experience seasonal, king tide, and storm surge flooding more frequently.

Water travel infrastructure could be compromised at ferry facilities in Larkspur, Tiburon, and Sausalito preventing commuters from traveling to work. Even if the facilities are able to handle near-term higher tides, providing safe parking and access to ferry users could prove challenging. Samller public and private and marinas and boat launches along the bay in Sausalito, Mill Valley, Strawberry, Tiburon, Belvedere, Bel Marin Keys, and Black Point could be flooded out and unusable. Storm surges can be powerful enough to damage and sink boats. This is especially a corncen for residential boats.

Southern Marin Fire Protection and Sausalito Police Deparmtent boats are included in the boats harbored in marinas vulnerable to sea level rise. The Castro Fire Station in San Rafael is vulnerable to tidal flooding in the near-term and the California Highway Partrol offices in Corte Madera could expect storm surge flooding in this time period. Most concerning, however; is the potential inability of emergency professionals and vehicles to access people in or through flooded areas.

In addition, the marshlands that buffer the shoreline communites from high tides and storm surges could begin to experience transitions in habitat, especially those in Southern Marin where they are typically bordered by urban development. Consequently, the waters here would get deeper and flood out the existing habitat, shifting high marsh to low marsh, low marsh to mud flat, and mud flats to open water. Without adequate light of shallow water, eelgrass beds would shrink. Collectively, these habitat shifts could have significant impacts on vulnerable specieis such as the salt marsh harvest mouse, Ridgway's Rail, or the long-fin smelt.

IMPACTS AT-A-GLANCE: SCENARIO 2

<table>
<tr><td>5,000 acres flooded @ MHHW</td><td>200,000+ residents plus commuting employees</td></tr>
<tr><td>8,000 acres flooded @ MHHW +100-year storm surge</td><td>2,000 agricultural acres
(mostly ranch)</td></tr>
<tr><td>4,500 homes, businesses, & institutions</td><td rowspan="3">Property Owners
County of Marin
Municipalities
Caltrans
Sanitary Districts
Water Districts
Fire Districts
Sausalito Police Department
CHP
SMART
GGBHTD
MTA
PG&E
AT&T
CADFW</td></tr>
<tr><td>30 miles of wet road,
3 ferry landings,
5 marinas,
4 boat launches</td></tr>
<tr><td>Beaches
Tidal Marshes
Eelgrass beds
Wetlands</td></tr>
</table>

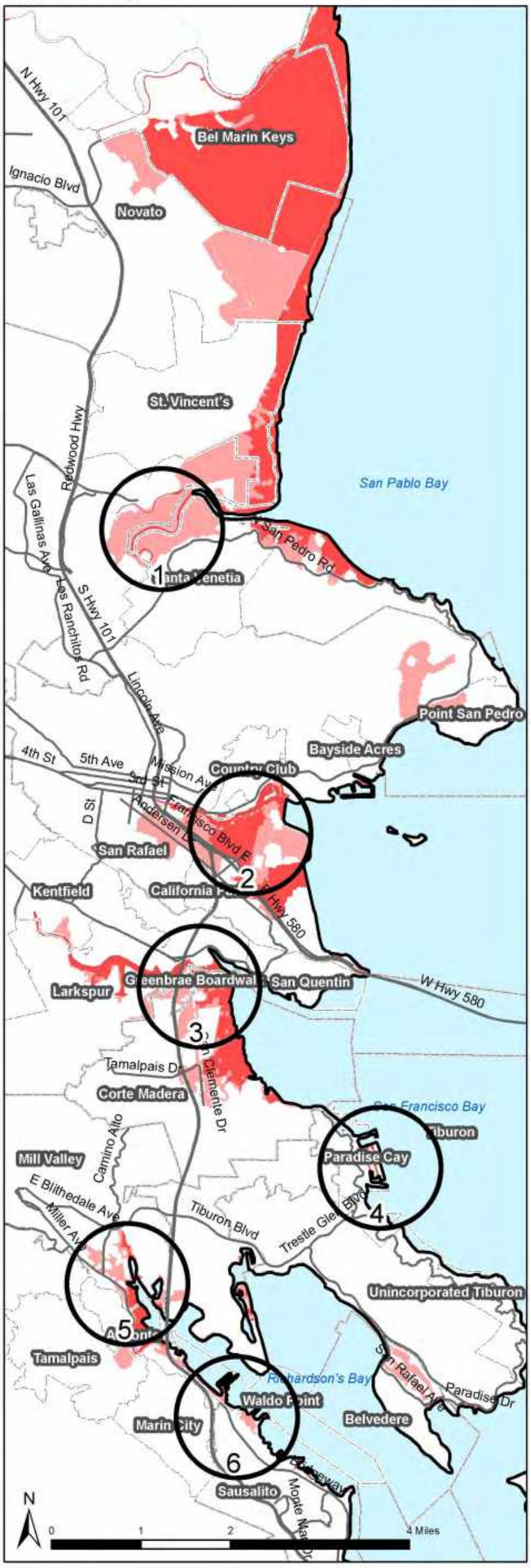
Map 131. Fifteen-year Expectation: Near-term Vulnerable Assets

NEAR TERM

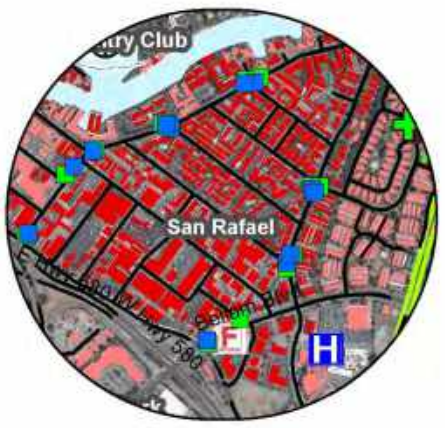
Scenario 1:
10 in. Sea Level Rise

Scenario 2:
10 in. Sea Level Rise
+ 100-year storm surge

In 15 years, high tides could threaten Marin's shoreline buildings, roads, and original utility systems. Damage and breakdowns in road and utility networks would impact the entire County, especially Southern Marin. Tidal flooding (red) could reach 5,000 acres, 1,300 parcels, 700 buildings, and 8 miles of road in San Rafael east of State Route 101, bayfront Belvedere and Tiburon, Greenbrae Boardwalk, Waldo Point, and Paradise Cay. A 100-year storm surge (pink) would flood these areas with storm surge flooding, and flood an additional 3,000 acres, 2,500 parcels, 3,800 buildings, and 20 miles of road in North Novato, Black Point on the Petaluma River, lower Santa Venetia, Belvedere Lagoon, bayfront Corte Madera and Mill Valley, Marinship in Sausalito, Marin Lagoon in San Rafael, Tamalpais, and Almonte. Flooded ferry facilities would prevent commuters and visitors from traveling across the Bay. Boating facilities in Sausalito, Mill Valley, Strawberry, Tiburon, Belvedere, San Rafael, Bel Marin Keys, and Black Point may be inaccessible. This is especially a concern for marinas with residential boats and Southern Marin Fire and Sausalito Police boats. The Castro St. Fire Station in San Rafael is vulnerable to tidal flooding, though all emergency professionals would be denied vehicular access to people in vulnerable areas Southern Marin marshlands would shift high marsh to low marsh to mud flat, and eelgrass beds could shrink under deeper darker waters. These habitat shifts would have significant repercussions for plant, insect, fish, and animal species.



1: Santa Venetia



2: Canal Area

3: Greenbrae Boardwalk/
Larkspur

4: Paradise Cay

5: Mill Valley

6: Waldo Point Harbor

Vulnerable Assets

Vulnerable Buildings
- Scen. 1: 10" Sea Level Rise (SLR)
- Scen. 2: 10" SLR+Storm Surge
- Park
- Vulnerable Road
- Marin Transit Stop
- Golden Gate Transit Stop
- Park & Ride
- SMART Track
- Ferry
- Airport
- Public Boat Launch
- Marina
- School
- Medical Facility
- Law Enforcement
- Emergency Shelter
- Fire Station
- District Office
- Gas Pipe
- Electrical Tranmission Tower
- Substation
- PG&E Property
- Transmission Lines

Sea Level Rise Scenarios
- Scen 1: 10" SLR
- Scen 2: 10"SLR+Storm Surge

Location Indicators
- Unincorporated
- Municipality
- Road
- Bay

Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data providers here in, make no warranties of the accuracy or completeness of maps and data. Maps are representational and subject to future revision. Local site conditions must be examined. Commercial use is prohibited.

Date: 2/18/2017

EXECUTIVE SUMMARY

IMPACTS AT-A-GLANCE: SCENARIO 4

6,700 acres flooded @ MHHW	200,000+ residents plus commuting employees
13,500 acres flooded @ MHHW +100-year storm surge	2,000 agricultural acres (mostly ranch)
5,600 homes, businesses, & institutions	Property Owners County of Marin Municipalities Caltrans Sanitary Districts Water Districts Fire Districts Sausalito Police Department CHP SMART GGBHTD MTA PG&E AT&T CA DFW
62 miles of wet road, 3 ferry landings, 5 marinas, 4 boat launches	
Beaches Tidal Marshes Creeks Eelgrass beds Ponds Wetlands	

King tides preview future water levels. Mill Valley. 10:41 a.m., Nov. 25, 2015. Credit: Light Hawk Aerial

Mid Century Expectations

In this medium-term timeframe, tidal flooding at 20 inches of sea level rise (MHHW) could reach nearly 7,000 acres, 3,000 parcels, and 2,000 buildings, potentially impacting even more residents, employees, and visitors than in the near-term. Regular high tide tidal flooding could adversely impact the same locations tidally flooded in the near-term, though more severely.

With an additional 100-year storm surge, the previously impacted acres, parcels, and buildings could face tidal and storm surge flooding, and an additional 7,000 acres, 2,200 parcels, and 3,600 buildings could anticipate storm surge flooding. These figures amount to eight percent of parcels and seven percent of buildings in the study area. Most levees south of Novato are not designed to withstand this level of flooding and could be overtopped. Storm surge flooding would impact the same locations as in near-term scenario 2, 10 inches with a 100-year storm surge, and extends further inland beyond the marshy areas of Mill Valley, Strawberry, San Rafael, St. Vincent's, and North Novato.

Eighteen miles of roadway, ten more miles than in the near-term, could expect tidal flooding. Many of the impacted roads are the same as those impacted in the near-term, though much greater lengths could anticipate tidal flooding and flooding depths would increase. Storm surge flooding could reach a total of 44 additional miles of roadway. Water travel could experience similar outcomes as in the near-term, though the highest high tides and storms surges would cause even more damage than weathered twenty years earlier.

With respect to utilities, pipelines under vulnerable roads, and lateral pipes to vulnerable properties, would become squeezed between rising groundwater and the confining roadway. This could cause pipes to bend and break, and could even damage roadways. In the medium-term, impacts to the North Marin Water District service area would impact water service in Bel Marin Keys and unincorporated Novato. In fact, Bel Marin Keys already experiences seasonal saltwater contamination. Vulnerable substations, electrical transmission towers and lines, and underground natural gas pipelines along the shoreline would be compromised by flooding and subsidence. Disruptions or failures in this network could also have far reaching impacts in transportation, sanitary

service, stormwater management facilities, food storage, communications, and general public safety.

This twenty inch increase in sea level would continue to shrink Southern Marin, Tiburon Peninsula, and Pt. San Pedro marsh and tidal habitats. Complimentary recreational trails, parks, althetic facilities would experience reductions in capacity with increases in maintainance costs.

Mill Valley-Sausalito Path. Credit: J. Poskazner

Historic Flood on US Highway 101 and fronting marshes. Larkspur. Credit: Marin DPW

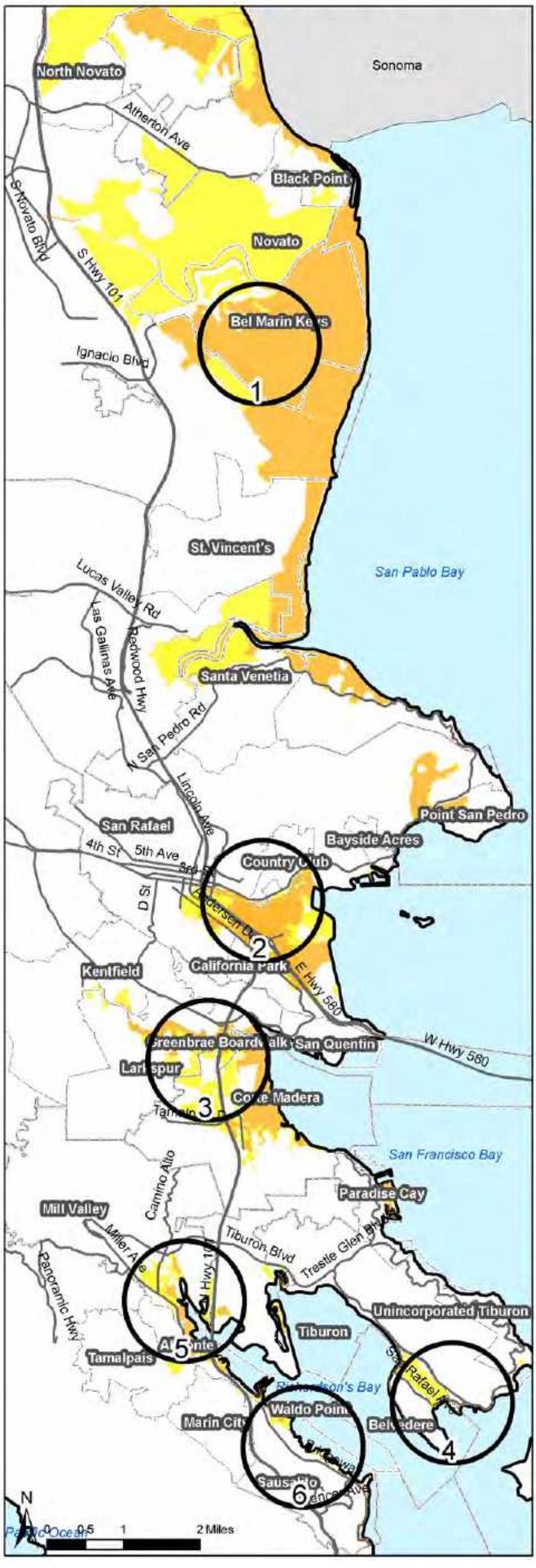
Map 132. Mid-century Expectation: Medium-term Vulnerable Assets

MEDIUM TERM

Scenario 3:
20 in. Sea Level Rise

Scenario 4:
20 in. Sea Level Rise
+ 100-year storm surge

Tidal flooding could reach 7,000 acres, 3,000 parcels, 2,000 buildings, and 18 miles of roadway in the same locations impacted in the near-term, though more severely. With a 100-year storm surge, the area vulnerable to tidal flooding would also experience storm surge flooding. An additional 7,000 acres, 2,200 parcels (8%), 3,600 buildings (7%), and 40 miles of roadway could anticipate storm surge flooding. Most levees south of Novato are not designed to withstand this level of flooding and would be overtopped. Storm surge flooding would extend further inland beyond the marshy areas of Mill Valley, Strawberry, San Rafael, St. Vincent's, and North Novato. Water travel could experience similar outcomes as in the near-term, though the highest high tides and storms surges would cause even more damage than weathered twenty years earlier. Pipelines beneath flooded roads could become squeezed between rising groundwater and the roadway, cause pipes to bend and break, and even damage roadways, this is true for sanitary, stormwater, and potable water pipes. PG&E substations, electrical transmission towers and lines, and natural gas pipelines could be bent or broken by flooding, subsidence, and erosion, with far reaching impacts on utilities, buildings, and transportation. This ten inch increase in sea level would continue to shrink trapped beach and marsh habitats in Southern Marin. Shoreline parks and pathways would flood often.



1: Southern Bel Marin Keys

2: U.S. Hwy. 101
@ Interstate 580

3: Riviera Circle

4: Tiburon/Belvedere

5: Mill Valley

6: Marinship

Vulnerable Assets

- Scen. 3: 20" Sea Level Rise
- Buildings Vulnerable to Storm Surge
- @20"+Storm Surge
- Park
- SMART Track
- Marin Transit Stop
- Golden Gate Transit Stop
- Park & Ride
- Ferry
- Airport
- Boat Launch
- Marina
- School
- Medical Facility
- Law Enforcement
- Emergency Shelter
- Fire Station
- District Office
- Gas Pipe
- Electrical Tranmission Tower
- Substation
- Transmission Lines

Sea Level Rise (SLR) Sceanrios
- Scen 3: 20" SLR
- Scen 4: 20"SLR+Storm Surge

Location Indicators
- Unincorporated
- Municipality
- Road
- Bay

Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data providers here in, make no warranties of the accuracy or completeness of maps and data. Maps are representational and subject to future revision. Local site conditions must be examined. Commercial use is prohibited.

Date: 4/1/2017

IMPACTS AT-A-GLANCE: SCENARIO 6

16,300 acres flooded @ MHHW	200,000+ residents plus commuting employees
18,000 acres flooded @ MHHW +100-year storm surge	4,150 agricultural acres (mostly ranch)
12,100 homes, businesses, & institutions	Property Owners County of Marin Municipalities Caltrans Sanitary Districts Water Districts Fire Districts Sausalito & Central Marin Police Departments CHP SMART GGBHTD MTA PG&E AT&T CADFW
$15.6 billion in assessed property value[4]	
200 miles of wet road, 3 ferry landings, 5 marinas, 4 boat launches	
Beaches Tidal Marshes Creeks Eelgrass beds Ponds Wetlands	

Kappas Marina. April 2016. Credit: Richardson's Bay Floating Homes Association.

[4] 2016 dollars

End of Century Expectations

In this long-term timeframe, tidal flooding at 60 inches of sea level rise (MHHW) could reach nearly 7,000 acres, 8,000 parcels, and 9,000 buildings, potentially impacting hundreds of thousands of residents, employees, and visitors. These figures amount to 13 percent of parcels and 12 percent of buildings in the study area. Regular tidal flooding could adversely impact the same locations impacted in the near- and medium-terms and significant portions of what would have previously only flooded from the 100-year storm surge. The additional areas that would tidally flood at 60 inches of sea level rise are:

- Tamalpais Valley,
- Mill Valley from the Richardson's Bay shoreline up to and beyond Camino Alto between Miller and East Blithedale Avenues,
- Mill Valley and Strawberry fronting US Highway 101 between Seminary Drive and Tiburon Boulevard,
- Santa Venetia north of N. San Pedro Boulevard,
- Cove Neighborhood, Tiburon,
- Belvedere Lagoon neighborhood,
- Paradise Cay
- Mariner Cove, Marina Village, Madera Gardens, and major retail centers lining US Highway 101,
- Riviera Circle, Creekside, and Heatherwood neighborhoods, Larkspur,
- Interstate 580 and westward towards Andersen Drive in San Rafael and the community of California Park,
- Marin Lagoon and Peacock Gap neighborhoods, San Rafael,
- Bel Marin Keys northern and southern lagoon areas,
- Hamilton, Vintage Oaks, and pockets of development east of US Highway 101 at Rowland Boulevard and State Route 37 in Novato, and,
- North Novato at US Highway 101 and Binford Road.

In long-term scenario 6, storm surge flooding could occur on nearly 13,500 acres hosting 12,600 parcels with 12,000 buildings, potentially impacting 200,000 residents, thousands of employees, and several million visitors. These figures amount to nearly one-fifth of parcels and more than 15 percent of the buildings in the study area. Area that could anticipate storm surge flooding are:

- Sausalito west of Bridgeway,
- Marin City neighborhood,
- Mill Valley east of East Blithedale Avenue at Alto Shopping Center,
- Las Gallinas and North San Pedro Boulevard, east of US Highway 101, San Rafael,
- Bayside Acres,
- Country Club, and
- Kentfield.

Tidal and storm surge flooding could cause significant economic losses. Minor storm impacts alone could account for $61 million[5] in property damages. The market value of vulnerable single-family homes could exceed $20 billion in 2016 dollars. The assessed value, typically less than market value, for all the vulnerable parcels in the study area is $15.6 billion.[6] By the end of the century, these figures could be even higher.

One-hundred miles of public and private roadways, or five percent of all road miles in the study area, could be vulnerable to tidal exposure. Roads could degrade more quickly, or if flood waters are deep enough, become impassable. Lane miles could be more than double this figure. An additional 30 miles of roadway could be vulnerable at 60 inches of sea level rise and a 100-year storm surge. Moreover, several park and rides, several hundred bus stops, and bus transit and SMART rail routes could flood. The San Rafael Transit Center, where the SMART train and nearly all local and regional buses stop, could expect tidal flooding at MHHW and storm surge flooding in the long-term. Breakdowns in the transportation network would have major impacts on the economy and daily life functions. In addition, significant safety hazards could cause injury or loss of life.

Flooding at the SASM and Novato Sanitary Wastewater Treatment Plants is a significant vulnerability that could arise, potentially disrupting hundreds of thousands of people. By this time, much of the low-lying shoreline sanitary sewer and stormwater infrastructure could be flooded out.

By the end of the century, sea level rise could have direct impacts to Tiburon Fire Station No. 1, Corte Madera Station No. 13, and Novato Atherton Avenue Fire Station. A few emergency shelters in Southern Marin communities could be vulnerable to tidal flooding, and several more could expect storm surge flooding and may not be available when needed most. By this time, the Central Marin Police Department could have to wade through saltwater surrounding the site to reach Larkspur and Corte Madera residents in need.

Southern Marin marshes may no longer exist by the end of the century, destroying the habitat of several shoreline birds and mammals. Northern Marin marshes would become increasingly tidally influenced, with tide water reaching US Highway 101 in Bel Marin Keys and North Novato up the Petaluma River. Typically freshwater marshes west of US Highway 101, for example, Sutton Marsh, could also expect damaging salinity impacts. Tidal marsh lands may increase in Northern Marin if they are not prevented from migrating inland.

In the long-term scenario, approximately 1,358 acres on 30 agricultural parcels could be vulnerable to sea level rise and storm conditions. Another 3,000 acres are public agency lands near Bel Marin Keys, Hamilton Field, and the Novato Sanitary District that are leased for agricultural use. Higher high tides could push brackish conditions inland, reducing grazing, manure spreading, and cultivation area. Moreover, reduced vehicular access on Highways 37, 101, and other major roads could disrupt product distribution.

Finally, all of these assets contain or contribute to the well-being of the region's cultural, archeological, and historic resources that constitute each community's sense of place. This is especially a concern for Sausalito, Tiburon, and Novato.

China Camp Historic pier. December 2016 King Tide. Credit: Ron Rothbart

[5] 2016 dollars
[6] 2016 dollars

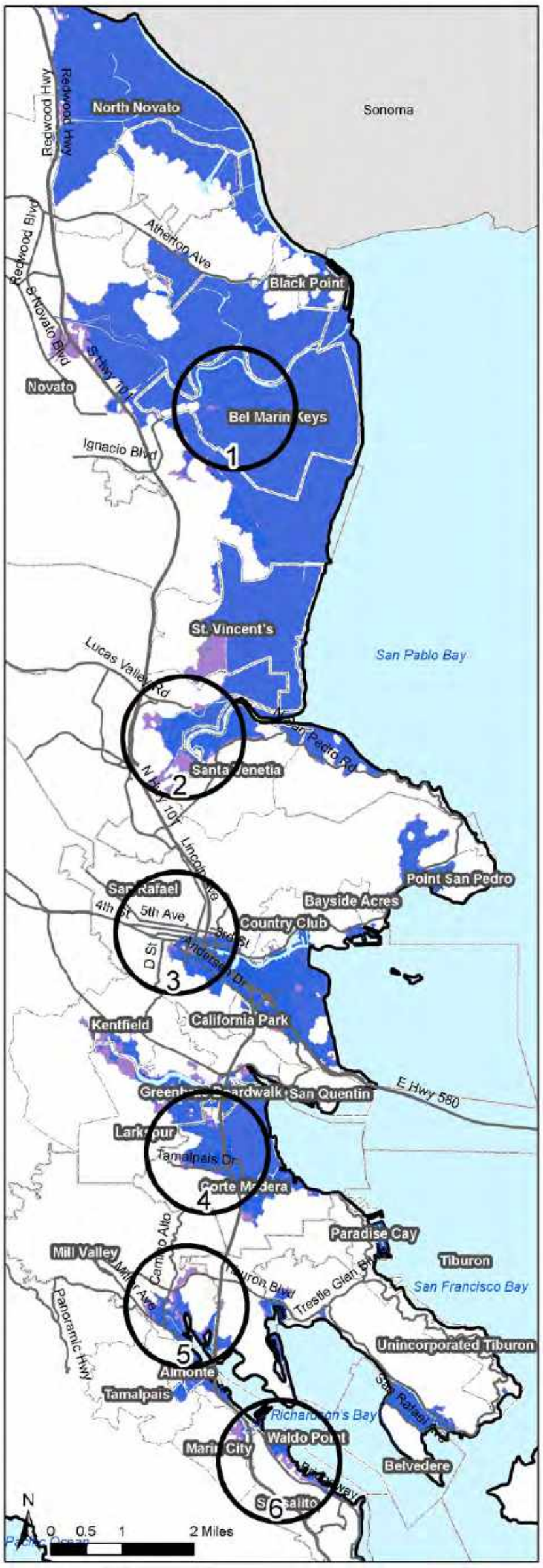
Map 133. End of Century Expectations: Long-term Vulnerable Assets

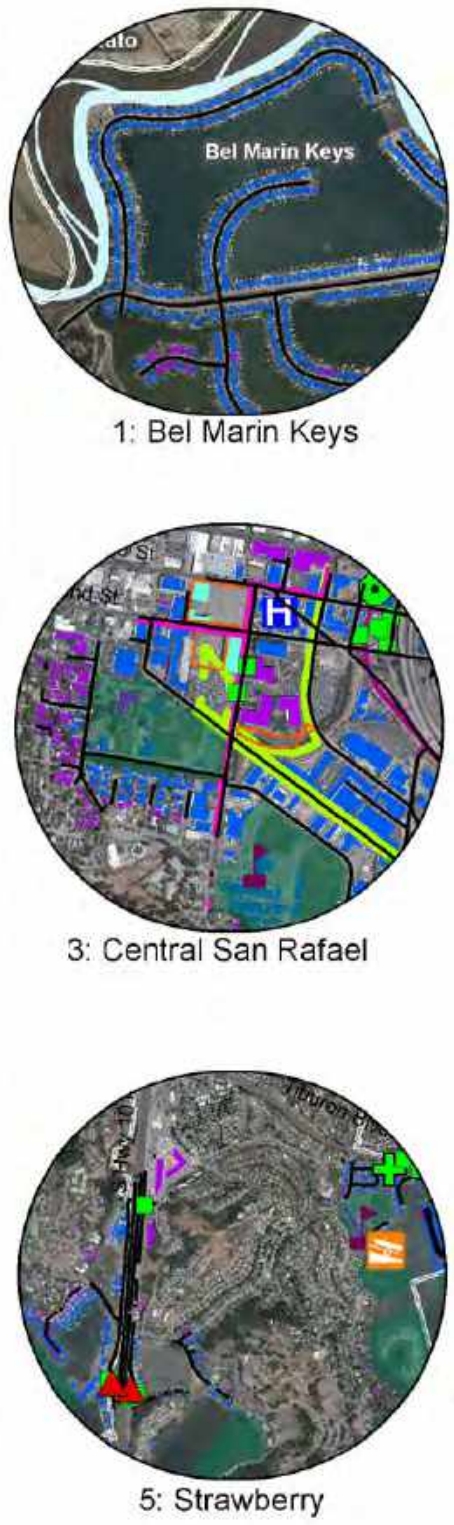
LONG TERM

Scenario 5:
60 in. Sea Level Rise

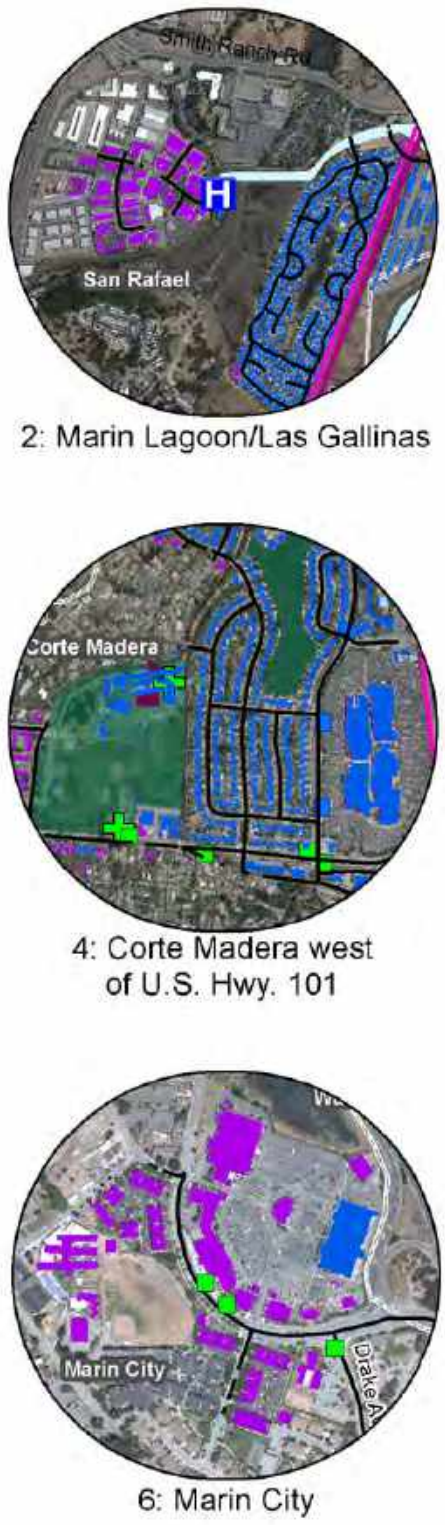
Scenario 6:
60 in. Sea Level Rise
+ 100-year storm surge

By 2100, tidal flooding could reach nearly 7,000 acres, 8,000 parcels (13%), 9,000 buildings (12%), and 100 miles of road. Higher high tides could adversely impact the locations flooded in medium-terms, and significant portions of the areas that previously suffered storm surge flooding. Tidal flooding would reach beyond the State Routes 101and 580 in low-lying areas, into Southern Marin's narrow valleys and creek sides, and over every levee in Marin County. A 100-year storm surge could flood these areas, and an additional 6,500 acres, 4,600 parcels (20% total), 3,000 buildings (15% total), and 30 miles of road, extending to Sausalito west of Bridgeway, Marin City housing, Mill Valley's Alto Shopping Center, Las Gallinas and N. San Pedro Blvd. in San Rafael, Bayside Acres, Country Club, and Kentfield. Minor building damage could amount to $61 million (2016 dollars). Vulnerable single family homes exceed $20 billion in market value (2016 dollars). Several park and rides, hundreds of bus stops, and bus routes, and SMART rail track, including the San Rafael Transit Center, could experience flooding. Disruptive flooding at the SASM and NSD wastewater treatment plants and pump stations would affect tens of thousands of people. Storm surges could flood Tiburon Fire Station No. 1, Corte Madera Fire Station No. 13, and Novato Atherton Ave. Fire Station. A few emergency shelters in Southern Marin flood at high tide, and many more could be closed during a storm. The Central Marin Police Department may have to navigate deep water to reach Larkspur and Corte Madera shoreline residents. In Southern Marin, mud flats and water would dominate existing marshes. In the north, tidal marshes could expand.





1: Bel Marin Keys



2: Marin Lagoon/Las Gallinas

3: Central San Rafael

4: Corte Madera west of U.S. Hwy. 101

5: Strawberry

6: Marin City

Vulnerable Assets

Vulnerable Buildings
- @60" Sea Level Rise
- @ 100-Year Storm Surge
- Park
- Park & Ride
- Marin Transit Stop
- Golden Gate Transit Stop
- Public Boat Launch

- SMART Station
- SMART Track
- School
- Medical Facility
- Emergency Shelter
- Gas Pipe
- Transmission Lines

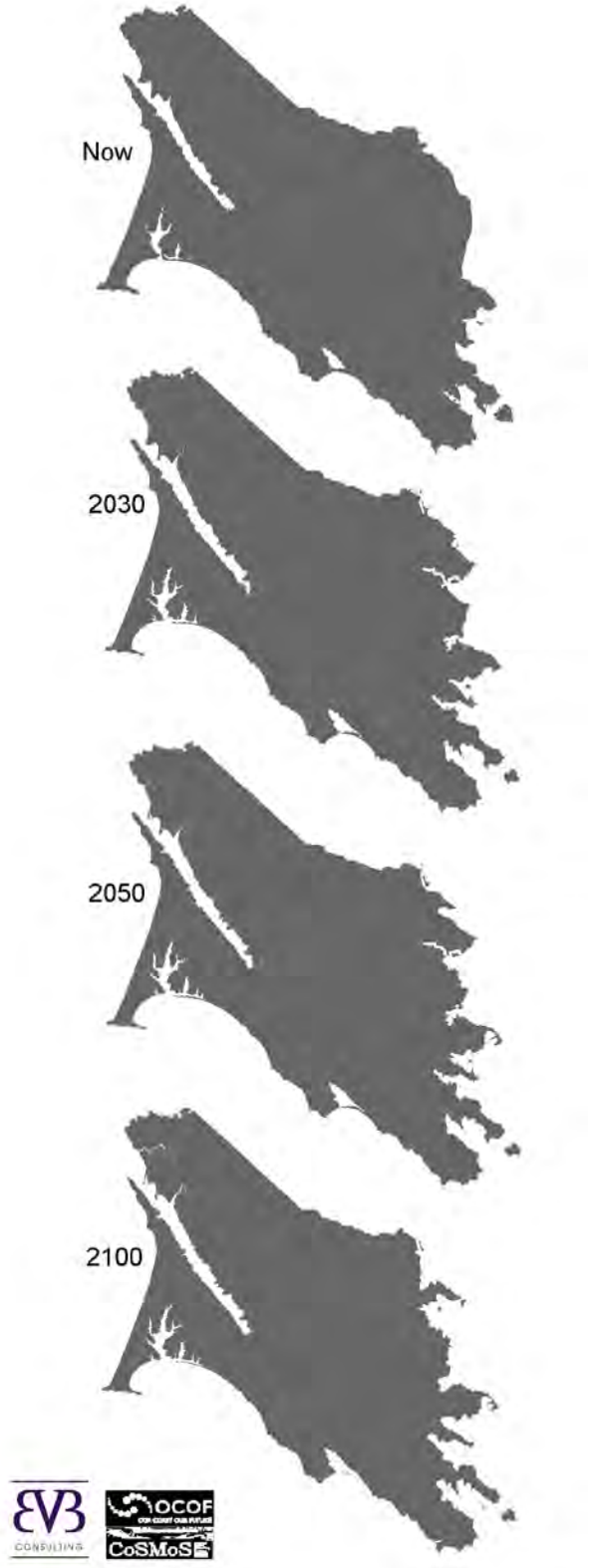
Sea Level Rise (SLR) Scenarios
- Scen 5: 60" SLR
- Scen 6: 60"SLR+Storm Surge

Location Indicators
- Unincorporated
- Municipality
- Road
- Bay

Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data providers here in, make no warranties of the accuracy or completeness of maps and data. Maps are representational and subject to future revision. Local site conditions must be examined. Commercial use is prohibited.

Date: 4/1/2017

Figure 6. Estimated Decreases in Marin County Land Area due to Sea Level Rise



A significant degree of uncertainty exists as to how soon these increases in sea level could occur because future carbon emissions are an unknown. However, even if global citizens stabilize carbon emissions, sea level rise would likely continue. Moreover, even if the growing global population reduces carbon emissions to levels where atmospheric concentrations decline, the decline will be slow and sea levels would still likely continue to rise for decades, and hundreds of years could pass before the sea level stabilizes or drops.[7,8] If emissions continue to increase, the rate of sea level rise is also likely to increase and these assets could be vulnerable sooner than this assessment presents. Because of this uncertainty, this assessment is the first step in an iterative process that will need to be updated as additional science becomes available and adaptation efforts are implemented. The sea level rise preparation process will require consistent monitoring and evaluation to improve modeling assumptions and ensure preparation efforts are effective and efficient.

Hamilton Wetlands and Aramburu Wildlife Preserve were recently enhanced, and wetland restoration is in planning for Bothin Marsh, McInnis Park, and Novato's baylands. Nonprofits are also working to include: Marin Audubon Society project in Corte Madera, and the Coastal Conservancy's Bel Marin Keys restoration project once funds are secured.

Combined with potential losses in West Marin due to potential sea level rise, the impacts to Marin County will be significant across all asset categories. The image to the left combines estimates for land area that would be lost at MHHW across the near-term, 2030, the medium-term, 2050, and the long-term, 2100 scenarios applied to Western and Eastern Marin.

[7] IPCC Fourth Assessment Report: Climate Change 2007. Climate Change 2007: Working Group I: The Physical Science Basis. 10.7.2 Climate Change Commitment to Year 3000 and Beyond to Equilibrium. https://www.ipcc.ch/publications_and_data/ar4/wg1/en/ch10s10-7-2.html

[8] IPCC Fourth Assessment Report: Climate Change 2007. Climate Change 2007: Working Group I: The Physical Science Basis. 10.7.4 Commitment to Sea Level Rise. https://www.ipcc.ch/publications_and_data/ar4/wg1/en/ch10s10-7-4.html

EXECUTIVE SUMMARY

With this vulnerability assessment, Marin County professionals, officials, residents, employees, and other Bay Area communities can gain an understanding of the potential fallout from higher high tides in a no action scenario. With this comprehensive view of the potential issues, Marin County communities can approach preparing for this shared concern with greater efficiency and collaboration.

Tiburon's Main Street buildings are from the early 1900s, and are adjacent to the ferry terminal. Credit: Marin CDA

Low lying properties in Black Point. Credit: Marin CDA

INTRODUCTION

Introduction

Climate change is affecting natural and built systems around the world, including the California coast. In the past century, average global temperature has increased about 1.4°F, and average global sea level has increased 7 to 8 inches.[9] Sea level at the San Francisco tide gauge has risen 8 inches over the past century, and the National Research Council (NRC) projects that by 2100, sea level in California south of Cape Mendocino may rise 66 inches.[10] The two major causes of global sea level rise are thermal expansion of warming oceans and the melting of land-based glaciers and polar ice caps.[11]

View of Almonte from Shoreline Highway. Dec. 2014. Credit: Marin DPW

While Marin's shoreline already experiences regular erosion, flooding, and significant storm events, sea level rise will exacerbate these natural processes, leading to significant social, environmental, and economic impacts. The third National Climate Assessment cites strong evidence that the cost of doing nothing exceeds the costs associated with adapting to sea level rise by 4 to 10 times.[12] Therefore, it is critical the County of Marin, municipalities, and special districts plan and prepare for the impacts of sea level rise to ensure a resilient county for present and future generations.

This publication presents the Bay Waterfront Adaptation and Vulnerability Evaluation (BayWAVE) for Marin's San Francisco, Richardson's, and San Pablo Bay communities' built and natural assets. This effort is part of an ongoing scientific, collaborative, and public process to understand and prepare for sea level rise along the Marin shoreline. This Vulnerability Assessment seeks to provide context and estimates of the physical and fiscal impacts to shoreline over the coming decades. This analysis highlights the complexity of the potential impacts and the need for both concerted and individual actions in the face of rising tides. The data presented can be used to prioritize efforts, seek funding, and shape policy and development discussions.

The County of Marin Department of Public Works is the project lead for the Bay Waterfront Adaptation & Vulnerability Evaluation (BayWAVE) program. The program began in September 2015 with funding from County of Marin and additional financial support from the California State Coastal Conservancy. Several multi-jurisdictional committees guide the BayWAVE process. The Executive Steering Committee consists of County of Marin and local jurisdiction representatives to guide staff and provide direction at critical milestones. The Policy Committee is made up of elected officials from each city and the County of Marin. The Technical Advisory

[9] Heberger, M., Cooley, H., Moore, E. and Herrera, P. 2012 The Pacific Institute. *The Impacts of Sea Level Rise on the San Francisco Bay.* California Energy Commission. Publication number: CEC-500-2012-014.

[10] *Sea-Level Rise for the Coasts of California, Oregon and Washington: Past, Present and Future.* National Research Council (NRC), 2012.

[11] Heberger, M., Cooley, H., Moore, E. and Herrera, P. 2012 The Pacific Institute. *The Impacts of Sea Level Rise on the San Francisco Bay.* California Energy Commission. Publication number: CEC-500-2012-014.

[12] Moser, S. C., M. A. Davidson, P. Kirshen, P. Mulvaney, J. F. Murley, J. E. Neumann, L. Petes, and D. Reed, 2014: Ch. 25: *Coastal Zone Development and Ecosystems. Climate Change Impacts in the United States: The Third National Climate Assessment*, J. M. Melillo, Terese (T.C.) Richmond, and G. W. Yohe, Eds., US Global Change Research Program, , 579-618. doi:10.7930/J0MS3QNW. http://nca2014.globalchange.gov/report/regions/coasts

INTRODUCTION

Committee includes staff from local, state, and federal agencies. These committees are essential in achieving the BayWAVE goals to establish an efficient shared learning process and messaging platform, and create a collaborative environment to prepare for sea level rise. See the Acknowledgements for a complete list of committee participants.

This Vulnerability Assessment is advisory and not a regulatory document or legal standard of review for action the County of Marin, municipalities or other involved special governments may take. Such actions are subject to the applicable requirements in each jurisdiction's governing documents and applicable state and local regulations.

The County of Marin, municipalities, and special jurisdictions participating in this assessment have engaged in sea level rise planning and climate action for several years. For example, Marin's Countywide Plan (2007) addresses sea level rise in two policies: EH-3.k Anticipate Climate Change Impacts, Including Sea Level Rise and C-EH-22 Sea Level Rise and Marin's Coast. Other local efforts include sea level rise white papers for San Rafael and Novato, the Here.Now.Us project started by Marin County Supervisor Kate Sears for Southern Marin, the Department of Public Works *Richardson's Bay Shoreline Study*, Novato, Southern Marin, and Gallinas Watershed Program's demonstration projects, and the Collaboration: Sea-level Marin Adaptation Response Team (C-SMART) Program for the West Marin coastline.

This assessment follows extensive efforts throughout the nation, state, and region to understand the science of sea level rise and the impacts it could have. The San Francisco Bay Conservation and Development Commission (BCDC) established the Adapting to Rising Tides program, which includes adaptation planning guidance, and local to regional case studies, and previously published *Living with a Rising Bay: Vulnerability and Adaptation in San Francisco Bay and on the Shoreline* and *Innovative Wetland Adaptation Techniques.* Most recently, BCDC released a Levee Overtopping Study that determines the water levels required to spill over the tops of levees into the areas the aim to protect. Pacific Gas & Electric (PG&E) also released a climate change vulnerability assessment for the Bay Area. In addition, the California Energy Commission (CEC) released *Impacts of Predicted Sea-Level Rise and Extreme Storm Events on the Transportation Infrastructure in the San Francisco Bay Region*. Finally, released two years ago with special attention to climate change impacts is the Baylands Ecosystem Habitat Goals Science Update 2015.

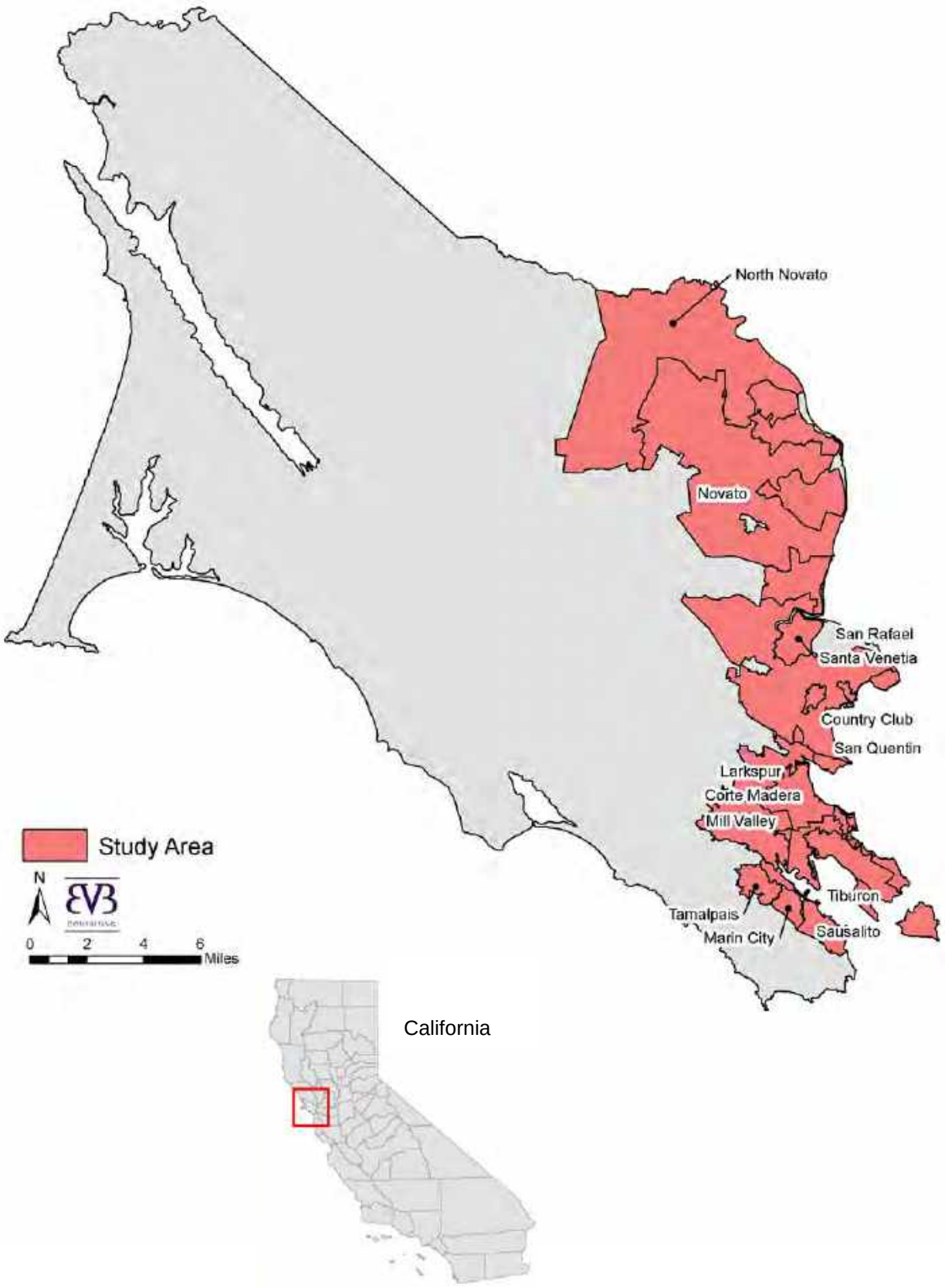
In an effort to dovetail with these studies, goals, and regulations, this assessment applies and presents the best available sea level rise and storm surge science to Marin's shoreline to generate an understanding of Marin's potential future.

This Assessment examines lands on the Marin County bay shoreline from the Golden Gate Bridge to the Petaluma River (see Map 1). The study area is approximately 85,840 acres and comprises of the entire jurisdiction for each municipality and unincorporated community vulnerable to sea level rise under the BayWAVE scenarios. Communities exposed to sea level rise are:

- Municipalities
  - Belvedere
  - Corte Madera
  - Larkspur
  - Mill Valley
  - Novato
  - San Rafael
  - Sausalito
  - Tiburon
- Unincorporated Jurisdictions
  - Almonte
  - Bayside Acres
  - Bel Marin Keys
  - Black Point
  - California Park
  - Country Club
  - Greenbrae
  - Kentfield
  - Marin City
  - North Novato
  - Paradise Cay
  - Point San Pedro
  - San Quentin
  - Santa Venetia
  - St. Vincent's
  - Strawberry
  - Tamalpais Valley
  - Unincorporated Tiburon
  - Waldo Point Harbor.

INTRODUCTION

Map 1. BayWAVE Study Area



v

INTRODUCTION

Tiburon revetment looking to Corinthian Marina and Tiburon Ferry Terminal, 2016. Credit: BVB Consulting LLC

The locations in the study area most likely to experience sea level rise and storm surge impacts in this century are low lying areas in Marin's shoreline communities, especially east of US Highway 101. However, the dry unexposed portions of every community in the study, Tamalpais Valley, Strawberry, Da Silva Island, Mill Valley, Belvedere Island, Tiburon uplands, Sausalito, and San Rafael, could be indirectly impacted. Similarly, East Marin communities outside of the study area, such as Fairfax, San Anselmo, Ross, Alto, Lucas Valley, and others could be vulnerable to transportation network and utility impacts.[13] Note that while in Marin County, the Marin Headlands and Fort Baker are Federal property and not the focus of this assessment. The Federal Parks assessment is at http://www.nature.nps.gov/geology/coastal/coastal_assets_report.cfm.

This assessment is organized into five major sections: (1) methods, (2) asset profiles, and (3) municipality profile, and (4) the Conclusion. The methods section details the background science and research methods used in the BayWAVE process. Asset profiles highlight the vulnerable features bayside residents, employees, and visitors depend on, such as buildings, roads, drinking water, septic, and others. The municipality profiles detail all asset vulnerabilities for each exposed municipality. The Unincorporated Marin profile also provides the same analysis for areas within County of Marin jurisdiction. Each profile details key issues and geographic locations. Asset Profiles highlight initial economic, environmental, equity, and management considerations related to sea level rise vulnerability. Each profile can be read independently, enabling asset managers to focus on a professional area, and community members, elected officials, and others to read about their community as a whole. The conclusion summarizes the impacts by time-period or onset of near-, medium-, and long-term impacts across all asset types and communities.

Key findings include:

- Southern Marin would likely suffer the worst flooding impacts, and could experience these impacts in the near-term.
- Increasingly compromised access to and from the Manzanita Interchange of US Highway 101 and 1 could affect hundreds of thousands of residents, employees, and visitors.
- Reductions in useable space for living, tourism, transportation, and natural resources could impact approximately 12,750 properties, more than 12,000 buildings, and 100 miles in roads.
- Based FEMA HAZUS damage estimates, waves, wind, and temporary flooding during storms could account for $60 million to $6 billion (2016 dollars) in building damages.
- Impacts to wastewater treatment in the Sausalito, Tamalpais, Almonte, Alto, Mill Valley, Novato, and Bel Marin Keys could affect tens of thousands of residents.
- Physical and economic impacts will be felt differently across the various income and age groups, causing social and economic inequities.
- In California, tidelands (land below the mean high water mark) and submerged lands are under public trust. As the sea level rises, thousands of private properties, if still in use, could be subject to the Public Trust Doctrine, become Waters of the State, and be required to pay a leasing fee.
- The most vulnerable habitats are shoreline beaches and marshes south of St. Vincent's.
- Areas that are not exposed to rising bay waters under the BayWAVE scenarios can still be vulnerable to sea level rise when the wastewater treatment plant, ports, and major roadways become compromised under flooding conditions.
- Marin is not self-contained and could feel impacts from across the Bay region, such as the Port of Oakland, which receives imports and exports for the entire Bay Area, or transportation network in San Francisco and the East Bay that,

[13] http://cal-adapt.org/sealevel/ Cal Adapt Sea Level Rise Threatened Areas Map

when flooded, would disrupt commuting, and regional and global travel.

- Sea level rise is one of several climate change impacts residents will likely face. Combined with typical hazards that already exist (e.g. liquefaction and ground shaking near fault lines, erodible soils, and heavy rainfall), Marin is more vulnerable than this assessment can describe.

This assessment is the first step in an ongoing iterative process. The sea level rise preparation process will require consistent monitoring and evaluation to improve modeling assumptions and ensure preparation efforts are effective and efficient. With this vulnerability assessment, Marin County professionals, officials, residents, employees, and other Bay area communities can gain an understanding of the potential fallout from higher high tides in a no action scenario. With this comprehensive view of the potential issues, Marin County communities can approach preparing for this shared concern with greater efficiency and collaboration.

Marin Flood History

Understanding past floods can inform future vulnerabilities. Marin is no stranger to damaging floods. Major floods occurred in 1952, 1955-1958, 1967, 1969 and 1970. In later years, portions of Corte Madera, Larkspur, Greenbrae, Mill Valley, Ross, San Anselmo, San Rafael and Novato flooded in the winters of 1982/1983, 1986, 1997/1998, and 2005/2006, during El Niño events. Recent media attention has focused on the king tides that flood Southern Marin.

Ross Business District during the 1925 flood.
Credit: Marin History Museum

February 10th 1925 More than seven inches of rain fell in the Ross Valley, overflowing creeks, and flooding streets. Extensive damage occurred to homes and infrastructure in San Anselmo, Ross and Kentfield.[14]

Credit: Independent-Journal

1956-58 Corte Madera Creek experienced major flooding that prompted a large Army Corps of Engineers flood control project. Due to continuous flooding, the Kentfield Fire Department tied a rowboat to the Laurel/Sir Francis Drake sign for use.[15]

Credit: San Anselmo Historical Museum

January 1982 The 'Great Storm of 1982,' dumped sixteen inches of rain that killed four residents, destroyed 35 Marin homes, and damaged 2,900 more, totaling $80 million in damages.[16, 17]

December 1969
Independent-Journal

I.J. 12/31/69 p. 1 WEATHER

Marin County Is Declared Disaster Area

I-J Special Report

SAN FRANCISCO — Marin County today was declared a disaster area by the Small Business Administration, Rep. William S. Mailliard, R-Sixth District, reported.

The declaration, one day after an official of the SBA toured the county to inspect homes and businesses damaged by the recent floods, means that property owners will be eligible for low-interest SBA loans to repair damages, and that the county will be eligible for flood relief grants.

The SBA based its declaration on an estimate by the county that damage by flood water and landslide damage totaled $400,000. Four homes suffered major damage, the SBA said, and minor damage was reported at 190 homes, five apartment buildings and 18 businesses.

The county estimated damages at $250,000 to private property and $150,000 to public property.

[14] San Anselmo Historical Museum. 2015. *San Anselmo's Long History of Flooding.* http://sananselmohistory.org/articles/flooding/. Accessed 1/29/16
[15] Source Unknown
[16] Blodgett J.C., and Edwin H. Chin. 1989. *Flood of January 1982 in the San Francisco Bay Area, California.*
[17] Marin Independent Journal. 2011. *Highlights of Marin's History, from 1850-2010*

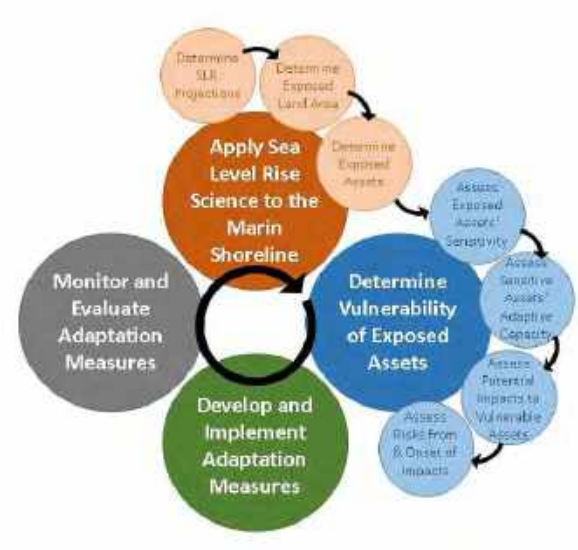
METHODS

Methodology

The BayWAVE Vulnerability Assessment process (see Figure 1) is guided by CalAdapt[18] through the following phases of analysis:

- Phase 1: Exposure: Assess potential changes in water level from sea level rise, storm events, and geomorphic change to determine the built and natural assets that could be exposed to saltwater.
- Phase 2: Sensitivity: Assess the degree of damage or disruption tidal and storm surge flooding could cause on the exposed assets.
- Phase 3: Adaptive Capacity: Assess each asset's adaptive capacity, or ability to respond successfully, to flooding, without human intervention
- Phase 4: Potential Impacts: Evaluate the potential consequences to the assets and larger context, assuming no intervention actions.
- Phase 5: Risk & Onset: Describe the certainty and timing of impacts.

Figure 1. BayWAVE Process



[18] CA Emergency Management Agency, CA Natural Resource Agency. *California Climate Adaptation Planning Guide (APG).* July 2012. http://resources.ca.gov/docs/climate/01APG_Planning_for_Adaptive_Communities.pdf

Modeling Methods

Sea level rise estimates used in this analysis are from the USGS Coastal Storm Modeling Systems (CoSMoS) and are viewable online through the Our Coast Our Future (OCOF) Flood Map tool. OCOF was developed through a partnership of several notable institutions and agencies, and represents the best available sea level rise and storm science.

OCOF uses the USGS's Digital Elevation Model (DEM) constructed for the region (http://topotools.cr.usgs.gov/topobathy_viewer/) with 2-meter horizontal grid resolution based on North American Vertical Datum of 1988 (NAVD88) elevations, and USGS's numerical modeling system called Coastal Storm Modeling System (CoSMoS) to produce a combination of 40 different sea level rise and storms scenarios. CoSMoS scales down global and regional climate and wave models to produce local hazard projections.[19]

High quality elevation data incorporated in the DEM was used to create maps of mean higher high water (MHHW) tidal elevation, and provides the option to add storm surges of different magnitudes. Mean higher high water is the average of the higher high water level of each tidal day observed over the National Tidal Datum Epoch.[20,21] Each day has two high tides, one typically higher than the other. The higher values are used for this analysis. Some days the higher high tide will be lower or higher than other days, however, several days of flooding a month, several months a year, or even once every year would be problematic depending on the resource being examined.

Note, also because the analysis uses high tide, properties near the inland extent of properties exposed to MHHW may not flood at low tides. On

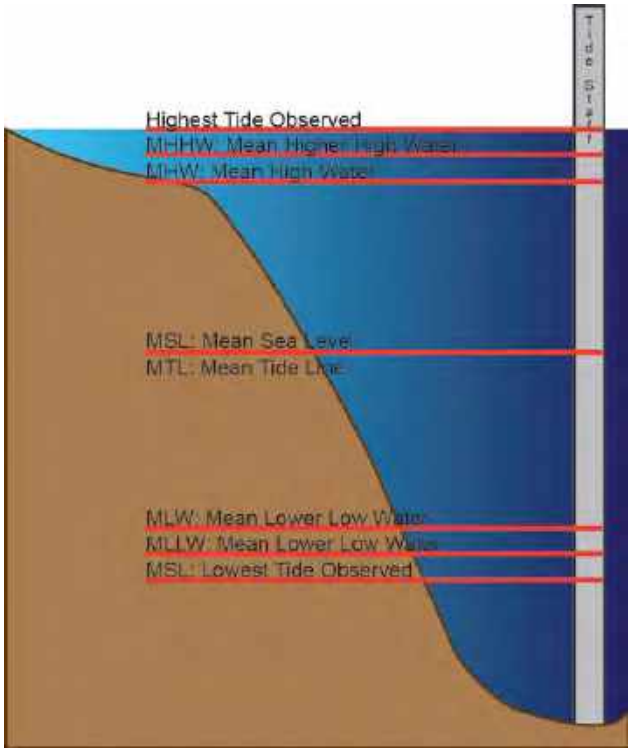
[19] Ballard, G., Barnard, P.L., Erikson, L., Fitzgibbon, M., Higgason, K., Psaros, M., Veloz, S., Wood, J. 2014. Our Coast Our Future (OCOF). [web application]. Petaluma, California. www.pointblue.org/ocof. (Accessed: Date August 2014]).

[20] National Tidal Datum Epoch is the specific 19-year period adopted by the National Ocean Service as the official time segment over which tide observations are taken and reduced to obtain mean values (e.g., mean lower low water, etc.) for tidal data.

[21] NOAA/National Ocean Service. *Tidal Datums*. Access Oct. 19, 2015. Last updated: 10/15/2013. Center for Operational Oceanographic Products and Services. https://tidesandcurrents.noaa.gov/datum_options.html.

the other hand, these properties, and properties just beyond the inland extent of scenario 6, the most-severe scenario examined in this report, could experience flooding from the highest high tides, especially in combination with storms and/or king tides.

Figure 2. Tidal Datum Comparing MHHW to Mean Sea Level and Low Water Levels



Source: National Oceanic and Atmospheric Administration. Credit: BVB Consulting LLC

King tides preview future water levels. Mill Valley. 10:41 a.m., Nov. 25, 2015. Credit: LightHawk

CoSMoS accounts for wave run-up and set-up, storm surge of the ocean, seasonal effects, tides, levees, river discharge, and wind from the San Francisco Bay. Note that this tool only accounts for bay water levels and does not assess fresh stormwater flooding upstream or changes in the shoreline (geomorphology) as erosion continues. Thus, storms used in this analysis include bay storm surge only, not additional freshwater creek flooding upstream. In addition, this analysis does not account for the ability of pump stations to drain flooded areas.

Table 1 shows the range of sea level rise projections for California adopted by the National Research Council in 2012. Given the uncertainty in the magnitude and timing of future sea level rise, this analysis uses a scenario based approach to assess a range of potential sea level rise and storm surge exposure. The six USGS CoSMoS scenarios selected for the BayWAVE Vulnerability Assessment in Table 2 align with the NRC 2012 estimates as follows:

- Scenarios 1 and 2 represent the near-term projection anticipated by 2030.
- Scenarios 3 and 4 represent the medium-term projection anticipated by 2050.
- Scenarios 5 and 6 represent the long-term projection anticipated by 2100.

Table 1. Sea Level Rise Projections for San Francisco, CA Region

Time Period	Projected Range
by 2030	1.6 – 11.8 inches
by 2050	4.7 – 24 inches
by 2100	16.6 – 65.8 inches

Source: NRC 2012

Table 2. BayWAVE Sea Level Rise & Storms Scenarios

Sea Level Rise Scenario		Term
1	10 inches	Near
2	10 inches+100-year storm	
3	20 inches	Medium
4	20 inches+100-year storm	
5	60 inches	Long
6	60 inches+100-year storm	

Figure 3. BayWAVE Scenarios Associated Water Levels

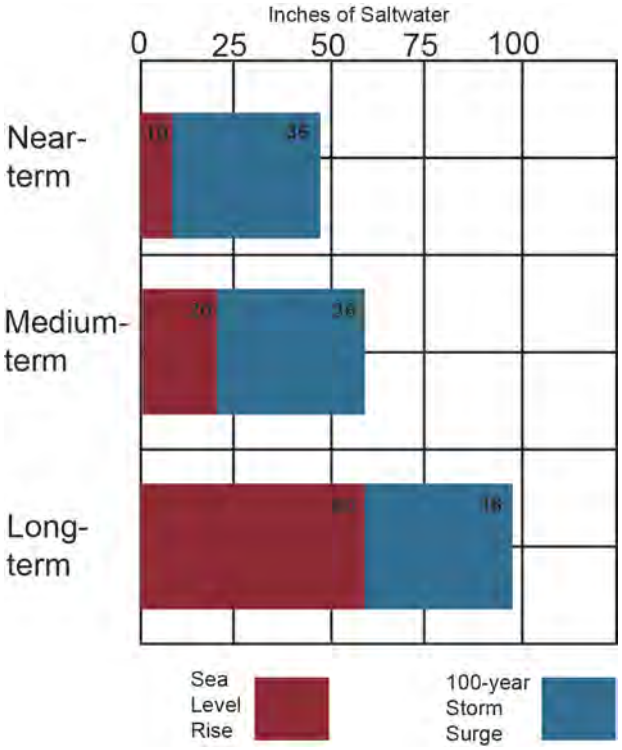


Figure 3 presents another view of the BayWAVE scenarios where the red lengths represent tidal flooding in sea level rise scenarios 1, 3, and 5, and the blue lengths represent the additional storm surge water level associated with scenarios 2, 4, and 6. Together these bands show the potential flooding in the near-, medium-, and long-terms.

The odd numbered scenarios illustrate sea level rise only. Even numbered scenarios illustrate sea levels and incorporate the storm flooding from a future based 100-year storm surge. The scenarios include storm surges because storm surges have the potential to cause catastrophic damage. The CoSMoS model uses research and predictions for future storm patterns to create the future storm typology used in the BayWAVE scenarios. Future storms are anticipated to come from a southerly direction, as opposed to historic storms, which tend to come from the north. For more information on how storms were modeled see references on the OCOF website.

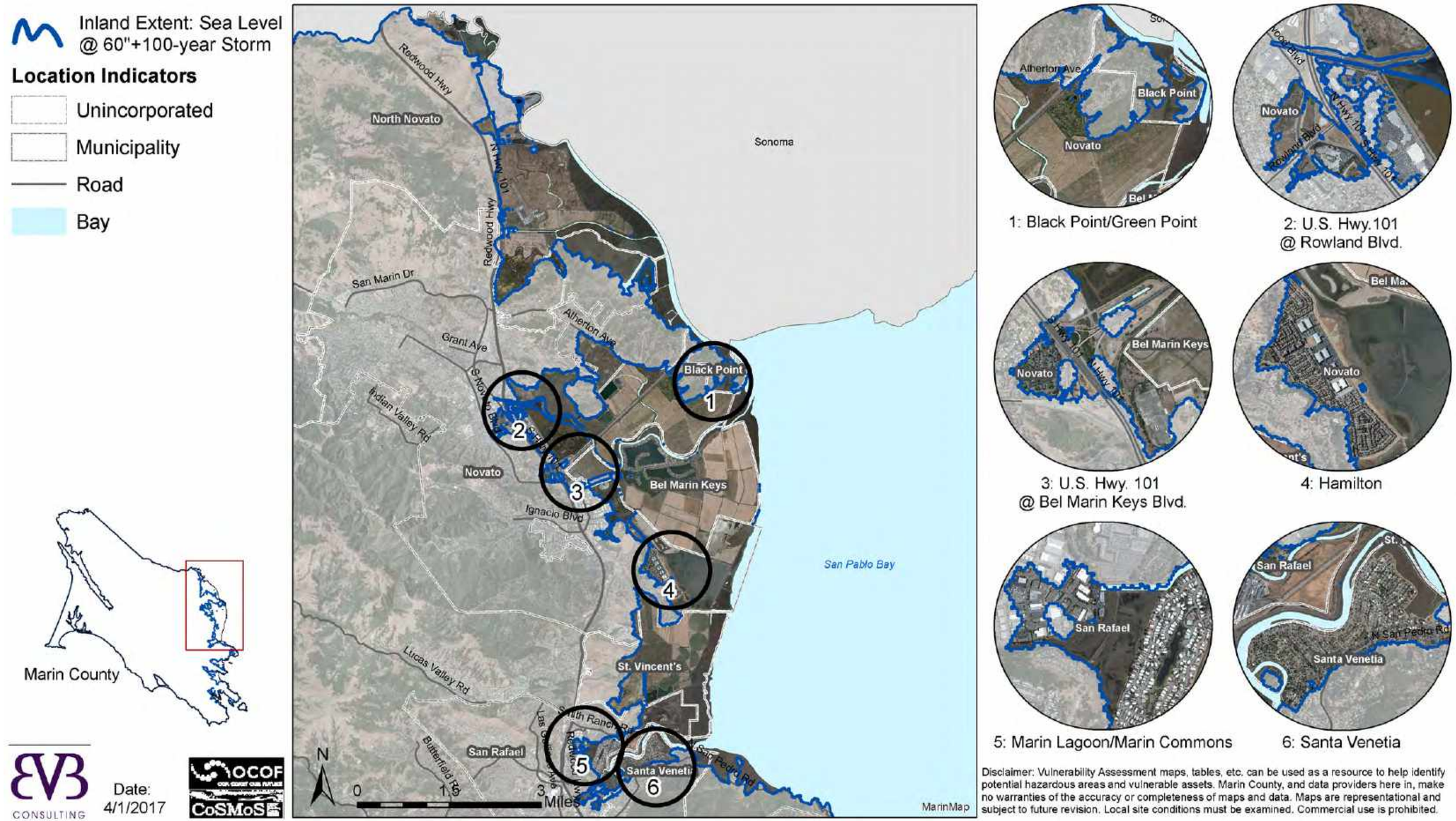
A 100-year storm surge has one percent chance of happening in any storm in a given year. Within a 30-year mortgage, a 100-year storm has a nearly 30 percent chance of occurring. Note that, as climate change continues, the 100-year storm surge level of flooding may occur more frequently, increasing the annual risk of this level storm occurring from a 100-year storm surge to a 50-year storm surge, for example. In addition, there are more frequent storm surges, and less frequent storm surges such as the, 200-year, 400-year, annual, or 5-year storm surges. Less frequent larger storms would result in more severe flooding than presented in this report,[22] whereas, smaller storm surges would produce less severe flooding.

Maps 2 and 3, on the following pages, show the furthest inland extent of scenario 6. Maps 4 and 5 show scenarios 1, 3, and 5, and Maps 6 and 7 show scenarios 2, 4, and 6. The shoreline is typically mapped in two maps: (1) the northern study area, north of Pt. San Pedro, and (2) the southern study area, south of Pt. San Pedro, halves of the study area. The call out circle maps show zoomed in images of locations that may be difficult to se. The circles do not indicate these do not indicate that there areas are more vulnerable than areas not depicted in the circular maps.

[22] W. Eisenstein, M. Kondolf, and J. Cain. *ReEnvisioning the Delta: Alternative Futures for the Heart of California.* Department of Landscape Architecture and Environmental Planning. University of California, Berkeley. University of California Publishing Services. IURD report # WP-2007-01. http://landscape.ced.berkeley.edu/~delta

METHODS

Map 2. Northern Study Area Inland Extend of Scenario 6



Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data providers here in, make no warranties of the accuracy or completeness of maps and data. Maps are representational and subject to future revision. Local site conditions must be examined. Commercial use is prohibited.

Map 3. Southern Study Area Inland Extent of Scenario 6

Inland Extent: Sea Level @ 60"+100-year Storm

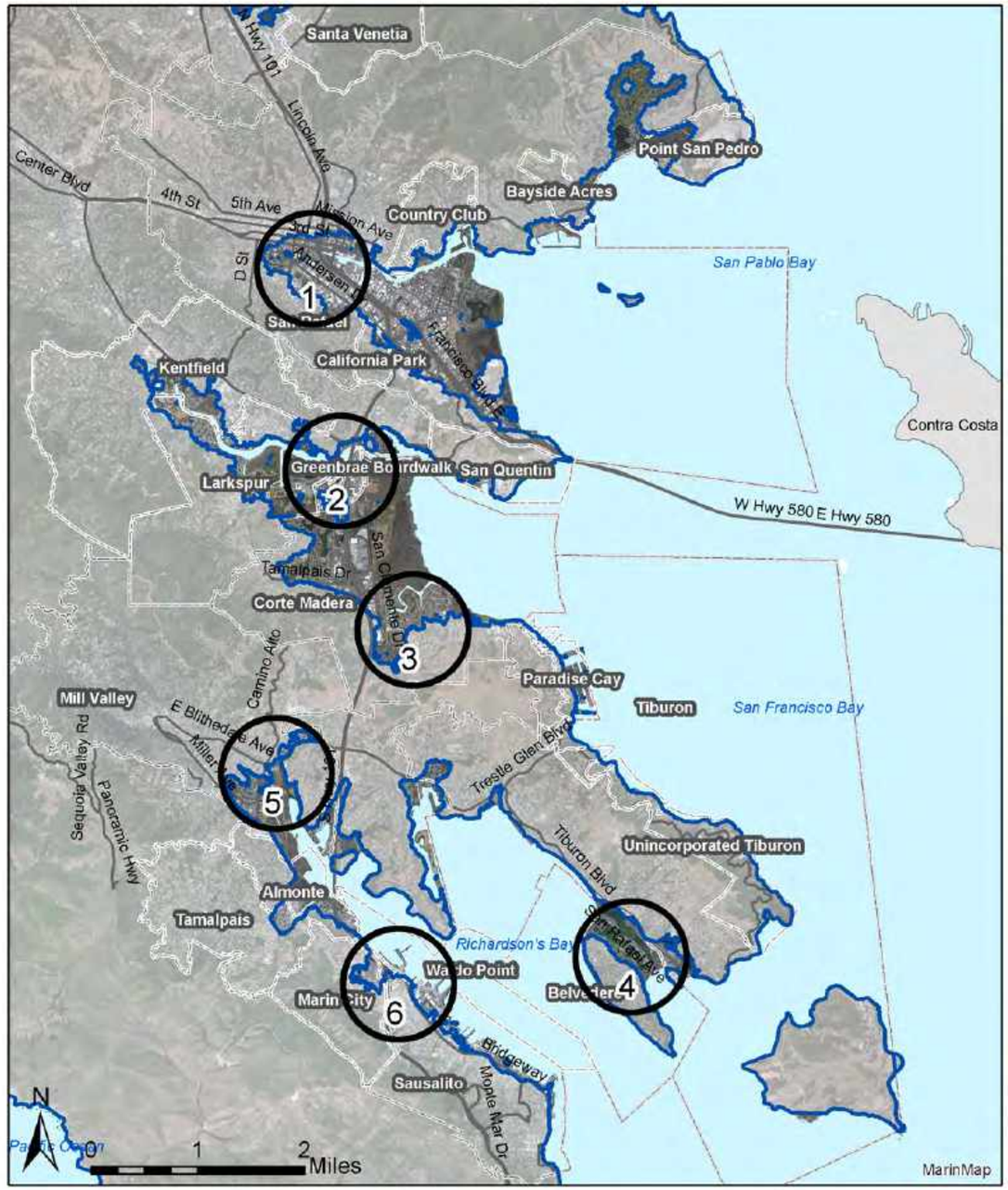
Location Indicators

Unincorporated

Municipality

Road

Bay



1:Downtown San Rafael

2: Greenbrae/Larkspur

3: Corte Madera

4: Belvedere/Tiburon

5: Mill Valley

6: Waldo Pt. Harbor

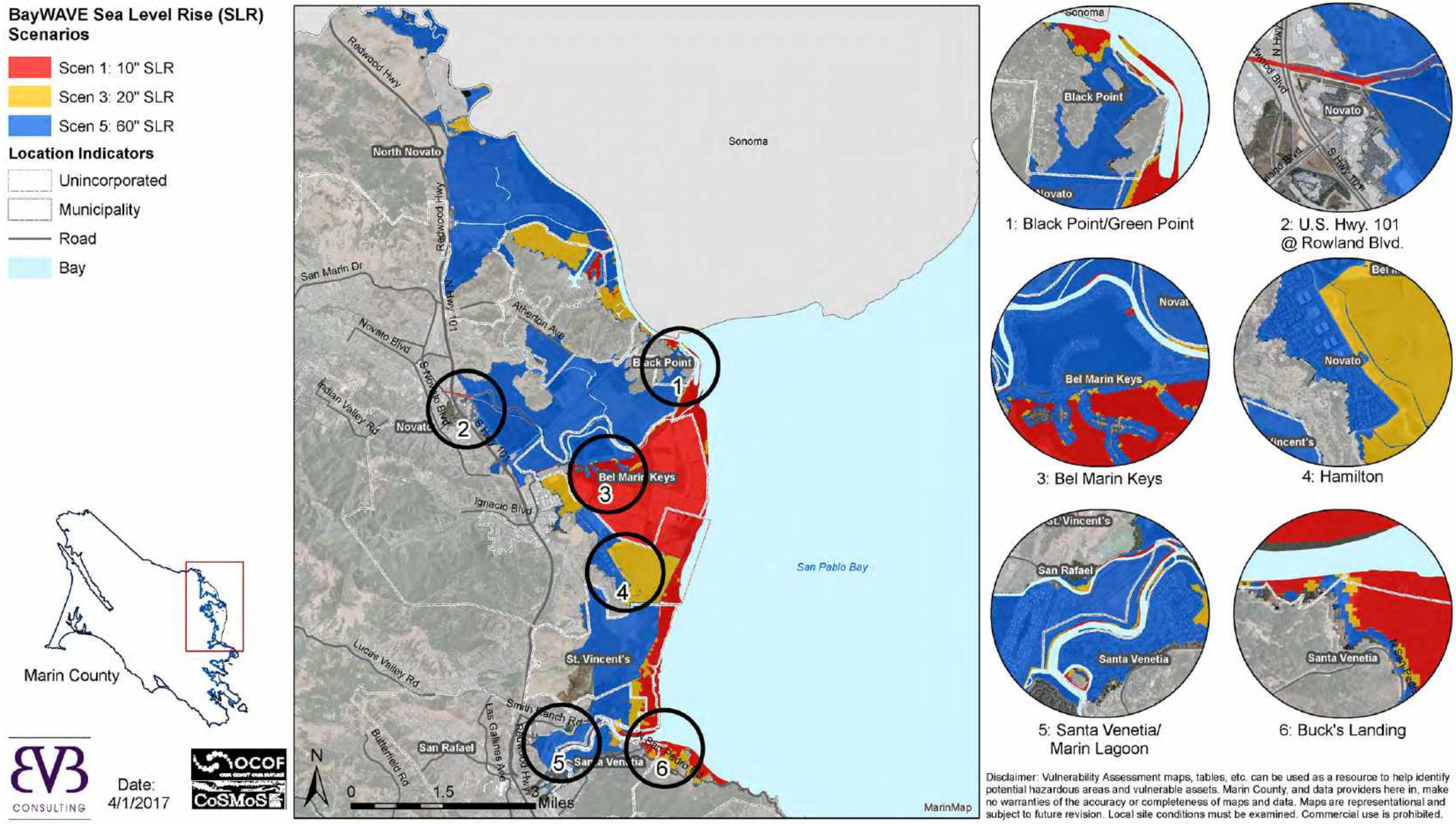
Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data providers here in, make no warranties of the accuracy or completeness of maps and data. Maps are representational and subject to future revision. Local site conditions must be examined. Commercial use is prohibited.

EVB CONSULTING

Date: 1/7/2017

OCOF CoSMoS

Map 4. Northern Study Area Sea Level Rise Scenarios



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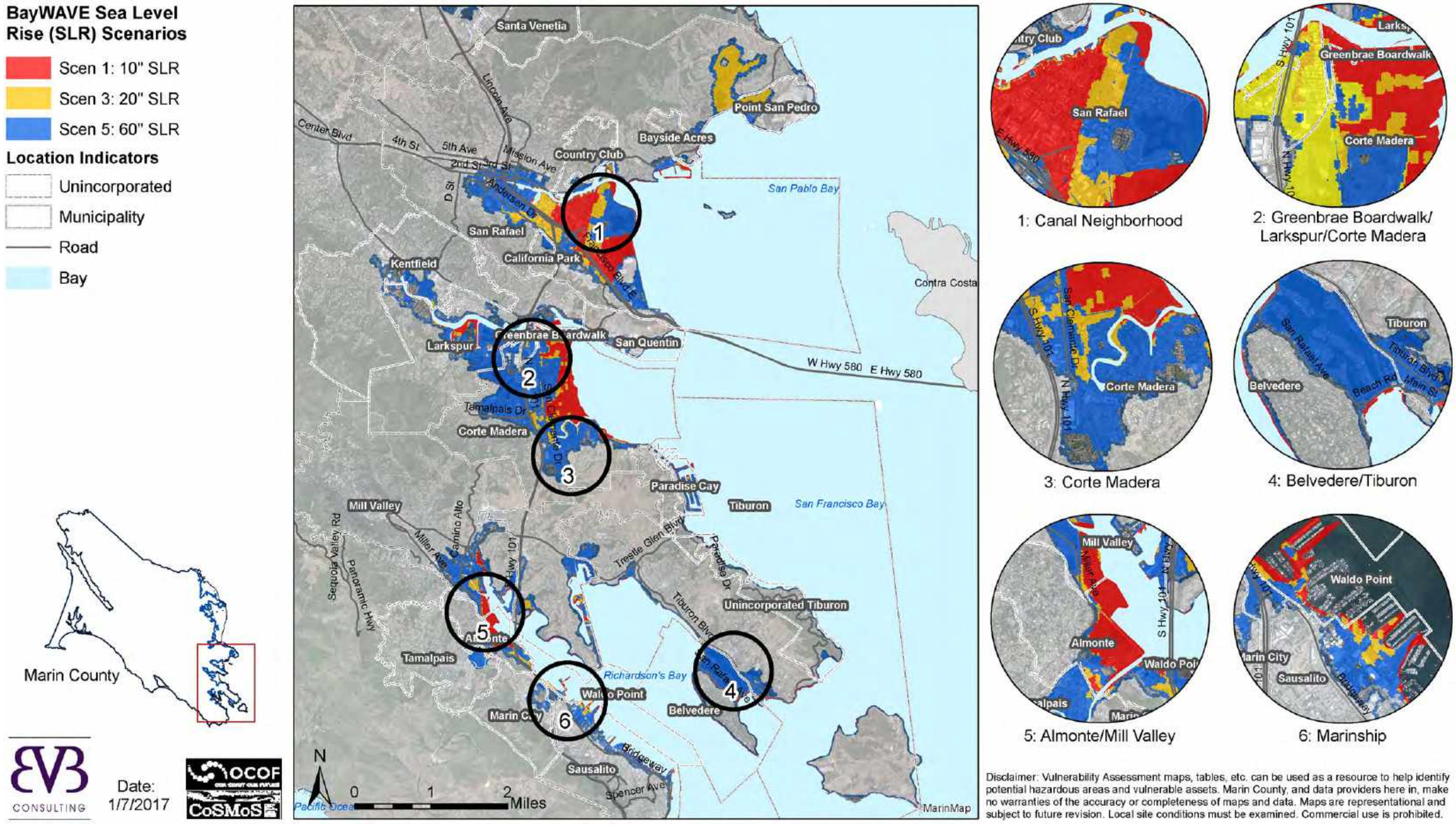
Map 5. Southern Study Area Sea Level Rise Scenarios



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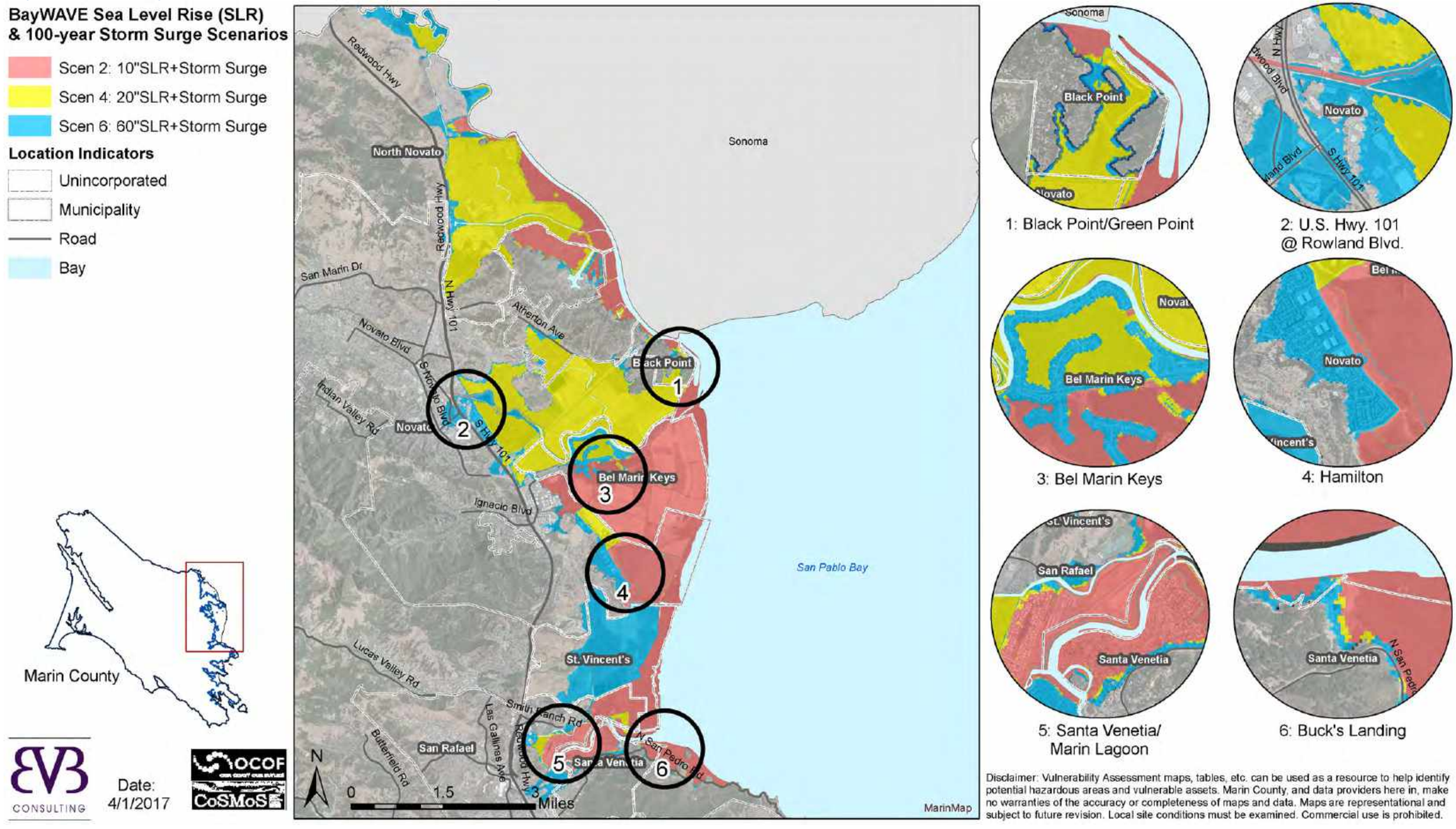
Map 6. Northern Study Area Sea Level Rise and 100-year Storm Surge Scenarios



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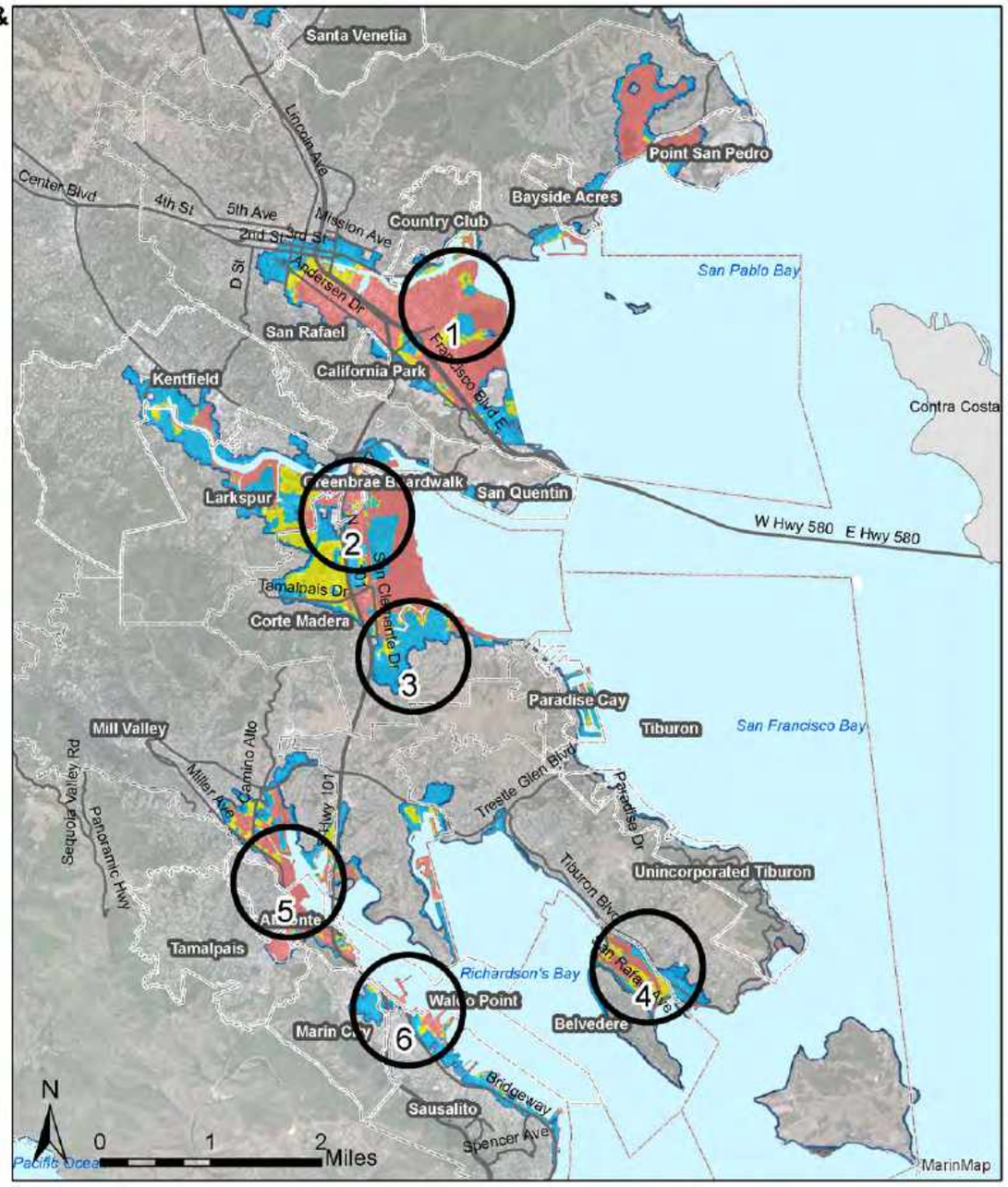
Map 7. Southern Study Area Sea Level Rise and 100-year Storm Surge Scenarios

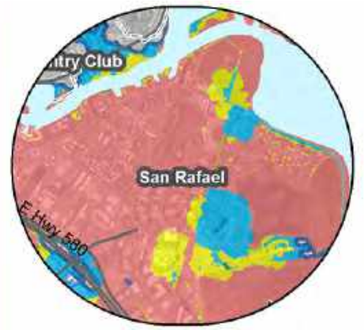
BayWAVE Sea Level Rise (SLR) & 100-year Storm Surge Scenarios

- Scen 2: 10"SLR+Storm Surge
- Scen 4: 20"SLR+Storm Surge
- Scen 6: 60"SLR+Storm Surge

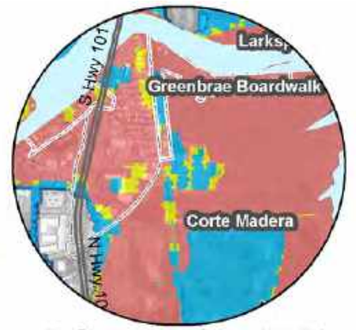
Location Indicators

- Unincorporated
- Municipality
- Road
- Bay

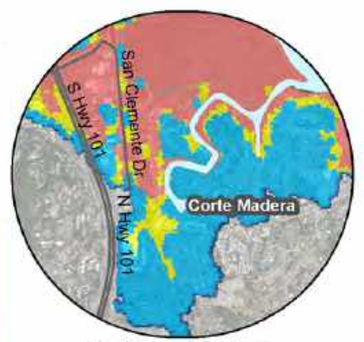




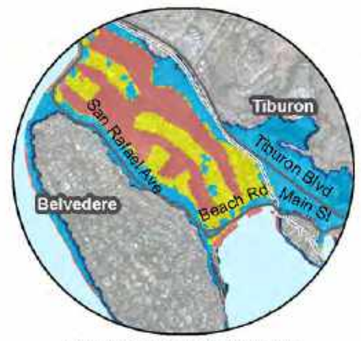
1: Canal Neighborhood



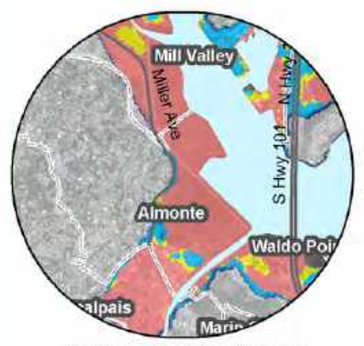
2: Greenbrae Boardwalk/ Larkspur/Corte Madera



3: Corte Madera



4: Belvedere/Tiburon



5: Almonte/Mill Valley

6: Marinship

Date: 1/7/2017

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According to the San Francisco Bay Conservation and Development Commission's *A Sea Level Rise Strategy for the San Francisco Bay Region* noted that it is particularly difficult to develop a strategy for dealing with sea level rise when the temperature increase scenarios yield a tenfold difference between the lowest and highest potential increases in the San Francisco Bay water level over the next 100 years.[23]

This high degree of uncertainty, due differing assumptions in carbon emissions, in sea level rise modeling results in a range of onset predictions. Variances between the predictions increase further out in time. This uncertainty is heightened by the non-linear growth rate of sea level rise.[24,25] Because of this variation, the BayWAVE scenarios do not focus on years, rather a framework of near-, medium-, and long-term scenarios. The OCOF tool enables the user to view the year a sea level projection could be met across the various published sea level estimates on the OCOF website.

Regardless, even if the world stabilizes carbon emissions, sea level rise will continue. Even if the global population reduces carbon emissions to levels where atmospheric concentrations decline, the decline will be slow, sea levels could continue to rise for decades, and hundreds of years could pass before sea level stabilizes or drops.[26,27]

Known Issues

The USGS acknowledges local modeling issues at the Petaluma River where dense vegetation leads to a false elevation reading and thus, under-predicts the potential flooding extent. Maximum flood potential indicates more probable flooding extents in these locations. In addition, the 100-year storm scenario flooding extents in the vicinity of Petaluma River and Novato may be under-predicted. The modeling team manually adjusted parameters to show more probable flooding behavior. Local professionals also suspect that water absorbed by the marshes at China Camp State Park may yield less flooding than the model estimates.

In addition, several sites underwent, or are currently undergoing, elevation increases after the baseline imagery was taken in 2010. Thus, the model and maps may overestimate flooding. These projects are shown on Maps 8 and 9 and include:

- Waldo Point Harbor: Filled and elevated parking and entrance area.
- Rose Garden Neighborhood, Larkspur: This recently completed development was elevated to meet FEMA and County flood prevention requirements.
- Aramburu Island, Strawberry: This man-made barrier island off Harbor Point in Strawberry was improved in 2012 and offers enhanced protection from wave impacts during storms.
- Hospice and base of Cal Park Hill: Recent construction may have elevated the site above 2010 elevations. This could result is less than flooding than estimated in this assessment.
- The Strand and Loch Lomond Marina, San Rafael: This project is near completion. The sites were filled with sediment and elevated to meet FEMA standards.
- Redwood Landfill: Roughly two feet in height was added to the external and internal levees after 2010.

Another issue arises with the Belvedere and Bel Marin Keys Lagoons. These lagoons are managed with tide gates that can close during high tides. The model treats these gates as open. So long as the tide gates and levees are not over topped, closing these protective devices could reduce flooding to properties on the lagoons in the near- and medium-terms.

Finally, note that the model does not take planned projects into consideration and assumes no action taken to prepare of adapt for sea level rise. Several projects along the shoreline are planned that could also help to reduce sea level rise flooding threats. These projects will be presented in the BayWAVE sea level rise early action report, the counterpart to this Assessment.

[23] San Francisco Bay Conservation and Development Commission. Revised September 2008. *A Sea Level Rise Strategy for the San Francisco Bay Region*

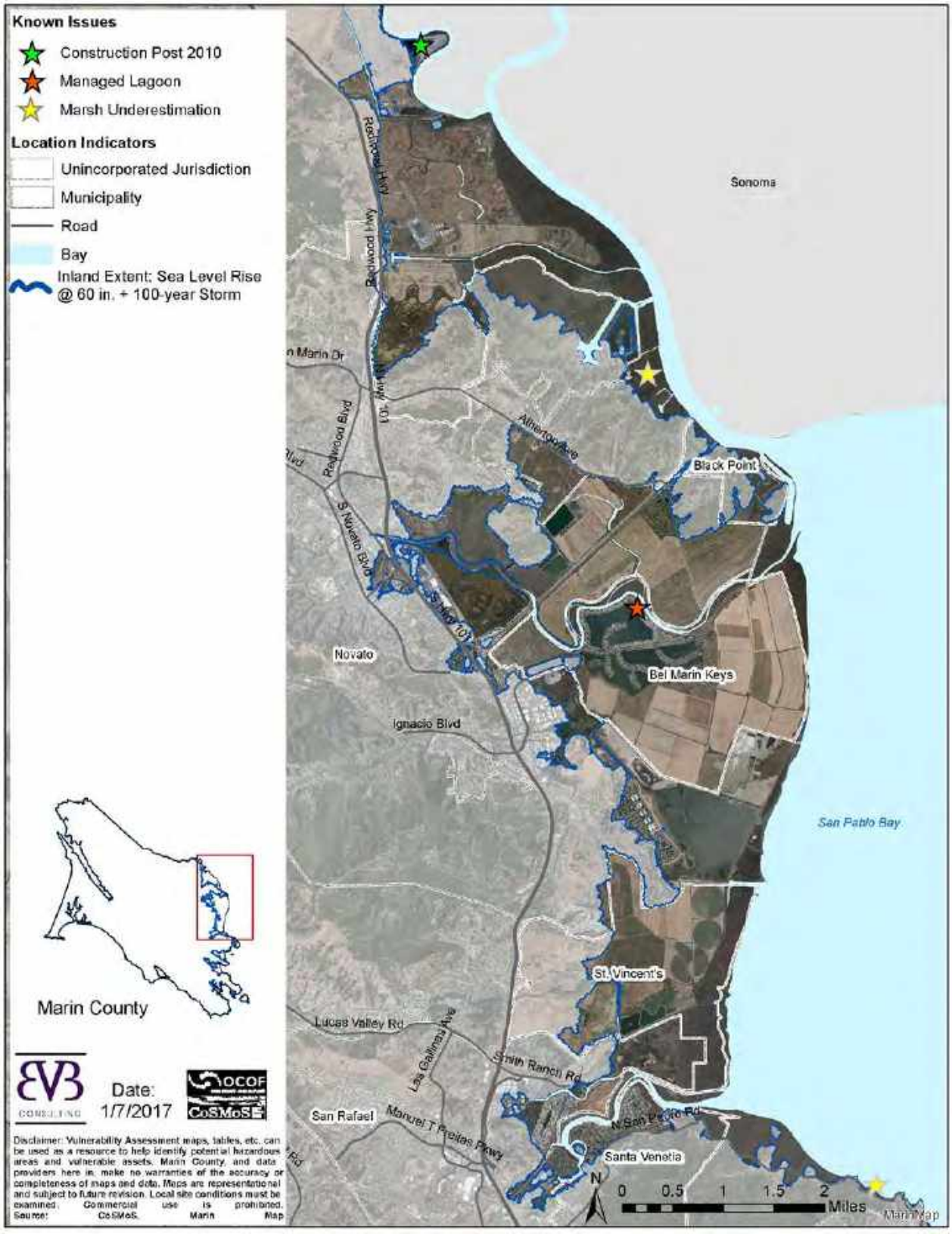
[24] P. Barnard. C-SMART Kick-off Meeting July 2014. htttp://walrus.wr.usgs.gov/coastal_processes/cosmos/

[25] Annual mean Sea Level Rise, San Francisco Tidal Gage. Wwwlpsmsl.org/data/obtaining/stations/10.php

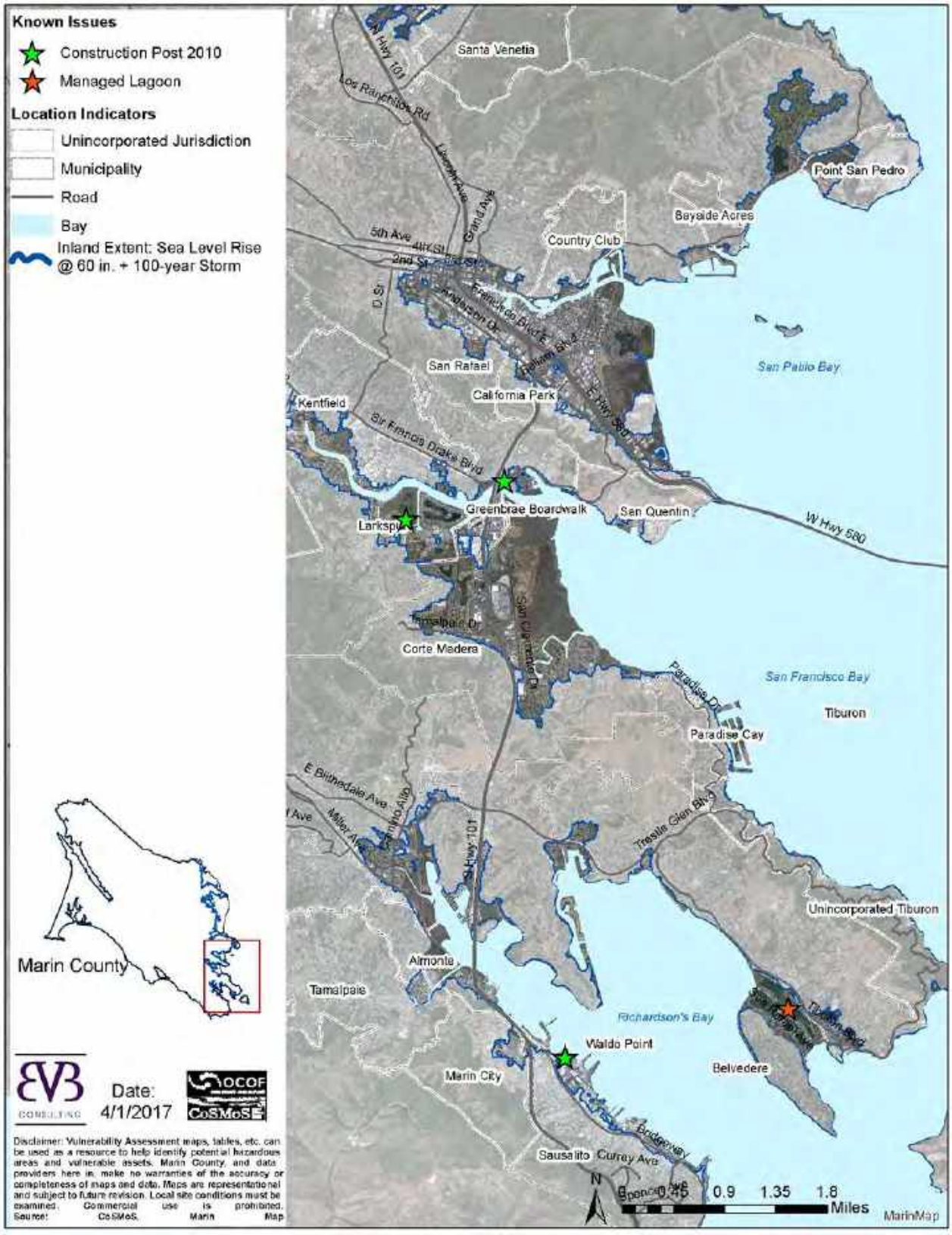
[26] IPCC Fourth Assessment Report: Climate Change 2007. Climate Change 2007: Working Group I: The Physical Science Basis. 10.7.2 Climate Change Commitment to Year 3000 and Beyond to Equilibrium. https://www.ipcc.ch/publications_and_data/ar4/wg1/en/ch10s10-7-2.html

[27] IPCC Fourth Assessment Report: Climate Change 2007. Climate Change 2007: Working Group I: The Physical Science Basis. 10.7.4 Commitment to Sea Level Rise. https://www.ipcc.ch/publications_and_data/ar4/wg1/en/ch10s10-7-4.html

Map 8. Northern Study Area Known Issues with CoSMoS Model



Map 9. Southern Study Area Known Issues with CoSMoS Model



METHODS

Sea Level Rise Maps & FEMA

Several shoreline communities already grapple with stormwater and storm surge flooding on a near yearly basis and qualify for federal flooding insurance under the Federal Emergency Management Agency (FEMA). FEMA maps flood prone area in maps called Flood Insurance Rate Maps (FIRMs). These maps, while related to flooding, do not consider future potential sea level rise flooding. As the sea level rises, FIRMS would need to be updated to represent the new existing conditions. Other major differences between FIRMs and the sea level rise maps in this assessment are:

- FIRMs are based on *historic and current* trends and assumptions. CoSMoS sea level rise maps are based on modeling of potential *future* conditions.
- FIRMS address bay surge and stormwater creek flooding. CoSMoS does not address stormwater creek flooding, and
- FIRMS can incorporate policy decisions to exclude the role of non-FEMA certified protective shoreline armoring. CoSMoS is based solely on elevation, such that any shoreline armoring that contributes to elevation is accounted for.

Assessment Methods

As described in CalAdapt, vulnerability is based on an asset's exposure, sensitivity, and adaptive capacity to rising tides and bay surge threats. Such that, if an exposed asset is moderately or highly sensitive to sea level rise impacts, with low to no adaptive capacity, the asset is vulnerable.

Assets were identified using existing MarinMap geographic data layers for roads, trails, parks, public facilities, utility districts, buildings, and parcels, and Department of Fish and Wildlife sources for wildlife species, habitats, fishing piers, marinas, access points, and ports. The Technical Advisory Committee supplemented these data sources with additional assets. Note that not all vulnerable assets are mapped due to data conflicts or unavailable geographic data. This does not imply that an asset is not vulnerable. This is especially true for utiltiy assets. The data layers generated span several years, and changes to the built environment may have occurred since the data was last updated. Where idetified, these areas were manually adjusted to reflect known current conditions. For example, based on aerial imagery, Niel Cumings Elementray school appears to be one large building, however, upon site visit, it becomes clear the site has four buildings connected by awnings. Improving the data comprehensively was not within the scope of this analysis, thus buildings numbers may be slightly off in some locations.

Phase 1: Exposure

To determine what could be exposed to sea level rise at MHHW and/or a100-year storm surge, the six BayWAVE scenarios, identified asset locations, and aerial imagery were overlaid in ArcGIS, a geographic statistical computer program. Assets intersecting sea level rise and storm scenarios were identified as exposed, and further assessed for sensitivity and adaptive capacity to determine if the asset is vulnerable to:

- Extreme event flooding during the annual highest high tides and/or storm surges that cause nuisance flooding,
- Inundation at,-at least, one high tide a day, several days a month, that results in chronic flooding,
- Erosion and geomorphic evolution from higher high tides and extreme storm events,
- Wave run up and high winds in extreme storm events,
- Saltwater intrusion,
- Rising water table, and/or
- Habitat shifts (applicable to natural resources).

In addition to geographic extent, CoSMoS GIS layers illustrating potential flood depth at MHHW were spatially joined with each vulnerable asset yielding average depths for scenarios 1, 3, and 5. Flood depth was calculated by converting GIS vector data to raster data to break the flood depth layer into thousands of cells, each with an assigned flood value. For roads, a high and low value was calculated on the line segment. Bridges are not quantitatively accounted for in this assessment. For buildings, cells underlying the building footprint were averaged to one flood depth at MHHW for scenarios 1, 3, and 5 for each building. Note that flood depth data is not available for all vulnerable areas and assets, especially those that exist in the bay beyond mean sea level and already subject to tidal influences. The data presented in this Assessment is

for what is available and may not directly compare with data presented under exposure.

Flood depth figures are displayed in the onset and depth tables in each profile. In these tables, roads were assigned high and low values along the exposed segments for each scenario. Exposed road mileage provided is road miles, not lane miles. Lane mileage would more than double the mileage figures presented in this assessment. Where buildings are presented as a neighborhood group, a maximum average flood depth is provided. Where data is available, additional analysis summarizes how many buildings in each community could flood by one-foot flood depth intervals for scenarios 1, 3, and 5.

Phases 2 & 3: Sensitivity & Adaptive Capacity

The project team interviewed more than 100 asset managers, such as fire chiefs, city planners, transportation agency staff, using the Asset Vulnerability Assessment Tool, available in Appendix A, to assess built and natural resource assets. The tool is designed based on previous pre- and post- disaster assessments conducted in the Bay Area, Southern California, New Orleans, New York City, and guidance from State of California and the US EPA.[28,29,30,31,32,33,34]

Several public agency professionals were interviewed due to a high number of public assets in the exposed areas. Homeowners' association representatives were invited to be interviewed; however, home owners or non-public property owners were not individually interviewed. A list of interviews can be found in Appendix A

Asset managers were interviewed in person or by phone to answer two primary questions:

1. How ***sensitive*** is the asset to each exposure or threat?[35]
2. And if sensitive, what is the ***adaptive capacity***, or the asset's ability to maintain its function without further intervention (human action)?[36, 37,38, 39]

Any asset deemed moderately or highly sensitive to flooding or storm damage, with low to no adaptive capacity is considered vulnerable. Other questions about previous disruptions and the nature of potential disruptions were discussed to provide context to the qualitative statements. The interview results were combined with geographic data to develop this Vulnerability Assessment.

Additional analysis was conducted to determine the potential monetary losses from storm damages to buildings in scenario 6. Scenario 6 is chosen because it is the worst case scenario selected for assessment. This method applies damage levels to all vulnerable buildings in scenario 6 based on the FEMA HAZUS model intervals for yellow, minor damage of $5,000-17,000; orange, damage of $17,001+; and red, destroyed, post-disaster inspection tags.[40,41] Information on the real estate website Zillow was used to estimate median market value of single-family homes in February 2016.

[28] US EPA. Being Prepared for Climate Change: A Workbook for Developing Risk-Based Adaptation Plans. August 2014.
[29] CURRV-Tijuana River Valley - http://trnerr.org/currv/
[30] Bay Conservation & Development Commission: Adapting to Rising Tides. Hayward Resilience Study. 2014.
[31] City and County of San Francisco Sea Level Rise Committee. Guidance for incorporating Sea Level Rise into Capital Planning in San Francisco: Assessing Vulnerability and Risk to Support Adaptation. September 2014.
[32] http://mitigationguide.org/task-5/steps-to-conduct-a-risk-assessment-2/3-analyze-risk/
[33] California Emergency Management Agency, California Emergency Natural Resource Agency. California Climate Adaptation Planning Guide (APG). July 2012. http://resources.ca.gov/docs/climate/01APG_Planning_for_Adaptive_Communities.pdf
[34] Department of Transportation, Federal Highway Administration, Office of Environment and Planning, Mike Culp, IFC International, *Literature Review: Climate Change Vulnerability Assessment, Risk Assessment, and Adaptation Approaches.* http://www.fhwa.dot.gov/environment/climate_change/adaptation/publications_and_tools/vulnerability_assessment/index.cfm#Toc236233837
[35] Guidance for Incorporating Sea Level Rise into Capital Planning in San Francisco. September 22, 2014. Appendix 5. OneSF Checklist
[36] Center for Science in the Earth System (CSES), University of Washington, *Conduct a Climate Resiliency Study*, Chapter 8. Conduct a Climate Change Vulnerability Assessment. http://cses.washington.edu/db/pdf/snoveretalgb574ch8.pdf
[37] Department of Transportation, Federal Highway Administration, Office of Environment and Planning, Mike Culp, IFC International, *Literature Review: Climate Change Vulnerability Assessment, Risk Assessment, and Adaptation Approaches.* http://www.fhwa.dot.gov/environment/climate_change/adaptation/publications_and_tools/vulnerability_assessment/index.cfm#Toc236233837
[38] California Energy Commission Public Interest Environmental Research Program. Adapting to Sea Level Rise: A Guide for California's Coastal Communities. 2012.
[39] Bay Conservation & Development Commission: Adapting to Rising Tides. Hayward Resilience Study. 2014.
[40] Federal Emergency management Agency (FEMA) Website. Hazus. Last updated July 8, 2015. http://www.fema.gov/hazus.
[41] 2016 dollars

Phase 4: Risk & Onset

Risk & onset assess when and how likely impacts will occur to prioritize actions, though this alone may not be adequate criteria for decision-making. Onset is determined by the scenario an asset is exposed under. The scenario indicates a "no later than" timeline, as opposed to a "not until after" timeline, thus onset could occur before the snap shot in time represented by each scenario. Because of this, this assessment uses near-, medium-, and long-term labeling corresponding with the NRC ranges for before 2030, 2050, and 2100 respectively in Table 1.

All vulnerable assets are at risk of flooding and/or increasing rates of subsidence. Two types of flooding could occur, tidal flooding at MHHW or seasonal storm flooding. All assets that experience tidal flooding will also experience storm surge flooding. Tidal flooding at the average higher high tide could flood an asset once a day, several days a month. Each day has two high tides, thus it is possible that some properties could flood twice a day. Land that is flooded at this frequency is not useable for land based development. Storms surge flooding analyzed in this assessment is a 100-year storm surge, such that this storm surge has a 1 percent chance of occurring each year.

Other Considerations Methods

As adaptation planning moves forward, more detailed study and assessment across each of the 3 E's: economy, environment, and equity, will be critical. Moreover, the California Coastal Commission's Sea Level Rise Policy Guidance calls for assessing these, legal consequences, and the cumulative and secondary consequences of the vulnerabilities.[42] The "Other Considerations" section in each asset profile begins to identify issues and opportunities for each "E," and management. These sections are informed through literature review, asset manager interviews, and policy discussions with professional staff.

Economic: Highlights costs of damage, or preparation, and the cost burden to residents. Potential economic issues and opportunities were determined using several geographic and tabular data sources maintained by the County of Marin, US Census, and Zillow. Note that population and monetary figures are based on current or historic values. Generally, both populations and property values are projected to grow, thus, this assessment underestimates the number of people and value of property that would be vulnerable in the future.

Environmental: Highlights how disruption to buildings, roads, septic systems, and other assets could have secondary impacts on the environment and wildlife. Environmental impacts were gathered from asset managers and literature review.

Equity: Highlights the disparity in cost burden across populations of different social and economic means, and how the social fabric of communities may shift. Several storms impacting the south (i.e. Hurricane Katrina, Hurricane Audrey) have "shown that natural disasters can cause the greatest harm to low-income communities and communities of color."[43] Populations that may be at higher risk include, low-income, limited English speaking, children, and those with limited mobility or sensory abilities.

Management: Highlights political and management issues that will need to be considered when planning for sea level rise to ensure the public health, safety, and welfare of East Marin residents.

To gain a better idea of these secondary consequences, asset managers were asked several questions about the nature of the damage or disruption that could happen, levels of risk, persons impacted, and if environmental, economic, equity, or political issues could arise. Potential secondary impacts include:[44, 45]

- Contaminant releases from industrial sites or storage tanks,
- Loss of habitat from increased erosion,
- Loss of jobs and revenue streams,
- Loss of community or sense of place,

[42] *California Coastal Commission Sea Level Rise Policy Guidance: Interpretive Guidelines for addressing Sea Level Rise in Local Coastal Programs and Coastal Development.* August 12, 2015. http://www.coastal.ca.gov/climate/slrguidance.html

[43] The Impacts of Sea-Level Rise on the California Coast. California Climate Change Center. Heberger, M., Cooley, H., et. al. The Pacific Institute. CEC-500-2009-024-F. May 2009

[44] Delaware Coastal Programs, *Sea Level Rise Adaptation*. http://www.dnrec.delaware.gov/coastal/Pages/SeaLevelRiseAdaptation.aspx

[45] City and County of San Francisco Sea Level Rise Committee. *Guidance for incorporating Sea Level Rise into Capital Planning in San Francisco: Assessing Vulnerability and Risk to Support Adaptation.* September 2014.

- Increased need for government services or intervention, and
- Potential injury and loss of life.

Though the methods for this countywide assessment are robust, some areas may be represented as more vulnerable or less vulnerable than available information suggests. Some locations can only be represented accurately with onsite inspections of ground-level conditions. For example, the homes on Greenbrae Boardwalk, in unincorporated Marin and on Boardwalk One, in the City of Larkspur are raised on piers above tidal marshes. Utilities run to homes above the marsh plain along raised, wooden boardwalks. These communities already live with water and are accustomed to high tides surrounding their homes. In theory, these buildings and associated utilities can be adapted with minimal expense compared to on-land buildings (although they would still be impacted by the flooding in surrounding neighborhoods and streets). Understanding the full vulnerability of these communities requires, at a minimum, onsite inspections of utilities and base floor elevations for each home; analysis that is beyond the scope of this report. The report uses the best available GIS data to analyze vulnerability. The data does not account for raised floor elevations. The County is committed to regularly updating its assessments in response to new sea level rise projections and the availability of new and better data.

Collectively these methods determine what is vulnerable to sea level rise on the Marin shoreline and at what levels of sea level rise impacts could be felt by. This analysis can be a useful in assessing asset and community sea level rise vulnerabilities, and developing adaptation strategies and policies well suited for this unique and valuable bay region.

BayWAVE ASSET PROFILES

LAND

Asset Profile: Land

Land is a significant asset along the Marin shoreline that provides space for homes, commercial goods and services, recreation and education, worship, and the ability to create financial equity and wealth. Within Eastern Marin's steep narrow valleys, dry, flat, and easily developable land a very limited resource. While a majority of the vulnerable properties feature buildings, several are agricultural, park, service oriented, or natural in use, and have unique vulnerabilities (see Utilities, Working Lands, Recreation, and Natural Resources Profiles). The following are general key issues related to land vulnerability:

- Almost all land hosting human activity identified in scenarios 1, 3, and 5 could be vulnerable to tidal flooding on a near daily basis, with some months worse than others.
- Shoreline property that becomes tidally flooded and transitions to the water side mean sea level boundary would become public trust land, and may be required to pay a leasing fee to the State Lands Commission.
- Many properties are built on fill and mud, which could become soggier and, consequently, vulnerable to increasing rates of subsidence.
- Shoreline armoring protecting land from flooding, except in Hamilton and the Redwood Landfill, is not regulated or certified, and could expect overtopping after three feet of sea level rise.
- Properties untouched by rising tides may become isolated and cut off from essential services, such as wastewater service and travel through low-lying areas.
- San Rafael's Canal neighborhood, one of the lowest income and most diverse areas of the shoreline, could expect a large number of rented or leased properties flooded at the average higher high tide in the near-term. By the end of the century, the entire area could flood daily, from the shoreline to Interstate 580.
- Marin County communities feature several house boat and unauthorized boat communities' that exist within the existing tidal range. These properties are especially vulnerable themselves, as is their connection to dry land.
- Sea level rise will likely simultaneously impact multiple jurisdictions and properties with differing ownership and financial capacities, creating imbalances in adaptation abilities.

IMPACTS AT-A-GLANCE: SCENARIO 6

13,000 properties	**100,000+ people**
$9 billion in assessed land value flooded (2016 dollars)	**Stormwater and tidal impacts already occur along the shoreline and up major creeks**
Residential, commercial, industrial, open space, parks, ranch lands, utilities, and transportation parcels	**Property Owners County of Marin Sausalito Mill Valley Belvedere Tiburon Corte Madera Larkspur San Rafael Novato**

Flooding around houseboats in Sausalito. Nov. 24, 2015. Credit: Marin County DPW

Subsidence in Marinship, Sausalito. C1edit: Marin County CDA

LAND

Corte Madera Ecological Reserve. Credit: C. Kennard

Acres

Near-term: Scenarios 1 &2
As shown in Table 3, overall, less than 5,000 acres could be tidally flooded by 2030, and an additional 3,000 acres could flood with saltwater during storm surges. These acreage figures amount to six percent of the study area as being vulnerable to tidal and storm surge flooding, and another three percent of land in the study area as being vulnerable to a 100-year storms surge alone.

In the near-term, as shown in Table 4, the most impacted communities by acreage are:

1. Bel Marin Keys, 1,759 acres
2. Waldo Point Harbor area, 598 acres, and
3. San Rafael, 449 acres.

Following these top three are Novato with 430 acres, and Strawberry, Corte Madera, and St. Vincent's with around 200 acres flooded each. All other communities could anticipate about or less than 100 acres being exposed to sea level rise. Note that many of these acres, especially in Bel Marin Keys, San Rafael, Novato, Corte Madera, and Larkspur, include several hundred acres in marshland that buffer development from the Bay. Southern Marin shoreline properties east of US Highway 101, especially those resting on fill in the low lying areas, are the most vulnerable to tidal flooding and subsidence. Adding a 100-year storm surge impacts several more properties in these communities, and several others in Corte Madera, Bel Marin Keys, Santa Venetia, and Tamalpais Valley.

Table 3. Exposed Acres by Scenario

Scenarios		Acres	
		#	% of study area
Near-term	1	4,829	6
	2	8,072	9
Medium-term	3	6,685	8
	4	13,544	16
Long-term	5	16,332	20
	6	17,854	21

Source: MarinMap, CoSMoS

Table 4. Acreage Exposed in the Near-term

Location		Scenario 1	Scenario 2
		10" MHHW	+100-year Storm Surge
Municipalities	San Rafael	449	1,360
	Novato	426	1,336
	Corte Madera	230	430
	Larkspur	132	202
	Tiburon	48	47
	Mill Valley	44	103
	Sausalito	26	52
	Belvedere	24	85
Unincorporated Jurisdictions	Bel Marin Keys	1,759	1,794
	Waldo Point	598	610
	St. Vincent's	256	346
	Strawberry	255	282
	North Novato	118	575
	San Quentin	116	115
	Tiburon	102	108
	Almonte	99	137
	Paradise Cay	67	69
	Santa Venetia	29	211
	Pt. San Pedro	14	62
	Greenbrae	13	21
	Kentfield	10	28
	Bayside Acres	9	9
	Country Club	4	4
	Black Point	1	58
	Tamalpais	0	28
Study Area		**4,827**	**8,062**

Source: MarinMap, CoSMoS

LAND

Table 5. Acreage Exposed in the Medium-term

Location		Scenario 3	Scenario 4
		20" MHHW	+100-year Storm Surge
Municipalities	San Rafael	869	1,590
	Novato	1,327	3,535
	Corte Madera	313	640
	Larkspur	147	299
	Tiburon	48	49
	Mill Valley	62	183
	Sausalito	35	65
	Belvedere	24	130
Unincorporated Jurisdictions	Bel Marin Keys	1,802	2,155
	Waldo Point	604	611
	St. Vincent's	339	353
	Strawberry	270	301
	North Novato	226	2,457
	San Quentin	115	115
	Tiburon	103	108
	Almonte	115	146
	Paradise Cay	69	74
	Santa Venetia	56	221
	Pt. San Pedro	58	65
	Greenbrae	14	22
	Kentfield	12	33
	Bayside Acres	10	10
	Country Club	4	4
	Black Point	62	346
	Tamalpais	1	29
	Marin City	None	3
Study Area		**6,685**	**13,544**

Source: MarinMap, CoSMoS

SMART Bridge, Novato. Credit: Marin County DPW

Medium-term: Scenarios 3 &4

A majority of the vulnerable communities do not see significant gains in tidally flooded acreage in medium-term scenario 3. Overall, less than 2,000 additional acres could expect MHHW tidal flooding over scenario 1. And, in general, 10 to 100 more acres are impacted in each community, though communities with large low-lying areas could expect twice as many acres exposed. This is observed for San Rafael, Novato, North Novato, and Santa Venetia. In this time period, Novato surpasses San Rafael in exposed acreage, though much of this land is marsh or wetlands, whereas San Rafael's exposed land is intensely developed. Within the study area, with the compounding 100-year storm surge in scenario 4, 5,000 more acres could flood compared to scenario 2. The 100-year storm surge is the major contributor to flooding on additional land in the medium-term compared to the near-term. This jump in vulnerable area is due to the potential failure of shoreline levees south of Novato.

Long-term: Scenarios 5 &6

At five feet of sea level rise, scenario 5, a much larger number of acres are impacted by higher high tides at 16,300 aces, and an additional 1,500 acres that could expect only storm surge flooding. The communities with the most land area that could be exposed to tidal flooding are:

1. Novato, 3,998 acres,
2. North Novato, 2,827 acres, and
3. Bel Marin Keys, 2,332 acres.

The flooded areas are primarily natural, agricultural, flood control, and sanitary district lands. Corte Madera follows these top three with 900 acres flooded at average high tides, though similarly, much of this land is marsh. With an additional 100-year storm surge, the majority of exposed acreage in the study area is in:

1. Novato, 4,000 acres,
2. North Novato, 3,000 acres
3. Bel Main Keys

Following these communities is San Rafael, with more than 2,100 acres, and St. Vincent's, with more than 1,400 flooded acres. Corte Madera could anticipate nearly 1,000 acres flooded from a storm surge. All other communities could expect 550 acres or less that could suffer 100-year storm surge flooding at 60 inches of sea level rise, scenario 6.

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Table 6. Acreage Exposed in the Long-term

Location		Scenario 5	Scenario 6
		20" MHHW	+100-year Storm Surge
Municipalities	Novato	3,998	4,249
	San Rafael	1,856	2,121
	Corte Madera	906	994
	Larkspur	379	544
	Tiburon	190	273
	Mill Valley	169	180
	Sausalito	106	135
	Belvedere	84	149
Unincorporated Jurisdictions	North Novato	2,827	2,930
	Bel Marin Keys	2,332	2,350
	St. Vincent's	1,240	1,413
	Waldo Point	611	613
	Black Point	388	408
	Strawberry	328	375
	Santa Venetia	232	269
	Almonte	146	157
	San Quentin	122	135
	Tiburon	107	113
	Paradise Cay	91	111
	Pt. San Pedro	78	83
	Kentfield	53	118
	Tamalpais	28	30
	Greenbrae	24	24
	Bayside Acres	12	24
	California Park	9	10
	Country Club	9	10
	Marin City	7	36
Study Area		**16,332**	**17,854**

Source: MarinMap, CoSMoS

House boats. Waldo Point Harbor. Dec. 2014 king tide. Credit: Marin County DPW

Vulnerable Parcels

Land is divided into parcels for ownership and development purposes. Examining parcels can provide a window into the land uses, and how much of each land use, that could be exposed, vulnerable, and by when.

Near-term: Scenarios 1&2

As shown in Table 7, by number of parcels, the top three vulnerable jurisdictions are:

1. San Rafael, 700parcels,
2. Larkspur , 90 parcels, and
3. Mill Valley, 80 parcels.

This highlights that while not the highest in acreage, San Rafael could have the highest number of properties, and therefore people, impacted, requiring a much greater level of preparation and coordination. By proportion a few smaller unincorporated communities emerge as being the most vulnerable. These are:

1. Greenbrae, 62 percent of parcels,
2. Almonte, 32 percent of parcels, and
3. Waldo Pt. Harbor, 12 percent of parcels.

Greenbrae's 62 percent of parcels is alarming, especially given that the parcels are primarily residential that extend into existing tidal areas accessible only by a long narrow boardwalk. The municipalities could expect five percent or less of their parcels tidally flooded within this time period.

With the additional storm surge, scenario 2, Greenbrae could experience increased tidal flooding on 78 percent of the parcels on both sides of US Highway 101. In fact, the homes within the Corte Madera Creek corridor, west of US Highway 101, could be subject to greater flooding than those extending into the marsh lands. Similarly, 68 percent of Almonte could be compromised, as could 36 percent of Santa Venetia, as the existing levees could be overtopped. San Rafael could expect up to 11 percent of its parcels impacted with the additional storm. All other municipalities could expect less than six percent of the parcels impacted by a bay 100-year storm surge.

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By type, the primary land use that could be flooded is tax exempt. These are primarily sanitary and flood control district owned lands, along with some park land. The next most impacted land use by parcel count is residential, with concentrations in San Rafael, Greenbrae, Almonte, Waldo Point, and Larkspur.

Countywide, two percent of parcels could be vulnerable in scenario 1 and an additional 4 percent could also face the storm surge. Broken down by major land use type, as shown in Table 14, one percent of residential, five percent of commercial, and eight percent of industrial parcels could face tidal flooding. Add on the bay storm surge, and an additional four, nine, and 27 percent, respectively, of parcels could weather storm surge flooding.

Table 7. Number and Proportion of Vulnerable Parcels in the Near-term

Location		Scenario 1		Scenario 2	
		#	%	#	%
Municipalities	San Rafael	709	4	1,926	11
	Larkspur	90	2	246	5
	Mill Valley	80	1	195	3
	Belvedere	51	5	56	6
	Tiburon	46	1	46	1
	Sausalito	40	1	61	2
	Corte Madera	9	0	201	6
	Novato	3	0	7	0
Unincorporated Jurisdictions	Waldo Point	59	12	68	13
	Greenbrae	54	62	68	78
	Bel Marin Keys	45	6	121	16
	Paradise Cay	28	8	34	9
	Strawberry	26	2	29	2
	Almonte	22	32	46	68
	Bayside Acres	19	9	19	9
	Tiburon	13	4	22	7
	St. Vincent's	7	10	12	18
	Santa Venetia	4	0	604	36
	Kentfield	2	0	4	0
	San Quentin	1	1	1	1
	Black Point	1	0	9	1
	Country Club	1	0	2	0
	Tamalpais	0		97	4
Study Area		**1,310**	**2**	**3,826**	**6**

Source: MarinMap, CoSMoS

By community, Greenbrae could expect up to 85 percent of its residential parcels compromised. Both Paradise Cay and Tiburon could expect 20 percent of their commercial parcels compromised. And San Rafael could expect 11 percent of their commercial and 17 percent of industrial parcels compromised. While only a few industrial parcels exist, nearly all of them could suffer tidal impacts.

Table 8. Vulnerable Parcels Land Uses in the Near-term

Land Use	Scenario 1		Scenario 2	
	#	Acres*	#	Acres*
Multi-family Residential Improved	131	51	166	69
Multi-family Residential Unimproved	5	1	7	1
Mobile Homes	7	0	202	1
Single Family Attached	716	11	1,283	36
Single Family-Residential Improved	508	142	2,274	464
Single- Family Residential Unimproved	52	24	93	76
Floating Home	52	1	53	1
Commercial Improved	249	311	437	640
Commercial Unimproved	22	109	67	275
Industrial Improved	109	57	181	123
Industrial Unimproved	11	3	25	143
Common Area	13	50	39	178
Rural Unimproved	0	0	1	169
Exemption Improved	0	0	3	223
Exemption Vacant	0	0	0	0
Tax Exempt	1	28	6	201
No Data	20	13	46	38

**Whole parcels are summed, not just the exposed portion of the parcel. Source: MarinMap, CoSMoS*

With the additional storm surge, these communities and several other could expect sizeable impacts to

residential, commercial, and industrial properties, both improved and unimproved. For example:

- Greenbrae could expect nearly 100 percent of its residential parcels to flood.
- Santa Venetia could expect nearly 40 percent of its residential parcels to flood with surge waters.
- Bel Main Keys and Waldo Point Harbor could expect 14 percent of residential parcels to flood.
- Waldo Point Harbor could anticipate 16 percent of its industrial parcels to be compromised.
- Tamalpais Valley could expect more than 75 percent of their commercial parcels long Shoreline Highway to be compromised.
- Almonte could also anticipate flooding on 50 percent of commercial parcels, and even more considerable, the less than 10 industrial parcels could flood.
- San Rafael could expect nearly ten percent of residential, 25 percent of the commercial compromised, and 52 percent of industrial parcels to suffer from temporary flooding.
- Eighty-three percent of Larkspur's industrial parcels could face storm surge flooding.
- Finally, Corte Madera could expect nearly 20 percent of commercial parcels to flood.

Medium-term: Scenarios 3 and 4

Medium-term scenarios 3 and 4 comparisons for parcels and land use are relatively similar to, though marginally more severe than, scenarios 1 and 2. The top three locations with the greatest number of vulnerable parcels are:

1. San Rafael, 1,301parcels,
2. Larkspur, 121 parcels, and
3. Bel Marin Keys, 97 parcels.

Adding the storm surge alters this order with San Rafael still topping the list, with more than 2,000 flooded parcels, Santa Venetia following with more than 650 parcels, and Corte Madera with slightly less than 650 parcels. Flooded parcels account for nearly 40 percent of the residential parcels in Bel Marin Keys. Several hundred parcels are also vulnerable in Larkspur and Mill Valley. Also of note, Belvedere Lagoon area homes could be temporary flooded with saltwater during a storm surge event.

Canal neighborhood, San Rafael, is highly vulnerable to sea level rise. Credit: MarinMap

As shown in Table 9, he ranking of communities by percent of parcels that could experience tidal flooding in medium-term scenario3 are:

1. Greenbrae, 66 percent of parcels
2. Almonte, 47 percent of parcels, and
3. St. Vincent's, 18 percent of parcels.

The additional 100-year storm surge increases the portion of vulnerable parcels to alarming levels in Greenbrae and Almonte. The top three vulnerable communities by proportion of parcels flooded during a storm surge event are:

1. Greenbrae, 80 percent of parcels,
2. Almonte, 76 percent of parcels, and
3. Santa Venetia, 36 percent of parcels.

Looking closer at land use county wide shows that the majority is vulnerable parcels is made up of residential parcels. This includes multi-family, single-family, and floating homes. As shown in Table 14, by proportion, about 20 percent of industrial parcels could anticipate tidal flooding at MHHW. At the community level:

- *All* of the residential parcels in Greenbrae could face some storm related flooding on the marshland parcels and the associated landward parcels, where many residents park their vehicles.
- If Santa Venetia's existing levees are overtopped as predicted, nearly 40 percent of

the residential parcels there could anticipate temporary bay flooding.

- Similarly, Belvedere could expect storm surge flooding on up to 22 percent of residential parcels.
- Corte Madera could experience storm surge flooding on 57 percent of its industrial parcels, and sixteen percent of its residential parcels eat of US Highway 101.
- Larkspur could expect storm flooding on 90 percent of its industrial parcels east of US Highway 101.
- San Rafael could experience flooding on 57 percent of industrial parcels and 28 percent of commercial parcels.
- Bel Marin Keys could anticipate storms urge flooding on 23 percent of residential parcels.

Table 9. Number & Proportion of Vulnerable Parcels by Community in the Medium-Term

Location		Scenario 3		Scenario 4	
		#	%	#	%
Municipalities	San Rafael	1,301	7	2,188	12
	Larkspur	121	3	445	10
	Mill Valley	80	1	338	6
	Belvedere	52	5	210	21
	Tiburon	47	1	49	1
	Sausalito	48	1	68	2
	Corte Madera	68	2	635	17
	Novato	6	0	55	0
Unincorporated Jurisdictions	Waldo Pt.	64	13	73	14
	Greenbrae	57	66	70	80
	Bel Marin Keys	97	13	172	23
	Paradise Cay	38	10	54	15
	Strawberry	25	2	76	5
	Almonte	32	47	52	76
	Bayside Acres	19	9	20	9
	Tiburon	16	5	22	7
	St. Vincent's	12	18	13	19
	Santa Venetia	4	0	652	39
	Kentfield	3	0	9	0
	San Quentin	1	1	1	1
	Black Point	15	2	46	5
	Country Club	2	0	2	0
	Tamalpais	3	0	98	4
	North Novato	None		24	3
Study Area		**3,191**	**5**	**5,372**	**8**

Source: MarinMap, CoSMoS

Long-term: Scenarios 5 &6

Throughout the study area, more than 8,000 parcels, or 10 percent of parcels in the study area, could be impacted by 60 inches of sea level rise. Add on the 100-year storm surge, and nearly 12,800 parcels, about 20 percent of all parcels in the study area.

Table 10. Vulnerable Land Uses in the Medium-term

Land Use	Scenario 3		Scenario 4	
	#	Acres*	#	Acres*
Multi-family Residential Improved	102	41	144	56
Multi-family Residential Unimproved	4	1	5	1
Mobile Homes	0	0	166	1
Single Family Attached	465	6	1,092	29
Single Family-Residential Improved	270	94	1,402	305
Single- Family Residential Unimproved	43	28	69	50
Floating Home	52	1	53	1
Commercial Improved	133	123	343	505
Commercial Unimproved	17	89	42	177
Industrial Improved	49	23	158	99
Industrial Unimproved	5	2	19	5
Common Area	12	48	30	122
Rural Unimproved	1	28	1	28
Exemption Improved	14	9	31	17
Exemption Vacant	5	69	5	69
Tax Exempt	135	2,738	314	4,636
No Data	4	9	4	9

Source: MarinMap, CoSMoS

** Whole parcels are counted, not just the exposed portion of the parcel.*

Table 11. Vulnerable Parcels at MHHW by Community in the Long-term

Location		Scenario 3	Scenario 4
		60" MHHW	+100-year Storm Surge
Municipalities	San Rafael	1,856	2,121
	Novato	3,998	4,249
	Corte Madera	906	994
	Larkspur	379	544
	Tiburon	106	135
	Mill Valley	190	273
	Sausalito	84	149
	Belvedere	169	180
Unincorporated Jurisdictions	Bel Marin Keys	2,332	2,350
	Waldo Point	611	613
	St. Vincent's	1,240	1,413
	Strawberry	328	375
	North Novato	2,827	2,930
	San Quentin	122	135
	Tiburon	107	113
	Almonte	146	157
	Paradise Cay	91	111
	Santa Venetia	232	269
	Pt. San Pedro	78	83
	Greenbrae	24	24
	Kentfield	53	118
	Bayside Acres	12	11
	Country Club	9	10
	Black Point	388	408
	Tamalpais	28	30
	Marin City	7	36
	California Park	9	10
Study		**6,685**	**16,332**

Source: MarinMap, CoSMoS

Marin Yacht Club, San Rafael. Credit: Marin County CDA

By number of parcels, the top three impacted communities in long-term scenario 5 are:

1. San Rafael, 2,650 parcels,
2. Corte Madera, 1,104 parcels, and
3. Novato, 800 parcels.

San Rafael, one of the largest communities in the study area, is the most impacted with more than twice as many impacted parcels as the next highest municipality. In San Rafael, the 2,650 vulnerable parcels account for 15 percent of all parcels, 12 percent of residential, and 40 percent of commercial parcels. With the additional 100-year storm surge, an additional 1,000 parcels in San Rafael could be vulnerable to temporary floodwaters. This could damage one fifth of the city overall, with 20 percent residential and 50 percent commercial parcels vulnerable.

According to San Rafael asset managers, vulnerable buildings include 30 grocery stores, 10 pharmacies, 16 medical clinics, 48 doctor offices, 35 childcare facilities, five residential care facilities, seven convalescent facilities, 16 gas stations, 29 building supply stores, and other critical facilities. These businesses contain essential goods, such as food, medical, and buildings supplies.

The second most impacted community by number of parcels, Corte Madera, is also the second most impacted by proportion of vulnerable parcels. One third of Corte Madera parcels could be vulnerable to sea level rise, and more than 40 percent of parcels could be impacted by additional storm surge at this sea level. Nearly 30 percent of residential and 70 percent of commercial parcels could be impacted as well. Adding the storm surge at this sea level, Corte Madera could anticipate impacts to nearly 40 percent of the residential parcels, and 80 percent of the commercial parcels. These properties include homes and major regional retailers.

Novato is the next highest by count; however, these parcels constitute a small percentage of residential and commercial parcels in the community, as many of these parcels are not developed. Larkspur follows, nearing 700 parcels, with a large portion of vulnerable commercial parcels. Similar is true for Tiburon. In Belvedere, 30 to 40 percent of parcels are vulnerable, including 30 to 40 percent of residential and commercial parcels. With the storm surge, these numbers rise to 50 to 60 percent. Mill Valley and Sausalito could anticipate significant

impacts as well, especially with the 100-year storm surge associated with scenario 6.

The top three vulnerable communities by portion of parcels flooded tidally by long-term scenario 5 are:

1. Bel Marin Keys, 94 percent,
2. Greenbrae, 80 percent, and
3. Almonte, 78 percent of parcels.

This outcome mirrors earlier outcomes, where the smallest shoreline communities could expect flooding throughout the entire developed area.

With respect to land use, 10 percent of residential parcels county wide could become vulnerable by long-term scenario 5. While less significant in number, by proportion, a concerning 27 percent of commercial, and 37 percent of industrial parcels county wide could be vulnerable to tidal flooding at MHHW with 60 inches of sea level rise.

The 740 commercial parcels in the study area that could flood at MHHW host 1,720 buildings with 115 living units that would become useable. Vulnerable businesses are concentrated in San Rafael, with more than 550 impacted parcels with structures, with Corte Madera, Larkspur and Sausalito being the next most impacted, nearing 100 parcels with structures each. Vulnerable residential parcels host approximately 8, 450 living units that would flood directly, or at least be difficult to leave or return to.

In unincorporated Marin, Strawberry could expect about 15 percent of commercial parcels to be impacted by sea level rise, and 30 percent of the commercial parcels to be impacted with the additional storm surge, though primarily in the parking areas. Commercial parcels in Black Point tend to be located in the low-lying State Route 37 corridor, and could tidally flood on about 30 percent of parcels, and storms urge flood an additional five percent of parcels. Waldo Point Harbor house boats and commercial areas could also be significantly impacted, especially to the 100-year storm surge.

Table 12. Number & Portion of Vulnerable Parcels in the Long-term

	Location	Scenario 5		Scenario 6	
		#	%	#	%
Municipalities	San Rafael	2,646	15	2,646	15
	Larkspur	687	15	687	15
	Mill Valley	361	6	361	6
	Belvedere	356	36	356	36
	Tiburon	145	4	145	4
	Sausalito	88	3	88	3
	Corte Madera	1,104	30	1,104	30
	Novato	800	4	800	4
Unincorporated Jurisdictions	Waldo Pt.	75	15	75	15
	Greenbrae	70	80	70	0
	Bel Marin Keys	711	94	711	94
	Paradise Cay	103	28	103	28
	Strawberry	155	9	155	9
	Almonte	53	78	53	78
	Bayside Acres	23	11	23	11
	Tiburon	18	5	18	5
	St. Vincent's	22	32	22	32
	Santa Venetia	653	39	653	39
	Kentfield	52	2	52	2
	San Quentin	1	1	1	1
	Black Point	66	8	66	8
	Country Club	6	1	6	1
	Tamalpais	94	4	94	4
	North Novato	30	4	30	4
	California Park	41	15	41	15
	Marin City	None		20	4
	Pt. San Pedro	None		5	50
	China Camp	None		5	45
Total		**8,360**	**13**	**12,763**	**19**

Source: MarinMap, CoSMoS

LAND

Table 13. Vulnerable Land Uses in the Long-term

Land Use	Scenario 5		Scenario 6	
	#	Acres*	#	Acres*
Multi-family Residential Improved	192	77	345	292
Multi-family Residential Unimproved	12	2	19	10
Mobile Homes	204	1	220	1
Single Family Attached	1,948	57	2,776	83
Single Family-Residential Improved	4,070	801	5,940	1,384
Single- Family Residential Unimproved	147	88	275	375
Floating Home	52	1	53	1
Commercial Improved	643	796	1,016	1,795
Commercial Unimproved	95	308	133	364
Industrial Improved	204	128	289	519
Industrial Unimproved	38	162	53	170
Common Area	55	188	143	392
Agricultural Improved	1	169	2	640
Agricultural Unimproved	4	317	5	721
Rural-(Improved)	0	0	3	275
Rural Unimproved	10	660	20	880
Exemption Improved	71	44	110	367
Exemption Vacant	19	491	23	494
Tax Exempt	582	8,903	983	16,277
No Data	18	88	28	132

Source: MarinMap, CoSMoS

**Whole parcels are counted, not just the exposed portion of the parcel.*

Condos along Saltworks Canal, Strawberry. Credit: Marin County DPW

In scenario 6, by nearly a factor of nine, the majority of the storm flooded parcels consists of residential parcels, and amounts to 15 percent of all residential parcels in Marin County. In addition, while significantly fewer in number, the vulnerable commercial parcels are more than 40 percent of all commercial parcels in the County. More alarming is that more than 50 percent of industrial parcels could be impacted by flooding during a 100-year storm surge. The 1,149 commercial parcels hosting 2,180 businesses and 258 living units could be vulnerable by scenario 6, 60 inches of sea level rise and 100-yearstorm surge.

As shown in Table 14, the community with the greatest portion of their residential parcels impacted is Greenbrae, with 100 percent of parcels potentially facing tidal flooding. If the tide gates are open or are unable to hold back water, 95 percent of Bel Marin Keys residential parcels could face tidally flooding. In addition, Santa Venetia could anticipate tidal flooding on up to 40 percent of residential parcels, followed by Belvedere and Paradise Cay.

With the 100-year storm surge variable, 100 percent of Greenbrae and Bel Marin Keys could flood making living on dry land a challenge for each entire community. Sixty percent of residential parcels in Paradise Cay and fifty percent in Santa Venetia could flood during a storm surge, only ten percent of which would only suffer storm surge flooding, while the other parcels would experience both tidal and storm surge flooding.

The community with the greatest portion of commercial parcels impacted by tidal flooding at 60 inches of sea level rise is Tamalpais Valley, where much of the commercial development is along

Shoreline Highway in Tamalpais Junction. Corte Madera's vulnerable highway corridor commercial development constitutes 66 percent of all commercial parcels in Corte Madera. Tiburon follows, with 64 percent of commercial parcels, concentrated in the downtown Tiburon area, under tidal influence by long-term scenario 5.

By long-term scenario 6, both North Novato, at Binford Road, and Black Point, along State Route 37, could expect 100 percent of commercial parcels to flood. Belvedere and Almonte could expect more than 80 percent of commercial parcels to flood. Tamalpais Valley and Corte Madera could anticipate about 80 percent of commercial parcels flooding.

By long-term scenario 5, all industrial land in Larkspur and Almonte could flood at MHHW. More than 70 percent of Corte Madera and North Novato industrial parcels could flood at the average higher high tide. By long-term scenario 6, these areas would experience additional storm surge flooding. In addition, 100 percent of North Novato and Pt. San Pedro industrial land could be compromised during a 100-year storm-surge event. San Rafael could suffer, followed by Sausalito, which could expect 62 percent of the industrial parcels to flood with surge waters.

Landfill Sites

Marin residential and business garbage is disposed of at Redwood Landfill. This site may be vulnerable to sea level rise; however, the CoSMoS model does not incorporate recent improvements to the levees surrounding the site intended reduce flooding potential. Thus, modeled sea level rise projections likely overestimate flooding potential on this site. Waste Management makes regular improvements to the levees to account for subsidence, sea level rise, and pest damage.

The formally operated and now inactive landfill sites in the exposure area are:

- San Quentin Disposal Site, San Rafael: Vulnerable at the existing Marin Honda dealership. Vulnerable by scenario 5.
- Ghilotti Brothers Disposal Site, San Rafael: Site is completely surrounded by tidal waters by scenario 5 water levels.
- Horst Hanf Landfill, now Bayview Business Park, San Rafael: Vulnerable at about 40 inches of sea level rise, between scenarios 3 and 5.
- Bellam Landfill, San Rafael: Vulnerable by scenario 5.
- Hamilton Army Airfield Landfill #26: Vulnerable by scenario 5.
- Dunphy Park, Sausalito: Completely covered by, scenario 5.
- Larkspur Disposal Site (Piper Park): Impacts as early as 40 inches of sea level rise, between scenarios 3 and 5, and could anticipate site wide impacts by scenario 5.
- Mill Valley Dump, now Mill Valley Middle School, vulnerable to overland flooding by scenario 5.

Landfills are often subjected to subsidence because they are typically located where marshes once existed, and because buried materials settle over time. If toxic substances are contained in these sites, the toxin could be carried off the site and into the bay.

The maps on the following pages show the northern and southern study area parcels that could be vulnerable to the rising average higher high tide and 100-year storm activity modeled across the 6 scenarios. The areas in the call out circles enable the reader the see areas that are difficult to see on the large scale map. The circles do not indicate that these areas are more vulnerable than others along the shoreline.

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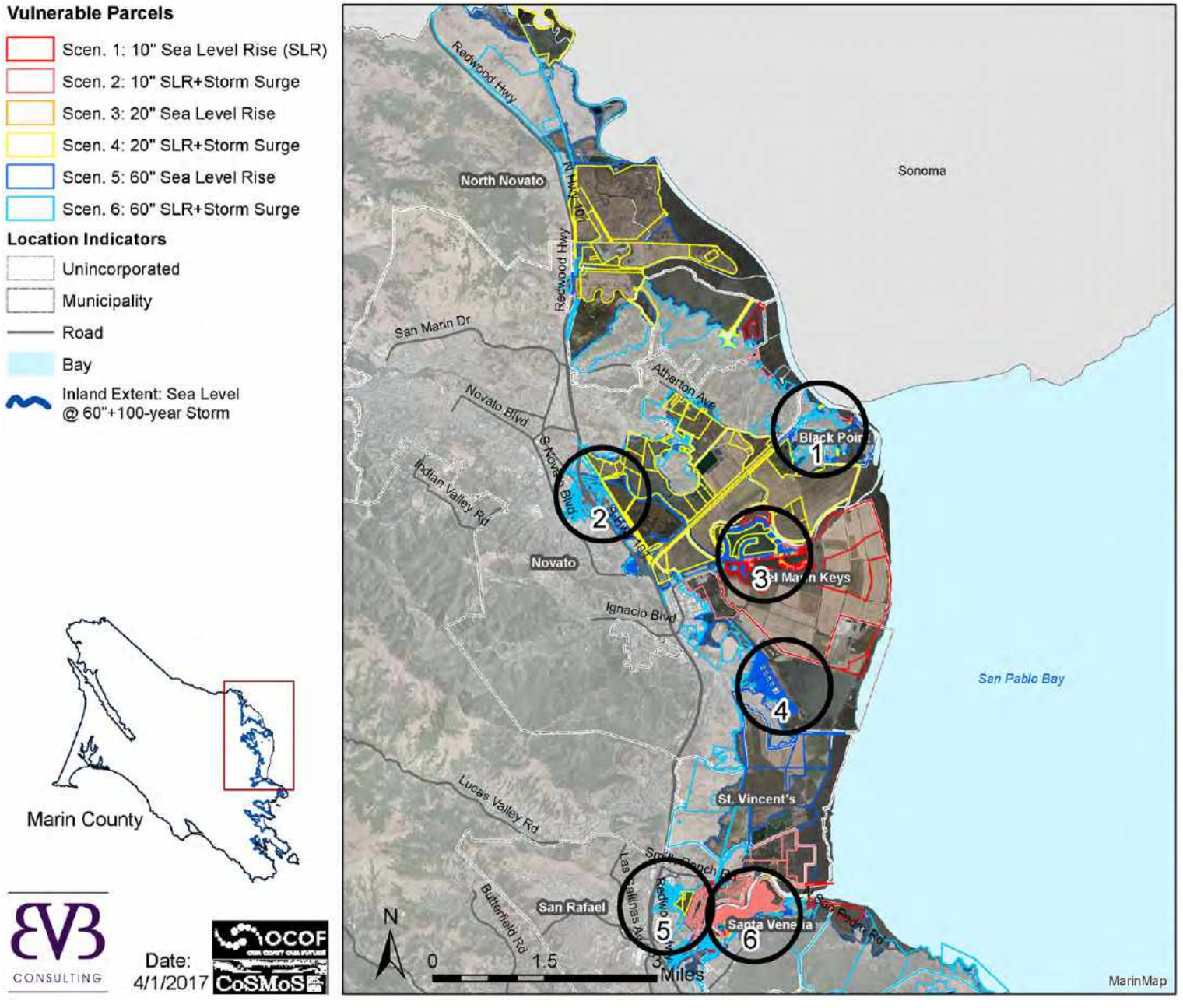
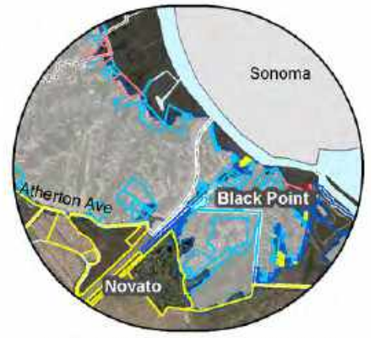
Table 14. Portion of Industrial, Residential, and Commercial Land Uses Vulnerable to Sea Level Rise by Community and Onset

	Location	Scenario 1			Scenario 2			Scenario 3			Scenario 4			Scenario 5			Scenario 6		
		% of industrial	% of residential	% of commercial	% of industrial	% of residential	% of commercial	% of industrial	% of residential	% of commercial	% of industrial	% of residential	% of commercial	% of industrial	% of residential	% of commercial	% of industrial	% of residential	% of commercial
Municipalities	San Rafael	17	3	11	52	9	24	37	6	19	57	10	28	61	12	40	76	16	50
	Larkspur	0	2	0	83	5	11	30	2	4	91	9	13	**100**	15	18	**100**	25	48
	Mill Valley	0	1	1	0	3	5	0	1	1	0	5	13	0	6	10	0	12	32
	Belvedere	0	5	0	0	5	0	0	5	0	0	22	25	0	37	33	0	47	58
	Tiburon	0	1	7	0	1	7	0	1	9	0	1	7	0	3	64	0	7	**84**
	Sausalito	3	0	2	21	0	4	8	0	3	30	0	5	41	0	10	62	2	51
	Corte Madera	0	0	0	0	5	17	0	2	3	9	16	41	**76**	29	66	76	39	77
	Novato	0	0	0	0	0	0	0	0	0	2	0	1	5	4	3	22	6	9
Unincorporated Jurisdictions	Almonte	75	0	1	**100**		48	**100**	0	2	**100**	0	70	**100**	0	74	**100**	1	87
	Bayside Acres	0	11	1	0	11	0	0	18	1	0	11	0	0	13	0	0	21	0
	Bel Marin Keys	0	4	0	0	14	0	0	47	0	0	19	0	0	95	0	0	100	0
	Black Point	0	0	0	0	0	0	0	0	0	0	4	18	0	6	27	0	19	36
	California Park	0	0	0	0	0	0	0	0	0	0	0	0	0	18	0	0	23	100
	China Camp SP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Country Club	0	2	0	0	0	0	0	3	0	0	0	0	0	2	0	0	6	0
	Greenbrae	0	85	0	0	97	0	0	85	3	0	100	0	0	**100**	0	0	**100**	0
	Kentfield	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	8	0
	Marin City	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	50
	North Novato	0	0	0	0	0	0	0	0	0	57	0	20	71	0	40	100	0	100
	Paradise Cay	0	20	1	0	12	0	0	19	1	0	19	0	0	36	0	0	66	0
	Pt. San Pedro	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100	**100**	0
	San Quentin	0	5	0	0	0	0	0	5	0	0	0	0	0	0	0	0	11	0
	Santa Venetia	0	3	0	0	38	5	0	3	0	0	39	5	0	40	10	0	50	10
	St. Vincent's	0	0	1	0	0	0	0	0	1	0	0	0	0	0	**100**	0	**0**	**100**
	Strawberry	0	7	0	0	1	2	0	7	0	0	4	9	0	9	15	0	17	32
	Tamalpais	0	0	0	0	3	76	0	0	0	0	0	76	0	3	76	0	3	76
	Tiburon	0	20	0	0	9	0	0	20	0	0	9	0	0	7	0	0	32	0
	Waldo Point	4	1	3	16	14	5	13	1	3	16	14	47	16	0	60	16	14	73
	Marin County	8	1	5	27	5	14	19	2	6	32	6	18	37	10	27	53	15	42

Source: MarinMap, CoSMoS

Map 10. Northern Study Area Parcels Vulnerable to Sea Level Rise





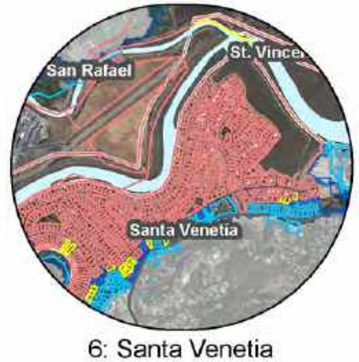
1: Black Point/Green Point

2: U.S. Hwy. 101 @ Rowland Blvd.

3: Bel Marin Keys

4: Hamilton

5: Marin Lagoon/ Marin Commons



6: Santa Venetia

Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data providers here in, make no warranties of the accuracy or completeness of maps and data. Maps are representational and subject to future revision. Local site conditions must be examined. Commercial use is prohibited.

Map 11. Southern Study Area Parcels Vulnerable to Sea Level Rise and a 100-year Storm Surge

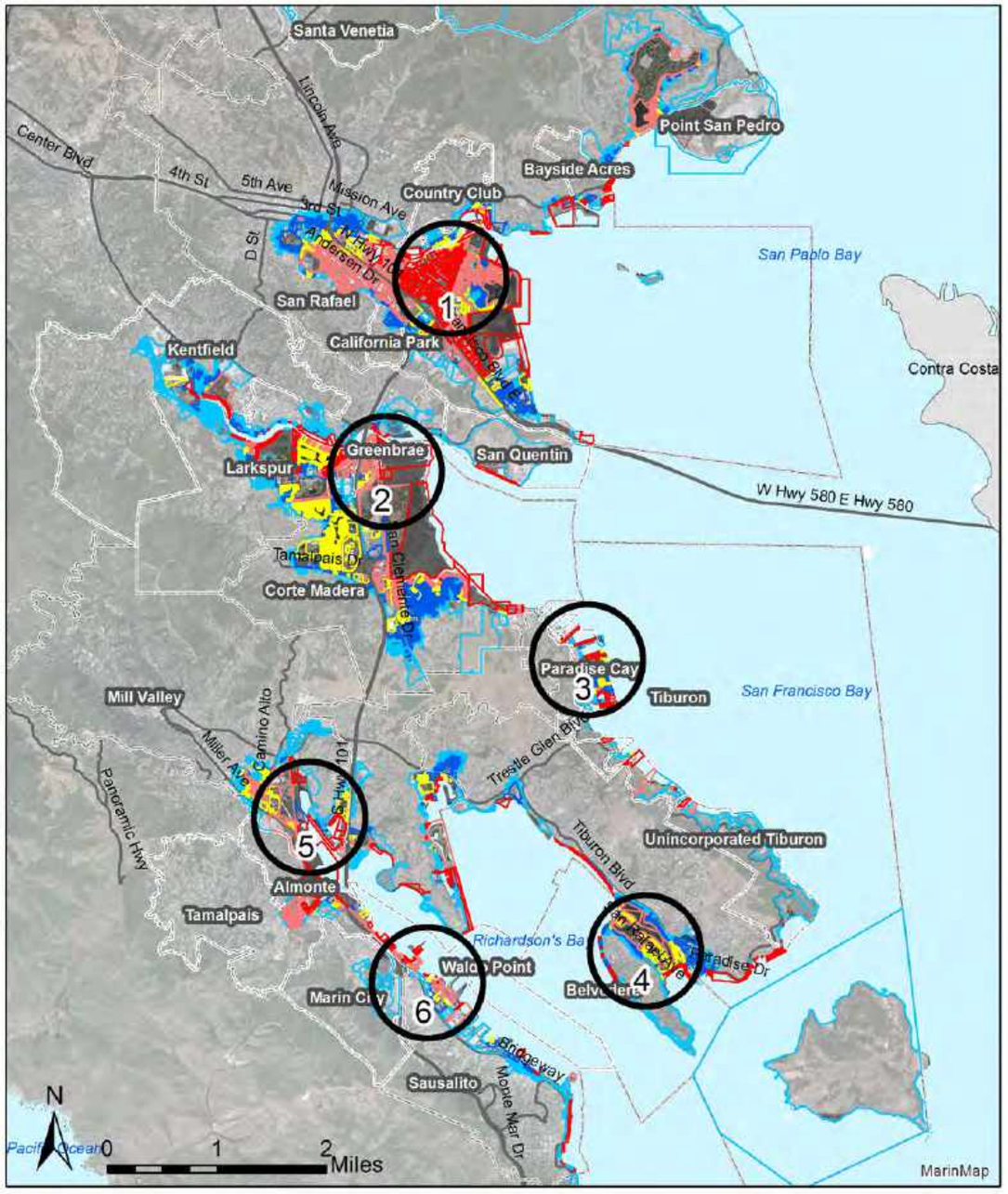
Ne residents

Vulnerable Parcels

- Scen. 1: 10" Sea Level Rise (SLR)
- Scen. 2: 10" SLR+Storm Surge
- Scen. 3: 20" Sea Level Rise
- Scen. 4: 20" SLR+Storm Surge
- Scen. 5: 60" Sea Level Rise
- Scen. 6: 60" SLR+Storm Surge

Location Indicators

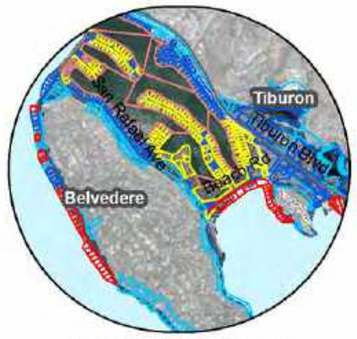
- Unincorporated
- Municipality
- Road
- Bay
- Inland Extent: Sea Level @ 60"+100-year Storm



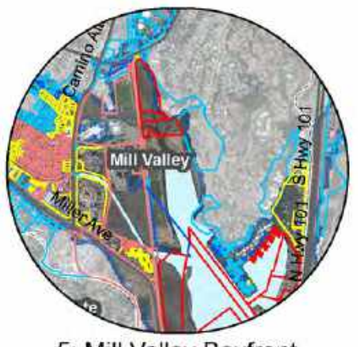
1: Canal Neighborhood

2: Greenbrae/Larkspur

3: Paradise Cay



4: Belvedere/Tiburon



5: Mill Valley Bayfront

6: Waldo Pt. Harbor

Date: 6/15/2017

Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data providers here in, make no warranties of the accuracy or completeness of maps and data. Maps are representational and subject to future revision. Local site conditions must be examined. Commercial use is prohibited.

Other Considerations

Economic

The Marin shoreline accounts for hundreds of millions of dollars in economic activity. The more than 12,000 vulnerable properties, account for $9 billion[46] in assessed land value as shown in Table 15. Buildings account for even more value, as presented in the Buildings Profile. Unincorporated Marin parcels that are expected to be vulnerable to sea level rise contribute $100 million[47] in annual property tax revenue to roughly 55 taxing agencies. Municipal tax revenues would add several hundred million in additional revenues to this figure. Table 16 breaks down the $100 million in property tax contributions from the vulnerable properties in unincorporated Marin. Improvements, such as buildings and utility services, also contribute to tax contribution figures.

Properties that become part of the tidal prism could face new or increasing lease costs for existing on what would become public trust land. This would add an extra cost of living for shoreline property owners. Consequently, in some cases, state regulatory requirements could be a hurdle for individual property owners in preparing for sea level rise and maintaining their properties in the most cost effective ways.

Finally, several areas are protected by shoreline armoring, such as seawalls, revetments, levees, bulkheads, bluff walls, and other hard engineering structures, to impede flooding and erosion. These protective structures may be, or become, too low, requiring increased maintenance, replacement, or relocation as tides rise. Typically, any of these improvements can be costly to a land owner or to tax payers. Many structures are in need of repair to withstand existing conditions. Several structures in the northern study area are on public lands and maintained by a government agency. Individual private properties in Santa Venetia and other shoreline locations also feature protective walls.

Table 15. Assed Value of Vulnerable Parcels in Long-term Scenario 6

Location	Assessed Land Value
Municipalities	
Belvedere	$514,534,915
Corte Madera	$587,230,682
Larkspur	$545,595,904
Mill Valley	$251,987,082
Novato	$367,196,698
San Rafael	$1,121,051,641
Sausalito	$208,295,600
Tiburon	$225,509,830
Unincorporated Jurisdictions	
Almonte	$257,783,545
Bayside Acres	$69,653,807
Bel Marin Keys	$189,484,482
Black Point	$160,685,655
California Park	$42,337,997
Country Club	$158,247,024
Greenbrae	$15,424,906
Kentfield	$1,680,999,994
Marin City	$114,975,806
North Novato	$186,992,022
Paradise Cay	$193,534,136
Pt. San Pedro	$26,235
San Quentin	$8,213,721
Santa Venetia	$347,647,404
St. Vincent's	$5,532,566
Strawberry	$954,668,631
Tamalpais Valley	$853,733,767
Tiburon	$170,837,044
Waldo Point Harbor	$6,174,871
Total	**$9,238,355,965**

Source: Marin County Department of Finance 2015/2016 tax year

[46] 2016 dollars
[47] 2016 dollars

Table 16. Tax Generation for Parcels Vulnerable to Sea Level Rise Long-term Scenario 6

Tax District	Tax Revenue
County General	$22,835,222
Tamalpais High School District	$10,781,271
Marin Community College	$7,360,565
Education Revenue Augment	$7,303,352
Mill Valley School District	$6,991,178
Southern Marin Fire	$5,750,363
Kentfield School District	$5,225,279
Kentfield Fire	$4,109,315
Novato Unified School District	$3,765,050
County Library	$2,954,595
County School Service Fund	$2,528,240
San Rafael Elementary Schools	$2,253,634
Community Service Area (CSA) #19 Fire Protection	$1,950,984
Novato Fire	$1,906,311
San Rafael High School	$1,690,337
Ross Valley Sanitation No. 1	$1,564,305
Reed Union School	$1,446,789
Marin County Open Space	$1,020,102
Tiburon Fire	$795,261
Richardson Bay Sanitation	$745,599
Tamalpais Community Service District (CSD)	$649,472
Flood Control Zone (FCZ) 3 Richardson Bay	$635,130
Marin County Highway Lt	$615,373
Sausalito-Marin City School District	$595,858
Marin County Transit	$586,546
County Fire Department	$512,272
Ross School	$493,532
Strawberry Recreation	$473,938
Bel Marin Keys CSD	$443,596
CSA 17 Kentfield	$401,931
FCZ 7 Santa Venetia	$359,149
Mosquito Abatement	$317,948
Corte Madera Sanitation No. 2	$288,308
Marin City CSD	$270,722
FCZ 1 Novato	$215,209
Bay Area Air Quality	$205,089
#6 Novato Sanitation	$146,654
CSA 18 Gallinas	$128,756
FCZ 4 Bel Aire	$127,962
Almonte Sanitation	$108,938
Las Gallinas Valley Sanitary District	$104,146
FCZ 9 Ross Valley	$81,954
Larkspur-Corte Madera School District	$80,287
San Rafael Sanitation	$64,836
CSA 6 Santa Venetia	$57,811
Sausalito-Marin City Sanitation	$55,230
CSA 16 Greenbrae	$46,234
Tiburon Sanitation No. 5	$41,804
Murray Park Sanitation	$41,684
San Quentin Sanitation	$19,282
Alto Sanitation	$19,182
CSA 9 Northbridge	$12,074
North Marin Water	$10,822
Petaluma Joint High	$7,026
Dixie School District	$6,543
Santa Rosa Junior College-Laguna Joint School	$1,275
Lincoln School	$723
Total	**$101,205,044**

Source: S. Kucharos, County of Marin Department of Revenue, June 6. 2016

Environmental

Existing seawalls and other shoreline protective devices that could be enhanced or added to protect buildings could result in the loss of beaches, wetlands, and other habitats and recreational areas by preventing these areas from migrating inland. Industrial sites could contain toxic chemicals that could be ecologically damaging if it enters the bay waters. As tidewaters move into marshlands, high marsh, or areas with infrequent saturation could become saturated more often and shift to low marsh, and eventually mudflats, and lastly open water. This could have devastating impacts on natural and recreational resources. Developing new unimproved lands to replace the land that becomes undevelopable could destroy inland habitats. Additionally, upgrading infrastructure that already passes through sensitive marsh and tidal habitats could be temporarily impaired as room is made to

undergo construction. To learn more about the outfall of these potential consequences, see the Natural Resources and Recreation Profiles.

Social Equity

The primary issue with respect to parcels is the difference in tenure. Property owners may be more able to prepare for and implement preparation measures to protect their wellbeing. Whereas, renters would not have the power or ability to change their residence in advance of sea level rise and would be dependent on the action of the property owner and larger public works. This is especially critical because a significant portion of the properties impacted in the near-term host large numbers of multi-family rental units, this disconnect could present challenges in reaching the residents and ensuring their safety.

Without programs to get the word out, renters may miss out on important information and resources to stay safe during storm events and prepare for sea level rise. With long-term sea level rise, displaced residents may not have access to equivalent or affordable housing near the jobs, schools, social networks, and facilities they rely on.

Public shoreline access may also be diminished as parks become inundated, impacting recreational opportunities for everyone, though these impacts could be disproportionately burdensome by lower-income households, especially those fish for food off of public piers and pathways. See the Recreation Profile to learn more about public land equity considerations.

Management

On County of Marin jurisdiction lands, the Baylands District provides for open space, outdoor recreation, and other open lands, including areas suited for park and recreational purposes, access to beaches, and areas that link major recreation areas. State and Federal areas are managed by policies of those governing agencies to provide public access as well.

The Bay Conservation Development Commission (BCDC) retains development permit authority over tidelands below mean high tide, submerged lands, and public trust lands. Potential state boundary changes could occur as waters rise and shift mean sea level rise inland. This would cause the public trust land boundary and regulations to move further inland. This could complicate existing property ownership and management.

In addition, political will and funding would be required to acquire land for necessary road alterations, or other public infrastructure relocations. In most cases, facilities and structures on private property are the responsibility of the property owner. This can present complications when shoreline armoring is owned by individual property owners as is the case in Santa Venetia. Efforts to improve the levees on a comprehensive scale may prove challenging amongst so many decision makers

BUILDINGS

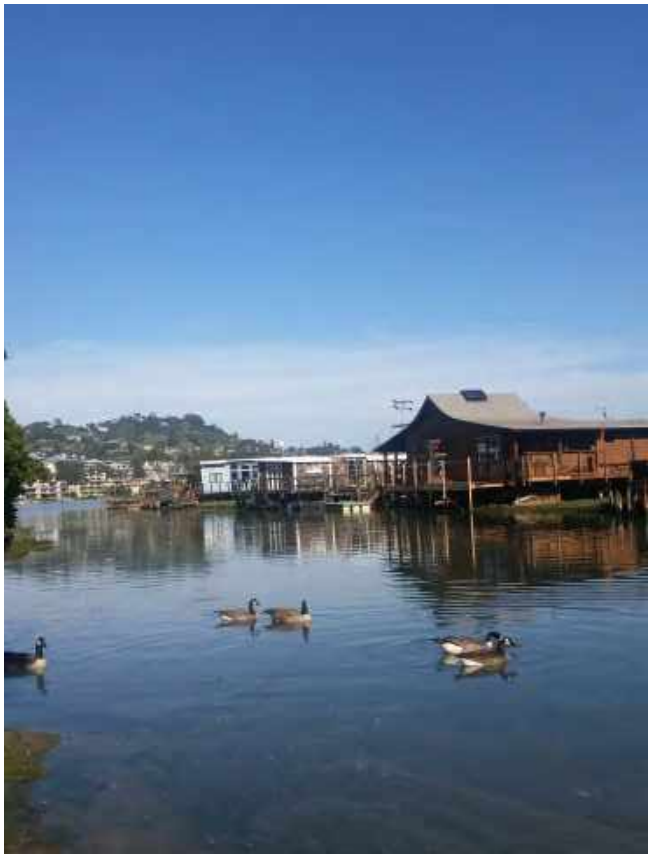
Asset Profile: Buildings

Buildings on the flooded parcels are significant assets along the Marin shoreline. Buildings house commercial activity, learning, worship, employment, home, and daily life. In addition, buildings provide a significant amount of wealth and equity for property owners. Moreover, everyone, despite age, income, or ethnicity uses and depends on the function of several buildings across the region. The following are key issues related to building vulnerability:

- Almost all buildings along Marin's shoreline could be vulnerable to tidal and/or storm surge flooding.
- Many homes and their surroundings are built on filled bay mud and could sink, or subside, as the ground below saturates with water.
- According to utility managers, the earliest threats of flooding and subsidence may be to non-structural building components, such as utility and mechanical systems at or below grade. Malfunctions could make a building unusable even if the building is dry.[48]
- Buildings untouched by rising tides may become isolated and cut off from essential services, such as wastewater service and roads.
- A large majority of existing armoring protecting buildings along the shoreline, except in Hamilton and the Redwood Landfill, could be overtopped daily after three feet of sea level rise.
- In San Rafael's Canal neighborhood, one of the lowest income and most diverse areas of the shoreline, a large number of residents and businesses could be impacted in the near-term. By the end of the century the entire area could flood daily from the shoreline to I-580 and US-101.
- Several public facilities, including three schools, the Tiburon Fire Station, San Rafael Fire Station 54, Larkspur Ferry and emergency fuel tanks, and the Sewerage Agency of Southern Marin (SASM) wastewater treatment plant could be vulnerable in the near to medium-term.
- The Belvedere/Tiburon Post Office, San Rafael Main Post Office, San Rafael Transit Center, and seven schools could be vulnerable to sea level rise in the long-term.
- Several retirement and/or lower income communities are impacted in the long-term.
- The majority of impacted buildings are on residential parcels.

IMPACTS AT-A-GLANCE: SCENARIO 6

12,000+ homes, businesses, & institutions	100,000+ people
Billions of dollars in built assets vulnerable	Regional
Houseboats, mobile homes, multi-family housing, single-family housing	Property Owners County CDA Sausalito Mill Valley Belvedere Tiburon Corte Madera Larkspur Corte Madera San Rafael Novato



Lagoon homes on Boardwalk I, Corte Madera Creek. Larkspur. Credit: BVB Consulting LLC

[48] See Appendix A for a list of interviewed utility managers.

BUILDINGS

Structural Factors

Most of the vulnerable buildings in the study area, especially residential and office, are wooden single-story or two-story buildings, and are susceptible to water damage from flooding and storm surges. Buildings built prior to 1970 typically have T-footing foundations that extend 18 inches deep. Such buildings are prone to scouring from water hitting above their foundations, and their wooden floors are more likely to slide off the foundation. This foundation type is very common amongst the vulnerable buildings in the study area.

Homes built after 1970 are secured to drilled piles 20-30 feet deep with reinforced steel cages and concrete to connect the homes to the foundation. These buildings are engineered to resist settling and earthquake impacts, and could withstand lateral forces from water and wind during storms. However, much of the older housing along the shoreline was built beginning in the 1950's. Areas such as Almonte, Waldo Point Harbor, and Marin City in Southern Marin were built as work force housing under low budget conditions. In the Canal neighborhood, vulnerable buildings are a mix of apartment complexes, light industrial sites, and neighborhood commercial sites. One section, near Spinnaker Point, is a single family home subdivision that is not directly at risk until later in the century; however, vehicular access during high tides and storm surges may prove challenging before then.

In addition, Almonte, Belvedere, Santa Venetia, Paradise Cay, Bel Marin Keys, the Corte Madera shoreline, the Marinship neighborhood of Sausalito, and shoreline and downtown portions of San Rafael were built on bay fill and mud, and already experience subsidence. These areas could anticipate increased rates of subsidence as bay waters saturate the soil from the below. Tamalpais, Corte Madera, Santa Venetia, Bel Marin Keys, Belvedere, and Almonte are bordered by earthen berms, or levees, that provide protection under current sea levels; however, these structures could expect overtopping after three feet of sea level rise. Bel Marin Keys, Corte Madera, and Belvedere also manage lagoons that are relatively protected from tidal influences if properly managed and overtopping does not occur.

A few mobile home parks are at risk including the Los Robles Park in Novato, Marin Valley Country Club in Novato, Contempo Marin in San Rafael, Golden Gate Trailer Park in Larkspur, and Marin RV Park in Greenbrae. All of these are relatively close to the shoreline marshes and are prone to flooding.

Floating homes are another major housing type in southern Marin and could be some of the most impacted. Many of these homes are tethered to pylons with u-locks that could float off the top of the pier if the tide is high enough. Others are tied with ropes that have their limits, and if the tides rise higher than the ropes, the boat could sink. The most vulnerable houseboat types, known as arks, are attached to the ground on a thick concrete foundation and do not fluctuate with the tides. About 20 arks are harbored in Richardson's Bay.

All 450 house boats in Richardson's Bay have the following vulnerabilities in common.

- They have utility lines tied to the docks and many of the docks are at a fixed elevation.
- Front entrances of many homes are on the lower level linked to the main dock with finger docks that go down or up with the tide. If the tide is too high, the finger docks may be dangerously slanted, or even flooded at one end or the other. These ramps are already relatively steep at king tides according to the Richardson Bay Floating Homes Association.
- In addition, the parking and access areas could be flooded and are already prone to continuous subsidence.

Area of Larkspur, Corte Madera, and Greenbrae could face similar impacts. Though unlike Waldo Point Harbor, metal utility pipes are fixed to the boardwalks.

Finally, though not buildings, unauthorized residential boats anchored in Richardson's Bay are highly vulnerable to storms and higher tides. According to the Richardson Bay Floating Homes Association, about 250 boats are in the Bay as residences, though some may be junk boats without residents.

Commercial structures, except for those on piers, and a few wooden structures, tend to be cinder block construction with stucco or paint sealing. Cinder block buildings built over twenty years ago are likely unreinforced and more vulnerable than newer reinforced buildings.

BUILDINGS

Greenbrae Boardwalk. April 2016. Credit: BVB Consulting LLC

Table 17. Vulnerable Buildings by Scenario

Scenario		Buildings	
		#	%
Near-term	1	717	1
	2	4,498	6
Medium-term	3	2,013	3
	4	5,608	7
Long-term	5	9,167	12
	6	12,138	16

Source: MarinMap, CoSMoS

Overall, Marin County shoreline properties, especially those on fill in the low-lying areas east of US Highway 101, are the most exposed and vulnerable to flooding, storm surges, and subsidence. The following sections present the available data for buildings in the near-, medium, and long-terms.

Near-term: Scenarios 1 & 2

In the near-term scenario 1, 10 inches of sea level rise, more than 700 buildings could be vulnerable to tidal flooding. The buildings are concentrated in:

1. San Rafael, 410 buildings,
2. Greenbrae, 72 buildings, and
3. Waldo Point Harbor, 61 buildings.

Table 18. Physical Vulnerabilities of Buildings

Factors	Influence
Building Elevation	▪ At or below grade – If the lowest floor is as high as or below the flood level, it is susceptible to saltwater flooding. Mechanical or electrical equipment, pumps, utilities, heat, ventilation, power, openings (e.g. windows, entryways, or ventilation grates), etc. can be vulnerable if at or below grade.[49] ▪ Bluff top developments are highly vulnerable to erosion and scouring of the bluff toe.
Materials	▪ Wooden buildings tend to be lighter and low-rise, and can incur structural damage.[50, 51] ▪ Cinder block, brick, and reinforced concrete built buildings are heavier, taller, and less vulnerable to damage.[52] Brick foundations are able to withstand up to 3 feet of flooding (highly unlikely unless building is very old).[53] ▪ Mobile and manufactured homes tend to be susceptible to flooding and may suffer in storm and high tide events.
Building Codes	▪ Buildings built before modern building codes and FEMA requirements for flood prone areas will be more susceptible.[54]
Surrounding environment	▪ Buildings in areas without or failing shoreline armoring are more vulnerable.
Foundation	▪ Older foundation types are more vulnerable to sea level rise. ▪ Buildings built on fill and/or bay muds could be vulnerable to worsening subsidence.

[49] The City of New York, *A Stronger, More Resilient New York* (2013), 75.
[50] Ibid.
[51] Bay Conservation and Development Commission, *Housing Indicators Table*. Unpublished document.
[52] The City of New York, *A Stronger, More Resilient New York* (2013), 75.
[53] Bay Conservation and Development Commission, *Housing Indicators Table*. Unpublished document.
[54] The City of New York, *A Stronger, More Resilient New York* (2013), 76.

BUILDINGS

Homes along San Pablo Bay, San Rafael. May, 2016. Credit: BVB Consulting LLC

Table 19. Vulnerable Buildings in the Near-term

	Location	Scenario 1		Scenario 2	
		#	%	#	%
Municipalities	San Rafael	410	2	1,846	10
	Larkspur	40	1	382	9
	Belvedere	32	2	84	5
	Tiburon	26	1	42	1
	Sausalito	21	1	113	4
	Novato	6	0	17	0
	Corte Madera	5	0	255	7
	Mill Valley	5	0	207	3
Unincorporated Jurisdictions	Greenbrae	72	59	112	91
	Waldo Point	61	16	89	23
	Bel Marin Keys	20	3	118	17
	Almonte	7	1	63	7
	Strawberry	7	0	58	3
	Paradise Cay	4	1	48	16
	Tiburon	1	0	18	6
	Santa Venetia			911	41
	Tamalpais			100	3
	Black Point			15	1
	North Novato			7	0
	Country Club			5	1
	Bayside Acres			3	1
	Pt. San Pedro			2	2
	China Camp			1	9
	De Silva Island			1	6
Total		**717**	**1**	**4,498**	**6**

Source: MarinMap, CoSMoS

Vulnerable buildings in San Rafael are concentrated in the Canal neighborhood, the lowest income and most diverse neighborhood in the region with many limited English proficient residents. Structures in Greenbrae and Waldo Point Harbor are houseboats that are highly vulnerable to higher high tides.

An additional storm surge, could impact more than 4,000 additional buildings, totaling six percent of the building stock in the study area. The top three communities with the highest number of vulnerable buildings under scenario 2 conditions are:

1. San Rafael, 2,000 buildings
2. Santa Venetia, 900 buildings, and
3. Larkspur, 400 buildings.

Of note, 250 buildings in Corte Madera, and 207 in Mill Valley could also experience flooding under the conditions of scenario 2.

By percent of building stock impacted under scenario 1 conditions, the top three vulnerable communities would be:

1. Greenbrae, 59 percent,
2. Waldo Point Harbor, 16 percent, and
3. Bel Marin Keys, 3 percent of buildings in the community.

These figures are presented in Table 19. During, a storm, significantly more buildings could be at risk, amounting to seven percent of buildings in the County. The top three communities by portion of building stock flooded are:

1. Greenbrae, 91 percent,
2. Santa Venetia, 42 percent, and
3. Waldo Point Harbor, 23 percent of buildings in the community.

These numbers are cause for concern in some of Marin's most unique small communities. And while this flooding may only be temporary, nuisance storm flooding could be reoccurring and devastating.

Flood Depth

Each property could flood with a different amount of water depending on the property's proximity to the Bay and its tributaries. While some buildings may be able to avoid some flooding because they are elevated above ground level, determining which of the 12,000 exposed buildings are elevated and by how much is beyond the scope of this report. Thus, the analysis in Table 20 assumes all vulnerable buildings are situated at ground level. This table illustrates how many of the vulnerable buildings are flooded with one, two, or ten feet of water in scenarios scenario 1, 3, and 5. Storm surge flooding in scenarios 2, 4, and 6, would add an additional three feet of flooding to the figures. In scenario 1, a majority of the vulnerable buildings could expect up to 3 feet of tidal flooding at MHHW. Flooding could be deeper at the highest tides and shallower at low tides. A few buildings could expect up to 9 or 10 feet of tidal flooding in the near-term.

Medium-term: Scenarios 3 & 4

In the medium-term, several more buildings in the communities vulnerable in the near-term could be flooded, especially during a 100-year storm surge. At 20 inches of sea level rise, scenario 3, over 2,000 buildings across the study area could be vulnerable to tidal flooding, about twice as many as in the near-term. By community the communities with the most buildings vulnerable to tidal flooding are:

1. San Rafael, 1,088 buildings,
2. Larkspur, 165 buildings, and
3. Corte Madera, 138 buildings.

Table 20. Vulnerable Buildings by Flooding* at MHHW in Near-term Scenario 1

Average Flood Level (feet)	Number of Buildings
0.1-1	156
1.1-2	204
2.1-3	284
3.1-4	48
4.1-5	9
5.1-6	9
6.1-7	7
7.1- 8	8
8.1-9	3
9.1- 10	1

**Flood depth data is not available for every vulnerable building. Buildings that already exist beyond mean sea level are not included.*

Source: MarinMap, CoSMoS

San Rafael's Canal neighborhood continues to experience the most severe flooding. In larkspur, the vulnerable buildings are on Boardwalk One and along the Corte Madera Creek. A stormy bay could surge waters into more properties in these communities and have some striking impacts in additional communities. The top three communities with the highest number of buildings vulnerable to storm surge flooding are:

1. San Rafael, 2,097 buildings,
2. Larkspur, 1,200 homes, and,
3. Santa Venetia, 945 buildings.

While San Rafael and Larkspur continue to expect worsening conditions, communities that are otherwise protected by some type of armoring to tidal flooding could flood during a 100-year storm surge combined with 20 inches of sea level rise. This includes Santa Venetia and Corte Madera. Sausalito could expect flooding in the Marinship and Old Town neighborhoods. Of note, Mill Valley's Redwoods Community, and several hundred additional buildings near Richardson's Bay, could experience storm surge flooding in this time period.

By percentage of buildings stock impacted, unincorporated water based communities could

expect the worst conditions, similar to the near-term. The top three communities that could expect the greatest portion of their building's flooded are:

1. Greenbrae, 66 percent,
2. Waldo Point Harbor, 23 percent, and
3. Paradise Cay, 17 percent of buildings in the community.

These small communities are surrounded by tidal water at high tides today. They incorporate boating and the water as a way of life, and are aware of the risks. Adding a storm surge at this level of sea level rise could even devastate some of these smaller bay oriented communities.

1. Greenbrae, 66 percent,
2. Santa Venetia, 42 percent, and
3. Paradise Cay, 26 percent of buildings in the community.

In addition, Bel Marin Keys and Corte Madera could expect about quarter to a fifth of their buildings stock compromised during a storm surge. Corte Madera could expect impacts in the San Clemente and Paradise Drive area. Note also that these communities were built on fill and thus, vulnerable to increased rates of subsidence.

East pier, Kappas Marina house boats, Waldo Point Harbor, March 10, 2016. Credit: BVB Consulting LLC

Table 21. Vulnerable Buildings in the Medium-term

	Location	Scenario 3		Scenario 4	
		#	%	#	%
Municipalities	San Rafael	1,088	6	2,097	11
	Larkspur	165	4	670	13
	Belvedere	65	4	90	5
	Tiburon	42	1	44	1
	Sausalito	67	2	133	4
	Novato	17	0	56	0
	Corte Madera	138	4	804	21
	Mill Valley	7	0	325	5
Unincorporated Jurisdictions	Greenbrae	81	66	115	98
	Waldo Point	87	23	90	23
	Bel Marin Keys	92	13	176	25
	Almonte	30	3	84	9
	Strawberry	33	2	117	7
	Paradise Cay	52	17	80	26
	Tiburon	13	4	18	6
	Santa Venetia	2	0	945	42
	Tamalpais	2	0	103	4
	Black Point	18	2	30	3
	North Novato	2	0	183	11
	Country Club	6	1	6	1
	Bayside Acres	2	1	5	2
	Pt. San Pedro	2	2	4	5
	China Camp	1	9	1	9
	De Silva Island	1	6	1	6
	Kentfield			11	0
Total		2,013	3	5,608	7

Source: MarinMap, CoSMoS

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Table 22. Vulnerable Buildings by Average Flooding* at MHHW in the Medium-term

Average Flood Level (feet)	Number of Buildings
0.1-1	342
1.1-2	469
2.1-3	366
3.1-4	281
4.1-5	118
5.1-6	30
6.1-7	47
7.1- 8	54
8.1-9	20
9.1- 10	2
10.1+	4

**Depth data is not available for every vulnerable asset.*

Source: MarinMap, CoSMoS

Flood Depth

In the medium-term, the portion of buildings vulnerable to three feet or less greatly increases with several hundred more buildings subject to this level of flooding. Nearly 500 buildings are vulnerable to deeper flooding of four to eight feet deep. Additionally, over 20 buildings could experience up to nine feet of flood waters.

Long-term: Scenarios 5 & 6

In long-term scenario 5, more than 9,130 buildings, 12 percent of all buildings in the study area, could be directly affected by sea level rise. With the 100-year storm surge added, scenario 6, 12,138 buildings, making up 16 percent of buildings in the study area could flood.

By number, San Rafael, Corte Madera, Santa Venetia, and Bel Marin Keys have the highest number of vulnerable parcels across every scenario. Figures for the top three are:

1. San Rafael 2,495 buildings
2. Corte Madera, 1,283 buildings, and
3. Santa Venetia, 982 buildings.

Several hundred other buildings in Larkspur, Belvedere, Mill Valley, and Novato could be vulnerable as well. And more than 100 buildings could be vulnerable to tidal flooding at 60 inches of sea level rise.

Table 23. Vulnerable Buildings in the Long-Term

	Location	Scenario 5		Scenario 6	
		#	%	#	%
Municipalities	San Rafael	2,495	13	3,247	18
	Larkspur	802	19	1,160	28
	Belvedere	423	24	470	27
	Tiburon	153	4	261	7
	Sausalito	154	5	299	10
	Novato	672	4	871	5
	Corte Madera	1,283	33	1,468	38
	Mill Valley	329	5	536	8
Unincorporated Jurisdictions	Greenbrae	119	97	120	98
	Waldo Point	90	23	386	100
	Bel Marin Keys	683	96	707	99
	Almonte	86	9	106	11
	Strawberry	185	11	264	15
	Paradise Cay	157	51	219	71
	Tiburon	17	6	23	7
	Santa Venetia	982	44	1,142	51
	Tamalpais	98	3	103	4
	Black Point	65	6	89	8
	North Novato	219	14	268	17
	Country Club	18	4	21	4
	Bayside Acres	5	2	6	3
	Pt. San Pedro	21	24	25	29
	China Camp	1	9	1	9
	De Silva Island	1	6	1	6
	Kentfield	79	3	247	8
	St. Vincent's	10	11	16	18
	San Quentin	10	3	32	9
	California Park	10	5	13	6
	Marin City	1	0	38	9
Study Area		**9,167**	**12**	**12,138**	**16**

Source: MarinMap, CoSMoS

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Homes in Black Point on San Pablo Bay. Credit: Marin County CDA

Table 24. Number of Vulnerable Buildings by Average Flood* Level at MHHW in the Long-term

Average Flood Level (feet)	Number of Buildings
0.1-1	564
1.1-2	1,235
2.1-3	1,344
3.1-4	1,762
4.1-5	1,486
5.1-6	1,011
6.1-7	489
7.1- 8	290
8.1-9	289
9.1- 10	167
10.1+	298

**Flood depth data is not available for every vulnerable asset. Source: MarinMap, CoSMoS*

Across the scenarios, San Rafael is one of the most vulnerable communities, especially in the Canal Area. According to San Rafael asset managers, vulnerable buildings, in addition to multi-family, and some single family housing, include thirty grocery stores, ten pharmacies, sixteen medical clinics, 48 doctor offices, 35 childcare facilities, five residential care facilities, seven convalescent facilities, 16 gas stations, 29 building supply stores, and other critical facilities. These businesses either contain essential goods like medications and access to medical and buildings supplies after a major storm or flooding event or house some of the most vulnerable populations in the region.

By percentage of buildings stock impacted, unincorporated water based communities could still expect the greatest impacts, similar to previous observations. The top three communities with the largest portion of their building stock that could flood at mean higher high tide are:

1. Greenbrae, 97 percent,
2. Bel Marin Keys, 96 percent, and
3. Santa Venetia, 44 percent of buildings in the community.

The top two of these communities are tidally flooded in their near-entirety. A 100-year storm surge at this level of sea level rise would devastate some of these smaller bay oriented communities.

1. Waldo Point Harbor, 100 percent,
2. Bel Marin Keys, 99 percent, and
3. Greenbrae, 98 percent of buildings in the community.

Flood Depth

In the long-term, over 3,000 buildings could be vulnerable to at least three feet of flooding, with more than 4,000 additional buildings experiencing more than three feet to six feet of flooding. An additional 1,000 buildings could be vulnerable to depths greater than 6 feet, with several hundred flooded by nine to ten feet of saltwater.

Table 25 lists some of the vulnerable buildings along Marin's eastern shoreline. This list shows onset and tidal mean higher high water (MHHW) for neighborhoods, and in some cases, specific buildings were assessed.

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Table 25. Example Vulnerable Buildings[a] Assets Ranked By Onset and Flooding at MHHW

Location	Asset	Scenario 1	Scenario 2	Scenario 3
		Near-term	Medium-term	Long-term
Sausalito	GGF Sausalito Ferry facilities	No data[b]		
Tiburon	Tiburon Ferry facilities	No data[b]		
Tiburon	Tiburon Waterfront	9'2"	9'11"	12'9"
Belvedere	West Shore Road homes	0-5'10""	0-6'5"	3"-9'3"
San Rafael	Canal neighborhood/ Spinnaker Pt.	0-5'3"	6"-5'	1"-7'4"
Greenbrae	Boardwalk homes north of 101	0-5'	0-5'8"'	3'-8'6"
Larkspur	Golden Gate Ferry Terminal buildings	0-5'	2'9"-5'4"	2'9"-6'9"
Greenbrae	Boardwalk homes south of 101	0-4'9"	0-5'5"	5'-8'5"
Corte Madera	Marina Village	0-3'5'	0-4'	11'-6'5"
Larkspur	Boardwalk One	2"-3'	5-"3'10"	3'2"-6'5"
Belvedere	Corinthian Hill homes	2'10'	3'2"	4'7"
Bel Marin Keys	Homes west of Bel Marin Keys Blvd.	0-2'7"	0-3'	3"-8'2"
Paradise Cay	Homes	0-2'4"	0-2'8"	5'3"
Larkspur	Industrial and commercial east of Hwy 101	0-1'9"	0-2'4"	2'2"-6'7"
San Rafael	GGBHTD headquarters & bus depot	0-1'6"	0-2'4"	4'2"-5'
Corte Madera	Mariner Cove neighborhood	0-1'3"	0-2'	1"-5'3"
Larkspur	Riviera Circle homes	0-10"	0-1'7"	1"-5'2"
San Rafael	Bahia Vista Elementary School	8"	2'3"	4'8"
Belvedere	Beach Road homes	6"	2'2"	4'
Waldo Point	Businesses		0"-7'7"	1'5"-10'10"
Strawberry	Greenwood Cove homes		0"-6'3"	6"-8'
Sausalito	Marinship neighborhood		0-6'	11"-9'
San Rafael	Peacock Gap Lagoon and golf course homes		0-6'	2"-8'9"
Santa Venetia	Santa Venetia homes		1"-3'6"	2"-6'7"
Corte Madera	Paradise Dr. auto dealerships and commercial		0-3'	2'-8'2"
Bel Marin Keys	Homes east of Bel Marin Keys Blvd.		1"-2'	3"-5'
Almonte	Shoreline development		0-2'	1'8"-5'
Tiburon	Tiburon Blvd. shopping		4"-2'	10"-4'2"
Greenbrae	Marin RV Park		0-1'10"	3'5"-6'8"
Tamalpais	Birdland Neighborhood		0-1'10"	2"-5'9"
Tamalpais	Tam Junction commercial		0-1'10"	2"-5'
Corte Madera	Aegis Senior Living		1'9"	4'7"
Tiburon	Cove Shopping Center		1'8"	3'11"
Mill Valley	Shelter Bay development		0-1'3"	5"-4'5"
Almonte	Caltrans Corporation Yard		1'	4'
San Rafael	Marin Community Clinic		10"	3'8"
Corte Madera	CA Highway Patrol Marin office		9"	6'
San Rafael	Marin County Health Innovation Campus		4"	3'4"
San Rafael	Montecito Plaza		1"	2'2"
Novato	Hamilton neighborhood			2"-12'4"
Novato	Vintage Oaks Shopping Center			5"-9'4"
Larkspur	Golden Gate Mobile Home Park			2'-8'4"
Belvedere	Belvedere Lagoon homes			5"-7'9"

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Location	Asset	Scenario 1 Near-term	Scenario 2 Medium-term	Scenario 3 Long-term
Corte Madera	Neil Cummins Elementary School			7'6"
Corte Madera	Madera Gardens			2'-7'4"
Larkspur	Heatherwood neighborhood			7'
San Rafael	Marin Lagoon			6"-7'
Corte Madera	Corte Madera Town Center Commercial			5'
North Novato	Binford Road Business Park			5'
San Rafael	Davidson Middle School			4'10"
Strawberry	Strawberry Circle homes			1'4"-4'8"
Mill Valley	Sycamore neighborhood			3"-4'5"
Larkspur	Multi-family on Larkspur Plaza Dr.			4'5"
Strawberry	Commercial along Seminary Marsh			5"-4'
Novato	NSD Wastewater treatment plant			4"-4'
Larkspur	San Andreas High School			4'
Mill Valley	Redwood Retirement Residential			7"-3'5"
Tiburon	Post Office			3'11"
Kentfield	Apartments/offices off Sir Francis Drake Blvd.			3'10"
Larkspur	Redwood High School			3'4"
Strawberry	Homes along Seminary Dr.			7"-3'2"
San Rafael	Downtown			1"-3'2"
Larkspur	Tamiscal High School			3'
San Rafael	PG&E office and yard			3'
San Rafael	Ritter Clinic			2'10"
Mill Valley	Mill Valley Shopping Center			6"-2'6"
Tiburon	Tiburon Fire Station			2'6"
Kentfield	Homes along McCallister Slough			6"-2'5"
San Rafael	San Rafael Transit Center			2'5"
Tiburon	Town Hall			2'4"
Tiburon	Library			2'4"
Mill Valley	SASM wastewater treatment plant			2'3"
Corte Madera	Cove Elementary School			2'3"
San Rafael	San Rafael High School			2'2"
San Rafael	Marin County Emergency Services			2'2"
Corte Madera	The Village at Corte Madera			5"-2'
Corte Madera	Aegis Senior Living			1'10"
Kentfield	Homes along Beren's Slough			10"-1'8"
Corte Madera	Marin Montessori			1'7"
Belvedere	Belvedere Corp Yard			1'5"
Bel Marin Keys	Bel Marin Keys CSD office			1'3"
Strawberry	Westminster Presbyterian Church & Preschool			1'2"
Larkspur	Tamalpais Adult School			1'2"
Mill Valley	Mill Valley Middle School temporary buildings			1'2"

[a]For groups of buildings, a maximum flood depth is provided. [b]No data provided for facilities located in water beyond mean sea level. Source: CoSMoS, MarinMap. Credit: BVB Consulting LLC

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All of these assets are also vulnerable to an additional 3 feet of storm surge flooding during a 100-year storm surge, not accounting for precipitation on the site. In addition, the following structures could be vulnerable to an additional storm surge at 60 inches of sea level rise:

- Marin Country Day School, Corte Madera (emergency shelter),
- Martin Luther King Jr Academy Marin City,
- Tamalpais High School Mill Valley,
- Glenwood Elementary. School San Rafael,
- Anthony G Bacich Elementary School, Kentfield,
- Adaline E Kent Middle School, Kentfield,
- Strawberry Point Elementary School,
- Belvedere City Hall, Police Department, Community Center
- Sanitary District No. 5 Paradise Cove treatment plant, Unincorporated Tiburon,
- Strawberry Village Shopping Center,
- Alto Shopping Center,
- Marin County Expo Center and Amphitheater, Santa Venetia,
- Novato Corp Yard,
- Las Robles Mobile Home Park Novato,
- Novato Fire Association office,
- Holy Innocents Episcopal, Corte Madera (emergency shelter),
- Marin Lutheran Church, Corte Madera (emergency shelter), and
- College of Marin, Kentfield.

Tamalpais High School athletic fields along Richardson's Bay. Nov. 25, 2015. 10:40 a.m. Credit: Light Hawk Aerial

Public Facilities

Vulnerable government, or public, facilities include: 24 schools, five fire stations, Larkspur Landing ferry facilities , SASM wastewater treatment plant, Golden Gate Bridge, Highway and Transportation District bus depot and maintenance facilities in San Rafael, and the CA Highway Patrol Marin Office could be vulnerable in the near to medium-term.

The post offices in Tiburon and San Rafael's Bellam Boulevard. location and the San Rafael Transit Center could be vulnerable nearing the end of the century. The Marin County Expo Center and Amphitheater is also vulnerable near the end of the century. To learn more about fire, police, and emergency shelter facilities see the Emergency Services Profile. For more information on transportation related facilities, see the Transportation Profile.

Several community centers including the Belvedere Community Center, Mill Valley Recreation Center, Corte Madera Community Center, and Belvedere CSD building could be vulnerable in the long-term. The Belvedere Community Center is housed in the same building as the police department and city hall. The Mill Valley Recreation Center also functions as an emergency shelter.

Also of concern are potentially vulnerable corporation yards in Belvedere and Novato. Corporation yards often contain heavy machinery and fuel tanks for refueling public fleets. These places often also contain tools that would be useful in emergencies and disaster recovery that could be threatened by flooding.

Though the buildings are not directly impacted, North Marin Water District headquarters and yard could experience access issues at high tide in the long-term, and could expect greater impacts in combination with stormwater flooding. The Central Marin Sanitation Agency treatment plant could also experience vehicular access issues nearing the end of the century. This could prevent employees from arriving at work to conduct the necessary operations and maintenance work that needs to be completed. For more details on buildings and facilities related to sanitary or water districts, see the Utilities profile. For parcels related to recreation, see the Recreation Profile.

Schools (Private and Public)
Schools vulnerable to sea level rise are listed in Table 26. Marin Montessori, Corte Madera, and Bahia Vista, San Rafael, could be vulnerable to storms at scenario 2 and to sea level rise by scenario 3. Neil Cummins Elementary, Corte Madera, is vulnerable to storms at 20 inches of sea level rise and is vulnerable to sea level rise at 60 inches, scenario 5, along with Cove Elementary School, Corte Madera, Tamiscal High School, Larkspur, Anthony G Bacich Elementary School, Kentfield, and Westminster Presbyterian Church Preschool, Tiburon. The remainder, and majority, of schools in the table are not vulnerable to sea level rise alone and can be found under scenario 6, with 60 inches of sea level rise and a 100-year storm surge.

Additionally, several of these schools, including Neil Cummins Elementary, Adeline E. Kent Middle School, and Anthony G Bacich Elementary School already experience stormwater back up flooding during high tides, and as time continues this confluence of flooding could worsen.

Once high tide reaches the school grounds they could likely be lost to marshlands. In many cases the athletic fields are compromised first. At Tamalpais High School, the only portion impacted by sea level rise alone is the low lying athletic fields. Flooding can debilitate a school's ability to perform, especially if the buildings are compromised. In 2005, the Cove School experienced a 6.5 foot king tide and a 2.5 foot stormwater level that shut down half of the school for two weeks of reconstruction. During this time, students doubled in the useable space.

In addition to the school property being impacted directly, the schools are also impacted by the ability of students, teachers, and staff to access the location. This is the case at nearly every school on the list. And, aside from busing in the Novato School District, all other students arrive individually by vehicle or non-motorized means. If too few students are able to travel, schools that are funded with state equalization aid, and required to meet an average daily attendance threshold, could experience losses in funding and capacity, and more frequent closures.

These issues are also a concern for childcare facilities, where the child population is typically younger than school-aged. Children at thirty-five different childcare facilities could be vulnerable in San Rafael alone. The Westminster Presbyterian Church's preschool also falls in this category.

Table 26. Schools Vulnerable to Sea Level Rise and the 100-year Storm Surge

	Scenario			
	2	4	5	6
Corte Madera		Neil Cummins Elem.	Schools in scenario 4 Marin Montessori Cove Elem.	Schools in scenarios 4 & 5 Marin Country Day School
Larkspur			Tamiscal High	Schools in scenario 5 Redwood High Henry Hall Middle School San Andreas High
Marin City			Martin Luther King Jr Academy (Middle)	Schools in scenario 5
Mill Valley			Mill Valley Middle School	Schools in scenario 5 Tamalpais High
San Rafael	Bahia Vista Elem. Trinity Preschool	See scenario 2	Schools in scenarios 2 & 4 Davidson Middle San Rafael High	Schools in scenarios 2, 4 & 5 Glenwood Elem.
Kentfield			Anthony G Bacich Elem. Adaline E Kent Middle	Schools in scenario 5
Strawberry			Strawberry Point Elem. Westminster Pres. Church Preschool	Schools in scenario 5

Source: MarinMap, CoSMoS

Medical Facilities
Several medical facilities, large and small could be vulnerable, and access to nearly all other in the study could be impeded from the east. Medical facilities in the tidally flooded area are:

- Marin Community Clinic, on Kerner Boulevard in San Rafael, is vulnerable to near-term storm surges, and medium-term sea level rise.
- Marin County Health, on Kerner Boulevard in San Rafael, is vulnerable to near-term storm surges, and medium-term sea level rise.
- Passport Health, on Eliseo Drive in Larkspur, is vulnerable to long-term tidal flooding, with worse conditions during a 100-year storm surge.
- Ritter Health Center, on Ritter Street in San Rafael, is vulnerable to long-term sea level rise flooding, with worse conditions during a 100-year storm surge.
- Marin County Emergency Medical Services, on Mitchell Boulevard in San Rafael, is vulnerable to long-term sea level rise flooding, with worse conditions during a 100-year storm surge.

The parking lots are also compromised on most of these sites. And while all emergency medical facilities are outside of the vulnerable area, access to them through the flooded area could be limited, leading to further injury, or worse, loss of life.

Retirement and Assisted Living

Several sites house people who are older in age and may have limited mobility or sensory abilities. These people may be especially vulnerable in floods, power outages, and other events that could isolate them. The locations that could be impacted are:

- The Redwood's, Mill Valley,
- South Eliseo Convalescent Home, Larkspur,
- Aegis, Corte Madera,
- Contempo Marin, San Rafael,
- Los Robles Park, Novato,
- Aegis, San Rafael,
- Golden Home Extended Care, San Rafael,
- Miracle Hands Homecare, San Rafael,
- Saint Michael's Extended Care, San Rafael,
- Schon Hyme Rest Home, San Rafael,
- All Saints Extended Care, Inc., San Rafael,
- Country Villa San Rafael,
- Harmony House, San Rafael,
- Kindred Transitional Care & Rehabilitation, San Rafael,
- Pine Ridge Care Center, San Rafael,
- San Rafael Care Center, Inc., and
- San Rafael Healthcare & Wellness Center, LP.

Potential Damages

Using the FEMA Hazus scale applied in post-disaster assessments for debris[55] Table 27 estimates the cost of damages to buildings and their contents depending on the severity of damage. This analysis uses scenario 6, the worst case scenario with a storm surge strong enough to cause significant damage. A smaller surge may cause minor damage, where as a large surge would cause moderate damage or even destroy buildings. This analysis assumes all buildings in scenario 6 are impacted either at a minor, moderate, or major level, and not a mix of minor, moderate, and major, which would likely reflect reality more closely.

According to the *Structure Debris Estimates: Hazus Level 1 Flood and Wind Losses*,[56] building damage costs[57] are assigned as:

- Yellow Tag
  - Affected: Loss is $0 to $5,000, or 2.05 tons of debris per 1,000 square feet.
  - Minor: Loss is $5,001 to $17,000, or 4.1 tons of debris per 1,000 square feet.
- Orange Tag: Loss is greater than $17,000 or 8 tons of debris per 1,000 square feet.
- Red Tag: Destroyed as defined by the FEMA inspector.

Waldo Point Houseboats. Nov. 24, 2015. Credit: Marin County DPW

[55] ArcGIS. FEMA Modeling Task Force (MOTF)-Hurricane Sandy Impact Analysis. Last update June 22, 2015. http://www.arcgis.com/home/item.html?id=307dd522499d4a44a33d7296a5da5ea0

[56] Federal Emergency management Agency (FEMA) Website. Hazus. Last updated July 8, 2015. http://www.fema.gov/hazus

[57] 2016 dollars

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By long-term scenario 6, if all vulnerable buildings experience minor injury, $60 million (2016 dollars) in damages could occur. If all of the buildings are moderately damaged, more than 200 million in damages could be incurred. If all of the buildings were to be destroyed by a storm surge and/ or lost to tidal flooding the assessed value of that lost buildings could surpass $6 billion (2016). If the land cannot be reclaimed for development, another $9 billion in assessed land value would be lost, totaling, $15 billion (2016 dollars) in assessed value. Reality would likely reflect a mix of these outcomes, costs would be incurred gradually in the previous decades, and damaging storm surges could occur multiple times within the timeframe of this assessment.

Maps on the following pages show vulnerable buildings by onset and location. Buildings in the southern portion could be vulnerable sooner than those in the northern portion of the study area. The areas in the call out circles enable the reader the see areas that are difficult to see on the large scale map. The circles do not indicate that these areas are more vulnerable than others along the shoreline. For even closer imagery, see the Community Profiles.

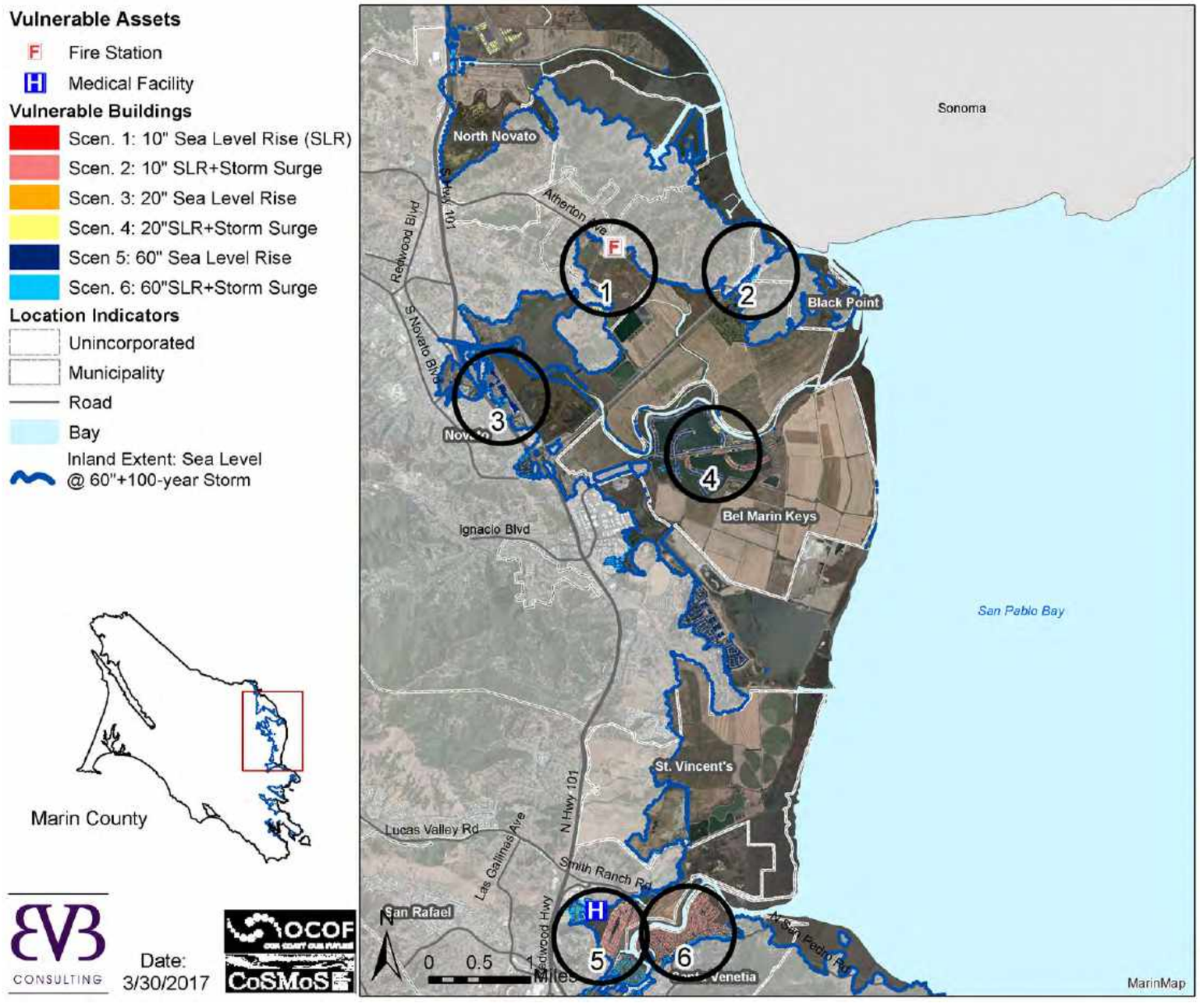
Table 27. Damage Cost [a] Estimates Applied to Vulnerable Buildings in Long-term Scenario 6

Location		Yellow Tag-Minor	Orange Tag-Moderate	Red Tag-Destroyed
		$5,000/building minimum	$17,001/building minimum	Assessed structural value
Municipalities	San Rafael	$16,235,000	$55,202,247	$1,496,065,489
	Corte Madera	$7,340,000	$24,957,468	$726,321,314
	Larkspur	$5,800,000	$19,721,160	$1,496,649,606
	Novato	$4,355,000	$14,807,871	$629,369,009
	Mill Valley	$2,680,000	$9,112,536	$300,215,511
	Belvedere	$2,350,000	$7,990,470	$356,209,805
	Sausalito	$1,495,000	$5,083,299	$228,617,482
	Tiburon	$1,305,000	$4,437,261	$187,457,062
Unincorporated Jurisdictions	Santa Venetia	$5,710,000	$19,415,142	$124,787,181
	Bel Marin Keys	$3,535,000	$12,019,707	$188,722,172
	Waldo Point	$1,930,000	$6,562,386	$21,056,654
	North Novato	$1,340,000	$4,556,268	$7,911,796
	Strawberry	$1,320,000	$4,488,264	$214,941,911
	Kentfield	$1,235,000	$4,199,247	$99,778,853
	Paradise Cay	$1,095,000	$3,723,219	$123,268,429
	Greenbrae Brdwlk	$600,000	$2,040,120	$8,836,871
	Almonte	$530,000	$1,802,106	$37,738,121
	Tamalpais	$515,000	$1,751,103	$22,654,207
	Black Point	$445,000	$1,513,089	$15,807,484
	Marin City	$190,000	$646,038	$24,685,548
	San Quentin	$160,000	$544,032	$689,013
	Pt. San Pedro	$125,000	$425,025	$33,137
	Tiburon	$115,000	$391,023	$36,868,808
	Country Club	$105,000	$357,021	$6,311,404
	St. Vincent's	$80,000	$272,016	$4,477,392
	California Park	$65,000	$221,013	$1,508,352
	Bayside Acres	$30,000	$102,006	$5,340,362
Total		**$60,690,000**	**$206,358,138**	**$6,366,322,973**

[a]2016 dollars. Source: MarinMap, CoSMoS, FEMA

BUILDINGS

Map 12. Northern Study Area Vulnerable Buildings



1: Green Point

2: Black Point

3: Vintage Oaks Shopping Center

4: Bel Marin Keys

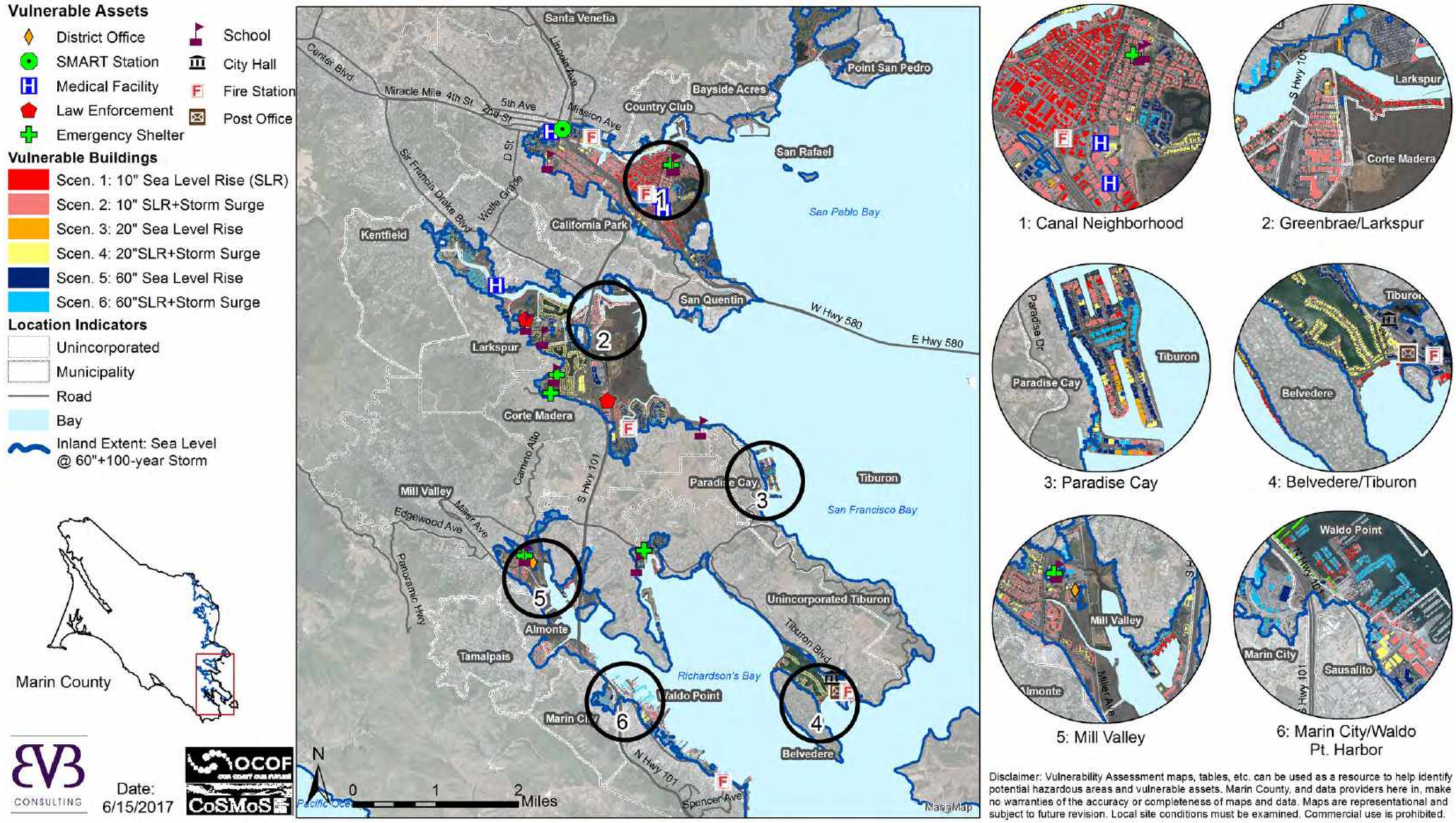
5: Western Santa Ventia

6: Eastern Santa Venetia

Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data providers here in, make no warranties of the accuracy or completeness of maps and data. Maps are representational and subject to future revision. Local site conditions must be examined. Commercial use is prohibited.

BUILDINGS

Map 13. Southern Study Area Vulnerable Buildings



Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data providers here in, make no warranties of the accuracy or completeness of maps and data. Maps are representational and subject to future revision. Local site conditions must be examined. Commercial use is prohibited.

Other Considerations

Economic

The Marin shoreline accounts for hundreds of millions of dollars in economic activity. The more than 12,000 vulnerable buildings, account for more than $6 billion in assessed improvement value as shown in Table 28. Unincorporated Marin properties that are expected to be vulnerable to sea level rise contributed $101,205,044[58] in 2015 property taxes to roughly 55 taxing agencies. Table 29 breaks down the multi-million-dollars in contributions from vulnerable properties in unincorporated Marin by taxing jurisdiction. Municipal tax revenues would add several hundred million in revenues.

Sales tax would also decline if the vulnerable commercial areas in Sausalito, Marin City, Corte Madera, Mill Valley, Larkspur, San Rafael, and Novato flood. Tourism tax could also decline because more than ten hotels could be impacted in Sausalito, Almonte, Mill Valley, Tiburon, and San Rafael. Access issues could impact other guest accommodations outside of the vulnerable portions of the study area.

Employment opportunities at shopping, industrial, and office sites could be lost. Moreover, businesses require transportation access for their deliveries, employees, and customers that is compromised under the BayWAVE scenarios, typically before the business itself is vulnerable. Employees within or who have to pass through the vulnerable areas may not be able to get to work. Access issues would also impact additional shopping centers, including the Marin Country Mart in Larkspur.

In addition to tax generation impacts, on-site expenses could be incurred by property owners. According to the National Flood Insurance Program, a 1,000 square foot home built on slab that experiences 1 foot of flooding can experience an estimate of $27,000[59] in damages to the structure and its contents.[60] A 2,000 square foot homes could anticipate an estimate of more than $52,000[61] in damages to structures and their contents.

Table 28. Economic Value of Vulnerable Buildings in Long-term Scenario 6

Location	Assessed Improvement Value[a]	Single Family Home Median Market Value[b]
Municipalities		
Larkspur	$1,496,649,606	$1,263,482,000
San Rafael	$1,496,065,489	$1,755,058,800
Corte Madera	$726,321,314	$1,475,834,400
Novato	$629,369,009	$684,226,000
Belvedere	$356,209,805	$1,397,145,700
Mill Valley	$300,215,511	$831,482,400
Sausalito	$228,617,482	$60,985,000
Tiburon	$187,457,062	$572,516,000
Unincorporated Jurisdictions		
Strawberry	$214,941,911	$1,665,727,200
Bel Marin Keys	$188,722,172	$569,754,900
Santa Venetia	$124,787,181	$1,243,810,000
Paradise Cay	$123,268,429	$581,863,200
Kentfield	$99,778,853	$3,080,781,000
Almonte	$37,738,121	$783,140,400
Tiburon	$36,868,808	$343,509,600
Marin City	$24,685,548	0
Tamalpais	$22,654,207	$2,762,400,000
Waldo Point	$21,056,654	0
Black Point	$15,807,484	$366,133,700
Greenbrae	$8,836,871	$76,532,500
North Novato	$7,911,796	$359,582,600
Country Club	$6,311,404	$252,193,200
Bayside Acres	$5,340,362	$109,798,400
California Park	$1,508,352	$103,793,800
San Quentin	$689,013	$27,449,600
Pt. San Pedro	$33,137	0
Total	**$6,366,322,973**	**$20,367,200,400**

Source: [a]Assessor Tax Data 2015/2016, [b]Zillow May 2015

[58] 2016 dollars
[59] 2016 dollars
[60] National Flood Insurance Program. The Cost of Flooding Estimator Tool https://www.floodsmart.gov/floodsmart/content/overlays/cost_of_flooding_nonajax.jsp. Accessed Dec. 13, 2016.
[61] 2016 dollars

BUILDINGS

Table 29. Sample Tax Generation for Parcels Vulnerable in Long-term Scenario 6

Tax District	Tax Revenue
County General	$22,835,222
Tamalpais High School District	$10,781,271
Marin Community College	$7,360,565
Education Revenue Augment	$7,303,352
Mill Valley School District	$6,991,178
Southern Marin Fire	$5,750,363
Kentfield School District	$5,225,279
Kentfield Fire	$4,109,315
Novato Unified School District	$3,765,050
County Library	$2,954,595
County School Service Fund	$2,528,240
San Rafael Elementary Schools	$2,253,634
Community Service Area (CSA) #19 Fire Protection	$1,950,984
Novato Fire	$1,906,311
San Rafael High School	$1,690,337
Ross Valley Sanitation No. 1	$1,564,305
Reed Union School	$1,446,789
Marin County Open Space	$1,020,102
Tiburon Fire	$795,261
Richardson Bay Sanitation	$745,599
Tamalpais Community Service District (CSD)	$649,472
Flood Control Zone (FCZ) 3 Richardson Bay	$635,130
Marin County Highway Lt	$615,373
Sausalito-Marin City School District	$595,858
Marin County Transit	$586,546
County Fire Department	$512,272
Ross School	$493,532
Strawberry Recreation	$473,938
Bel Marin Keys CSD	$443,596
CSA 17 Kentfield	$401,931
FCZ 7 Santa Venetia	$359,149
Mosquito Abatement	$317,948
Corte Madera Sanitation No. 2	$288,308
Marin City CSD	$270,722
FCZ 1 Novato	$215,209
Bay Area Air Quality	$205,089
#6 Novato Sanitation	$146,654
CSA 18 Gallinas	$128,756
FCZ 4 Bel Aire	$127,962
Almonte Sanitation	$108,938
Las Gallinas Valley Sanitary District	$104,146
FCZ 9 Ross Valley	$81,954
Larkspur-Corte Madera School District	$80,287
San Rafael Sanitation	$64,836
CSA 6 Santa Venetia	$57,811
Sausalito-Marin City Sanitation	$55,230
CSA 16 Greenbrae	$46,234
Tiburon Sanitation No. 5	$41,804
Murray Park Sanitation	$41,684
San Quentin Sanitation	$19,282
Alto Sanitation	$19,182
CSA 9 Northbridge	$12,074
North Marin Water	$10,822
Petaluma Joint High	$7,026
Dixie School District	$6,543
Santa Rosa Junior College-Laguna Joint School	$1,275
Lincoln School	$723
Total	**$101,205,044**

Source: S. Kucharos, County of Marin Department of Revenue, June 6. 2016

In addition, several existing buildings are protected with shoreline armoring, such as seawalls, revetments, levees, bulkheads, bluff walls, and other hard engineering structures, to impede flooding and erosion. With higher tides, these protective structures may become compromised and require increased maintenance or replacement, or relocation. Some may already be in need of repair to withstand existing conditions. These expenses can be significant and would require increasing upkeep and improvement as tides rise.

For properties that become part of the public trust lands, regulations could diminish an individuals' capacity to maintain and retain value in their properties in the most cost effective ways. The equity held in these properties could be lost; negatively impacting a major contributor to wealth. In addition, these homeowners may be required to pay leasing fees to the State of California.

Several low-income and affordable housing locations, the Canal neighborhood, Marin City, and other locations along the shoreline, could be compromised by higher sea levels, having significant economic and displacement impacts on the most vulnerable citizens in the county. Moreover, as developable land area diminishes and housing supply is lost, the cost of housing in the County could escalate more rapidly, making it difficult for low income resident to relocate nearby.

Environmental

Storm damage could result in building debris that could pollute the bays and ocean. Many buildings also contain potential water contaminants that could be swept out to sea. When homes are repaired or rebuilt, resource consumption will occur. As homes are demolished and relocated, additional consumption could occur, and degradation of the relocation site is likely. Additionally, using seawalls and other shoreline protective devices to protect buildings could result in the loss of beaches, wetlands, and other habitats and recreational areas by preventing these areas from migrating inland.

Social Equity

Equity concerns may arise regarding who should pay for adaptation or recovery related to sea level rise impacts, or what places should be protected and when. Temporarily or permanently relocating residents can sever neighborhood relationships, reducing neighborhood cohesion and breaking down emergency networks. Neighborhoods without these social networks are especially vulnerable to sea level rise and storm threats, and may have a harder time recovering from disasters.

People living with scarce financial resources are especially vulnerable to sea level rise. According to the Healthy Marin Partnership, 2013 Community Health Needs Assessment, between 50 and 70 percent of Marin's shoreline residents in the BayWAVE study area pay more than 45 percent of their income on housing and transportation combined.[62] The affordability standard is 30 percent of income on housing and 15 percent on transportation.[63] This indicates that a large portion of residents are already burdened by these basic expenses. Consequently, these households have less income for other necessities such as emergency preparedness, medical care, healthy food, child care, and education.

In addition, those with health or mobility constraints, who do not own a home or car, or are not proficient in the English language, may be disproportionally burdened by sea level rise and storms. Notably, in the Canal neighborhood of San Rafael, hundreds of residents meet several of these criteria. If displaced, the loss would be significant to these residents, their neighborhood, and the regional economy. In addition, the cost of repairs may be passed on to the tenants and increase the cost of living, potentially pricing existing residents out of their neighborhood.

Table 30. Income Spent on Housing & Transportation, 2005-2009

Jurisdiction	% residents paying more than 45% on housing & mobility
SF-Oakland-Fremont Region	48
Marin County	56
Sausalito	52
San Rafael	50
Larkspur	54
Corte Madera	55
Mill Valley	61
Strawberry	61
Kentfield	67
Belvedere	58
Tiburon	70
Novato	54
Santa Venetia	53
Tamalpais-Homestead	67
Black Point-Green Point	64
Marin City*	No data

Source: Human Impact Partners, 2015, H+T Index, CNT

** No data is available for Marin City, though Marin City figures may be incorporated with a nearby community.*

62 Human Impact Partners. 2013. Healthy Marin Partnership. Community Health Needs Assessment Sub-county Health Indicators.

63 Human Impact Partners. Healthy Marin Partnership. Community Health Needs Assessment Sub-county Health Indicators. 2013.

In Marin City, also a low-income community, the commercial shopping center is already vulnerable to stormwater flooding in combination with existing storm and king tides. Sea level rise could push tides even closer to stormwater outlets preventing the release of stormwater, and causing it to back up into the community. By scenario 6, storm surge flooding could reach directly over US Highway 101 and into the commercial and multi-family affordable housing on the other side. The loss of the shopping center could reduce local employment opportunities, shopping options, and community character. The apartments across from the shopping center could also be impacted by storm surge flooding. Combined with existing stormwater issues, this could displace several vulnerable residents and trap many more.

At worst, with long-term sea level rise, displaced residents the Canal neighborhood of San Rafael may not have access to equivalent affordable housing near the jobs, schools, and facilities they rely on and may be forced to leave their neighborhood. Residents in Marin City may be temporarily displaced by the long-term, with the potential to return to restored housing. In both areas, the residents are not responsible for restoring the buildings, and dependent on the investment and action of property owners. This would also apply to the many businesses serving these communities that lease their facilities.

Management

The Bay Conservation Development Commission (BCDC) retains development permit authority over tidelands (below mean high tide), submerged lands, and public trust lands. Potential state boundary changes could occur as tide levels rise. This could significantly impact private property rights when flooded land becomes lands of the State and existing residents are forced to pay leasing fees.

Individual property owners may take individual measures to protect their property that could be damaging to neighboring properties, creating private property conflicts. And in some communities getting property owners to work together towards a shared goal may prove challenging.

In addition, as housing units are lost to the Bay, political representation based on population could shift to other areas, both with in and out of the County. Planning and implementing adaptation measures for higher water levels could span several election cycles across several levels of government. Successful preparation would require continuous political support from mayor to mayor, council to council, state congress person to person, and so on for several decades. If government priorities shift away from supporting sea level rise preparation, communities could be less equipped to weather increased flooding.

TRANSPORTATION

Asset Profile: Roads, Trails, & Waterways

Low lying roads and other ground transportation infrastructure in Marin's bayside communities are already susceptible to flooding at high tides, especially king tides combined with storms. At worst, some roadways will become completely inundated most hours of the day, or degraded and eroded beyond repair.

If the road network becomes compromised, communities would be extremely vulnerable to reduced goods movement and limited access to supplies essential for daily living, such as food, gasoline, medications, or other household items. Emergency service, postal service and garbage disposal could be interrupted, highway on and off ramps closed down, and commuting and tourism capacity significantly reduced. This will impact the vulnerable communities on the shoreline and in the inland valleys that depend on vehicular access through the flooded areas. Water travel will likely be able to adapt, however during storms, boats and boat lauches, marinas, and piers could experience significant damage and acess to them could be cut off. The following are key issues related to transportation vulnerability:

- The road network acts as a lynch pin, such that, if disrupted or destroyed, several other assets will also be disrupted or destroyed. While temporary shut downs could be tolerated in the near-term, chronic flooding could render road segments permanently impassable.
- Several key corridors, including the Manzanita Park & Ride and Tamalpais Junction corridor, already experience seasonal flooding that will likely worsen in the near-term.
- Many roadways serve as emergency access and evacuation routes, and could be flooded when residents need them most.
- Providing lifeline services to communities with limited access is an existing challenge during storm events.
- Vulnerable roadways can also cover and protect critical utility lines.
- .Not all residents have cars. Thousands of residents and visitors travel by foot, bike, depend on others, or use transit, and may not be able to evacuate in emergencies.

IMPACTS AT-A-GLANCE: SCENARIO 6

Nearly 130 miles of wet road, 3 ferries, 15 marinas	300,000+ people
Everyday living, tourism	Regional
More than $1 billion needed	Caltrans Marin County & Local Departments of Public Works Private Road Owners and HOAs Marin Transit Golden Gate Bridge, Highway and Transportation District Sonoma Marin Area Rail Transit Transportation Authority of Marin

US Highway 101 on ramp at Manzanita is already flooded at high tides, especially combined with storms. Credit: Unknown

- Transit services would become increasingly interrupted during high tides and storms, disproportionately impacting households with incomes below the county median income.
- While roads and parking areas can tolerate infrequent storm flooding, erosion susceptible areas, and those vulnerable to frequent flooding, could experience recurring damage and capacity reductions. Lighting systems in parking lots and along roads could be impacted, and could cause electrical hazards.
- Subsidence is already a factor for many roads and will likely worsen as the ground becomes saturated with bay waters further inland.
- The weakest points for the highways systems are on and off ramps, which are typically at the lowest elevations. Without access on and off the highways, they are not useable by several hundred thousand residents, commuters, and visitors.
- Roadways are also compromised by flooding from freshwater creeks during storms.

The most vulnerable high capacity roads are:

- Shoreline Highway from the Manzanita Park and Ride to Tam Junction,
- Highways US-101, I-580, and 37,
- Miller Avenue and Camino Alto in Mill Valley,
- Tiburon Boulevard in Tiburon,
- San Rafael Drive in Belvedere,
- San Clemente, Paradise, and Lucky Drives in Corte Madera,
- Redwood Highway and Sir Francis Drake Boulevard in Larkspur,
- Several arterials and local streets downtown around the US Highway 101 corridor and in the Canal neighborhood in San Rafael,
- Rowland Way in Novato, and
- Bel Marin Keys Boulevard.

These highways and arterials are the access ways to neighborhoods, major employers and commercial areas, and the rest of the bay area region. Commuting within and in and out of the County could become an increasing challenge as tides reach new heights and floodwaters deepen. These routes are also the backbone of the transit system, which Marin's autoless households depend on. Table 31 shows the cumulative lengths of all the roads and trails vulnerable in each community.

The table also annotates who is responsible for the roadway. In several cases, responsibility for a road may be divided amongst several governments that will need to work together when making improvements and adjustments for higher flood waters. Some important examples are Point San Pedro Road, Paradise Drive, and Sir Francis Drake Boulevard. In addition, several streets are privately maintained and could necessitate action by homeowner's associations or individual property owners. The property owners would likely need to work in cooperation with the public street improvement the private street connects to. The annotations are as follows:

M = Marin County
C = State of California
L = Local Municipality
P = Private

One limitation of this assessment is the ability to analyze bridges. Bridges within Highways US-101 and I-580, in most cases, are elevated above future flood depths analyzed in this analysis. However, flooding at higher levels on the support pillars, and the weight of water at the low ends of a bridge could cause increased wear and tear and compromise structural integrity.

Traffic backed up on Gate 6 Rd. in Waldo Point Harbor. Dec. 12, 2015. Credit: Marin County DPW

Table 31. Roads & Routes Vulnerable to Sea Level Rise and Storms by Community

	Near-term		Medium-term		Long-term	
	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
	8 miles (0% of study area)	30 miles (2% of study area)	20 miles (1% of study area)	62 miles (4% of study area)	100 miles (6% of study area)	130 miles (8%) of study area
Bus Routes	GGT:8, 10, 18, 24, 27, 37, 38, 40, 44, 54, 56, 58, 70, 72, 74, 76, 80, 97, 101 MT: 17, 23.29, 35, 36, 71, 228	Routes in Scenario 1	GGT: 4 MT: 19, 22, 61, 66, 113, 115, 117, 119	Routes in scenarios 1-3	GGT: 2 MT: 45, 49, 68, 219, 233, 251, 251, 251, 257, 259, 125, 126, 127, 145, 151, 154	Routes in scenarios 1-5
Municipalities						
Belvedere		San Rafael Ave [L] Hilarita Cir [L] Edgewater Rd [L]		Roads in scenario 2 Barn Rd [P] Beach Rd [L] Community Rd Cove Rd [L] Cove Road Pl [L] Leeward Rd [L] Mallard Rd [P] Peninsula Rd [L] Teal Rd [P] Windward Rd [L]	Roads in scenarios 2 & 4 Embarcadero Dr [P] Lagoon Rd [L] Maybridge Rd [L] West Shore Rd [L]	Roads in scenarios 2, 4, & 5 Bellevue Ave [L] Golden Gate Ave [L]
Mill Valley		Redwood Hwy [L] Amicita Ave [L] Camino Alto [L] Gomez Way [P] Miller Ave [L] Nelson Ave [L] Oxford Ave [L] Park Ter [P] Plymouth Ave [L] Frontage Rd [L] Surrey Ave [L] Sycamore Ave [L] Tamalpais Commons Ln [P] Valley Cir [L]		Roads in scenario 2 Hamilton Dr [L] Ryan Ave [L]	Roads in scenarios 2 & 4 E Blithedale Ave [L] Plymouth Cir [L] Roque Moraes Dr [L]	Roads in scenarios 2, 4, & 5 Ashford Ave [L] La Goma St [L] Leyton Ct [L] Lomita Dr [L] Matilda Ave [L] Meadow Rd [L] Nelson Ave [L] Shelter Bay Ave [L] Somerset Ln [L]

TRANSPORTATION

	Near-term		Medium-term		Long-term	
	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
Corte Madera		Hwy 101[C] Redwood Hwy[L] Paradise Dr[L] Baja Ct[L] Casa Buena Dr[L] Channel Dr[L] Conow St[L] Ebbtide Passage[L] Echo Ave[L] Fifer Ave[L] Golden Hind Passage[L] Harbor Dr[L] Lucky Dr[L] Nellen Ave[L] San Clemente Dr[L] Tamal Vista Blvd[L] Tamalpais Dr[L] Yolo St[L]		Roads in scenario 2 Apache Rd[L] Arrowhead Ln[L] Birch Ave[L] Cheyenne Way[L] Chickasaw Ct[L] Council Crest Dr[L] Edgemar Way[L] Hickory Ave[L] Lakeside Dr[L] Madera Blvd[L] Madera del Presidio Dr[L] Meadowsweet Dr[L] Mohave Ct[L] Mohawk Ave[L] Monona Dr[L] Navajo Ln[L] Sanford St[L] Seamast Passage[L] Seminole Ave[L] Tradewind Passage[L]	Roads in scenarios 2 & 4 Diamond Head Passage[L] El Camino Dr[L] Estrada Ln[L] Flying Cloud Course[L] Foremast Cv[L] Granada Dr[L] Key Largo Course[L] Key Largo Cv[L] Lanyard Cv[L] Meadow Creek Dr[P] Morning Star Course[L] Pacific Queen Passage[L] Paloma Dr[L] Prince Royal Dr[L] Prince Royal Passage[L] Sandpiper Cir[P] Seawolf Passage[L] Simon Ranch Rd[P] Spindrift Passage[L] Staghound Passage[L] Wornum Dr[L]	Roads in scenarios 2, 4, & 5 Ash Ave[L] Cay Passage[L] Chapman Dr[L] Council Crest Dr[L] Creekside Ct[P] Eastman Ave[L] Hickory Ave[L] Laurel Dr Parkview Cir[P] Pixley Ave[L] Redwood Ave Westward Dr[L]
Sausalito		Anchor Street[P] Coloma St[L] Gate 5 Rd[L, P] Harbor Dr[L] Heath Wy[L] Liberty Ship Wy[P] Spinnaker Dr[P] Varda Landing Rd[P]		Roads in scenario 2 Humboldt Ave[L, P] Turney St[L]	Roads in scenarios 2-4 Bridgeway[L] Johnson St[L] Litho St[L] Locust St[L] N Bridge Blvd[L] Napa St[L] Road 3[P]	Roads in scenarios 2-5 Bay St[P] Bee St[L] Caledonia St[L] El Portal St[L] Ensign St[L] Marina Plaza[P] Marinship Wy[L, P] Napa St[L] Pine St[L] Princess St[L] Richardson St[L] San Carlos Ave[L] Tracy Wy[L] Wateree St[P]

TRANSPORTATION

	Near-term		Medium-term		Long-term	
	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
Tiburon		Brunini Wy [L]		Roads from scenario 2	Roads from scenarios 2 Beach Rd [L] Blackfield Dr [L] Blackies' Pasture Rd [L] Cecilia Wy [L] Claire Wy [L] Harriet Way [L] Juanita Ln [L] Lagoon Vista [P] Leland Wy [L] Main St [L] Mar West St [L] Marsh Rd [P] Pamela Ct [L] Paradise Dr [L, M]	Roads in scenarios 2 & 5 Tiburon Blvd [C] Jefferson Dr [L] Washington Ct [L]
Larkspur	Hwy 101 [C] Redwood Hwy [L] Bon Air Rd [L] Greenbrae [M, P]	Roads in scenario 1 Creekside Dr [L] Doherty Dr [L] Industrial Wy [L, P] Larkspur Plaza [L] Rich St [L, P] Riviera Cir Dr [L]	Roads in scenarios 1 & 2	Roads in scenarios 1-3 Corte del Coronado [L] Diane Ln [L] Liberty St [L] Midway Rd [L] Tulane Dr [L] Via la Brisa [L] William Ave [L]	Roads in scenarios 1-4 Sir Francis Drake Blvd [L, M] Camellia Cir [P] Heather Wy [L] Rose Ln [P] S Eliseo Dr [L] Stanford Ct [L]	Roads in scenarios 1-5 Barry Way [L, P] College Ave [L, M] Cornell Ave [L] Corte del Bayo Real [L] Creek View Cir [P] Cross Creek Pl [P] Dartmouth Dr [L] Elizabeth Cir [P] Estelle Ave [L] Frances Ave [L] Gregory Pl [P] Gretchen Pl [P] Harvard Dr [L] Laderman Ln [P] Larkspur Lndg Cr [L] Lupine Ct [P] Magnolia Ave [L] Murray Ave [L] Orchid Dr [P] Sandy Creek Wy [P] Scott Pl [P] Victoria Wy [L] Yale Ave [L]

TRANSPORTATION

	Near-term		Medium-term		Long-term	
	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
Novato	Hwy 101 [C] Hwy 37 [C] Redwood Blvd [L] Rowland Wy [L]	Roads in scenario 1 Burma Rd [L] Perimeter Rd [L] Terminal Rd [L]	Roads in scenario 1	Roads in scenarios 1 & 2 Hamilton Dr [L] Ryan Ave [L] Deer Island Ln [L] Hanna Ranch Rd [L] Marsh Rd [L] Olive Ave [L] Two Water Trail	Roads in scenarios 1-4 Rowland Blvd [L] Bel Marin Keys Blvd [L] Hamilton Pkwy [L] Alconbury Wy [L] Alhambra Ct [L] Amelia Dr [L] Arnold Dr [L] Audubon Wy [L] Avocet Ct [L] Caliente Real [L] Club Dr [L] Emerson Ave [L] Ferdinand Way [L] Gann Way [L] Gateway Ct [L] Greenham Ct [L] Hamilton Landing [L] Hangar Ave [L] Hayford Ct [L] Holliday Dr [L] Hospital Dr [L] Inyo Cir [L] Laconheath Ave [L] Lassen Ln [L] Lavenham Rd [L] Los Padres Cir [L] Manuel Dr [L] Maybeck St [L] Mildenhall St [L] Modoc Pl [L] Moore Rd [L] Palm Dr [L] Pizarro Ave [L] Plumas Cir [L] Presidio Dr [L] Renaissance Rd [L] Richardson Rd [L] Richardson Wy [L] Ripley Ln [L] S Palm Dr [L] San Pablo Ave [L] San Pablo Ct [L] Stern Dr [L] Stonetree Ln [L] Tahoe Cir [L] Trinity Dr [L] Vintage Wy [L] Woodbridge Wy [L]	Roads in scenarios 1-5 Balboa Ct [L] Binford Rd [L] Donna St [L] El Arroyo Pl [L] El Granada Cir [L] Emerson Ave [L] Fairhaven Wy [L] Frosty Ln [L] La Crescenta Cir [L] Lea Dr [L] Leafwood Dr [L] Loleta Ln [L] Louis Dr [L] Palm Dr [L] Pamaron Wy [L] Rush Landing Rd [L] San Pablo Wy [L] Terminal Rd [L] Topaz Dr [L] Toyon Wy [L] Vera Cruz Ave [L]

TRANSPORTATION

	Near-term		Medium-term		Long-term	
	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
San Rafael	Hwy 101 [C] Hwy 580 [C] Bellam Blvd [L] Francisco Blvd E [L] Kerner Blvd [L] Grand Ave [L] Irwin St [L] Canal St [L] Alto St [L] Amalfi Pl [L] Bahia Pl [L] Bahia Wy [L] Bahia Cir [L] Bay Harbor Wy [P] Belvedere St [L] Capri Ct [L] Castro Ave [L] Charlotte Dr [L] Elaine Wy [L] Fairfax St [L] Front St [L] Golden Gate Dr [L] Irene St [L,P] Larkspur St [L] Lido Ln [L] Lisbon St [L] Louise St [L] Madera St [P] Marian Ct [L] Market St [L] Medway Rd [L] Mill St [L] Mooring Rd [L] Novato St [L] Portofino Rd [L] Sea Wy [L] Shoreline Path San Rafael Airport [L] Sonoma St [L] Sorrento Wy [L] Summit Ave [L] Tiburon St [L] Verdi St [L] Vivian St [L] Yosemite Rd [L]	Roads in scenario 1 Pt. San Pedro Rd [L, C] Acadia Ln [L] Bahia Ln [L] Baxters Ct [P] Bedford Cv [L] Billou St [L] Bret Ave [L] Bryce Canyon Rd [L] Carlsbad Ct [L] Catalina Blvd [L] Crater Lake Wy [L] De Luca Pl [L] Dolores St [L] Du Bois St [L] Duffy Pl [L] Duxbury Cv [L] Falmouth Cv [L] Gary Pl [L] Glacier Way [L] Gloucester Cv [L] Hingham Cv [L] Hoag St [L] Hyannis Cv [L] Isla Vista Ln [L] Isle Royale Ct [L] Jordan St [L] Lagoon Pl [L] Lagoon Rd [L] Lincoln Ave [L] Loma Vista Pl [L] Lovell Ave [L] Marina Way [L] McNear Dr [L] Mesa Verde Wy [L] Nantucket Cv [L] Narragansett Cv [L] Newport Wy [L] Olympic Wy [L] Peacock Dr [L] Playa Del Rey [L] Plymouth Cv [L] Porto Bello Dr [L] Rice Dr [L] Riviera Dr [L] Rockport Cv [L] Salem Cv [L] San Marcos Pl [L] Shenandoah Pl [L] Shoreline Pkwy [L] Spinnaker Point Dr [L] Tahoe Pl [L] Teton Ct [L] Vista Del Mar [L] Windward Wy [L] Woodland Ave [L] Yellowstone Ct [L] Zion Ct [L]	Roads in scenario 1 Francisco Blvd W [L]	Roads in scenarios 1-3 2nd St [L] 3rd St [L] Lindaro St [L] Aqua Vista Dr [L] Baypoint Dr [L] Baypoint Village Dr [L] Biscayne Dr [L] Dodie St [L] Egret View [L] Loch Lomond Dr [L] Novato St [L] Pelican Wy [L] Royal Ct [L] Simms St [L] Yacht Club Dr [P]	Roads in scenarios 1-4 4th St [L] A St [L] B St [L] Hetherton St [L] Albert Park Ln [L] Avocet Ct [P] Brooks St [L] Chapel Cove Dr [L] Cijos St [L] Dowitcher Wy [P] Embarcadero Wy [L] Glacier Pt [L] Grange Ave [L] Jacoby St [L] Knight Dr [L] Leith Ln [L] Lido Ln [L] Lochinvar Rd [L] Lootens Pl [L] Mariposa Rd [L] Mary St [L] Mission Ave [L] Morphew St [L] Park St [L] Peacock Ln [L] Piombo Pl [L] Portsmouth Cv [L] Ritter St [L] Riviera Pl [L] Silk Oak Cir [L] Summit Ave [L] Surfwood Cir [L] Tern Ct [P] Turnstone Dr [P] Union St [L] Warner Ct [L]	Roads in scenarios 1-5 C St [L] Bayview St [L] Bridgewater Dr [L] Commercial Pl [L] Loma Linda Rd [L] Main Dr [L] Mariners Cir [L] Mark Dr [L] McInnis Pkwy [L] Milano Pl [L] Mitchell Blvd [L] Newport Wy [L] Octavia St [L] Paul Dr [L] Pelican Wy [L] Riviera Manor [L] Rockport Cv [L] San Pedro Cv [P] Sandpiper Ct [L] Shores Ct [L] Smith Ranch Rd [L] Taylor St [L] Waterside Cir [L] Willow St [L] Woodland Pl [L]

TRANSPORTATION

	Near-term		Medium-term		Long-term	
	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
Unincorporated Jurisdictions						
Almonte		Hwy 101 [C] Bolinas St [M] Pohono St [M] Shoreline Hwy [C]		Roads in scenario 2	Roads in scenarios 2 Almonte Blvd [M]	Roads in scenarios 2 & 5 Helen Ave [M]
Bayside Acres				Beach Dr [M]	Road in scenarios 4	Road in scenarios 4 & 5
Bel Marin Keys	Bel Marin Keys Blvd [M]	Roads in scenario 1 Bahama Reef [M] Del Oro Lagoon [M]	Roads in scenario 1	Roads in scenarios 1-3	Roads in scenarios 1-4 Bermuda Harbour[M] Calypso Shores [M] Caribe Isle [M] Cavalla Cay [M] Dolphin Isle [M] Montego Key [M]	Roads in scenarios 1-5
Black Point				Atherton Ave [M] Bachelors Rd [P] Bayview St [P] Beattie Ave [P] Buck's Landing Rd [M] Cavallero Ct [P] Channel Dr [P] Days Island Rd [P] Holly Ave [P] Norton Ave [P] Olive Ave [M] School Rd [M]	Roads in scenario 4 Glen Rd [P] Harbor Dr [P] Hunters' Club Rd [P] Tamarin Ln [P]	Roads in scenarios 4 & 5
California Park					Auburn St [M] Woodland Ave [M]	Roads in scenario 5
China Camp		N San Pedro Rd [M]		Roads in scenario 2	Roads in scenario 2	Roads in scenario 2
Country Club		Harbor View Ct [M]		Roads in scenario 2	Roads in scenario 2	Roads in scenario 2 Pt. San Pedro Rd [M] Summit Ave [M]

TRANSPORTATION

	Near-term		Medium-term		Long-term	
	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
Greenbrae	Greenbrae Boardwalk[P]	Hwy 101[C] Lucky Dr [M]		Roads in scenarios 1& 2	Roads in scenarios 1& 2	Roads in scenarios 1& 2
Kentfield				Berens Dr [M] Lilac Ave [M] McAllister Ave [M]	Roads in scenario 4 Lancaster Ave [M] Sherwood Ct [M] Stadium Wy [P]	Roads in scenarios 4 & 5 Acacia Ave [M] Bon Air Rd [M] College Ave [M] Hillside Ave [M] Kent Ave [M] Laurel Grove Ave[M] Sir Francis Drake Blvd [M]
Marin City					Hwy 101[C] Donahue St [M] Drake Ave [M]	Rods in scenario 5 Terners Dr [M]
North Novato	Hwy 37 [C]	Roads in scenario 1	Roads in scenarios 1 &2	Roads in scenarios 1-3 Airport Rd [M] Binford Rd [M]	Roads in scenarios 1-4 Hwy 101 [C]	Roads in scenarios 1-5
Paradise Cay		St. Lucia Place [M]		Roads in scenario 2 Jamaica St [M] Paradise Cay Marina [P] St Thomas Wy [M]	Roads in scenarios 2 & 4 Martinique Ave [M]	Roads in scenarios 2, 4, & 5 Saba Ln [M] Trinidad Dr [M]
Pt. San Pedro		McNear Brickyard Rd [P] McNears Rd [P]		Roads in scenario 2 Pt. San Pedro Rd[M]		
San Quentin	Hwy 580 [C]	Roads in scenario 1	Roads in scenarios 1 &2	Roads in scenarios 1-3	Roads in scenarios 1-4 Levee Rd [P]	Roads in scenarios 1-5 Waterfront Rd [P]

TRANSPORTATION

	Near-term		Medium-term		Long-term	
	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
Santa Venetia		N San Pedro Rd [M] Adrian Wy [M] Ash Wy [M] Birch Wy [M] Descanso Wy [M] Estancia Wy [M] Galerita Wy [M] Geneva Wy [M] Hacienda Wy [M] Hawthorn Wy [M] La Pasada [M] La Playa Wy [M] LaBrea Wy [M] Mabry Wy [M] Meadow Dr [M] Palmera Wy [M] Rafael Wy [M] Rosal Wy [M] Vendola Dr [M]		Roads in scenario 2 Rincon Wy [M]	Roads in scenarios 2 & 4	Edward Ave [M] Lowell Ave [M] Mark Twain Ave [M] Steven Wy [M] Whittier Ave [M]
Strawberry	Hwy 101 North bound [C]	Roads in scenario 1 Barbaree Way [M] Channel Lndg [P] Greenwood Bay Dr [P] Greenwood Cove Dr [M] Redwood Hwy Frontage Rd [M] Salt Lndg [M] Seminary Dr [M]	Roads in scenarios 1 & 2	Roads in scenario 2 De Silva Island Dr [P] E Strawberry Dr [M] Strawberry Cir [M]	Roads in scenarios 2 & 4 Belvedere Dr [M] Captains Lndg [M] Harbor Cove ay [M] Ricardo Rd [M] Seadrift Lndg [M] Tiburon Blvd [C] Villa Laguna [P]	Roads in scenarios 1-5 Heron Dr [M] Strawberry Lndg [P] Strawberry Village [P] Weatherly Dr [M]
Tamalpais Valley		Shoreline Hwy [C] Tennessee Valley Rd [M] Almonte Blvd [M] Cardinal Ct [M] Cardinal Rd [M] Flamingo Rd [M]		Roads in scenario 2	Roads in scenarios 2 & 4	Roads in scenarios 2, 4, & 5 Gibson Ave [M]
Waldo Point Harbor	Gate 6 Dock [P] Gate 6 Rd [M]	Gate 6 1/2 Rd [P] Liberty Dock [P]	Roads in scenarios 1 & 2	Roads in scenarios 1-3 Shoreline Hwy [C] Bolinas St [M]	Roads in scenarios 1-4	Roads in scenarios 1-5 Main Dock [P]

Source: MarinMap, CoSMoS

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Rowland Blvd., bike lane, and SMART rail line behind the Vintage Oaks Shopping Center could be vulnerable. Credit: BVB Consulting LLC

Table 32. Roadway Vulnerabilities

Elevation	▪ Roads at grade could be vulnerable to inundation, scouring, and erosion. ▪ During storms, or increased wave exposure, roads above grade, on bluffs, or adjacent to hill sides, are also vulnerable to erosion. ▪ Roads on bay mud could be vulnerable to subsidence and erosion.
Soils	▪ Most soils in the study area are erodible soils and are susceptible to slides, scouring, and subsidence.
Materials	▪ Asphalt and concrete exposed to frequent flooding and high levels of salt could deteriorate faster than in drier times. ▪ Lighting in parking lots could be vulnerable to flooding.

Source: Asset Manager Interviews

With few exceptions, all of the vulnerable municipal and unincorporated areas have at least one vulnerable roadway. As seen in the maps at the end of this profile, the majority of the roads vulnerable in scenario 1 are in San Rafael, with seven miles of the eight miles exposed. This includes US-101 and I-580 on and off ramps, and the actual roadway in some locations. The areas in the call out circles enable the reader the see areas that are difficult to see on the large scale map. The circles do not indicate that these areas are more vulnerable than others along the shoreline.

If a 100-year storm surge were to occur at 10 inches of sea level rise, scenario 2, Santa Venetia and Mill Valley also join San Rafael in having the majority of impacted roadways by number, and in mileage. Scenario 3, or 20 inches of sea level rise, is very similar in impact as scenario 1 and in the lowest lying areas, some roads in scenario 2 are also impacted under scenario 3. For scenario 3, in several locations, the extent is greater than scenario 1, but less than scenario 2 with the storm surge. Adding a 100-year storm surge to scenario 3 has a significantly greater impact, though temporary for those impacted in this scenario for the first time. And at 60 inches, or 5 feet, of sea level rise, hundreds of miles of roads and hundreds of roads could become flooded several hours a day during the highest tides each month.

Communities that could face sea level rise direct impacts to roads network in the near-term are Larkspur, Novato, San Rafael, Sausalito, Bel Marin Keys, North Novato, San Quentin, Strawberry, and Waldo Point Harbor. Those that will be impacted only under the storm scenarios in the near- and medium-terms include: Belvedere, Tiburon, Corte Madera, Mill Valley, Almonte, Greenbrae, Country Club, China Camp State Park, Tamalpais Valley, Santa Venetia, Point San Pedro, and Paradise Cay. Of note, several communities may not experience dramatic roads impacts from sea level rise until the long-term projection in scenario 5. These communities include: Marin City, Kentfield, California Park, Black Point, and Bayside Acres. These communities, especially Marin City and Kentfield, experience severe stormwater backups that could get worse as higher tides prevent precipitation from draining to the bays. Some of these communities may experience storm surge impacts under scenario 4 conditions. By this scenario, saltwater becomes a contributing factor to the already significant stormwater backups. Nevertheless, these communities depend on the networks in other shoreline communities, and could expect significant ripple effects from compromises in the network in before mid-century. In addition, the roads host nearly 2,500 streetlights that could be vulnerable. Repeated saltwater exposure could increase corrosion of the metal posts, rotting of wooden posts, and damage low lying electrical components.

The County of Marin's major vulnerable roads include Sir Francis Drake Blvd., portions of Point San Pedro and North San Pedro Blvd. Some less traveled roads include residential streets along the shoreline in Santa Venetia, Bayside Acres, and

Almonte. Marin County Public Works stressed that roadway impacts from water will severely degrade the base and surface materials from the weight of vehicle traffic breaking up the roadway. The goal to limit water intrusion and avoid damage to the roadway system, including the roadway drainage facilities, is not easily met. Identifying cost effective and environmentally feasible solutions will require engineering studies with partnerships from local stakeholders and permitting agencies.

Caltrans is the asset manager for Highways US-101, I-580, 37, and 1, also known as Shoreline Highway. Marin County is in Caltrans District 4 with Sonoma, Solano, Napa, Contra Costa, Alameda, Santa Clara, San Mateo, and San Francisco Counties (see Map 15). Adapting District 4 systems for near-term exposure levels could cost billions of dollars. According to the *Caltrans Guidance on Incorporating Sea Level Rise*, the State Highway System is limited in adaptive capacity because of the numerous services it facilitates, its permanent location, longitudinal nature, long lifespan, and uncertain funding resources.[64]

Caltrans asks three questions in assessing sea level rise planning:

- Is the project located on the shoreline or in an area vulnerable to sea level rise?
- Will the project be impacted by the stated sea level rise (as determined by a range based on several models and adopted by the Ocean Protection Council in March 2011)?
- Is the design life of the project beyond year 2030?

Other factors include anticipated travel delays, goods movement, emergency evacuation, travel safety, burden on public funds, impacts on connecting streets, and environmental constraints. Preliminary conversations with Caltrans asset managers indicate that Caltrans is well aware of the existing and arising concerns in the County.[65] According to Caltrans and the CoSMoS model the following are areas of concern:

- Manzanita Park and Ride Lot and Shoreline Highway, Almonte: This area already floods at high tides at about 4.5 feet NGVD about 20 to 30 times every year.
- US Highway 101 from Seminary Drive to Route 131 (Tiburon Boulevard), Strawberry: This stretch is prone to flooding at high tide and storm events, especially at the off ramps. This stretch of the highway is unprotected.
- US Highway 101 at Rowland Boulevard, Novato: This stretch floods, is adjacent to Scottsdale Pond, and a series of ponds, levees, and pumps operated by others protect it.
- US Highway 101 at the 101/37 Interchange, Novato: This vulnerable 3,100-foot stretch is protected by levees and pumps operated by others.
- US Highway 101 in low spots between Corte Madera and San Rafael: These low spots typically benefit from levees and pumps others operate to protect the larger area from flooding. These locations are south of Tamalpais Drive to Nellen Avenue, from Corte Madera Creek to Lucky Drive, and south of the US Highway 101/ I-580 Interchange to the south of San Rafael Harbor.
- State Route 37 between Atherton Avenue and US Highway 101: This stretch of 37 is protected by non-engineered levees that have a history of overtopping with combined high tides and Novato Creek flows.

Making improvements to these locations could cost $825 million to $1.1 billion depending on the adaptation methods chosen.[66,67]

Overall, a significant amount of transportation assets could be vulnerable. This could impact individual mobility and the movement of goods and services. Some critical examples are food delivery, solid waste and recycling removal, emergency and repair vehicles, and transit vehicles.

64 Caltrans Climate Change Workgroup, and the HQ Divisions of the Transportation Planning, Design, and Environmental Analysis. Guidance on Incorporating Sea Level Rise: For use in planning and development of Project Initiation Documents. May 26, 2011.

65 Sea Level Rise Vulnerability Assessment Interview. Caltrans. April 30, 2015. J. Peterson. D. Fahey. Marin County Development Agency. BVB Consulting LLC.

66 Sea Level Rise Vulnerability Assessment Interview. Caltrans. April 30, 2015. J. Peterson. D. Fahey. Marin County Development Agency. BVB Consulting LLC.

67 2014 dollars

Richardson Bay Flooding, Jan. 1982. Credit: Marin DPW

Waldo Point Harbor King Tide. Nov. 24, 2015. Credit: Marin County CDA

Map 14. Manzanita Park & Ride Sea Level Rise Exposure

Note: Due to mapping limitations this image is misleading at the freeway overpass. The water on top of the overpass in the image represents water under the overpass at ground level. The overpass is elevated above Richardson's Bay. Source: MarinMap, CoSMoS. Credit: BVB Consulting LLC.

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Map 15. Caltrans District 4

Transit Service

Several entities provide transit services in Marin County both locally and regionally that could be impacted by sea level rise. Regional bus and ferry service is provided by the Golden Gate Bridge, Highway and Transportation District (GGBHTD) as Golden Gate Transit (GGT) and Golden Gate Ferry (GGF). Local bus transit is provided by the Marin Transit (MT). Several airporters and other charter buses transport travelers as well. Private ferry services are provided by Blue and Gold Ferries amongst other private services.

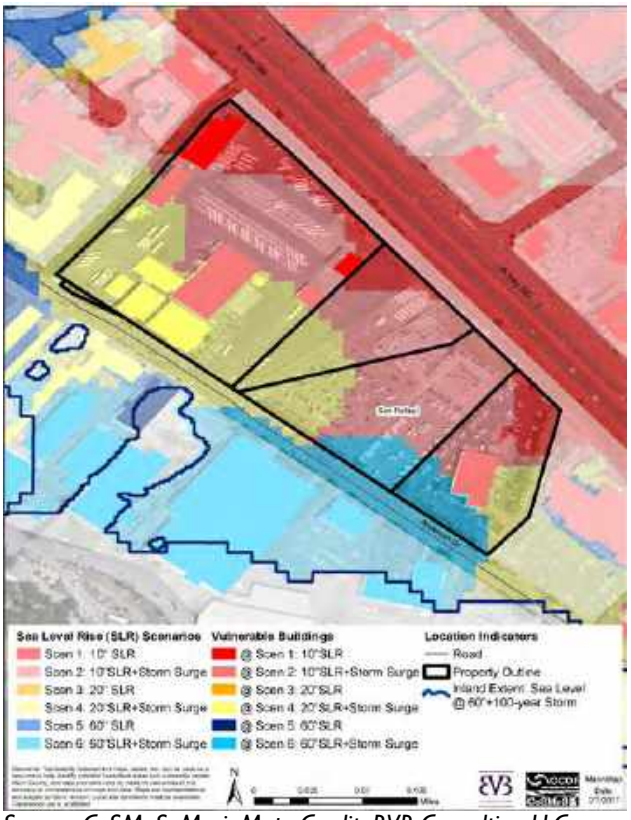
Bus routes that run on roads vulnerable to storm impacts and sea level rise are:

- GGT routes:
  - Scenario 1: 8, 10, 18, 24, 27, 37, 38, 40, 44, 54, 56, 58, 70, 72, 74, 76, 80, 97, and 101.
  - Scenario 3: 4
  - Scenario 5: 2
- MT routes:
  - Scenario 1: 17, 23.29, 35, 36, 71, 228;
  - Scenario 3: 19, 22, 61, 66, 113, 115, 117, 119
  - Scenario 5: 45, 49, 68, 219, 233, 251, 257, 259, 125, 126, 127, 145, 151, 154.

These routes could be vulnerable to dangerous conditions and loss of access at stops and between them. MT has more than 170 stops and GGT has about 115 stops that could be vulnerable at MHHW in the long-term. Several of these stops are also used by the Marin Airporter and the Sonoma Airport Shuttle, including Manzanita Park and Ride in Almonte and the San Rafael Transit Center. Additional private company buses, such as Genentech, also pick-up commuters from the Manzanita site. Manzanita is already seasonally vulnerable and the San Rafael Transit Center is vulnerable in the medium- to long-terms.

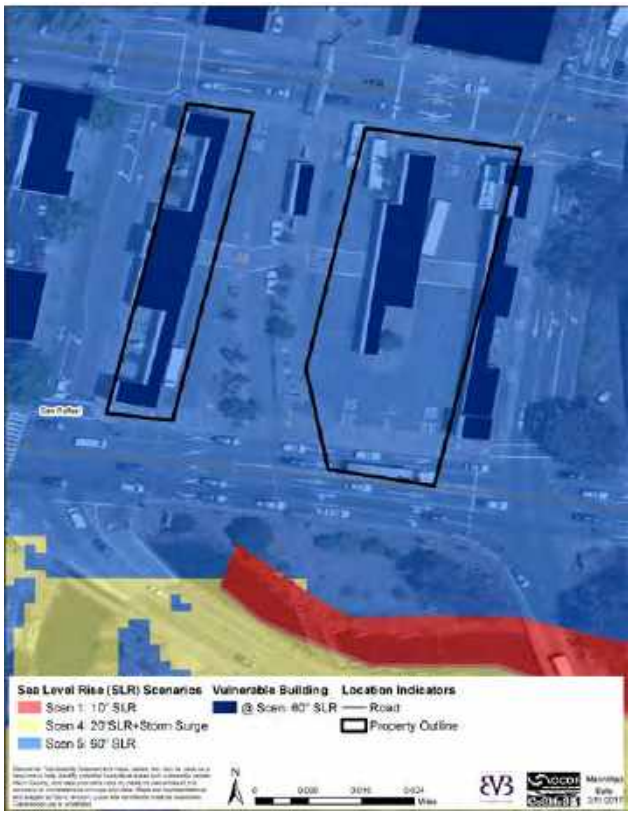
In addition, the GGT Headquarters, Machine Shop, and Bus Depot could be vulnerable to sea level rise starting in the near-term. Exposure could be significant enough in the medium-term to warrant action on site. The facility is on Andersen Drive in San Rafael and also hosts the Marin Airporter depot, offices, and pick up location.

Map 16. GGBHTD Headquarters & Bus Depot Sea Level Rise Exposure



Source: CoSMoS, MarinMap. Credit: BVB Consulting LLC

Map 17. San Rafael Transit Center Sea Level Rise Exposure



The SMART train is the only regional rail service soon to be available to Marin County residents. This new service could flood at several points along its rail line from Sonoma County, through Novato, San Rafael, and terminating in Larkspur.

The track itself is vulnerable to weakness in the base, or ballast, of pervious stones piled in a trapezoid. If flooded often enough these areas could subside and weaken overtime. Moreover, the rail right-of-way typically contains embedded utilities, and signal, switches, and electrical equipment.

The train cars themselves could be vulnerable to flooding because much of the mechanical equipment is on the bottom of the train car. Continued exposure to saltwater could cause increased rates of corrosion. If the water is deep enough, the train may not be able to pass at all. The mile posts where the track could flood include:

- 15.9 to 16.9, San Rafael/Santa Venetia
- 19.8 to 20.9, Central San Rafael
- 21.4 to 23.0, St. Vincent's
- 25.3 to 27.4, Novato behind Rowland Way
- 29.6 to 29.8, Novato
- 30.1 to 31.9, Novato
- 32.9 to 33.4, Novato, North Novato

The San Rafael Transit Center is the only SMART stop that could expect tidal flooding at 60 inches of sea level rise in long-term scenario 5.

Bicycling

Bike paths along existing roadways could be vulnerable as well, and much like cars, bicycles could be vulnerable to frequent saltwater exposure. In addition, several multi-use trails such as the Mill Valley-Sausalito and Corte Madera Creek Pathways could be vulnerable in the near-term because of the waterway crossing and bordering routes. Bikeways are also vulnerable to flooding in the northern part of the study area around Bel Marin Keys.

SMART railroad in Novato. Credit: BVB Consulting LLC

Mill Valley-Sausalito Multi-Use Path at high tide. Credit: J. Poskazner

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View of Larkspur Ferry parking lot and boats from Greenbrae Boardwalk. Credit: BVB Consulting LLC

Water Transportation

Boasting for commuting to work, leisure, sport, shipping, and other activities are important vulnerable uses of the Marin shoreline.

Ferry Service

Three ferries service the regional transportation network and one offers transport to Angel Island State Park. The three providing commuting services dock in Sausalito, Tiburon, and Larkspur. The Tiburon Ferry also serves a good portion of tourists, especially on sunny weekends. Of these, the most vulnerable is Larkspur Landing.

According to GGBHTD ferry asset managers, the Larkspur Ferry Terminal uses a hydraulic system that reaches its limits at king tides today. Major improvements to the site, parking capacity, and dock operating systems are discussed in the 10-year Master Plan for the facility. These plans include updating the facility to a float system capable of accommodating higher sea levels. Without this effort, the GGF Larkspur Ferry may have to eliminate service when tides are too high. At worst the majority of the property could flood tidally, eliminating access, parking, and offices.

The parking area is already susceptible to riverine flooding, and if the earthen berm is breached by the bay, the parking lot would have to weather saltwater exposure as well. This could lead to vehicle damage, especially over the extended periods of time commuters leave their vehicles on site. The ferry facility fuel containers could also experience tidal flooding. If this fuel source is compromised during a storm or through long-term exposure to corrosive saltwater, not only is this region wide resource threatened, the bay could be contaminated with fuel and other chemicals.

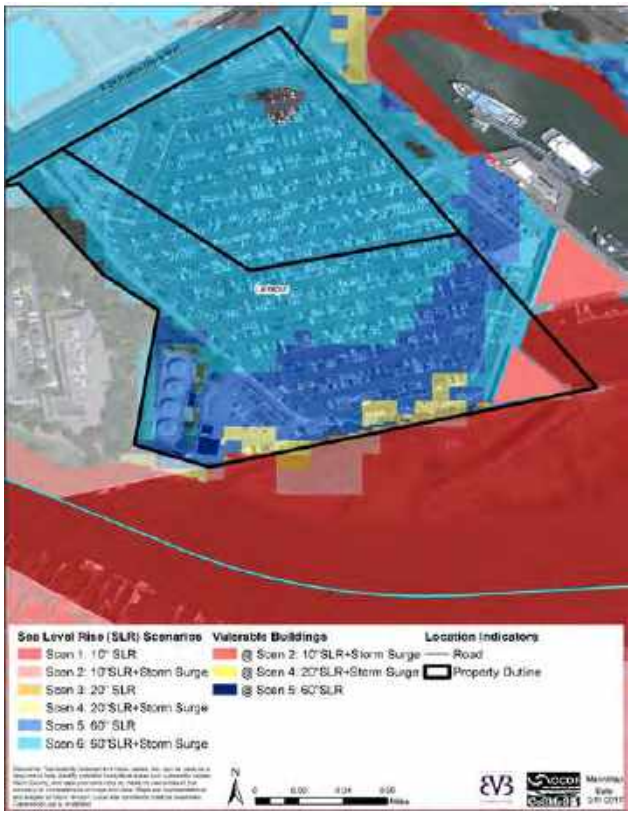
The Blue & Gold and Angel Island Ferry landings in Tiburon are vulnerable to sea level rise in the near-term. The GGF Sausalito Ferry operates on a float system that may be able to withstand sea level impacts in the near-term.

Harbors and Marinas

Privately owned boats are housed and/or leave from the following vulnerable water transportation facilities:

- Arques Shipyard and Marina, Sausalito,
- Buck's Landing (public),
- Cass Gidley Marina, Sausalito (public),
- Corinthian Yacht Club, Belvedere,
- Clipper Yacht Harbor, Sausalito,
- Five Star Yacht, Sausalito,
- Hi-Tide Boat Sales & Services, San Rafael,
- Loch Lomond Marina, San Rafael,
- Liberty Ship Marina, Sausalito,
- Lowrie Yacht Harbor, San Rafael,
- Marin Yacht Club,
- Marina Plaza Harbor, Sausalito,
- Paradise Cay Yacht Harbor,
- Pelican Yacht Harbor, Sausalito,
- Petaluma River Public Fishing Access (public),
- Richardson Bay Marina & Kappas Harbor, Waldo Point Harbor,
- San Rafael Port,
- San Rafael Yacht Club,
- San Rafael Yacht Harbor,
- San Francisco Yacht Club, Belvedere,
- Sausalito Marina,
- Sausalito Port,
- Sausalito Yacht Harbor,
- Schoonmaker Point Marina, Sausalito,
- Tiburon Yacht Club, Paradise Cay,
- Travis Marina, Fort Baker, and
- Waldo Point Harbor.

Map 18. Larkspur Ferry Terminal Sea Level Rise Exposure



Loch Lomond Marina, San Rafael. Credit: BVB Consulting LLC

Water transport facilities vary in vulnerability depending on the docks system, if the pylons the docks attach to are high enough for the highest high tides, and to subsidence of jetty walls. Just like Larkspur Landing, these harbors, if not set up high enough to handle the future's new high tides, could be vulnerable. Storms are known to cause damage to docks, piers, and boats as well, and damages to boats could lead to loss of life and/or significant economic losses.

Marina and harbor facilities serve several purposes and contribute significantly to economic strength and community character. The Sausalito shoreline has a concentration of boating industry activities. Several locations in Sausalito, Waldo Point Harbor, Belvedere, Tiburon, and Paradise Cay also serve as places to live. To learn more about residential vessels, see the Buildings profile. In addition to private residences, these harbors house tourist attractions, restaurants, and other forms of recreation that are a major draw for Marin County.

And while not located in Marin, Marin residents and businesses could be vulnerable to damages and shut downs at the region's ports. In 2007, the four major ports in Oakland, San Francisco, Redwood City, and Richmond processed nearly 2,388 thousand twenty-foot equivalents of marine cargo and 29.4 million tons of bulk cargo.[68] The port of Oakland hosts the largest volume of cargo as the nation's fourth busiest port, and carries more exports cargo than imports The Bay Area Region airports and sea ports are gateways to Marin and the world and generate a significant amount of productivity that Marin County benefits from and depends on.

Airports

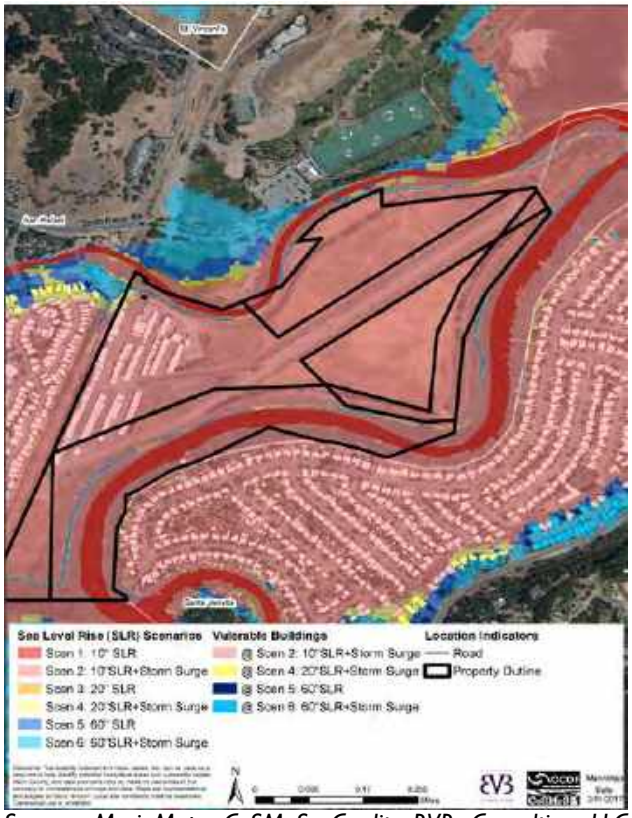
The Marin County Gnoss Field Airport in North Novato could be vulnerable in the long-term, and San Rafael Airport could be vulnerable in the medium-term. Both of these small plane facilities depend on levees for flood protection; however, Gnoss Field depends on levees managed by other land owners closer to shoreline. If the respective levees fail, both airfields would be vulnerable to high tides sooner than the timeline of this assessment

[68] Biging, Greg S., John D. Radke, and Jun Hak Lee (University of California, Berkeley). 2012. *Impacts of Predicted Sea-Level Rise and Extreme Storm Events on the Transportation Infrastructure in the San Francisco Bay Region.* California Energy Commission. Publication number: CEC-500-2012-040.

would anticipate. Flooding would reduce flight time windows, and would damage airplane storage areas and airplanes stored on site. Finally, increased subsidence could warp the buildings and runway.

Table 33 lists some of the potentially vulnerable transportation assets in the study area. This list shows onset as near-, medium-, and long-term time intervals, and the flood depth values calculated for tidal mean higher high water (MHHW). High and low values along each vulnerable roadway or pathway segment are provided. In scenarios 1, 3 and 5, a roadway may be impacted for short periods of daily high tides, be submerged, or somewhere in between.

Map 19. San Rafael Airport Sea Level Rise Exposure



Source: MarinMap, CoSMoS. Credit: BVB Consulting LLC

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Table 33. Example Transportation Assets Ranked by Onset and Flooding at MHHW

Location	Asset	Near-term	Medium-term	Long-term
		Scenario 1	Scenario 3	Scenario 5
Sausalito	GGF Sausalito Ferry facilities	No data[a]		
Tiburon	Ferry facilities	No data[a]		
Sausalito	Marina Plaza Harbor	5'7"	8'6"	21'9"
Larkspur	Bay Trail	0-5'4"	0-6'	0-8'6"
Larkspur	GGF Larkspur Ferry facility	5'	5'4"	6'9"
Waldo Point	Richardson Bay Marina	4'5"	7'4"	18'7"
San Rafael	Hwy 580 East bound	0-4'	0-4'10"	4"-7'8"
San Rafael	Kerner Blvd	0-4'	0-4'7"	8"-7'5"
Belvedere	Corinthian Yacht Club	4'	4'3"	11'
San Rafael	Francisco Blvd E	0-3'10"	0-4'7"	1'-7'5"
Bel Marin Keys	Bel Marin Keys Blvd	0-3'10"	0-4'6"	0-8'6"
San Rafael	Bellam Blvd	0-3'5"	0-4'	0-7'3"
San Rafael	Canal Street	0-3'4"	1'2"-4'2"	2'-7'11"
San Rafael	Bahia Way	2'-3'3"	2'4"-3'11"	5'2"-6'10"
Tiburon	Richardson Bay Lineal Park	0-3'	1"-3'7"	1"-15'
San Rafael	Hwy 580 West bound	1"-2'10"	1"-3'7"	1"-6'5"
San Rafael	Bay Trail	0-2'3"	0-3'	0-10'3"
Belvedere	San Francisco Yacht Club	2'2"	3'6"	8'10"
Greenbrae	Greenbrae Boardwalk	5"-1'7'	1'-2'4"	3'3"-5'
San Rafael	Hi-Tide Boat sales & services	6"	3'4"	8'5"
Almonte	Caltrans Corp Yard	0-6"	1'4"-1'9"	3'4"-4'5"
Sausalito	Sausalito Yacht Harbor	4"	1'	3'
Larkspur	Corte Madera Creek Path	0-3"	1"-2'	0-6'9"
Paradise Cay	Paradise Cay Yacht Harbor	2"	1'6"	3'10"
San Rafael	Lowrie Yacht Harbor	2"	9"	3'7""
San Rafael	GGBHTD headquarters & depot	0-1'6"	0-2'4"	4'2"-5'
San Rafael	San Rafael Yacht Harbor	1'2"	4'	10'4"
San Rafael	San Rafael Municipal Harbor	1'	2'	6'
San Rafael	Marin Yacht Club	1"	1'6"	3'9"
Mill Valley/ Sausalito	Mill Valley/ Sausalito Pathway		0-8'5"	1"-11'8"
Mill Valley	Bay Trail		0-8'	3"-12'5"
Tamalpais	Shoreline Highway		5"-7'5"	2"-12'5"
San Rafael	Grand Avenue		0-6'	7"-9'
San Rafael	Andersen Drive		0-5'	3"-8"
San Rafael	Francisco Blvd W		0-4'9"	1'8"-9'5"
North Novato	Gnoss Field Airport		4'	10'4"
San Rafael	Peacock Drive		0-4'	9"-6'8"
Almonte	Shoreline Highway		0-3'10"	1'6"-7'
San Rafael	SMART rail in central San Rafael		1'8"-3'9"	1'2"-6'8"
San Rafael	Loch Lomond Marina		3'7"	9'7"
San Rafael	San Rafael Airport		3'5"	8'10"

TRANSPORTATION

Location	Asset	Near-term	Medium-term	Long-term
		Scenario 1	Scenario 3	Scenario 5
Corte Madera	Bay Trail		0-3'4"	0-8'6"
Sausalito	Schoonmaker Point Marina		3'3"	8'2"
San Rafael	Canal neighborhood		1"-3'	2"-7'8"
Corte Madera	Paradise Drive		0-2'5"	4"-9'
Sausalito	Clipper Yacht Harbor		2'5"	6'3"
San Rafael	Hwy 101North bound		0-2'5"	6"-5'3"
Corte Madera	San Clemente Drive		1'2"-2'3"	1'9"-7'4'
San Rafael	Pt. San Pedro Road		0-2'2"	4"-5'10"
San Rafael	San Rafael Yacht Club		2'2"	5'7"
Sausalito	Gate 5 Road		0-2'2"	10"-4'10"
Sausalito	Cass Gidley Marina		2'	3'2"
Corte Madera	Tamalpais Drive		0-2'	2"-7'6"
San Rafael	Hwy 101South bound		0-2'	1'4"-5'
Waldo Point	Gate 6 Road		0-1'9"	1'10"-4'9"
China Camp	N. San Pedro Road		0-1'8"	1'7"-3'8"
Mill Valley	Miller Avenue		0-1'7"	2'-4'8"
Larkspur	Larkspur Landing fuel storage		1'7"	4'2"
San Rafael	Downtown		1"-1'3"	3"-3'3"
Bayside Acres	Beach Drive		1"-1'	2'4"-3'10"
Corte Madera	CA Highway Patrol Marin office		9"	7'2"
Santa Venetia	N. San Pedro Road		0-9"	1'8"-3'5"
Novato	Bay Trail		0-8"	0-12'7"
Belvedere	Belvedere Corp Yard		4"	1'5"
Larkspur	Doherty Drive		0-3"	05'5"
Belvedere	San Rafael Avenue		0-3"	2"-4'3"
San Rafael	3rd Street		5"	9'-3'10"
San Rafael	San Rafael Airport			1"-12'5"
Novato	Hamilton Parkway			4'8"-10'9"
St. Vincent's	SMART rail			0-10'9"
San Rafael-East	SMART rail			1"-10'3"
Novato	SMART rail			0-9'8"
Novato	Hwy 37 West bound			2"-8'4"
Corte Madera	Hwy 101North bound			6"-7'8"
San Rafael	Lincoln Avenue			10"-7'4"
North Novato	SMART rail			0-7'
Novato	Hwy 37 East bound			0-7'
Corte Madera	Redwood Highway			1'2"-6'8"
Santa Venetia	Neighborhood Streets			6"-6'8"
Black Point	Atherton Avenue			0-6'
Belvedere	West Shore Road			2'3"-5'5"
Corte Madera	Hwy 101South bound			1'-5'5"
Larkspur	Hwy 101North bound			3'6"-5'3"
Larkspur	Redwood Highway			4'2"-5'2"

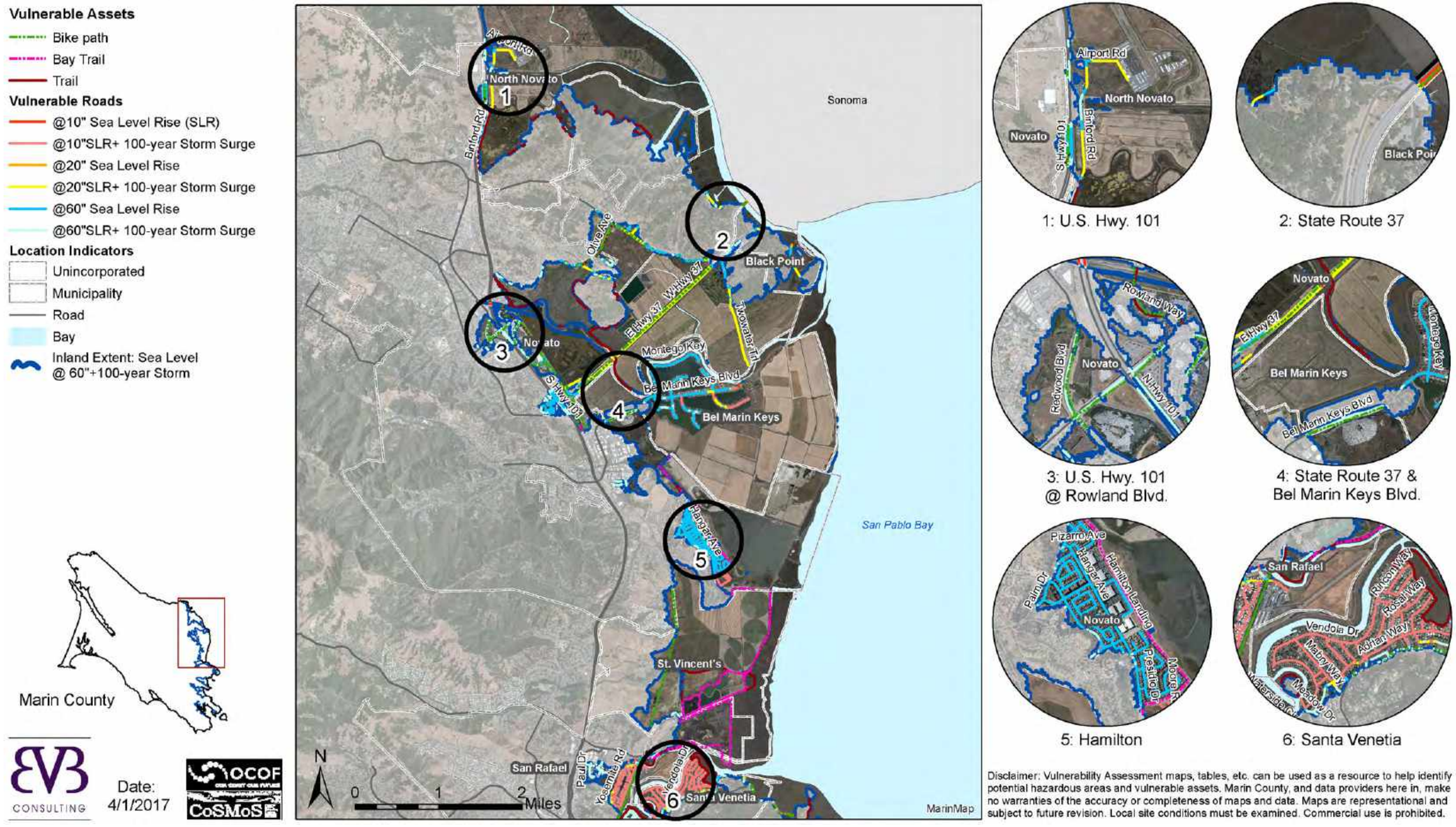
TRANSPORTATION

Location	Asset	Near-term	Medium-term	Long-term
		Scenario 1	Scenario 3	Scenario 5
Belvedere	Beach Road			11”-5’
Tiburon	Tiburon Blvd.			9”-5’
Larkspur	Hwy 101South bound			2’3”-5’
Strawberry	Redwood Highway Frontage Rd			1’2”-4’10”
Larkspur	Riviera Circle			1’8”-4’9”
Mill Valley	Sycamore Avenue			0-4’7”
Larkspur	Hwy 101South at Lucky Dr.			2’7”-4’4”
Larkspur	Hwy 101North at Lucky Dr.			3’10”-4’3”
Larkspur	Redwood Highway Frontage Rd			3’-4’2”
Mill Valley	Redwood Highway Frontage Rd			9”-4’2”
Country Club	Pt. San Pedro Rd			5”-4’
Marin City	Hwy 101South bound			5”-4’
Strawberry	Seminary Drive			7”-3’7”
Mill Valley	Camino Alto between Miller and E. Blithedale Avenues			2”-3’6”
San Rafael	4th Street			1’-3’5”
San Rafael	2nd Street			1’-3’4”
Strawberry	Tiburon Blvd.			5”-3’4”
Tiburon	Bay Trail			6”-3’
Marin City	Redwood Blvd.			1”-3’
Larkspur	Sir Francis Drake Blvd			7”-2’9”
North Novato	Hwy 101South bound			1’9”-2’7”
Novato	Rowland Blvd.			0-2’7’
Almonte	Almonte Blvd.			1’10”-2’5”
Tamalpais	Tam Junction			1’6”-2’5”
Tiburon	Main Street			4”-2’5”
San Rafael	San Rafael Transit Center			2’5”
North Novato	Redwood Highway			1’9”-2’4”
San Rafael	Hetherton Street			1’4”-2’4”
North Novato	Hwy 101 North bound			4”-2’4”
Sausalito	Bay Trail			7”-2’3”
Sausalito	Bridgeway			7”-2’
Marin City	Hwy 101North bound			0-2’
Novato	Hwy 101North bound			0-2’
Strawberry	De Silva Island Drive			10”-1”10”
Kentfield	Stadium Way			1’5”-1’9”
Novato	Hwy 101South bound			0-1’9”
Paradise Cay	Paradise Cay Marina			1’-1’10”
Strawberry	Hwy 101North bound			1’7”-1’8”
Strawberry	Hwy 101South bound			2”-1’
Mill Valley	E. Blithedale Avenue			1”
Sausalito	Pelican Yacht Harbor	No data		

[a] Data not available for assets are located bayside of mean sea level. Source: MarinMap, OCOF Exposure and Flood Depth data, Asset Manager Interviews

TRANSPORTATION

Map 20. Northern Study Area Study Area Roads, Trails, and Bike Paths Vulnerable to Sea Level Rise



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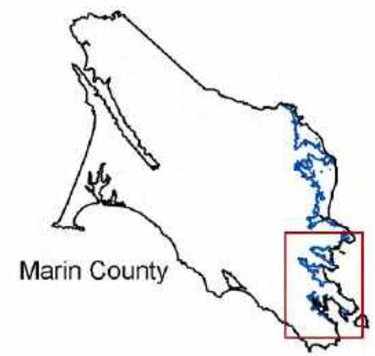
TRANSPORTATION

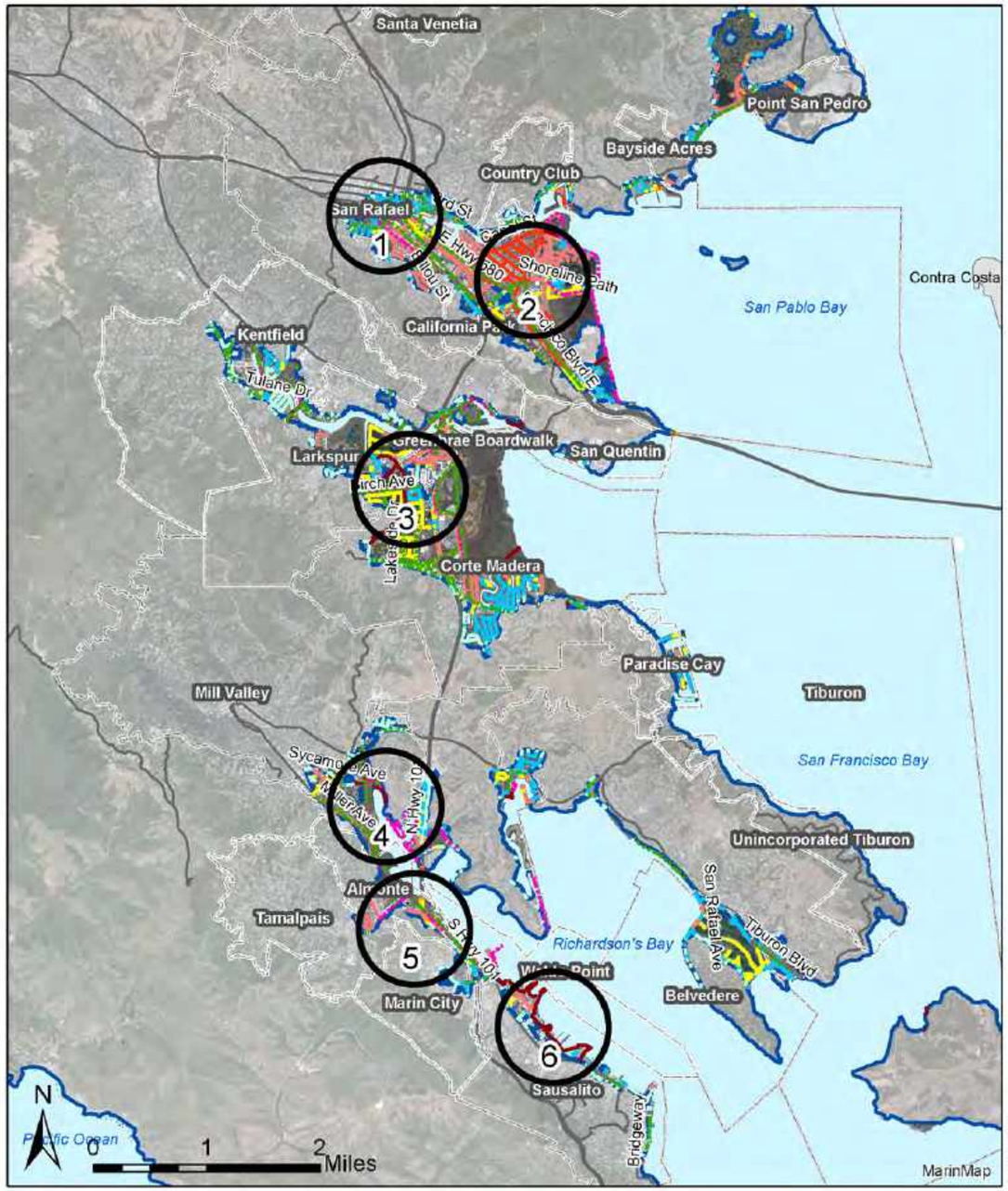
Map 21. Southern Study Area Roads, Trails, and Bike Paths Vulnerable to Sea Level Rise

Vulnerable Assets
- Bike path
- Bay Trail
- Trail

Vulnerable Roads
- @10" Sea Level Rise (SLR)
- @10"SLR+ 100-year Storm Surge
- @20" Sea Level Rise
- @20"SLR+ 100-year Storm Surge
- @60" Sea Level Rise
- @60"SLR+ 100-year Storm Surge

Location Indicators
- Unincorporated
- Municipality
- Road
- Bay
- Inland Extent: Sea Level @ 60"+100-year Storm





1: Central San Rafael

2: Canal Neighborhood

3: Larkspur/ Corte Madera

4: Mill Valley

5: Almonte/Manzanita Park & Ride

6: Marin City/ Waldo Point Harbor

EVB CONSULTING

Date: 2/11/2017

OCOF CoSMoS

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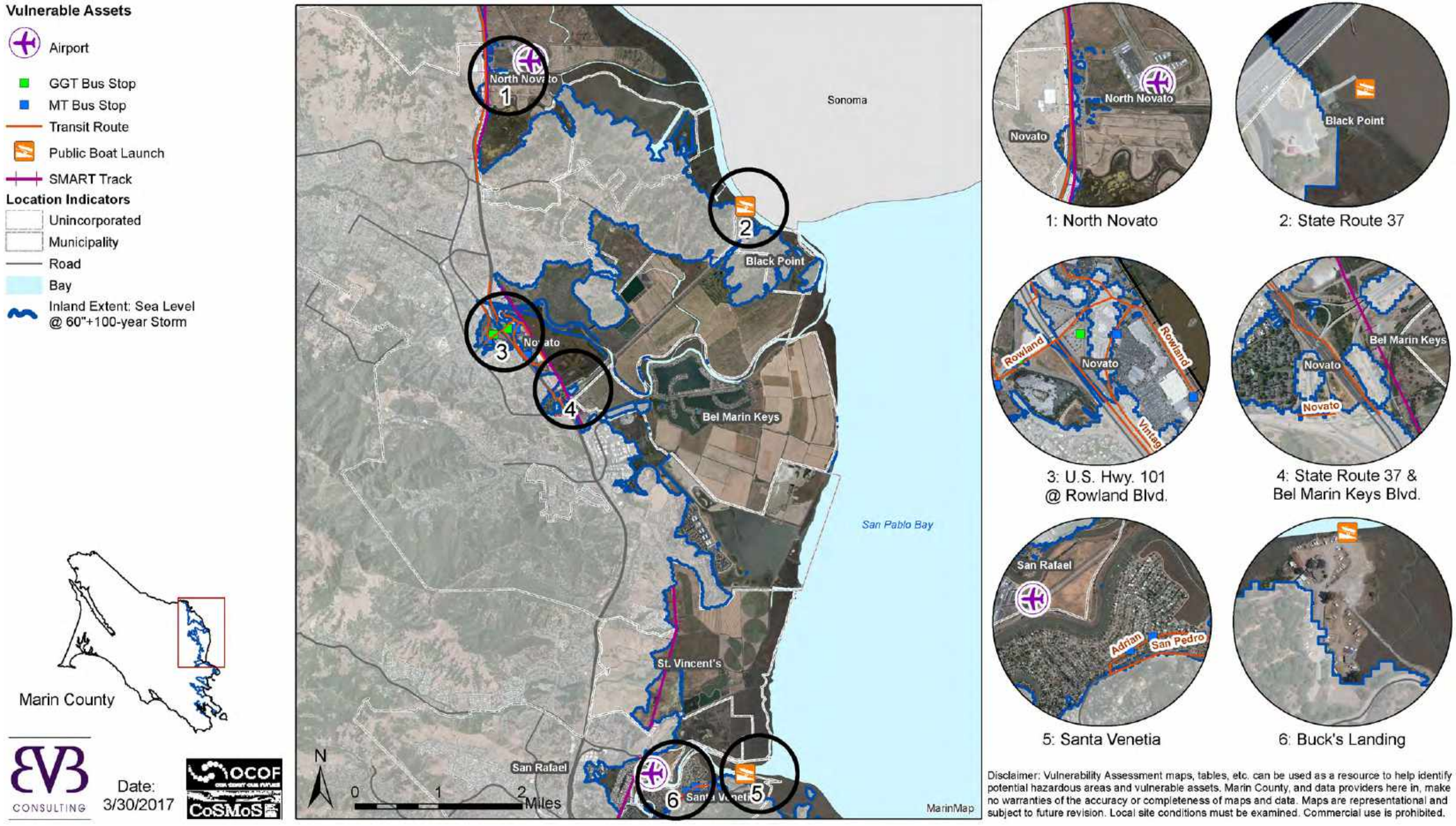
TRANSPORTATION

Map 22. Northern Study Area Vulnerable Transit, Air, and Marine Transportation Assets



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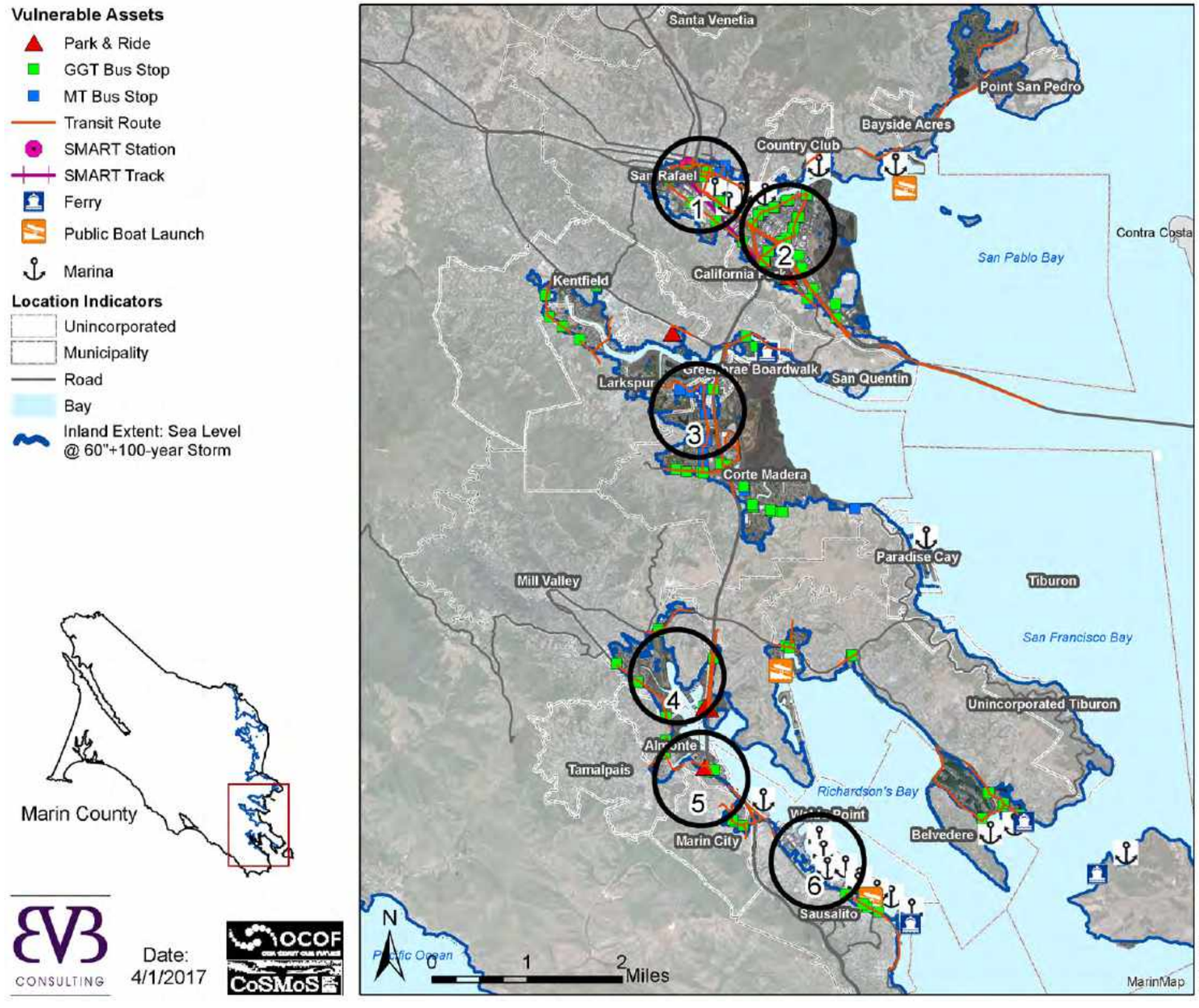
TRANSPORTATION

Map 23. Southern Study Area Vulnerable Transit and Marine Transportation Assets



1: Central San Rafael

2: Canal Neighborhood

3: Larkspur/ Corte Madera

4: Mill Valley

5: Almonte/Manzanita Park & Ride

6: Marin City/ Waldo Point Harbor

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Other Considerations

Economic
Goods movement throughout the county is critical to all residential and employment uses. Road access, even water access, is essential for daily life activity, whether it facilitates supply transport, commuting to work, getting to school, or accommodating the several million tourists that visit Marin annually. Disruptions, large and small, can have significant economic ripple effects across many, if not most, sectors of the Marin community. Moreover, direct costs for damages to and upgraded transportation routes could run in the billions over the next several decades.

Allocating adequate funding for elevating roads will likely be difficult, straining limited local and county sources, and highly competitive allocations for state and federal funding sources.

Several road segments are protected by armoring, such as seawalls, revetments, bulkheads, bluff walls, and other hard engineering solutions to prevent flooding and erosion. These structures may become compromised and require increasingly costly maintenance or replacement. In some cases, where retreat is selected, the roads and protecting structures may be closed and abandoned in place, or relocated. If seawalls and bulkheads along the shoreline fail, repairs to the road and utilities underneath could be costly. Creating alternative routes may require acquiring private property and meet political resistance.

Environmental
Road repair and construction can have significant environmental impacts. When roads completely fail, sediment, asphalt, and automotive pollutants can enter into the surrounding properties and habitat. Constructing new roadways as alternative routes can also have significant environmental impacts, including significantly altering or developing existing habitats and/or becoming new barriers to habitat migration.

If not contained, fuel storage tanks in the study area could leak petrochemicals into the floodwaters or groundwater and into the San Pablo or Richardson's Bays before entering San Francisco Bay and beyond. This is a concern for the automobile gas stations, fuel supplies at government work yards, and at Larkspur Ferry Facility.

Finally, abandoned boats anchored in Richardson's Bay could sink or be damaged in a storm leaving debris and other contents in the water.

Social Equity
While Marin County has a relatively high household median income across the state and nation, neighborhoods of low-income residents and with low income residents are a significant portion of the vulnerable population and work force. Example locations include Marin City, San Rafael's Canal neighborhood, The Redwoods community, several mobile home parks, and houseboats in Richardson's Bay. Roads serving these communities along the US Highway 101 corridor already experience stormwater flooding and tidal flooding that can disrupt traffic flow for hours. More severe flooding would only increase the frequency and length of traffic delays, and further prevent residents from traveling to work, school, or other appointments in a timely manner. The congestion could lead to loss of work hours and income, or lead to serious injury or loss of life in emergency situations.

This congestion would also disproportionally impact those who depend on public transportation. First, flooding could prevent timely travel, second, flooding could prevent safe travel, and third, expenses to protect or relocate the San Rafael Transit Center and the GGBHTD facilities and buses may be shared by public transit patrons, increasing transportation costs for those who tend to be from lower income groups relative to the County median income.[69]

According to the Healthy Marin Partnership, 2013 Community Health Needs Assessment, roughly 20 percent of residents in the study area pay more than 15 percent of their income towards transportation costs alone, paying more than the national average. This cost burden is especially significant for Marin's retired residents, Marin City and San Rafael's Canal neighborhood residents, residents on boats in Richardson's Bay, and other low-income communities that could experience the disruptions and damages of sea level rise and storms. This indicates that a some residents are already overburdened by this basic expenses; leaving less income available for other necessities such as emergency preparedness, medical care, healthy

[69] Marin Transit. July 2015. 2016-2025 Short Range Transit Plan. Pg. ES-3 <http://www.marintransit.org/pdf/SRTP/2016-2025/2016-2025SRTP_FINAL.pdf>, Accessed Jan. 6, 2017.

food, child care, or education. Vulnerable household with vehicles may require more frequent body work as saltwater exposure corrodes the body and mechanical components. And for residents of lesser means, recovery from temporary flooding damage may be a slower process than for residents with greater purchasing power and financial flexibility. Saltwater exposure to mechanical components could prevent a vehicle from working.

According to the Healthy Marin Partnership, 2013 Community Health Needs Assessment, between 50 and 70 percent of Marin's shoreline residents in the BayWAVE study area pay more than 45 percent of their income on housing and transportation combined.[70] The affordability standard is 30 percent of income on housing and 15 percent on transportation. [71] This indicates that a large portion of residents are already overburdened by these basic expenses, leaving less income available for other necessities such as emergency preparedness, medical care, healthy food, child care, or education. Households with vehicles could be burdened body maintenance expenses as saltwater exposure corrodes the body and mechanical components. And for residents of lesser means, recovery from temporary flooding damage may be a slower process than for residents with greater purchasing power and financial flexibility.

Management

Efforts to proactively reengineer existing routes will require collaboration amongst several land owners, private and public. Routes require connections to adjacent driveways and streets and must coordinate with access to underground utilities and drainage. Coordination is critical to ensure consistent access and wise use of financial resources. Environmental and land condemnation processes to acquire land for new routes can be extremely political, lengthy, and expensive. Planning and implementing adaptation measures for higher water levels could span several election cycles at all levels of government. Successful preparation would require continuous political support from mayor to mayor, council to council, state congress person to person, and so on for several decades. If government priorities shift away from supporting sea level rise preparation, communities could be less equipped to weather increased flooding.

Table 34. Income Spent on Transportation, 2005-2009

Jurisdiction	% residents paying more than 15% on mobility
SF-Oakland-Fremont Region	18
Marin County	21
Sausalito	20
San Rafael	20
Larkspur	20
Corte Madera	20
Mill Valley	21
Strawberry	21
Kentfield	21
Belvedere	21
Tiburon	21
Novato	21.
Santa Venetia	21
Tamalpais-Homestead	21
Black Point/Green Point	24
Marin City*	No data

Source: Human Impact Partners, 2015, H+T Index, CNT

** No data is available for Marin City, though Marin City figures may be incorporated with a nearby community.*

70 Human Impact Partners. 2013. Healthy Marin Partnership. Community Health Needs Assessment Sub-county Health Indicators.

71 Human Impact Partners. Healthy Marin Partnership. Community Health Needs Assessment Sub-county Health Indicators. 2013.

UTILITIES

Asset Profile: Water, Wastewater, Stormwater, Gas, Electricity, & Telecommunications

Most habitable buildings depend on several utility systems including: water supply, onsite wells, septic systems (regulated as onsite wastewater treatment systems (OWTSs)), regional waste systems, electricity, propane, communications, and stormwater infrastructure. These systems are significant assets and can be disrupted or severely damaged before a building's structural components. Marin residents occasionally weather temporary disruptions; however, at some point in the coming decades, these occurrences could become more frequent and costly. The following are key vulnerabilities for vulnerable utilities:

- Three wastewater treatment plants could expect flooding impacts if no actions are taken.
- All sanitary districts could be vulnerable to increasing saltwater infiltration into pipes and the treatment process.
- Subsidence can cause the roadway over a pipe to sink, placing bending pressure on the pipe.
- If the water table rises significantly, buoyancy forces could stress and push pipelines closer to the surface.
- Homes in Black Point using OWTSs could expect reduced percolation area during high tides. Older systems without automatic shut-offs could contaminate the bay.
- PG&E electricity transmission lines may be prone to subsidence in bay mud and inundated areas along most of the shoreline.
- PG&E underground natural gas lines are also present in the study area in several communities and could be vulnerable.
- Stormwater drainage backups could increase with higher tides, and consequently flooding properties along creeks and creek tributaries.
- High winds and falling trees during storms threaten overland power and communication lines.
- Novato and Belvedere corporation yards could be vulnerable.
- Utility service employees may be prevented from travelling to office or worksite locations.

IMPACTS-AT-A-GLANCE: SCENARIO 6

12,100 buildings+

100,000+ people affected

Increased operation costs and energy demands

Local & Regional

Property Owners
Marin County Public Works
Municipalities
Sanitary Districts
North Marin Water District
PG&E
AT&T

Greenbrae Boardwalk utility lines and control systems. Credit: BVB Consulting LLC

UTILITIES

Potable Water

According to engineers at North Marin Water District and the Marin Municipal Water District, potable water provision and district facilities are moderately sensitive to sea level rise and are unique to each district.

Pipelines are principally buried within existing roadways and would not be immediately affected by sea level rise. Improvements to the roadways to address sea level rise would facilitate improvements to buried infrastructure.

North Marin Water District (NMWD)

North Marin Water District supplies drinking water the City of Novato, northeastern Marin, and portions of west Marin. NMWD has several medium- and long-term vulnerabilities.

By the medium-term, the already vulnerable Bel Marin Keys distribution system could expect impacts from water table and saltwater intrusion that may get worse until the system is upgraded. In addition, a cathodic protection anode bed that serves this community is also vulnerable. Also in the medium-term, emergency reserves in vulnerable area could face infiltration and corrosion from saltwater exposure.

By the long-term, an intertie valve at State Route 37 that connects NMWD and Marin Municipal Water District could be vulnerable. In addition, there are potential threats to underground pipelines and above ground air valves that release air from the pipelines. And also in the long-term, the Deer Island Recycled Water Facility and Recycled Water Transmission Main from Las Gallinas Valley Sanitary District could be vulnerable. And also vulnerable in this time period are aqueduct control valves at Redwood and San Marin Drive.

Finally, the NMWD headquarters itself may be vulnerable to storm and tidal flooding due to existing hydraulic conditions along Rush Creek. This facility is where personnel, vehicles, equipment, and records are housed, and billing and other professional services are provided.

Marin Municipal Water District (MMWD)

Marin Municipal supplies drinking water to most of communities along the shore south of Novato. MMWD asset managers are confident that the water distribution system can sustain the impacts of regular high tides. For example, it would take more than 5 feet of sea level rise to compromise the pressurized water pipes. However, in scenario 6, five feet of sea level rise with a 100-year storm surge, the MMWD headquarters in Corte Madera is impacted. The impacted area contains the corporation yard, operations laboratory, workshop, emergency generators, and above ground fuel tanks. And in both scenarios 5 and 6, access to the facility could be challenging during high tides. Increased exposure to saltwater could also cause more rapid degradation of trucks and other equipment brought in and out of the facility.

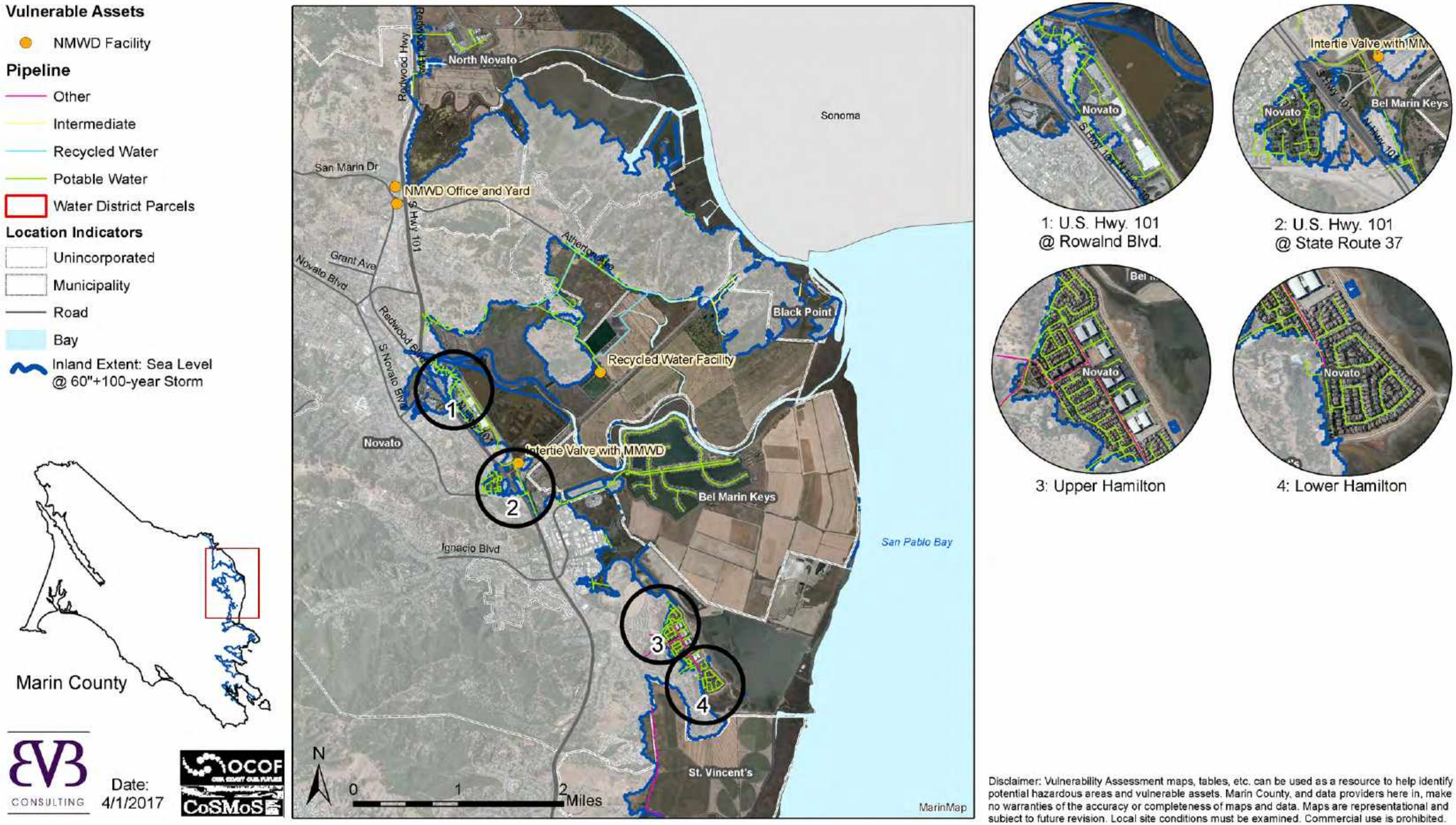
Table 35. Potable Water Vulnerabilities

Underground Issues	• Saltwater intrusion could contaminate water in pipes through air valves, and wells for drinking and fire protection. • Water distribution: Pipes must maintain 24” of space from the groundwater table, and 32” below ground. As the water table rises, pipes will be exposed to saltwater and shift underground. • Pipes may be vulnerable to increased saltwater corrosion and subsidence.
Above Ground Issues	• Some houseboats use flexible hose connections that would wear more quickly if submerged in saltwater more often. • Saltwater could damage pipes that line boardwalks serving over water or marsh homes.

Source: NMWD Asset Manager Interview

UTILITIES

Map 24. Northern Study Area Vulnerable Water Service Assets



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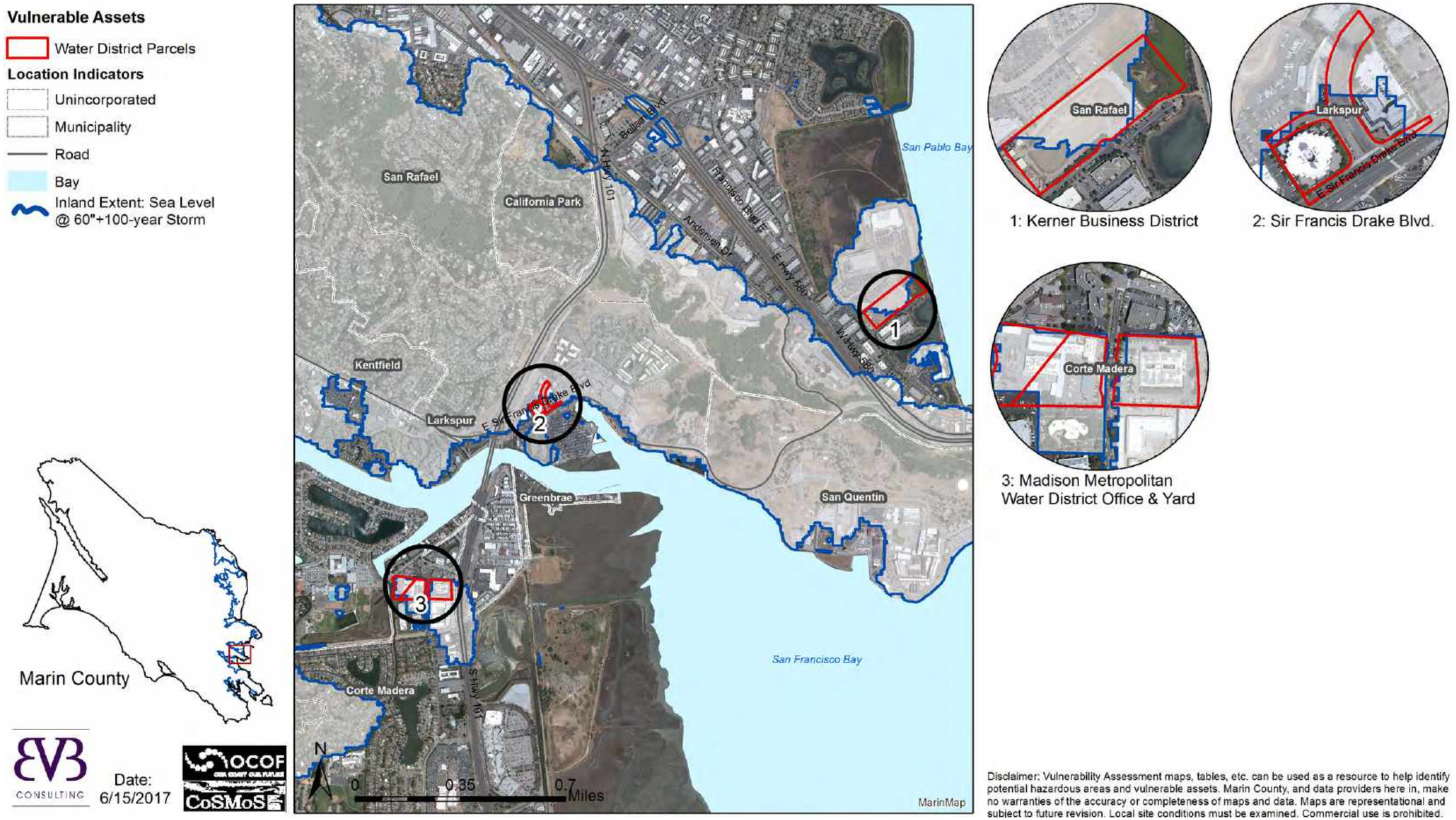
UTILITIES

Map 25. Southern Study Area Vulnerable Water Service Assets



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UTILITIES

Sewer Service

The majority of businesses, facilities, and residences on the eastern shoreline of Marin County depend on community wastewater systems, and in several cases these systems connect to a treatment plant, or NMWD and MMWD water recycling systems. Sanitary districts with vulnerable assets include:

- Sausalito Marin City Sanitary District
- Sewerage Agency of Southern Marin
  - o Almonte Sanitary District
  - o Alto Sanitary District
  - o Tamalpais Valley Sanitary District
  - o Homestead Sanitary District
  - o Richardson Bay Sanitary District
  - o City of Mill Valley
- Central Marin Sanitation Agency
  - o Ross Valley Sanitary District
  - o San Rafael Sanitation District
  - o Corte Madera, Sanitary District No. 2
  - o City of Larkspur
- Las Gallinas Valley Sanitary District
- Novato Sanitary District

Because of its low lying nature, development on bay mud, and population density, southern Marin communities are most vulnerable to wastewater treatment issues. The most vulnerable are those dependent on the Sewerage Agency of Southern Marin (SASM) treatment plant. However, all sanitary districts could be impacted by inflow and infiltration into sanitary pipes and manholes. The excess water creates inefficiencies in treatment, and potentially flooding the system. Impacts to buildings near damaged pipeline or backed up systems is also possible in all of these districts. Cleaning up an individual single-family residence from sanitary sewer back-ups can cost more than $5,000.[72] If this combines with additional flooding, costs would soar even higher. In addition, subsiding pipes, mains, and pump stations are also a common concern. Finally, if the power is out for extended periods of time, diesel emergency sources for back-up generators at pump stations could at least be significantly more expensive to operate. If pump stations fail, sewage could back up and out of manholes and into the streets, parks, or yards where they exist. If the area is also flooded, harmful sewerage could spread widely throughout the flooded area creating significant public health risks.

Figure 4. Inflow and Infiltration Sources to the Sanitary System Pipeline

Source: King County Department of Natural Resources and Parks, Wastewater Treatment Division

Many systems were built decades ago and the original piping is ageing, punctured by tree roots, and/or bent from shifting soils. Because of this, storm and tidal waters can enter into the pipeline, diluting the effluent being sent for treatment. One of the largest sources of storm and tidal waters is the lateral pipes that connect each building to the shared district pipeline.

Storm and tide water infiltration can alter the chemistry needed for treatment and force more water than necessary to be treated; driving up costs, energy use, and processing times. According to asset managers, each treatment plant is designed for wet weather flows. If sea levels and storm waters infiltrate the system enough, wet weather protocols may be required more often, and could be severe enough to require nearly twice the quantity of chemicals, double the energy, and in the end, could be far less effective at disinfecting the wastewater. Disinfecting becomes challenging when water flows too quickly through the system, and when high salinity kills bacteria and organisms critical to the process.

Several districts offer cost share or loan programs to assist willing property owners in updating their lateral systems.

[72] 2016 dollars

Another concern asset managers have is that the top of the hatches at the treatment facilities, extending from treated effluent pipes already in the water, could be overtopped more frequently. This may warrant extending the apron and hatches upwards to accommodate higher tides and maintain safe access. Water over the hatches; however, does not impact pumping potential, as the system is pressurized and can withstand high water levels.

Table 36. Sanitary District System Vulnerabilities

Pump Stations	• Lift stations or pumps below water. • Pump stations can be overburdened by saltwater infiltration into the pipelines.
Pipes	• Older underground metal pipes are corroding and more susceptible to increased saltwater exposure. • Older clay or metal pipes have cracks and wear that allow for inflow and infiltration. If not replaced, this will likely worsen, and could burden treatment plants. • Not all systems are pressurized and vulnerable to changes in the ebb and flow of the tides. • Subsidence can place bending forces on pipes. • Manholes extend below grade. If flooded, access will be lost and inflow and infiltration could occur.
Treatment Plants	• Levees protecting low-lying treatment plants could be overtopped, flooding the plants, offices, and exposing the facility to corrosive saltwater. • Facilities built on mud may experience increased rates of subsidence. • Administrative and maintenance buildings are vulnerable to flooding.
Utility Users	• The lateral pipes connecting each building to the sewer mains could be vulnerable to infiltration of saltwater. This decreases efficiency and effectiveness of treatment. • Excess water can cause back-up into and damage buildings.

Source: Sanitation District Asset Manager Interviews

In addition to these general concerns, a few wastewater assets warrant further analysis because critical facilities could be directly impacted.

Sewerage Agency of Southern Marin (SASM)
The SASM treatment plant is located in Mill Valley and is bound by Bayfront Park featuring Arroyo Corte Madera Del Presidio Creek where it meets the marshes that lead to Richardson's and San Francisco Bays. The facility serves the needs of nearly 30,000 people.[73] Because it is so close to shoreline in a low lying area, critical components of the waste water treatment plant could be vulnerable.

According to CoSMoS, the site could be impacted in combination with a 100-year storm surge in the storm scenarios 2, 4, and, 6. The tidal waters flow to and enter the property from the back of the site where the creek is closest and the elevation is the lowest. A few feet of sea level rise later and water travels from the opposite side of the plant, and the two sources meet in the middle. The plant could be vulnerable to sea level rise at around 4 feet, and certainly by scenario 5 at 5 feet. By 5 feet of sea level rise, the buildings could be tidally flooded with more than two feet of saltwater.

The maintenance and shop buildings are the first to be impacted, followed by the Secondary Clarifier opposite these buildings. Subsequently, the Primary Clarifiers and Recirculation and Effluent Pump Station could be vulnerable. By scenario 5, the remaining Secondary Clarifier, Gravity Thickener, Thickened Sludge Pump Buildings/Shop, Digesters No. 1 and 2, Digester Control Building, Administration Building, Reclaimed Water Facilities, and all parking areas could expect tidal exposure. The only remaining area is where the Equalization Basins, Emergency Overflow, and Trickling Filters are. With the storm surge on top of this all of these components are vulnerable to ocean waters.

SASM commissioned a flood study for the treatment plant property in 2014. The report examines FEMA stormwater flooding in combination with sea level rise amounts of 16 inches by 2050 and 55 inches by the end of the century from the NOAA Sea Level Rise Viewer.[74] While these scenarios are not directly comparable with the BayWAVE scenarios the resulting analysis provides additional timelines for

[73] SASM Master Plan. 2014.
[74] Carollo Engineers. June, 2014. *Sewerage Agency of Southern Marin Wastewater Treatment Plant Master Plan, Technical Memorandum No. 6 Flood Study*. Walnut Creek, CA.

factors not considered in this assessment. Table 6.1 in the report lists the following buildings as vulnerable to 100-year floods and sea level rise:

- By 2050
  - o Headworks and Solids Buildings, and
  - o Electrical Substation Buildings
- By 2100
  - o Control Buildings,
  - o Primary Clarifiers,
  - o Secondary Clarifiers,
  - o Recirculation and Effluent Pump Station,
  - o Recirculation Valve Vault,
  - o Effluent Metering Vault, and
  - o Equalization Basin.

Note that these features could be vulnerable during the coincidence of 100-year storm rain amounts from the land and sea level rise. The report does not include the 100-year storm surge from ocean in that time period. Both models likely under estimate the potential total flooding because neither incorporate both storm components of rainfall and ocean surge.

Map 26. SASM Exposure to Sea Level Rise

The SASM Technical Flood Study also provides proposals for protecting the site. According to the report, protecting the site for the long-term, not accounting for the ocean storm surge, with a berm, wall, and tide gates could cost more than $2.5 million. Marin County Public Works is also working with the agency and other partners to enhance the marshes protecting the channel to harness the effectiveness of nature based methods. These proposals and others are discussed in greater detail in the technical study and the Richardson Bay Shoreline Study.

Of the sanitary districts associated with SASM, the primary issues are related to inflow and infiltration on private properties, and old deteriorating pipelines slated for replacement in the coming decades.

Sausalito Marin City Sanitary District (SMCSD)
Sausalito Marin City Sanitary District could be burdened by several impacts within the district. The treatment plant is generally high enough to avoid significant impact to the facilities. SMCSD vulnerabilities are:

- Marinship area service could diminish as development is flooded out.
- The Main Street Pump Station in Sausalito collects and transports 95 percent of the effluent brought to the treatment plant and borders the shoreline.
- Locust Pump Station could become burdened with tidal water infiltration.
- Anchor Street Pump Station could become burdened.
- Princess Pump Station, 500 block of Bridgeway could become burdened, and controls across the street near the Trident Restaurant could be flooded.
- Marin City Pump Station could become burdened with tidal water infiltration.
- Drake Pump Station could become burdened with tidal water infiltration.
- Two pumps Stations on Gate 5 Road could become burdened with tidal water infiltration and could be vulnerable to subsidence.
- Two sewer pipes extending under US Highway 101 could be vulnerable to subsidence and road shifts.
- Access hatches along effluent pipes extending into Richardson's Bay could be overtopped frequently.

- Below grade electrical motors at the treatment plant could be flooded in the long-term at high tides with a storm surge.

Sanitary District No. 2
Sanitary District No. 2 serves Corte Madera and small areas of Tiburon and Larkspur. The district is vulnerable is similar ways to other sanitary districts such that:

- Underground pipes face compounding pressure forces from water and the road,
- Road erosion and collapse with underlain pipes,
- Saltwater inflow and infiltration causing inefficiencies in wastewater treatment,
- Continuously subsiding soils or fill, and
- Escalating activity, capacity demands, energy consumption, and wear and tear on pump stations in stormwater and wastewater systems,
- Aging individual site connections for water, sewer, and electrical, and
- Flood waters interrupting access for employees to reach work sites.

The district connects to the Central Marin Sanitation Agency treatment plant in San Rafael. The treatment plants is not physically vulnerable to sea level rise, however, employees may be prevented from traveling to the site to conduct their work activities.

Las Gallinas Valley Sanitary District (LGVSD)
The Las Gallinas Valley Sanitary District residents could be highly vulnerable. The treatment plant site could be vulnerable around the edges; however, the district is currently elevating the levee protecting the property. The district is planning for six feet of sea level rise and elevating the perimeter road 3-4 feet to an elevation nearly 12 feet above typical 100-year stormwater flood levels. In addition, they are participating with Marin County Public Works to complete a protective eco-tone slope and levee along the shoreline.

LGVSD vulnerabilities include:

- Santa Venetia relies on several pump stations located in the exposure area with tidal water infiltration.
- Marin Lagoon relies on 9 pump stations in the exposure area with tidal water infiltration.
- Solar energy produced on site is located in the sea level rise exposure area.
- Santa Venetia and Marin Lagoon residents may flea the area in the face of sea level rise and reduce service needs.

Ross Valley Sanitary District
The Ross Valley Sanitary District office is in a flood prone area and could be vulnerable to sea level rise by scenario 1. In addition, according to asset managers, 3-feet or more of sea level rise combined with a storm surge could flood pump station-15 near the outlet of the Corte Madera Creek concrete flood channel section. Pump station 15 conveys more than 60 percent of all Ross Valley area wastewater.

San Rafael Sanitation District
In addition to the common issues, the San Rafael Sanitation District office is in a flood prone area and could be vulnerable to sea level rise and storms by scenario 6, and could experience access issues are early as scenario 1. The area surrounding the district office extending to the San Rafael Canal and downtown could also be flooded out of the service area if no action is taken to protect development.

Sanitary District No. 5
The smaller of two treatment plants in the District, the Paradise Cove Plant, is impacted at scenario 6, 5 feet of sea level rise, plus 100-year storm surge. The main issues are worsening erosion and flooding at this site, saltwater intrusion for sewer lines along Tiburon Blvd. that run along the beach, a manhole at Beach and Tiburon Blvd. that already floods, and pump station electrical panels.

The primary treatment facility off Tiburon Boulevard could anticipate some flooding during storm surges in the parking lot. This flooding may also create access issues for employees and cause wear and tear on facility vehicles and equipment.

A majority of the pipes are original, and are planned for replacement, including the force main for Belvedere. All sewage is pumped from smaller pump stations to one main pump station and the 50-year old connecting pipe needs repair.[75]

[75] Sea Level Rise Interview. Jan. 20, 2016. Sanitary District No. 5. Tony Rubio. Interviewed by C. Choo, Marin County Public Works.

UTILITIES

Novato Sanitary District

The Novato Sanitary District Treatment plant is vulnerable just before 3 feet of sea level rise. By scenario 5, the lower half of the plant covered by tidal waters. Bay storm surges may impact the plant sooner. The over flow basins could be impacted by after the medium-term. Next to be impacted are the Ultra-Violet Disinfection and Final Effluent Processing buildings. By 5 feet of sea level rise, tides reach the anaerobic digestion and clarification tanks. Adding a storm surge could also flood around the secondary clarifiers. The water will not likely be high enough to impact the process, however, electrical components may be lower and saltwater corrosion of the tanks and buildings could take a toll. The site is bordered by a flood protection wall that could be elevated to protect the property from rising high tides through the long-term.

On-site Waste Water Treatment (OWTS)

The only community in the study area using OWTSs is Black Point. However, many of the built areas of these properties are at higher elevations and may be free from impacts from sea level rise. In the worst case, sea level rise could alter soil permeability and chemistry in the disposal field. If water levels are high and sustaining enough, effluent from the disposal field could contaminate the estuary waters. Even new shallow or above ground systems, with high water level kill switches, could be impacted by flood waters and affected by power outages. Erosion could also reduce land area available for percolation. Finally, if ground water rises under septic tanks it could have enough pressure to cause tanks to pop out of the ground.

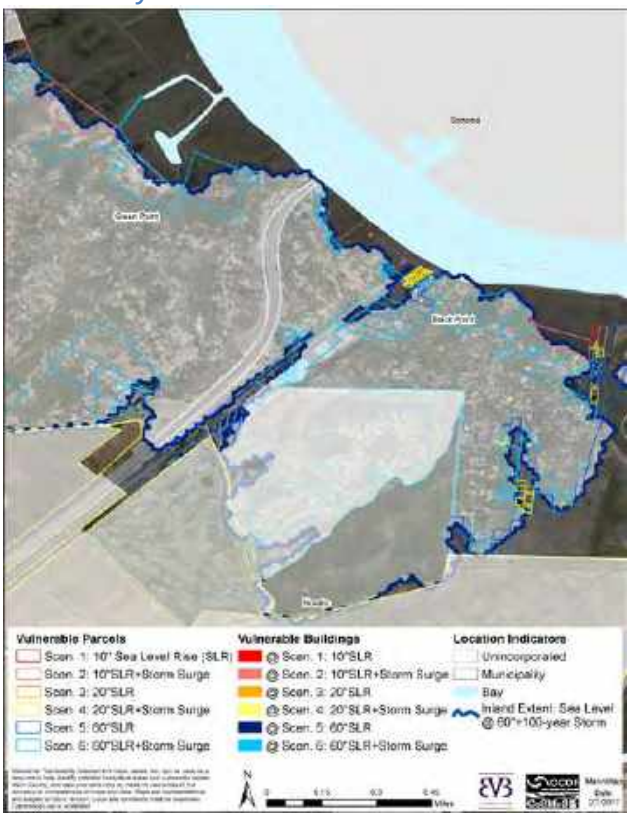
These systems are privately managed by the land owner and regulated by Marin County and the Regional Water Quality Control Board. Septic systems in are regulated by the Marin Countywide Plan (CWP), the Marin County Development Code, and the State Water Control Board's Onsite Wastewater Treatment Systems Policy. More information on regulations can be found at http://www.marincounty.org/depts/cd/divisions/environmental-health-services/septic-systems.

Table 37. OWTS System Vulnerabilities

Land Area	• Erosion can reduce the land area available to percolate waste. Saltwater intrusion into the leach field could impact percolation rates and reduce useable area.
Materials/ Models	• Older single field gravity systems are more susceptible to storm flooding than modern systems equipped with "flip" switches that turn off percolation when groundwater elevates too high. • Newer systems are vulnerable to power outages.

Source: Marin County Environmental Health and Safety

Map 27. Black Point Properties with Potentially Vulnerable OWTSs



UTILITIES

Map 28. Unincorporated Tiburon Properties with Potentially Vulnerable OWTSs

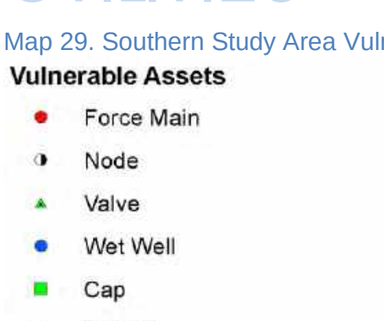
Map 29. Southern Study Area Vulnerable Wastewater Assets

Vulnerable Assets

- Force Main
- Node
- Valve
- Wet Well
- Cap
- Lateral
- Manhole
- Pump Station
- Residential Lateral
- Treatment Plant
- Pipe

Location Indicators

- Unincorporated
- Municipality
- Road
- Bay
- Inland Extent: Sea Level @ 60"+100-year Storm Surge



EVB CONSULTING

Date: 1/31/2017

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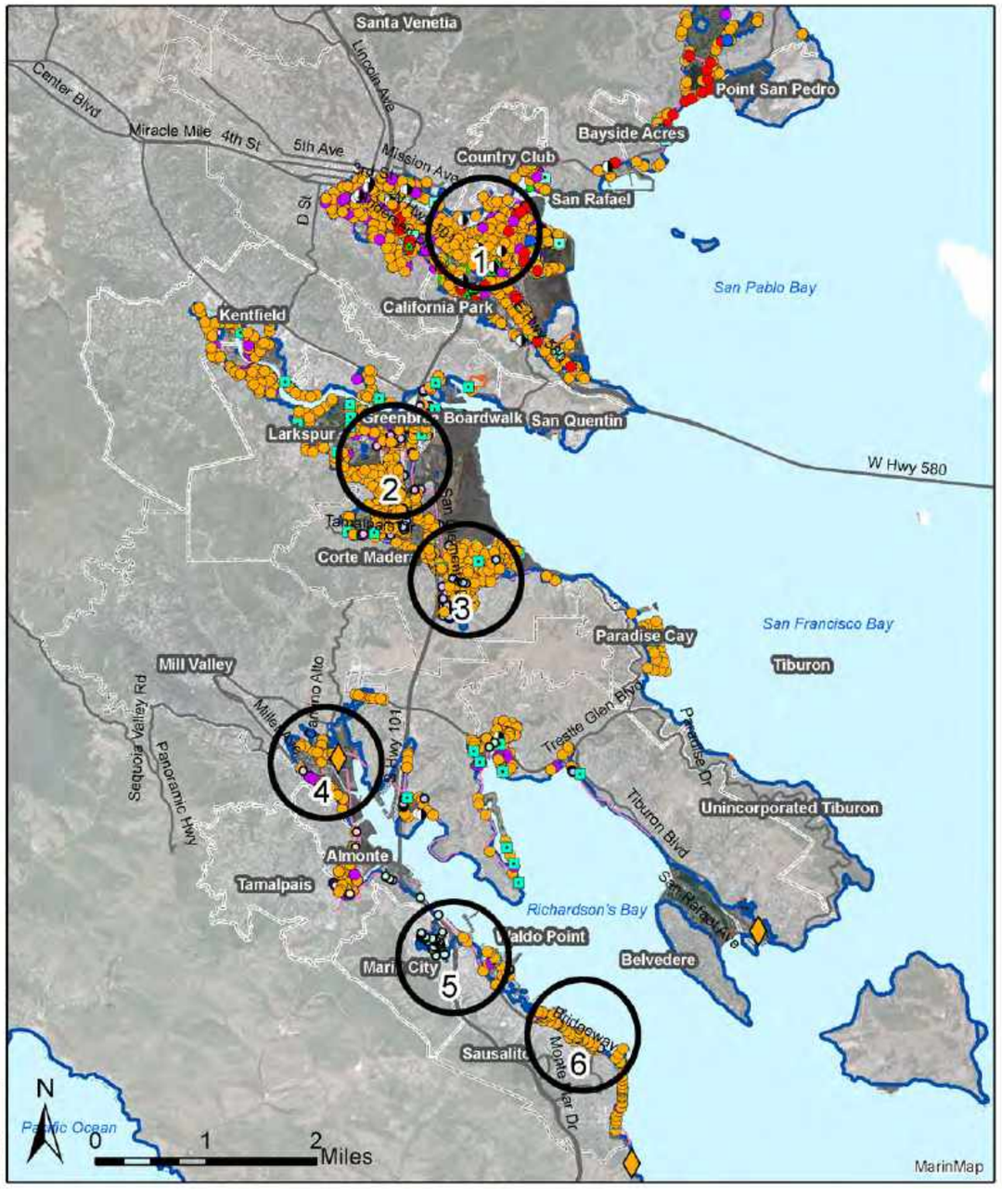
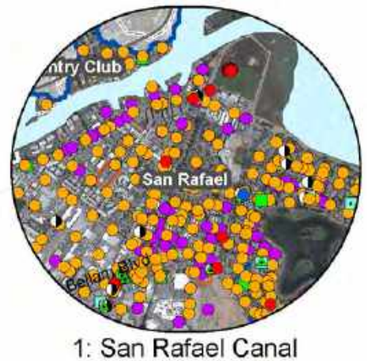


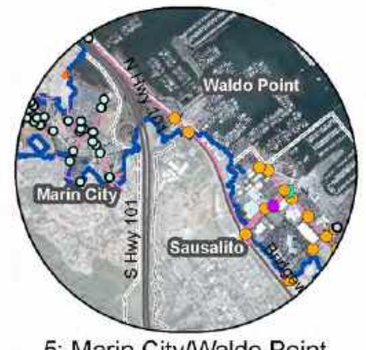


1: San Rafael Canal

2: Larkspur

3: Corte Madera

4: Mill Valley



5: Marin City/Waldo Point

6: Sausalito Shoreline

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UTILITIES

Fuels (Home and Automotive)

Natural gas is the primary source of home fuel and Pacific Gas and Electric Company (PG&E), a California corporation, provides the gas through a network of stations and pipes to the majority of eastern Marin buildings. Within the natural gas service network distributions mains, distribution services, regulating stations, and transmission pipes and stations could be vulnerable to sea level rise.

As part of their own Natural Hazards Asset Performance initiative, PG&E found that nearly 30 percent of its gas transmission pipelines in Marin County are located in FEMA's 100-year flood zones, and about 9 percent are located within areas modeled for two feet of sea level rise, similar to scenario 3.[76] According to CoSMoS and Marin Map, PG&E has one above ground natural gas facility in San Rafael located in the exposed area. Distribution pipelines could be vulnerable in several locations from Tamalpais to Black Point. These include:

- Corte Madera: Pipelines are underneath Paradise Drive to Madera del Presidio to Paloma.
- Larkspur: Pipelines stretch aligned with US Highway 101.
- San Rafael: Pipelines are underneath Lindaro, 3rd, and Lincoln Streets.
- San Rafael: Pipelines extend along McInnis Blvd. to the North West Pacific Rail Road. The portion where the railroad line cuts through a tidal marsh could expect more frequent inundation.
- Novato: Pipelines are underneath Cutlass to Redwood Blvd.
- North Novato: Pipelines are along US Highway 101 North near the North West Pacific Rail Road and Gnoss Field Airport.

The current physical condition of PG&E's natural gas assets is estimated to be good based on inspections of selected pipe segments in 2010 and 2013 for corrosion potential. At this time, the condition is not expected to worsen.[77] However, flooding events could potentially induce landslides, which, in turn, could place bending stress along these pipelines, given the terrain conditions. As a longer-term risk, sea level rise may introduce buoyancy forces on pipeline segments.

Residents in northeastern Marin do not have natural gas service and may use propane for heat, hot water, and cooking. According to asset managers, propane tanks in the exposure area are highly vulnerable to sea level rise and storm impacts because propane tanks are stored outside at or slightly above grade. If waves and water dislodge a propane tank, the risk of rupture or explosion could greatly increase. Additionally, propane is transported to the area through private contractors, such as McPhails, ProFlame, DiCarli's, Blue Rhino, etc. Route blockages could prevent residents from refilling tanks in a timely manner. With the most severe storms and high tides in the winter, these disruptions could occur when residents need the propane most.

Several automotive gas stations exist in the vulnerable area, including an emergency reserve set of tanks at Larkspur Landing holding more than 400,000 gallons of fuel. If the emergency reserve is compromised, the impact could be felt for nearly all emergency service providers in the North Bay. Moreover, gasoline from these sites could also contaminate the bay, potentially with severe economic and environmental outcomes. In addition, smaller underground tanks, common at gas stations, can be vulnerable to water exposure and the corrosive properties of saltwater.

Gas stations along the 101 corridor in Strawberry and sixteen additional gas stations, in San Rafael could be vulnerable to higher tides and/or a 100-year storm surge.

PG&E repair from storm damage in Tam Valley. Credit: Marin DPW

[76] Pacific Gas and Electric Company. 2016. *Climate Change Vulnerability Assessment.* http://www.pgecurrents.com/wp-content/uploads/2016/02/PGE_climate_resilience.pdf.

[77] Pacific Gas and Electric Company. 2016. *Climate Change Vulnerability Assessment.* http://www.pgecurrents.com/wp-content/uploads/2016/02/PGE_climate_resilience.pdf.

Table 38. Potential Risks to Vulnerable PG&E Natural Gas Assets

Storm Flooding	• Reduced soil cover on pipeline or unsupported pipeline spans due to soil scour or erosion. • Damage from floating debris—such as tree limbs—coming into contact with gas pipelines (known as dynamic loading) and potentially collecting against the pipeline like a dam (known as static loading), resulting in bending stress. • Bending stress on the gas pipeline from unstable soil.
Sea Level Rise	• Damage from buoyancy forces on pipeline segments, and potential for erosion around segments

Source: PG&E, Asset Manager Interview Response, 2016

Electricity

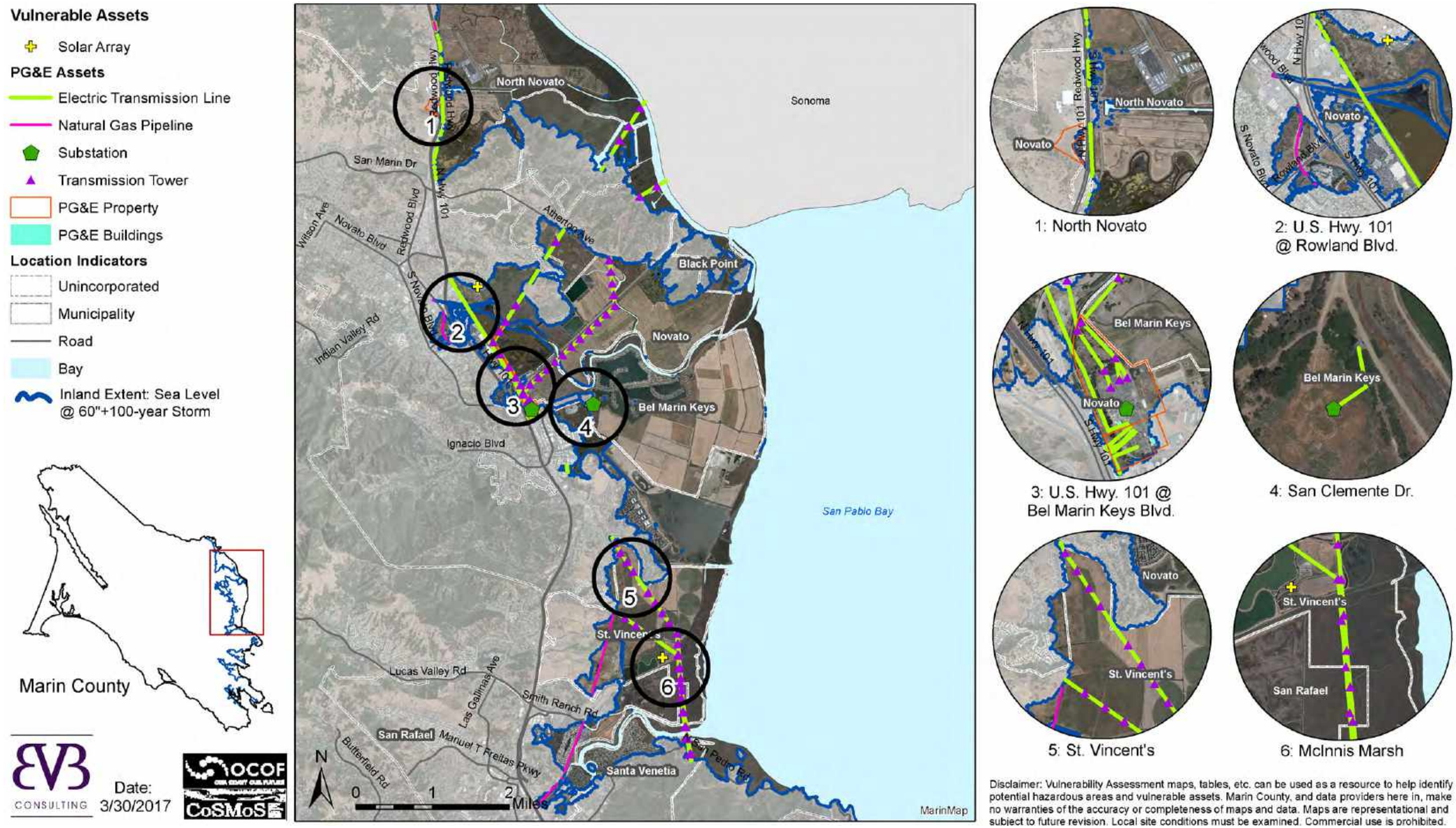
According to PG&E, some electric distribution lines, distribution transformers, transmission lines, substations could be vulnerable to sea level rise. Vulnerable substations are located in Greenbrae, Larkspur, Ignacio (Novato), and Hamilton Wetlands (Novato).

Nearly 80 transmission towers are in the vulnerable portions of the study area east of Bel Marin Keys and South of Novato over to the Sonoma County boarder. While these towers can tolerate flooding, they are susceptible to increased rates of subsidence and erosion from near the mounting platform that supports it. Several other transmission towers are already in the bay off the shores of Corte Madera and Mill Valley that will be subject to even higher water lines and tidal pressure, and subsidence rates.

Other features that could expect increased rates of wear and tear from increased tidal influence are electrical poles. The tall large wooden poles could be vulnerable, currently and into the future, to falling tree branches; however, they can withstand some degree of flooding. Excessive or permanent flooding could weaken the poles over time, warranting replacement. Poles are also vulnerable to roadway collapse because the poles are often located in the right-of-way alongside roads.

UTILITIES

Map 30. Northern Study Area Vulnerable Natural Gas and Electric Assets



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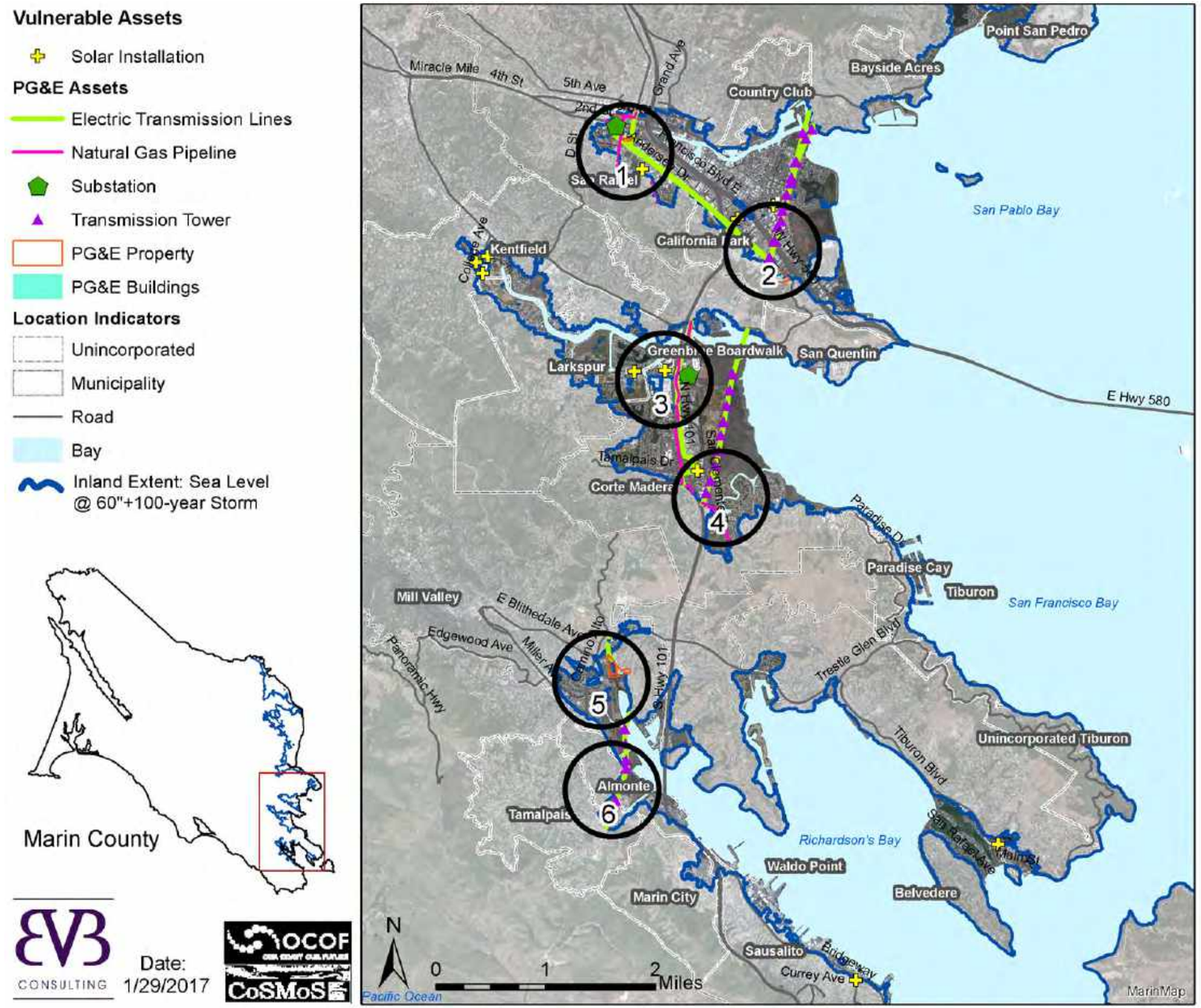
UTILITIES

Map 31. Southern Study Area Vulnerable Natural Gas and Electric Assets



1: San Rafael Canal

2: Andersen Dr.

3: Larkspur Industrial Area

4: San Clemente Dr.

5: Sutton Marsh

6: Bothin Marsh

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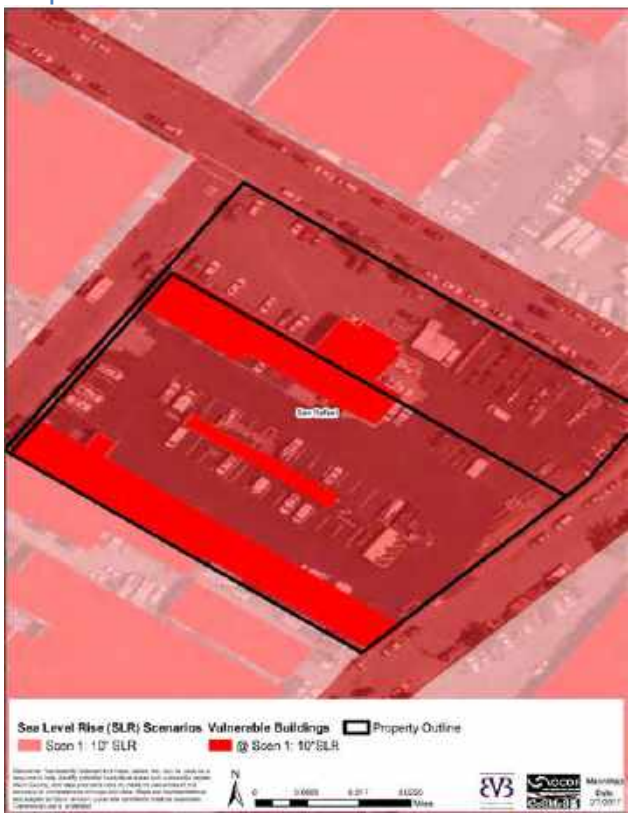
UTILITIES

Telecommunications

Several asset managers provide telecommunication services including: AT&T, Comcast, Charter, Dish, and others. According to AT&T asset managers, telecommunication assets are not vulnerable on their own, as they are designed to withstand wet weather and tidal impacts. In addition, consistent level of service is a primary goal of these companies; therefore, the company would anticipate and prepare for potential impacts. The most vulnerable assets are the communication cables under vulnerable roads. Poles are also vulnerable during storms to falling trees.

In addition, the AT&T Marin yard and office, located in the Canal neighborhood of San Rafael, is vulnerable to more than one foot of tidal flooding at MHHW in the near-term scenario 1. By medium-term scenario 3, tidal waters could be one foot deeper, and by long-term scenario 5, tidewaters could be another 5 feet deeper. Storm surges would only increase flood depths. Tidal flooding of this nature would prompt relocating the facility to higher ground.

Map 32. AT&T Yard & Office at MHHW



Utility lines crossing Coyote Creek where it enters Richardson's Bay. Credit: Marin DPW

Stormwater Systems

Storm drains, culverts, pipes, storm sewers, outfalls, and pump stations are also a critical utility aligned with or under the road. Sediment build-up and sea level rise can block gravity flow through stormwater drainage paths that travel under the roads. This is especially common in areas with lagoons or other retention areas such as Marin City, Mill Valley, Corte Madera, San Rafael, and Santa Venetia. Several outlets to the bay are regulated by tidal flap gates that would not be operable as sea level rises past design elevations. If the storm drains are unable to function, upstream flooding could occur and potentially flood buildings, weaken and erode the road, or worse, a hillside. These assets are managed by Marin County Flood Control.

Pump stations that are under tidal and storm surge influence could become ineffective and over worked. Tidal inundation of these facilities may impact their ability to convey upland stormwater downstream and may lead to flooding[78]. Exposed pump station in the study area are also vulnerable to extended power outages as other others outside the study area. If back-up generator, diesel fuel supplies, and stormwater professionals cannot perform under these conditions, these systems could malfunction. Stormwater pump stations at risk are they are Crest Marin, Cardinal Court, Shoreline pump stations in the Mill Valley and Tamalpais Valley corridor, and the Seminary and Reed Creek pump stations in Strawberry could face tidal flooding. In Tiburon,

[78] San Rafael Public Works Asset Manager Interview.

UTILITIES

Pamela Court and Cove pump stations could face tidal flooding as well.

Stormwater infrastructure along private properties is typically managed by the property owner. However, there are extensive stormwater management systems in place in incorporated and unincorporated areas alike. According to several stormwater engineers, sea level rise could over burden and corrode pump stations, and lead to stormwater back-ups into the surrounding neighborhoods.

Caltrans manages storm drainage systems that are prone to backing up, such as Manzanita and Shoreline Highway in Mill Valley, and Lucky Drive in Larkspur. In addition, as discussed in the transportation section, US Highway 101 depends on the county, city, and town investments in stormwater management.

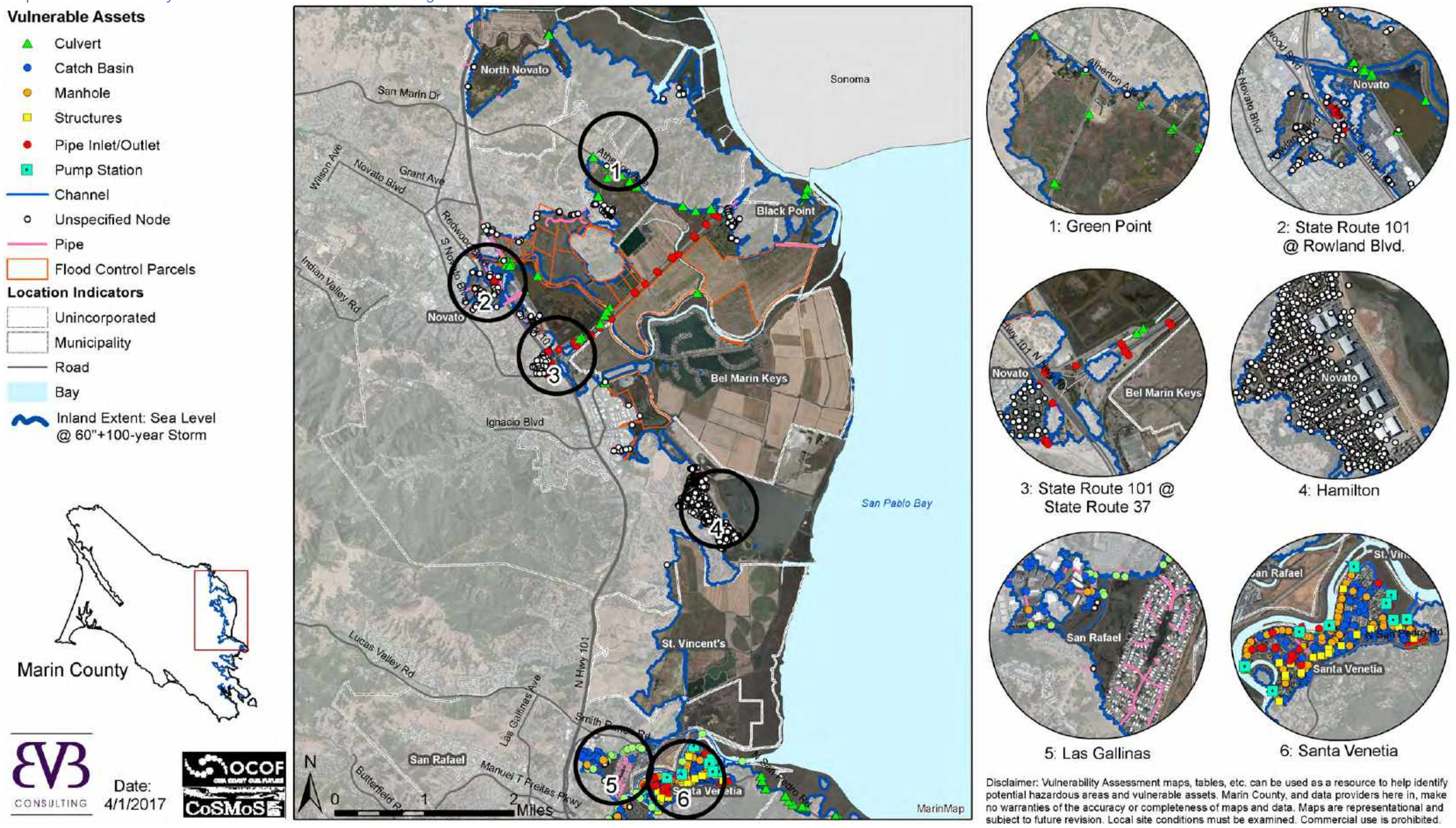
Overburdened stormwater systems could cause road flooding and traffic delays, or even flood buildings, such as school and recreation areas. Pump stations may also be vulnerable in a storm if electrical power is down for an extended period of time, though not likely from sea level rise alone. Instead, pumping may be required more often causing an increase in energy consumption, if the power fails, diesel consumption, and may cause more wear and tear on the machine. Pump stations vary in size, and even a smaller system can cost several hundred thousand to one million dollars. Larger systems can cost more.

The maps on the following pages highlight vulnerable San Rafael, Marin County Flood Control and Caltrans owned and operated stormwater facilities that could be vulnerable to sea level rise and storm burden. The areas in the call out circles enable the reader the see areas that are difficult to see on the large scale map. The circles do not indicate that these areas are more vulnerable than others along the shoreline.

Stormwater Pump Station in Santa Venetia. Credit: BVB Consulting LLC

UTILITIES

Map 33: Northern Study Area Vulnerable Stormwater Management Assets



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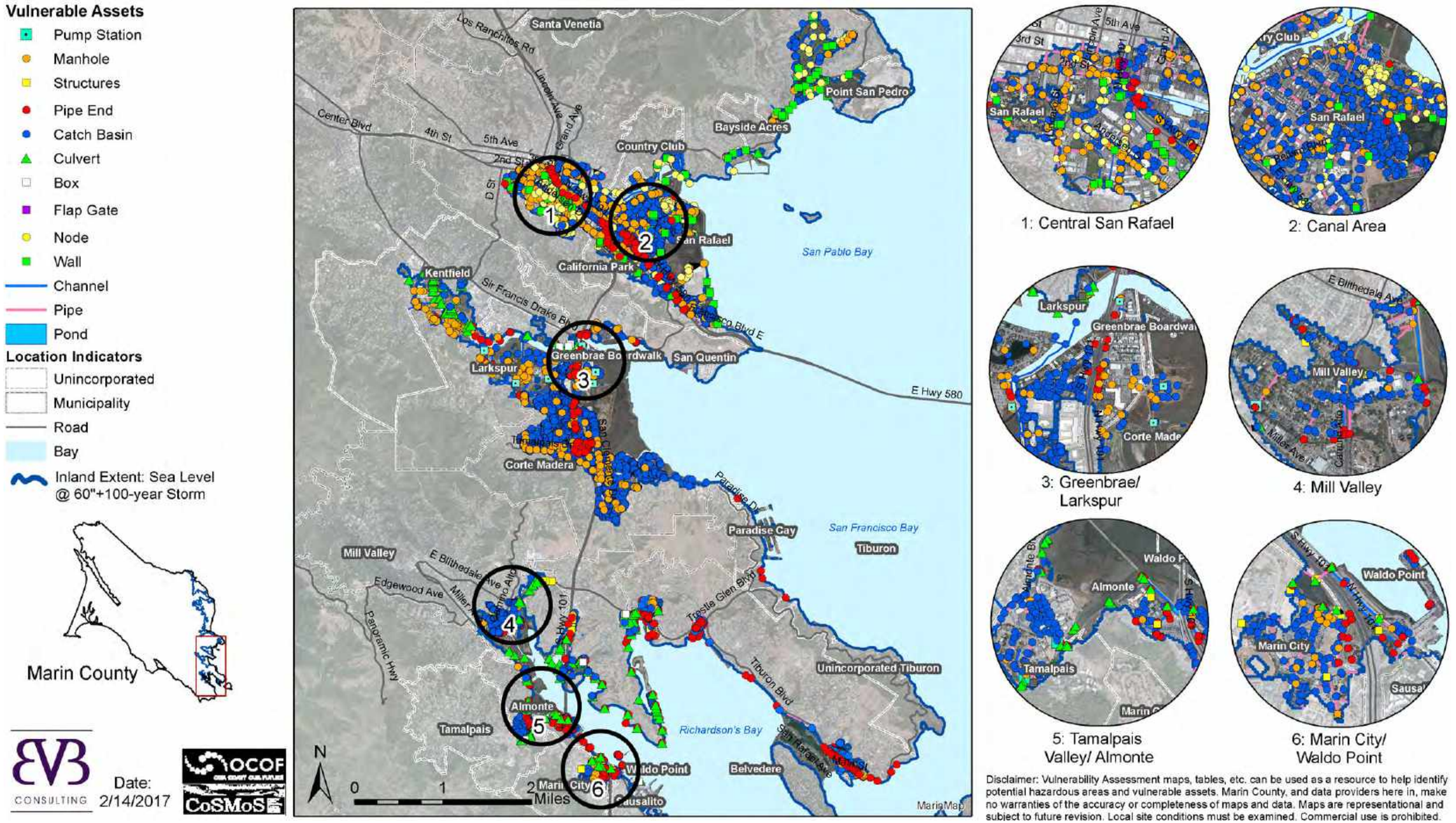
UTILITIES

Map 34. Southern Study Area Vulnerable Stormwater Management Assets



1: Central San Rafael

2: Canal Area

3: Greenbrae/ Larkspur

4: Mill Valley

5: Tamalpais Valley/ Almonte

6: Marin City/ Waldo Point

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UTILITIES

Table 39 lists some of the potentially vulnerable utility assets in the study area. This list measures onset and tidal mean higher high water (MHHW). Note that many utilities assets are underground and could be influenced before these scenarios are discernable on the surface.

Where buildings could be vulnerable to surface flooding, underground water, wastewater, and communications utilities could also be threatened. To learn more about threatened buildings read the Community, Land, and Building Profiles.

In addition to the sites listed in the table below the following sites, would only be vulnerable in scenario 6 to storm impacts:

- PG&E substation Novato,
- Sausalito-Marin City treatment plant,
- Tiburon Paradise Cove treatment plant, and
- Marin Municipal Water District (MMWD) headquarters, Corte Madera

Table 39. Example Vulnerable Utility Assets Ranked by Onset and Flooding at MHHW.

Location	Asset	Near-term	Medium-term	Long-term
		Scenario 1	Scenario 3	Scenario 5
Bel Marin Keys	NMWD cathodic protection well	Underground asset		
Bel Marin Keys	NMWD water distribution system	Underground asset		
Most shoreline communities	PG&E natural gas lines	Underground asset		
Greenbrae Bdwk	PG&E substation		No data	
San Rafael	AT&T headquarters and yard	1'4"	2'5"	6'
Novato	Novato Sanitary District treatment plant		2"-1'7"	5"-4'6"
Larkspur	PG&E Substation			4'
San Rafael	PG&E Headquarters			3'
Mill Valley	Sewerage Agency of Southern Marin (SASM) treatment plant			2'3"
Bel Marin Keys	PG&E electrical substation		No data	
Novato	NMWD air valves		No data	
Novato	Automated valve interconnecting NMWD and MMWD		No data	
Novato	NMWD fire water reserves	No data		
Marin City	Sewage pipes under 101	Subsidence, underground asset		
Most shoreline communities	PG&E transmission lines	Subsidence		

Source: MarinMap, CoSMoS, Asset Manager Interviews

UTILITIES

Other Considerations

Economic
If these essential utility systems fail and residences become unlivable, depopulation could have significant impacts on the local year-around economy. If vacation homes are no longer able to offer essentials or amenities, such as internet, tourists could begin to find the area undesirable and seek other destinations. Visitor serving vacation rentals, bed and breakfasts, inns, and restaurants could expect significant declines in patronage as well. Repairs to community and private systems could cost hundreds of millions of dollars.

Environmental
If wastewater systems fail due to sea level rise, environmental contamination is highly likely and could become a hazard to people and wildlife vulnerable to the flood waters. Negative impacts to water quality are a major concern and are governed by the Clean Water Act.

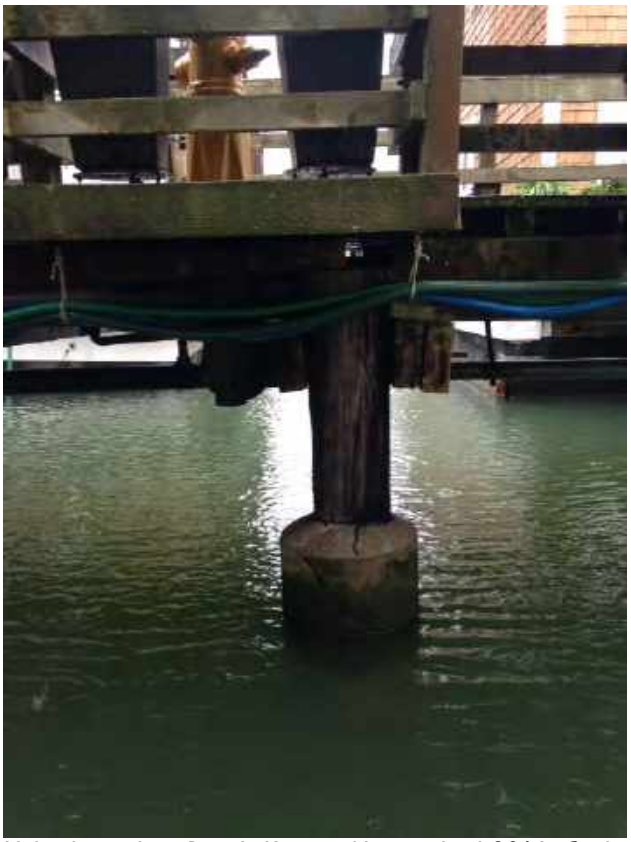
Burdened pump stations and treatment plants would also increase energy consumption, and therefore greenhouse gas emissions. According to asset managers, twice as many chemical inputs would be needed, otherwise less effective treatment could contaminate the bay.

Stormwater system backups can also send pollutants from roadways and industrial sites into natural resources and places where people live, work, and play, creating environmental health hazards.

Finally, multiple utility transmission lines and others are located in marsh areas or along waterways. If these systems were to become damaged, fire, or other electrical damage could occur.

Social Equity
Those on well and septic without financial means to update their utility systems to account for higher water levels are more vulnerable than those who can. Typically, unless financed via special assessment, funding measures are community wide, and in many of the shoreline communities not all homes and businesses are directly impacted and may not be willing to share the cost burden for those who are directly impacted. This community separation could divide the community into factions, increase tension, and reduce community cohesion and resiliency.

Management
Several asset managers indicated that utility lines are often placed under and along publically owned roads. Additional public right-of-way to move the roads and utility assets is inadequate, and new land would need to be acquired. Utility systems are often managed or regulated by state agencies, such as the Regional Water Quality Control Board and the California Public Utilities Commission, and any improvements would require their involvement.



Utility lines along Pier 6, Kappas Marina. April 2016. Credit: BVB Consulting LLC

WORKING LANDS

Asset Profile: Agriculture

Working lands host cultivation and livestock activities. The majority of operations exposed to sea level rise on the Marin shoreline are ranches, dairies, and small produce farms. The parcels are concentrated in St. Vincent's, surrounding Bel Marin Keys, and in North Novato. The following are vulnerabilities these operations could face:

- Loss of vehicular access to and from sites and processing facilities during storms, and eventually, on a regular basis. Heavy vehicles may lose access as roadways become compromised by flooding.
- Flooding could reduce useable space more often and, in some locations, permanently.
- If operations maintain on site wells to care for their animals that are located in the exposed area, the water source could be vulnerable to saltwater intrusion and could become unusable without treatment.

As shown in Table 40, the majority of flooded agricultural uses are on public land that is leased to ranchers for grazing. Under scenario 5, with 60 inches of sea level rise, just over 4,100 acres across 27 parcels could be vulnerable. With storm conditions, an additional 200 acres across twelve parcels could be vulnerable. Two of the largest property owners are the Corda and Silviera families; dedicated primarily to ranching. These are some of the last privately held operations on the Marin's eastern shore.

Table 40. Vulnerable Agricultural Parcels and Acreage (ac.) by Community

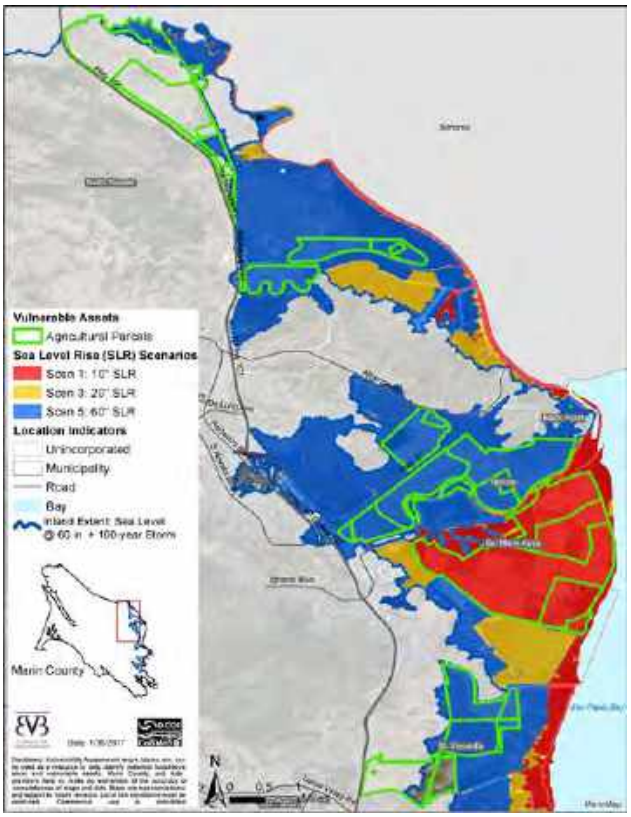
Term	Near		Medium		Long	
Scenario	1		3		5	
Location	#	Ac.	#	Ac.	#	Ac.
Bel Marin Keys	1	28	1	28	4	178
North Novato					7	510
St. Vincent's					5	460
Public Land	8	1,924	8	1,924	11	3,000
Total	**9**	**1,952**	**9**	**1,952**	**27**	**4,148**

Source: MarinMap, CoSMoS

IMPACTS AT-A-GLANCE: SCENARIO 6

4,150 agricultural acres (mostly ranch)	**13 land owners**
Site specific	**Vehicular access**
27 Parcels	**Property owners Lessees**

Map 35. Northern Study Area Vulnerable Working Lands



Other Considerations

Economic
Vulnerable land based operations account for $17,745,567[79] in assessed land and improvement value that could decrease as lands newly under water become waters of the State. If exporting agricultural goods becomes an ever increasing challenge on flooded roads, economic impacts could be incurred, including job losses, and at worst complete operation relocation or closure.

Environment
Intrusion of brackish water could change the ecological conditions of the ranchlands and ranch management practices. Invasive species are already a growing concern in the agricultural community, and warming conditions, with a weakening in the native flora, could increase the extent of some heat loving invasive plant species. In addition, as grazing land becomes more tidally influenced, the opportunity water quality contamination from manure and wading increases. If agricultural wells are in the exposed are, they could be vulnerable to saltwater intrusion. This could necessitate additional engineering or new water sources all together.

Social Equity
Employees of these operations could be disproportionately impacted if operations need to reduce labor. Losing agricultural businesses and jobs could have significant impacts on social outcomes.

Management
Agriculture is a highly regulated industry at nearly all levels of government. For example, at the federal level is the Clean Water Act (Sections 401 and 404)[80] and total maximum daily sediment loads that farmers must comply with to reduce erosion and sediment loads to creeks. In several cases, to comply and improve water quality, farmers have fenced off creeks from livestock wading, installed new stream crossings and restored riparian areas that could be compromised under these sea level rise scenarios. Habitat changes prompted by sea level rise could require new conservation management plans and improvements in the coming decades to ensure water quality standards are upheld.

The Countywide Plan strongly supports continued diversified agricultural uses. The Agricultural Production Zone (APZ) and Agriculture, Residential Planned (ARP) districts are the zoning for most of the properties vulnerable in the study area.

[79] 2016 dollars
[80] US Environmental Protection Agency. Water: Clean Water Act. *Water Quality and 401 Certification.* http://water.epa.gov/lawsregs/guidance/cwa/waterquality_index.cfm

NATURAL RESOURCES

Asset Profile: Habitats & Wildlife

Marin County is known and treasured for its beaches, estuaries, wetlands, marshes, creeks, national and state park lands, and wildlife preserves. Several natural resource assets on the Marin shoreline could be vulnerable to sea level rise and storms, however; it is important to note that a significant portion of the shoreline is developed or bordered by development in some way. This development and human activitvity has reduced the natural resilience of the baylands by constricting habitat, fragmenting habitat, altering sediment supply, and cutting off wildlife corridors.[81] Simultaneously, urbanization stresses wildlife with pollution, invasive species, food web disturbances, and close proximity to people and pets.[82] Natural habitats tend to be resilient to storms, however, some storms may be stonrg enough to cause large changes in landscape and worse, permanant inundation could shift habitats from one type to another in the same location, for example marsh to mudflats.[83]

Sea-level rise would cause fundamental changes in the bay and bayland habitats.[84] The following are natural resources and wildlife habitat vulnerabilities to sea level rise:

- Where space exists, sea level rise may push shoreline beaches and marshes inland, and shift existing tidal areas to standing water and/or flood inland areas with saltwater.
- Roads, rail, storm drains, and development greatly restrict habitats from migrating landward, and could completely eliminate them.
- Increases in salinity in freshwater and brackish water habitats can impact habitat suitability for existing species.
- Endangered species and special habitats are especially vulnerable.
- Ecosystem services, such as water filtration and existing levels of flood protection, may be compromised.

IMPACTS AT-A-GLANCE: SCENARIO 6

6,500 acres of wetlands	CA DFW
5,500 acres of marshland	USFWS
5+ Narrow Beaches	State Lands Commission
568+ acres of Eelgrass	County of Marin
Ridgeway's rail	Local municipalities
Soft salty bird's-beak	Marin Audubon Society
White-rayed pentachaeta	National Audubon Society
Salt-marsh harvest mouse	Nature Conservancy
Tidewater goby	
And more…	

Corte Madera Ecological Reserve bordering Greenbrae Boardwalk, looking on to San Quentin. Credit: BVB Consulting LLC

[81] Goals Project. 2015. *The Baylands and Climate Change: What We Can Do*. Baylands Ecosystem Habitat Goals Science Update 2015 prepared by the San Francisco Bay Area Wetlands Ecosystem Goals Project. California State Coastal Conservancy, Oakland, CA. Pg. 27
[82] Ibid.
[83] Ibid. Pg. 156, 158
[84] Ibid., Pg. 37

NATURAL RESOURCES

Figure 5. Shoreline Habitat Zones

Insert natural resources graphic

A majority of the natural resource areas are managed by government agencies for public use. Major examples include: Golden Gate National Recreation Area, Bothin Marsh, China Camp State Park, and San Pablo Bay National Wildlife Refuge. In addition, natural resource lands are also held by non-profit organizations such as the Nature Conservancy or Audubon Society, and some habitats are privately owned.

Beaches

Sea level rise can inundate beaches and increase rates of shoreline erosion. This could potentially force beach inland.[85] However, in most cases along the urbanized shoreline, development, roads, or steep slopes, limit landward migration, causing beaches to shrink or disappear.[86] Several of the beaches along the shore are narrow and short and could be completely lost. This shift could affect many species, including pinnipeds (seals and sea lions), snails, and tidal and freshwater plants. In addition, shifts and losses in beach ecological zones could degrade the food web[87] and ecosystem.[88]

Bluff erosion can be exacerbated by sea level rise along the shoreline and can have varying impacts on beach habitats. Eroding bluffs can be a major source of sediment or rock, allowing beaches to evolve.[89] Alternatively, beach loss due to a major bluff collapse can negatively impact sand crabs, wrack consumers, and species that depend on beach habitats for breeding and nesting.[90] Beaches known to provide habitat include:

- Brick Kiln Park, Larkspur,
- Brick Yard Cove Beach, Strawberry,
- China Camp State Park Beaches,
- ESR Shoreline Park,
- Remillard Pond Beach,
- Marin Rod & Gun Club, San Rafael,
- McInnis Park,
- McNears Beach, Pt. San Pedro,
- Paradise Beach, Unincorporated Tiburon,
- Richardson Bay Center and Sanctuary beach, Tiburon,
- Private Beaches in Unincorporated Tiburon,
- San Pedro Cove Open Space, and
- Schoonmaker Beach, Sausalito.

[85] Feagin, R.A., D.J. Sherman, and W.E. Grant. 2005. *Coastal erosion, global sea-level rise, and the loss of sand dune plant habitats.* Frontiers in Ecology and the Environment 7:359-364.

[86] Largier, J.L., B.S. Cheng, and K.D. Higgason, editors. 2010. *Climate Change Impacts: Gulf of the Farallones and Cordell Bank National Marine Sanctuaries*. Report of a Joint Working Group of the Gulf of the Farallones and Cordell Bank National Marine Sanctuaries Advisory Councils.

[87] Dugan, J.E., D.M. Hubbard, I. F. Rodil, D. L. Revell and S. Schroeter. 2008. *Ecological effects of coastal armoring on sandy beaches.* Marine Ecology 29: 160-170.

[88] Feagin, R.A., D.J. Sherman, and W.E. Grant. 2005. *Coastal erosion, global sea-level rise, and the loss of sand dune plant habitats*. Frontiers in Ecology and the Environment 7:359-364.

[89] Baye, P. R., 2014. Memorandum: Bolinas Lagoon Restoration Project Design Review Group (DRG) Meeting San Francisco Bay Joint Venture Meeting Summary and Synthesis Draft.

[90] Largier, J.L., B.S. Cheng, and K.D. Higgason, editors. 2010. *Climate Change Impacts: Gulf of the Farallones and Cordell Bank National Marine Sanctuaries*. Report of a Joint Working Group of the Gulf of the Farallones and Cordell Bank National Marine Sanctuaries Advisory Councils.

Mc Nears Beach. April 2016. Credit: BVB Consulting LLC

China Camp State Park, San Rafael. Credit: Marin County CDA

Tidal Estuaries, Wetlands, & Marshes

An estuary is a partially enclosed shoreline body of brackish water, or a mixture of fresh and saltwater, with one or more rivers or streams flowing into it that mix with and transition to open ocean. Additionally, timing and extent of the rise and fall of the tide may be altered in estuaries and tidal rivers.[91]

Many estuaries feature marine wetlands and marshes. Wetlands and marshes also occur in other locations along the shoreline. Overlaying the BayWAVE scenarios on habitat data layers reveals that approximately, 6,500 acres of wetlands and 15,500 acres of marshlands along Richardson's Bay, San Francisco Bay, San Pablo Bay, and up the Petaluma River and several creeks could be impacted to varying degrees across all of the scenarios. Key sensitivities include drowning, erosion, and increased salinity.[92]

Data examined in the Bayland Habitat Goals Update (2015) indicate that tidal marshes in San Francisco Bay can withstand current 2–3 mm/year increase in sea level, as long as sediment availability is relatively high.[93] Without a comparable increase in land elevation from sediment delivery from erosion, and slowing subsidence, these intertidal habitats will be unable to adjust and thus, flood more frequently.[94,95] Much like beaches, these areas can be prevented from moving landward when backed by development, shoreline armoring, or cliffs.

Increased storm severity could have significant implications for erosion. Increased storm surge severity could also increase salinity of shoreline

[91] Largier, J.L., B.S. Cheng, and K.D. Higgason, editors. 2010. Climate Change Impacts: Gulf of the Farallones and Cordell Bank National Marine Sanctuaries. Report of a Joint Working Group of the Gulf of the Farallones and Cordell Bank National Marine Sanctuaries Advisory Councils.

[92] Knowles, N. and D.R. Cayan. 2002. *Potential effects of global warming on the Sacramento/San Joaquin watershed and the San Francisco estuary*. Geophysical Research Letters 29:1891.

[93] Goals Project. 2015. *The Baylands and Climate Change: What We Can Do*. Baylands Ecosystem Habitat Goals Science Update 2015 prepared by the San Francisco Bay Area Wetlands Ecosystem Goals Project. California State Coastal Conservancy, Oakland, CA. Pg. 24

[94] Largier, J.L., B.S. Cheng, and K.D. Higgason, editors. 2010. Climate Change Impacts: Gulf of the Farallones and Cordell Bank National Marine Sanctuaries. Report of a Joint Working Group of the Gulf of the Farallones and Cordell Bank National Marine Sanctuaries Advisory Councils.

[95] Ackerly, D. D., R. A. Ryals, W. K. Cornwell, S. R. Loarie, S. Veloz, K. D.Higgason, W. L. Silver, and T. E. Dawson. 2012. Potential Impacts of Climate Change on Biodiversity and Ecosystem Services in the San Francisco Bay Area. California Energy Commission. Publication number: CEC-500-2012- 037.

wetlands and marshes further upland until freshwater inputs can balance out salinity. Studies on the effect of salinity extremes indicate that, when combined with temperature stress, salinity can negatively impact intertidal invertebrates through increased embryonic mortality[96,97] and decreased adult aerobic performance.[98] In addition, projected increases in storm activity can remove larger intertidal organisms.[99] If tides do not retreat as far as they currently do with sea level rise, these areas could shift from intertidal to underwater habitats.

In general, vegetation occurs from just above mean sea level (MSL) to just above mean higher high water. Cordgrass is found at lower elevations, and pickleweed is typically at the MHHW limit with a number of other species depending on local elevation, drainage, soils, site history and other factors. As sea level rises, these plants will need to migrate to higher lands land if sediment accretion does not maintain marsh elevation in relation to water level. The following are examples of vulnerable locations featuring estuarine, tidal wetland, and marsh habitats:

- Aramburu Wildlife Preserve, Strawberry
- Bahia/Rush Creek Marshes, Novato
- Bothin Marsh, Almonte
- Cal Park Hill wetlands
- Canalways Marsh, San Rafael
- China Camp State Park,
- Diked baylands, Novato
- Gallinas Creek, San Rafael
- Hamilton Wetlands, Novato
- Island Park,
- Madera Gardens Lagoons, Corte Madera
- Marin Audubon Society Lands,
- Marin Conservation League Lands,
- McInnis Marsh, San Rafael
- McNears Beach Park,
- Corte Madera Ecological Reserve,
- Triangle Marsh, Corte Madera
- National Audubon Society Lands,
- Nature Conservancy Lands,
- Paradise Beach Park, Unincorporated Tiburon
- Pt. Tiburon Marsh,
- San Pablo Bay National Wildlife Refuge, St. Vincent's
- Santa Margarita Island, Santa Venetia
- Santa Venetia Marsh,
- Scottsdale Marsh, Mill Valley
- Shorebird Marsh, Strawberry
- Spinnaker Point Marsh, San Rafael
- Strawberry Point Tidal Area, and
- Tiscornia Marsh, San Rafael.

Bay

Eelgrass is also a critical tidal habitat, typically in slightly deeper, saltier waters, associated with rocky ground. These habitats can be found in Richardson's Bay in Sausalito, Belvedere, and Tiburon. Eelgrass is a vascular, perennial marine plant that typically occurs in shallow waters from 0 to 6 feet below mean low tide.[100] Eelgrass beds trap suspended materials, take up nutrients and other dissolved substances, help to prevent erosion, increase water clarity and quality, produce organic matter, and export dying plant materials. Eelgrass beds also provide food and feeding grounds for several marine food chains.[101] As mean low tide rises closer to shore, these essential plants could be flooded out and denied adequate sunlight to survive and maintain this valued habitat.

Eelgrass beds are recognized by both federal and state agencies as sensitive and highly valuable habitat for a suite of species. They are regulated under the Magnuson-Stevens Fishery Conservation and Management Act. Eelgrass beds are listed as a Habitat Area of Particular Concern because they are susceptible to degradation, especially ecologically important, and/or located in an environmentally stressed area. National Oceanic and Atmospheric Association's fisheries policy recommends no net loss of eelgrass habitat function in California.[102] The policy establishes protocols for mitigating adverse

[96] Przeslawski, R., Davis, A. R. and Benkendorff, K. (2005), *Synergistic effects associated with climate change and the development of rocky shore mollusks*. Global Change Biology, 11: 515–522. doi: 10.1111/j.1365- 2486.2005.00918.x

[97] Deschaseaux, E.S.M, A.M. Taylor, W.A. Maher, A.R. Davis. 2009. Cellular responses of encapsulated gastropod embryos to multiple stressors associated with climate change. JEMBE 383(2):130-136.

[98] Vajed Samiei, J., Novio Liñares, J.A., Abtahi, B. 2011. *The Antagonistic Effect of Raised Salinity on the Aerobic Performance of a Rocky Intertidal Gastropod Nassariusdeshayesianus* (Issel, 1866) Exposed to Raised Water Temperature. Journal of the Persian Gulf 2(6): 29-36.

[99] Largier, J.L., B.S. Cheng, and K.D. Higgason, editors. 2010. *Climate Change Impacts: Gulf of the Farallones and Cordell Bank National Marine Sanctuaries*. Report of a Joint Working Group of the Gulf of the Farallones and Cordell Bank National Marine Sanctuaries Advisory Councils.

NOAA Fisheries West Coast Region. 2014. The Importance of Eelgrass. Updated fall 2014. http://www.westcoast.fisheries.noaa.gov/stories/2014/04_1107 2014_eelgrass_mitigation.html. Accessed 1/18/17

[101] Ibid

[102] Ibid

impacts on eelgrass, restoration, monitoring, and evaluation

Freshwater Resources

Freshwater habitats are also likely to be subject to flooding impacts from sea level rise and storm surges. Changes in salinity and water levels could cause habitat shifts, especially when these influences are regular and not seasonal. In scenario 6, with 60 inches of sea level rise and 100-year storm surge, saltwater can travel miles inland, totaling 211 miles of creeks that could be impacted by higher levels of saltwater. San Antonio Creek in North Novato could fill with saltwater up to ten miles upstream in the long-term. Similarly, the Corte Madera channel could fill with saltwater nearly eight miles inland. On average, up to one half of a mile upstream could be under tidal influence. This could shift existing freshwater habitat to brackish habitat. Creeks that could be affected by rising bay waters include:

- Armory Creek
- Arroyo Corte Madera del Presidio,
- Arroyo de San Jose,
- Baccaglio Basin Drainage,
- Basalt Creek,
- Beach Marsh Channel,
- Black John Slough,
- Castro Ditch,
- Cheda Creek,
- Corte Madera Channel,
- Corte Madera Creek,
- Corte Madera Outfall Channel,
- Coyote Creek,
- Deer Island Channel,
- East Creek,
- Estancia Ditch,
- Gallinas Creek,
- Glen Creek,
- Glenwood Creek,
- Greenbrae Creek,
- High Canal/Irwin Creek,
- King Mountain Creek (Brixon Creek),
- Larkspur Creek,
- Leveroni Ditch,
- Low Canal,
- Lynwood Slough,
- Mabry Ditch,
- Mahon Creek,
- McAllister Creek,
- Meadow Sweet Creek,
- Miller Creek,
- Murphy Creek,
- Novato Creek,
- Novato Ditch System,
- Nyhan Creek,
- Pacheco Creek,
- Peacock Gap Creek,
- Petaluma River,
- Reed Creek,
- Rush Creek,
- Ryan Creek,
- Salt Works Canal,
- San Antonio Creek,
- San Clemente Creek,
- San Rafael Airport Ditch,
- San Rafael Creek
- Simmons Slough,
- Strawberry Ditch,
- Strawberry Marsh,
- Sunny Oaks Drainage,
- Tamalpais Creek,
- West Creek,
- Willow Creek, and
- Wolfe Grade Creek.

In addition, freshwater ponds and vernal pools within the Petaluma Marsh System in North Novato, large freshwater emergent marshes along the western side of Novato Creek north of Highway 37, and Pacheco Pond could experience increased salinity and water level impacts, and therefore, habitat impacts, in the long-term.

Bothin Marsh bordering Richardson's Bay. Credit: MarinMap

Saltworks Canal, Strawberry. Credit: DPW

Wildlife & Endangered Species

The most vulnerable species are those that use the vulnerable habitats. Vulnerable habitats are beaches, tidal marshes, freshwater streams and ponds, eel grass beds in the intertidal zone. These habitats offer feeding and breeding ground for several mammal, birds, and insects, and host several rare and valued plants along Marin's eastern shoreline. Several species, and/or their habitats, are protected under federal, state, or regional regulations. Meeting existing habitat goals and needs may prove challenging as tides rise. Species potentially located within the geographic extent of scenario 5, when significant habitat changes could occur, are listed in Table 41.

Mammals

According to the Department of Fish and Wildlife, the following are recorded locations marine mammals inhabit (does not include federal park locations):

- Sausalito Basin 3,
- Strawberry Spit,
- Corte Madera Ecological Reserve,
- Angel Island, and
- Castro Rocks.

The Pacific Harbor Seal and Southern, or California, Sea Otter are known to use the San Francisco Bay. San Francisco Bay Pacific harbor seals have spotted coats, and many are fully or partially reddish in color. They reach six feet in length and weigh up to 300 pounds. Harbor seals are the third most common patient at The Marine Mammal Center. In general, Harbor seal colonies in the Bay Area are vulnerable to human disturbance, climate change and human-produced pollutants.[103]

The Southern Sea Otter is among the smallest of marine mammals and may live for 15-20 years in the wild. Sea otters occupy marine habitats from the littoral zone to depths of less than 330 feet, including protected bays. Sea otters in California are a threatened species due to past over hunting for their fur. Although they are protected from hunting, sea otters are still vulnerable, especially to habitat loss and oil spills.[104]

Mammal species are already vulnerable, typically due to habitat destruction. Sea level rise would likely exacerbate the fragility of these habitats and the threatened and endangered specieis in them.

Another vulnerable mammal in the study area is the Salt marsh harvest mouse. Salt marsh harvest mice are endangered because of habitat loss,

[103] The Marin Mammal Center Website. Harbor Seal. Accessed Jan. 18, /2017. Last updated: Jan. 2017 http://www.marinemammalcenter.org/education/marine-mammal-information/pinnipeds/pacific-harbor-seal/ accessed.

[104] The Marin Mammal Center Website. Sea Otter. Accessed Jan. 18, 2017. Last updated: Jan. 2017 http://www.marinemammalcenter.org/education/marine-mammal-information/sea-otter.html.

fragmentation, and alteration.[105] These mice are only found in the marshes of Corte Madera; the Marin Peninsula and San Pablo Bay, typically in the upper half of tidal salt marshes and the adjacent uplands during high tides.[106] Sea level rise would greatly impact this species, especially if the mouse's habitat is trapped by development. If high inundation rates occur in areas without upland habitat then reproduction could be reduced or eliminated. This is more likely an issue in the narrow valley outlets of southern portion of the study area, than the larger basins of the northern study area. Other potential impacts of sea level rise include changes and shifts in vegetation composition and the overtopping of all intertidal vegetation by higher storm surges. Such severe inundation could increase predation[107] and decrease reproductive success by flooding nests.[108]

Fish

The two listed fish off the shores of the study are the tide water goby and the longfin smelt. The tidewater goby is listed as Endangered at state and federal levels. Tidewater gobies are about two inches in length, translucent with gray, green, and brown. The tidewater goby's ideal habitat is a brackish estuary or marsh with shallow water, a sandy bottom, and cool temperatures. Tidewater gobies are vulnerable to the introduction of non-native species and sudden increases in salinity levels.[109] As brackish waters push further and further up narrow valleys during storms or the highest tides, and existing habitats increase in salinity, the amount of suitable habitat could decrease significantly. The longfin smelt is listed as threated on the California list and a candidate on the federal list. The largest longfin smelt population occurs in the San Francisco Estuary and Sacramento-San Joaquin Delta. This species occupies bay waters throughout summer and moves into lower reaches of rivers in fall to spawn.[110]

Harbor Seal. Credit: Bay Nature

Table 41. Example Vulnerable Species

Federal: Endangered	• Ridgeway rail • Soft salty bird's-beak • White-rayed pentachaeta • Salt-marsh harvest mouse • Tidewater goby • Chinook Salmon
Federal: Threatened	• Western snowy plover • California red-legged frog
Federal: Candidate	• Longfin smelt
Others	• Salt Marsh Yellowthroat • Southern sea otter • Delta smelt • Green Sturgeon Pacific Herring • Steelhead • Monarch Butterfly

Source: California Natural Diversity Database

[105] Shell hammer, H. 2000. Salt Marsh Harvest Mouse. Pp. 219 – 228 in Goals Project. 2000. Baylands Ecosystem Species and Community Profiles: Life history and environmental requirements of key plants, fish and wildlife. Prepared by the San Francisco Bay Area Wetlands Ecosystem Goals Project. P. R. Olson, editor. San Francisco Bay Regional Water Quality Control Board, Oakland, California.

[106] Goals Project. 2015. *The Baylands and Climate Change: What We Can Do*. Appendix 5.1 Salt Marsh Harvest Mouse. Ecosystem Baylands Habitat Goals Science Update 2015 prepared by the San Francisco Bay Area Wetlands Ecosystem Goals Project. California State Coastal Conservancy, Oakland, CA.

[107] Johnston, R. F. 1957. Adaptation of salt marsh mammals to high tides. Journal of Mammalogy, 38:529-531.

[108] Hardaway. H. C. and J. R. Newman. 1971. Differential responses of five species of salt marsh mammals to inundation. Journal of Mammalogy, 52:818-820.

[109] Farallones Marin Sanctuary Association Website. Endangered Spotlight: Tidewater Gobi Updated 2005. http://www.farallones.org/e_newsletter/2008-02/TidewaterGoby.htm Accessed Jan. 18, 2017.

[110] Goals Project. 2015. *The Baylands and Climate Change: What We Can Do*. Appendix 3.9 Longfin smelt. Ecosystem Habitat Goals Science Update 2015 Baylands prepared by the San Francisco Bay Area Wetlands Ecosystem Goals Project. California State Coastal Conservancy, Oakland, CA.

Other important fish species that are sensitive changes in environmental conditions that could occur in the San Francisco, San Pablo, and/or Richardson's Bays are:

- Chinook salmon: These fish spend time in the ocean and migrate into freshwater rivers to spawn.
- Delta smelt: Delta smelt are endemic to the Sacramento-San Joaquin River Delta, occupies saltwater habitats, and spawns in freshwater.
- Green sturgeon: These large and long living fish spend time in the ocean and migrate into freshwater rivers to spawn every three to five years and can be found traveling through the bay to breeding grounds in the Sacramento River.
- Pacific herring: The Pacific herring is typically found in large schools. Adults breed in estuaries in shallow areas along shorelines. Eggs are laid on kelp and eelgrass November through April. Richardson's Bay is considered a critical spot for spawning.
- Steelhead: Adults spend time in the ocean and migrate into freshwater rivers to spawn, after spending two to three years in the ocean. San Francisco Bay is within the range of two runs of steelhead.

Ridgway's Rail at High Tide. Credit: Chris Cochems

Birds

Shoreline wetlands, marshes, mudflats, and ponds provide valuable bird habitat. One of the largest protected habitats is the San Pablo Bay National Wildlife Refuge (SPBNWR) managed by United States Fish and Wildlife Service (USFWS), which connects to the Petaluma Marsh Wildlife Area managed by California Department of Fish and Wildlife (CDFW), another extensive area of habitat to the northeast. Both of these areas, and smaller marsh lands further south, are major winter-migration stopovers along the Pacific Flyway for waterfowl. Smaller shoreline habitats in southern Marin are also known to support vulnerable and valuable bird species.

Vulnerable bird species that could be found in or moving through the eastern Marin shoreline include the Ridgway's rail, the Western snowy plover, and salt marsh yellowthroat. The Ridgway's rail is one of the largest rails in North America, very secretive, and primarily lives in salt and brackish marshes. The following locations are known to support Ridgway's rail populations:

- Richardson's Bay is known to support a small number of Ridgway's rails.
- Bothin Marsh Preserve, Mill Valley.[111]
- The marsh at the mouth of Gallinas Creek, including China Camp, supports what appears to be the largest population of Ridgway's rails in the North Bay.[112]
- The Corte Madera Ecological Reserve supports one of the densest populations of Ridgway's rails in the northern San Francisco Bay.[113]

The Western snowy plover is a small shorebird that occurs along the Pacific Coast. They forage for small invertebrates in beach sand, kelp, and low--growing dune vegetation. A small population nests on and near the shores of the San Francisco Bay and may forage in Richardson's Bay. The San Francisco common (salt marsh) yellowthroat is

[111] Distribution and population trends for the Endangered California Clapper Rail. State of the Estuary Conference, 26 October 2013, Oakland, CA.

[112] Goals Project. 2015. *The Baylands and Climate Change: What We Can Do*. Baylands Ecosystem Habitat Goals Science Update 2015 prepared by the San Francisco Bay Area Wetlands Ecosystem Goals Project. California State Coastal Conservancy, Oakland, CA. Pg. 156

[113] Goals Project. 2015. *The Baylands and Climate Change: What We Can Do*. Baylands Ecosystem Habitat Goals Science Update 2015 prepared by the San Francisco Bay Area Wetlands Ecosystem Goals Project. California State Coastal Conservancy, Oakland, CA. Pg. 168

a subspecies of the common yellowthroat and is endemic to the San Francisco Bay region in wetland and riparian habitats. Other unique and valuable bird species common in the study area are:

- California brown pelican: The California brown pelican, the smallest species of pelican, forages within Richardson's Bay and may be present in the study area.
- California least tern: The California least tern is the smallest of North American terns, has nesting colonies in the San Francisco Bay, and may forage within Richardson's Bay.
- Double-crested cormorant: Double-crested cormorant are large seabirds that live year-round in the San Francisco Bay. Cormorants forage within Richardson's Bay. The Richmond-San Rafael is a nesting site.
- San Pablo (Samuels) song sparrow: This subspecies lives in tidal marshes throughout the San Pablo Bay, San Francisco, and Richardson's Bays year-round. They are primarily associated with high marsh habitats dominated by pickleweed.

Additional migratory birds were reported in study area are Allen's hummingbird, marbled godwit, Nuttall's woodpecker, and the eastern grebe. Most migratory bird species, with a few specific exceptions, are protected under the federal Migratory Bird Treaty Act and California Fish and Game Code.

Insects

Insects could also suffer from impacts to their habitats. The Monarch butterfly, an orange and black milkweed butterfly with a wingspan of 3.5 to 4 inches, could suffer from impacts to milkweed habitat along the coast. Populations of monarch butterfly are found in the San Francisco Bay region especially during the winter months. The Mission blue butterfly has a small a wingspan of 1 to 1.5 inches. They occur in coastal chaparral and grassland habits and depend on lupine plants for the egg, larvae, and pupae life phases. The butterfly was documented at Fort Baker, though it was not detected in the 1984 and 1985 during last survey.

Plants

Numerous special status plants with habitats that are expected to be vulnerable to sea level rise are:

- Franciscan thistle,
- Hairless popcornflower,
- Marin western flax,
- Oregon polemonium,
- Point Reyes salty bird's beak,
- Tiburon buckwheat,
- Tiburon paintbrush, and
- White-rayed pentachaeta.[114]

Salt marshes are host a variety of unique and valuable plants, such as pickleweed and cordgrass, in Novato, San Rafael, St. Vincent's, Tiburon, Strawberry, Tamalpais Valley, and Mill Valley. Patches in Novato, St. Vincent's, Mature wide salt marsh habitat has regenerated near the mouth of Coyote Creek, supporting regionally rare plant populations, including some of the largest colonies of northern salt marsh bird's beak in San Francisco Bay.[115]

In addition, eelgrass beds off the shores of Sausalito, Tiburon, and Belvedere previously discussed under Tidal Estuaries, Wetlands, and Marshes, are also vulnerable to sea level rise.

[114] Prunuske Chatham, Inc. March 2016. Draft Biological Resources Assessment: Dunphy Park Improvement Project Sausalito, Marin County.

[115] Goals Project. 2015. *The Baylands and Climate Change: What We Can Do*. Baylands Ecosystem Habitat Goals Science Update 2015 prepared by the San Francisco Bay Area Wetlands Ecosystem Goals Project. California State Coastal Conservancy, Oakland, CA. Pg. 168

Table 42. Example Vulnerable Natural Resource Assets Ranked by Onset and Flooding at MHHW

Location	Asset	Near-term	Medium-term	Long-term
		Scenario 1	Scenario 3	Scenario 5
Sausalito	Swedes Beach	Floods at existing high tides		
Novato	Scottsdale Marsh	Floods at existing high tides		
Unincorporated Tiburon	Paradise Beach Park	Floods at existing high tides		
Mill Valley	Bothin Marsh	Floods at existing high tides		
Corte Madera	Corte Madera Ecological Reserve	Floods at existing high tides		
Corte Madera	Triangle Marsh	Floods at existing high tides		
San Rafael	Tiscornia Marsh	Floods at existing high tides		
Novato	Bahia marshes	Floods at existing high tides		
State Park	Angel Island State Park	14’1”	14’10”	17’9”
San Rafael	Shoreline Open Space	10’3”	11’1”	25’4”
Tiburon	Pt. Tiburon Shoreline Park	8’	8’8”	11’6”
Pt. San Pedro	China Camp State Park	7’6”	8’1”	18’4”
San Rafael	John F. Mc Innis Park	7’6”	8’6”	10’6”
Larkspur	Piper Park	7’2”	7’11”	10’8”
Santa Venetia	Santa Venetia Marsh	7’	7’10”	9’11”
San Pablo Bay	Wildlife Refuge	6’9”	7’2”	19’
Santa Venetia	Santa Margarita Island	5’8”	6’8”	8’8”
Sausalito	Arques Shipyard & Marina	5’7”	8’6”	21’9”
Sausalito	Marina Plaza Harbor	5’7”	8’6”	21’9”
San Rafael	Jean & John Starkweather Shoreline Park	5’4”	6’	16’3”
Bel Marin Keys	Del Oro Park	5’2”	5’8”	8’9”
Sausalito	Dunphy Park	5’1”	5’8”	13’8”
Bel Marin Keys	Cavalia Cay Park	5’1”	5’8”	8’9”
San Rafael	Pickleweed Park	5’	5’8”	8’9”
Larkspur	Cal Park wetlands at Corte Madera Creek	4’10”	5’3”	8’2”
Waldo Point	Richardson Bay Marina	4’5”	7’4”	18’7”
Larkspur	Bon Air Landing Park	4’4”	5’	8’6”
Pt. San Pedro	McNears Beach Park	4’4”	5’9”	8’
Belvedere	Corinthian Yacht Club	4’	4’3”	11’
Tiburon	Mc Kegney Green	3’1”	5’7”	15’3”
Tiburon	Richardson Bay Lineal Park	0-3’	1”-3’7”	1”-15’
Larkspur	Remillard Park beach	2’11”	3’6”	6’2”
Belvedere	San Francisco Yacht Club	2’2”	3’6”	8’10”
Tiburon	Blackie's Pasture	0-9”	5’4”	12’9”
Tiburon	The Cypress Garden Park	7”	1’4”	4’4”
Sausalito	Sausalito Yacht Harbor	4”	1’	3’
Paradise Cay	Paradise Cay Yacht Harbor	2”	1’6”	3’10”

NATURAL RESOURCES

Location	Asset	Near-term	Medium-term	Long-term
		Scenario 1	Scenario 3	Scenario 5
San Rafael	Lowrie Yacht Harbor	2”	9”	3’7””
San Rafael	Marin Yacht Club	1”	1’6”	3’9”
Sausalito	Pelican Yacht Harbor	No data	No data	No data
Strawberry	Aramburu Wildlife Preserve	No data	No data	No data
San Rafael	San Rafael Yacht Harbor	No data	No data	No data
San Rafael	Beach Park		8’11”	11’10”
Mill Valley	Bayfront Park		8’3”	4’-11’6”
Sausalito	Schoonmaker Beach		7’2”	10’1”
Strawberry	Brickyard Cove		6’11”	9’11”
Corte Madera	Hal Brown Park		6’3”	9’2”
Strawberry	Strawberry Point Tidal Area		5’1”	8’1”
Strawberry	Seminary Marsh		4’4”	8’1”
Corte Madera	Shorebird Marsh		5’3”	10’9”
Strawberry	Strawberry Point Park		4’10”	9’2”
San Rafael	Loch Lomond Marina		3’7”	9’7”
Sausalito	Clipper Yacht Harbor		2’5”	6’3”
San Rafael	San Rafael Yacht Club		2’2”	5’7”
Bel Marin Keys	Montego Park		2’	5’4”
Sausalito	Cass Gidley Marina		2’	3’2”
Larkspur	Hamilton Park		10”	3’9”
Mill Valley	Shelter Bay		2”-9”	6”-1’10”
Novato	South Hamilton Park			11’6”
Novato	Deer Island Baylands			10’10”
Corte Madera	Madera Gardens Lagoons			10’4”
CA Fish & Wildlife	Gallinas Creek			10’2”
Corte Madera	Town Park			9’10”
Novato	Rush Creek			8’10”
Mill Valley	Sycamore Park			8’6”
Novato	Slade Park			8’
Bel Marin Keys	Caribe Isle Park			7’6”
Sausalito	Tiffany Beach			7’4”
Santa Venetia	Castro Park			7’
Santa Venetia	Adrian Rosal Park			6’3”
San Rafael	Shoreline Pathway			5’10”
Santa Venetia	Pueblo Park			5’1”
Tiburon	Zelinsky Park			4’11”
Tiburon	Pt. Tiburon Marsh			4’10”
San Rafael	Schoen Park			4’4”
Mill Valley	Freeman Park			4’2”
Strawberry	Greenwood Cove			4’1”
Corte Madera	Ring Mountain			3’6”
Mill Valley	Hauke Park			3’6”
Corte Madera	Skunk Hollow Park			3’4”

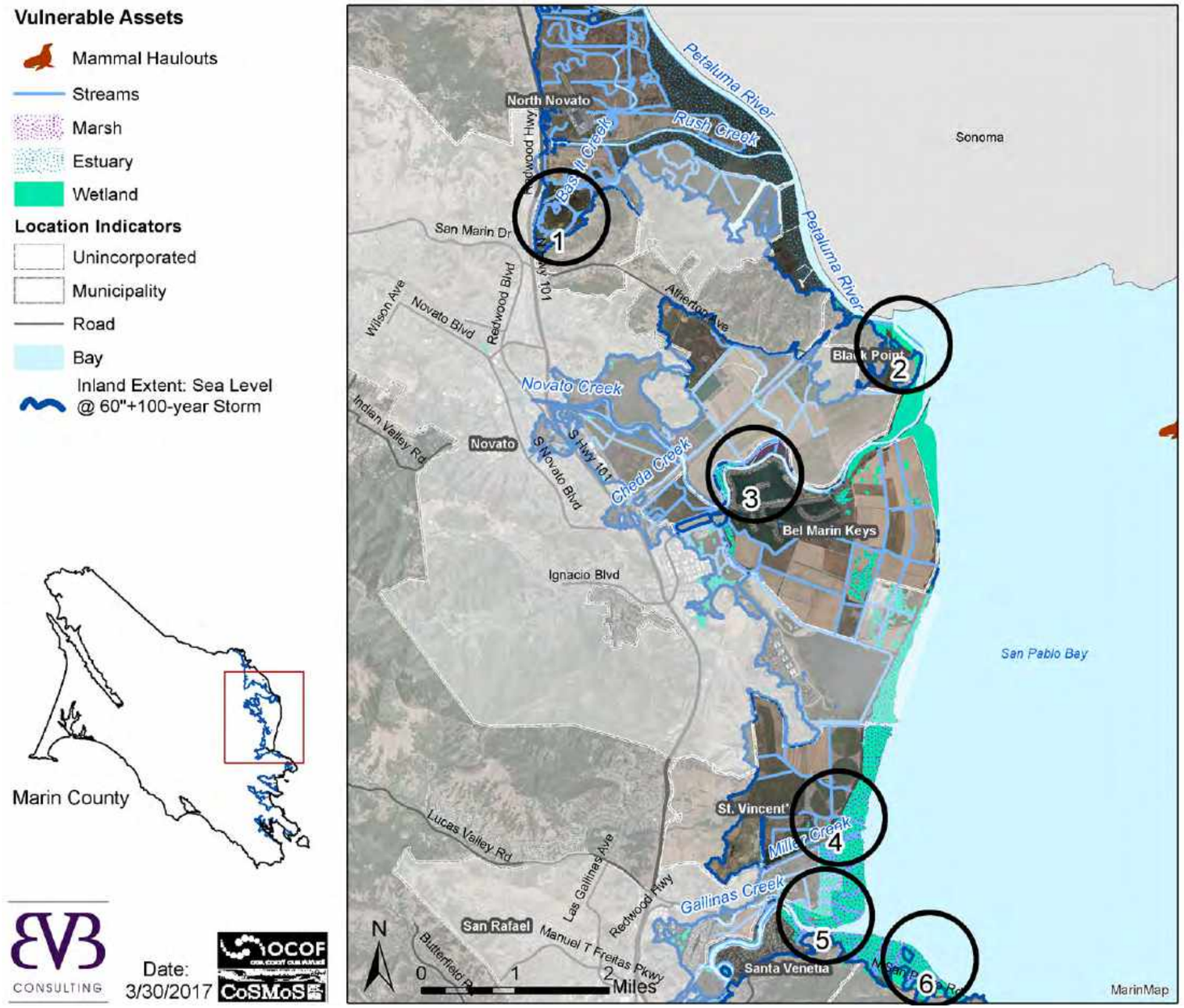
NATURAL RESOURCES

Location	Asset	Near-term	Medium-term	Long-term
		Scenario 1	Scenario 3	Scenario 5
Tiburon	Bel Aire Park			3’
Larkspur	Bon Air Landing Park			2’4”
Corte Madera	San Clemente Park		No data	No data
Bayside Acres	Marin Islands Ecological Reserve		No data	No data
North Novato	Petaluma Marsh Ponds			No data
Mill Valley	Arroyo Corte Madera del Presidio	Water resource		
Larkspur	High Canal	Water resource		
Larkspur	Larkspur Creek	Water resource		
Larkspur	Low Canal	Water resource		
Novato	Novato Creek	Water resource		
Novato	Petaluma River	Water resource		
Strawberry	Salt Works Canal	Water resource		
San Rafael	San Rafael Canal	Water resource		

Source: MarinMap, CoSMoS

NATURAL RESOURCES

Map 36. Northern Study Area Vulnerable Natural Resources



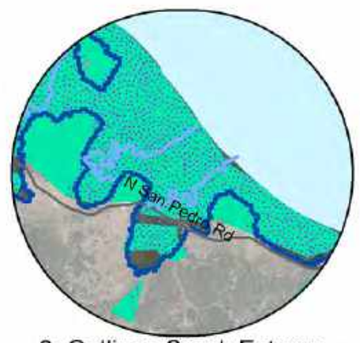
1: Rush Creek

2: Black Point

3: Upper Bel Marin Keys

4: Miller Creek

5: Santa Venetia Marsh



6: Gallinas Creek Estuary

EVB CONSULTING

Date: 3/30/2017

OCOF CoSMoS

Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data providers here in, make no warranties of the accuracy or completeness of maps and data. Maps are representational and subject to future revision. Local site conditions must be examined. Commercial use is prohibited.

NATURAL RESOURCES

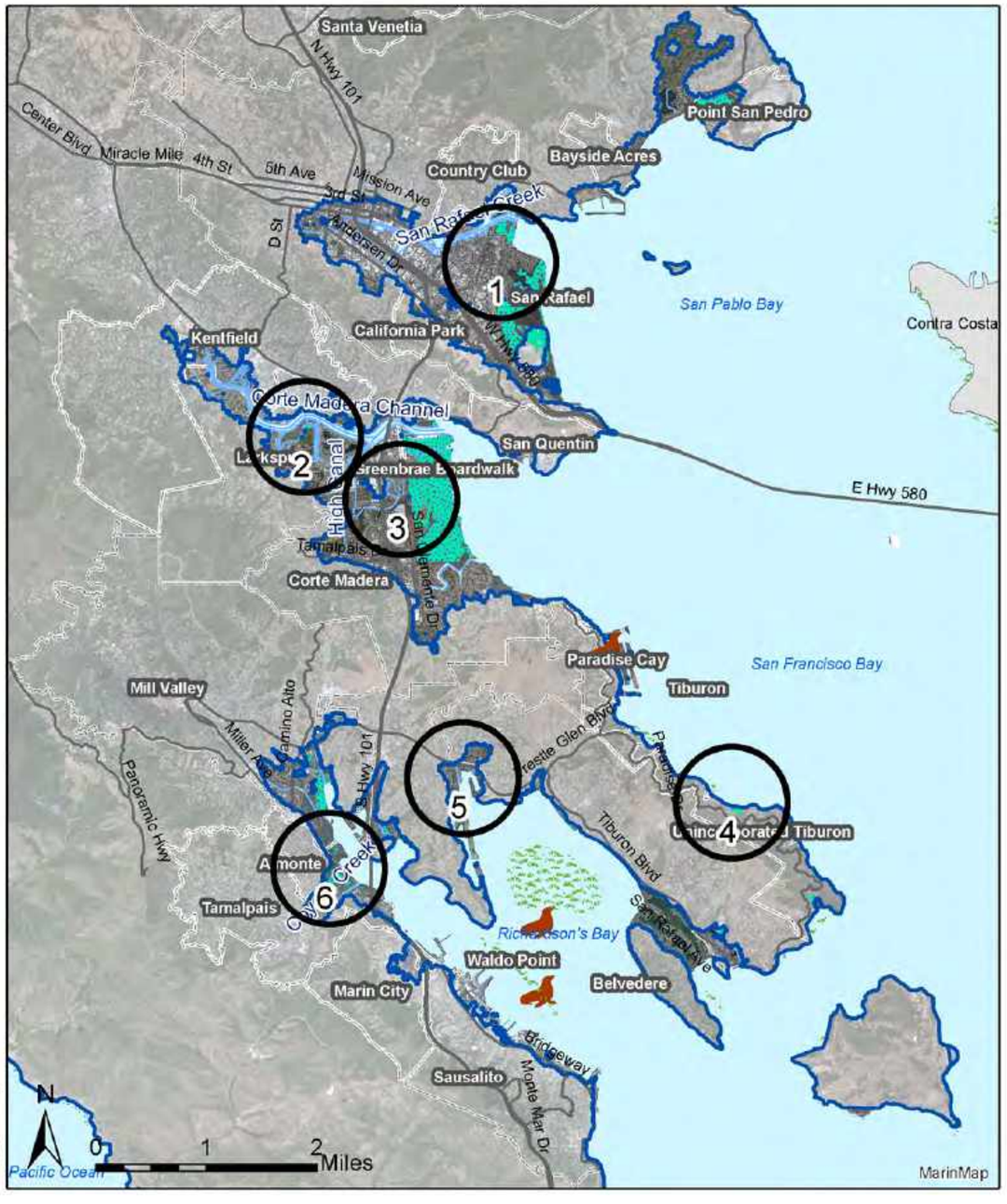
Map 37. Southern Study Area Vulnerable Natural Resources

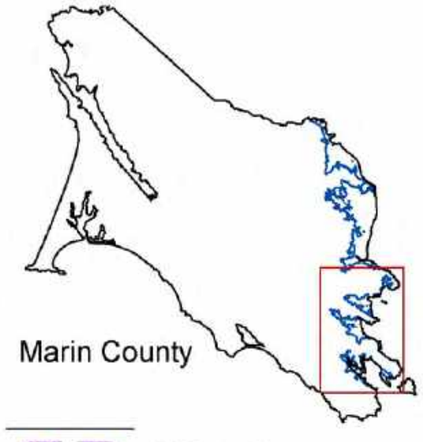
Vulnerable Assets

- Mammal Haulouts
- Streams
- Eelgrass
- Marsh
- Estuary
- Wetland

Location Indicators

- Unincorporated
- Municipality
- Road
- Bay
- Inland Extent: Sea Level @ 60"+100-year Storm





EVB CONSULTING

CA Dept. of Fish & Wildlife

Date: 3/30/2017

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CoSMoS

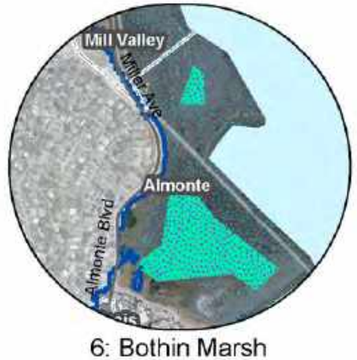
1: Pickleweed & Tiscornia Marshes

2: Corte Madera Creek

3: Corte Madera Ecological Reserve

4: Paradise Beach

5: Strawberry Point



6: Bothin Marsh

Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data providers here in, make no warranties of the accuracy or completeness of maps and data. Maps are representational and subject to future revision. Local site conditions must be examined. Commercial use is prohibited.

Other Considerations

Economic
Active and passive recreation on Marin's shoreline beaches, trails, and roads are major economic contributors to Marin (see the Recreation Profile for more information). Wildlife viewing is a major draw to the region and the inability to do so could significantly reduce tourism.

In addition, park maintenance costs could increase and substantial funding would be needed to relocate or improve infrastructure due to the high degree of scrutiny and environmental compliance required. These increased costs would be passed on to the tax payers and park users, creating potential disproportionate impacts across economic brackets.

Estuaries, beaches, bluffs, marine wetlands, and marshes also provide ecosystem services as buffers protecting development from waves and floods, filtration systems for pollutants, provide oxygen, and many others. Their loss could increase the cost of maintaining flood protection at the least.

Environmental
The complete or partial loss of tidal marshlands and other natural shoreline features could increase the reliance on structural shoreline protection to create a buffer from the rising waters, and would place shoreline residents at a greater risk of flooding. If compromised, multiple utility transmission lines and pipelines located in marsh areas or along waterways could cause fire, or other electrical hazards. Finally, efforts to protect vulnerable built assets with new shoreline armoring could have detrimental impacts on shoreline habitats by reducing their ability to adapt. Several studies have also shown that walls can increase erosion on neighboring land areas.[116]

According to the Bayland Habitat Gals Update (2015), other challenges to improving or restoring habitat in the northern study area are:

- Commercial and residential developments at Bel Marin Keys,
- Hamilton Field, and at several sites to the south;
- Diked golf course in Black Point;
- Low-lying segments of State Route 37 and US Highway 101, other roads,
- Northwestern Pacific railroad track, and
- Development between the railroad and the highway.[117]

In the southern portion of the study area, primary constraints would be:

- US Highway 101,
- An urbanized edge with roadways and infrastructure that currently flood (e.g., Miller Avenue, Manzanita parking areas, the Mill Valley sewer plant),
- Northwestern Pacific railroad tracks,
- Erosion from the Golden Gate Ferry in Larkspur,
- Exotic predators (e.g., rats and red fox),
- Invasive Spartina, and
- On-site contaminants.[118]

Social Equity
As preparations are made to protect existing areas, or create new public areas, costs could increase, entrance fees, or in some cases, require new fees. These added could make visiting county, federal, and state parks cost prohibitive for those of lesser means. Loss of any protected, publicly accessible lands would reduce the opportunities for visitors to these open spaces. These losses could disproportionately impact those who enjoy nearby public space along our shoreline as access becomes increasingly difficult, and in some cases access could be impeded entirely.

Management
Protecting natural resources and wildlife can be highly controversial. For example, protecting breeding areas may limit public access or economic activity. As tides rise, developable land area will be

[116] California Coastal Commission Sea Level Rise Policy Guidance: Interpretive Guidelines for Addressing Sea Level Rise in Local Coastal Programs and Coastal Development. August 12, 2015. http://documents.coastal.ca.gov/assets/slr/guidance/August2015/0_Full_Adopted_Sea_Level_Rise_Policy_Guidance.pdf

[117] Goals Project. 2015. *The Baylands and Climate Change: What We Can Do*. Baylands Ecosystem Habitat Goals Science Update 2015 prepared by the San Francisco Bay Area Wetlands Ecosystem Goals Project. California State Coastal Conservancy, Oakland, CA. Pg. 159

[118] Goals Project. 2015. *The Baylands and Climate Change: What We Can Do*. Baylands Ecosystem Habitat Goals Science Update 2015 prepared by the San Francisco Bay Area Wetlands Ecosystem Goals Project. California State Coastal Conservancy, Oakland, CA. Pg. 172

reduced and, consequently, increase competition for resources. Limited financial resources could reduce priorities for wildlife protection, park maintenance, and investment. Park management would be affected because infrastructure within parks may become inaccessible or degraded due to flooding and saltwater exposure. Large amounts of funds would be needed to relocate or improve infrastructure due to the high degree of scrutiny and environmental compliance that would be necessary. Making improvements for public access or restoring habitats would also need to be sensitive to the multiple cultural sites relating to Coast Miwok habitation and early European and Asian settlements in the vulnerable portions of the study area.[119]

Developing and implementing large projects will require multiple agencies and private partners to coordinate and contribute financially. Moreover, natural resources often cross political borders and require intergovernmental collaboration. Any in many cases, especially in the northern study area, changes to or failures in flood protection in the baylands or managed land areas could impact development further inland, such as State Routes 101 and 37, SMART rail lines, and Gnoss Field. Planning would necessitate coordination amongst local municipalities, Marin County, California Department of Fish and Wildlife, and Caltrans.

The Marin Countywide Plan and local jurisdiction general plans guide protecting natural resources and sensitive habitats when land is developed, preserving public access to the coast, and maintaining and enhancing shoreline resources. Other regional, state, and federal regulators may also be involved, and commonly local plans reflect these goals and take advantage of any programs and funds at the higher levels of government.

[119] Goals Project. 2015. *The Baylands and Climate Change: What We Can Do*. Baylands Ecosystem Habitat Goals Science Update 2015 prepared by the San Francisco Bay Area Wetlands Ecosystem Goals Project. California State Coastal Conservancy, Oakland, CA. Pg. 159

RECREATION

Asset Profile: Recreation & Public Access

Marin County is treasured for its immense recreation opportunities. Vulnerable recreation assets are small beaches, parks, marsh lands, trails, boating and fishing along the shoreline. Several of these recreational activities, and other such as wildlife viewing and kayaking, may simply shift as sea level rises, or require minimal management actions. However, ensuring continued safe public access to existing recreation areas could be a challenge.

Most recreation areas vulnerable to sea level rise are managed by local, county, state, and federal agencies for public use. Major examples include: Golden Gate National Recreation Area, China Camp State Park, the Bay Trail, Paradise Beach, Mc Near's Beach, and others. Others, such as the biplane rides, are privately managed.

The following are key issues related to public access and recreation vulnerability:

- Sea level rise may push shoreline and bay recreation opportunities inland where possible. Where not possible, the asset could be lost.
- Access to recreational areas may become limited as roads and trails flood and erode.
- Tour buses could be impeded from visiting the area.
- Visitor serving business, such as restaurants, hotels and inns, boat rentals, and others, could be vulnerable to sea level rise and storm damage, and also to a host of other potential vulnerabilities in utility networks.

About 100 parks could be impacted to some degree, whether just kissed by the sea or completely claimed by it. Roughly 1,100 acres of the 12,000 acres in these parks could flood at MHHW. With a 100-year storm surge coincidence, an additional five parks and 120 acres could be impacted. Counted separately, school playgrounds amount to roughly 200 acres across 15 schools. For details on impacts to schools, see the Parcels & Buildings Profile.

Thousands of residents, millions of visitors

Boating Facilities **Pathways & trails** **Athletic fields** **Playgrounds** **Parks** **Fishing Piers**	**Property Owners** **CSP** **County Parks & Roads** **Caltrans**
8 Beaches	**20 Parks**

Boats docked at a Lowrie Yacht Harbor, San Rafael. Credit: BVB Consulting LLC

Mill Valley-Sausalito Multi-use path is well used by residents and visitors. Credit: S. Crooks.

IMPACTS AT-A-GLANCE: SCENARIO 6

RECREATION

Table 43. Recreation Assets Vulnerable to Sea Level Rise at MHHW

M= Marin County Jurisdiction

	Near-term		Medium-term		Long-term	
	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
All	**47 Parks 287 Acres**	**47 Parks 718 Acres**	**47 Parks 510 Acres**	**47 Parks 810 Acres**	**94 Parks 1,084 Acres**	**105 Parks 1,222 Acres**
Incorporated Jurisdictions						
Belvedere					Belvedere Community Center Mini Park	
Corte Madera	Triangle Marsh	See scenario 1	See scenario 1	See scenario 1 Susan Marker Trail [L]	See scenario 1 Bike Trail[M] Hal Brown Park[M] Madera Gardens Lagoons Ring Mountain[M] Shorebird Marsh Town Park Skunk Hollow Park	See scenarios 1 & 5
Larkspur	Bon Air Landing Park Cal Park Wetland[M] Bon Air Landing Park Piper Park Remillard Park	See scenario 1	See scenario 1	See scenario 1	See scenario 1 Heatherwood Park Niven Park San Clemente Park	See scenarios 1 & 5 Hamilton Park
Mill Valley	Bayfront Park Mill Valley/ Sausalito Path[M]	See scenario 1	See scenario 1	See scenario 1	See scenario 1 Freeman Park Hauke Park Mill Valley Rec Center Sycamore Park	See scenarios 1 & 5 Enchanted Knolls Park
Novato					Bahia Mini Parks Future Hamilton Rec Area Hamilton Airport Park Hamilton Amphitheater Park Slade Park Hamilton Community Center South Hamilton Park	See scenario 5 Scottsdale Marsh

RECREATION

	Near-term		Medium-term		Long-term	
	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
San Rafael	Beach Park Gallinas Creek Pickleweed Park Starkweather Shoreline Park Open space off Bay Way	See scenario 1	See scenario 1	See scenario 1	See scenario 1 Albert Park Peacock Gap Park Schoen Park Canal/Shoreline Open Space	See scenarios 1 & 5
Sausalito	Dunphy Park Mill Valley/ Sausalito Path [M] Schoonmaker Beach Swedes Beach Tiffany Beach Turney Street Boat Ramp Yee Tock Chee Park	See scenario 1	See scenario 1	See scenario 1	See scenario 1	See scenario 1 City Government Facilities Gabrielson Park Island Park Marinship Park
Tiburon	Blackie's Pasture McKegney Green Pt. Tiburon Richardson Bay Lineal Park Shoreline Park The Cypress Garden Park	See scenario 1	See scenario 1	See scenario 1	Bel Aire Park Pt. Tiburon Marsh Zelinsky Park	See scenarios 1 & 5 Pt. Tiburon Tennis Courts South-Of-The-Knoll Park
Unincorporated Jurisdictions						
Almonte	Charles F. McGlashan Pathway[M]	See scenario 1	See scenario 1	See scenario 1	See scenario 1	See scenario 1
Bel Main Keys	Cavalia Cay Park Bahama Reef Boat Launch Dolphin Isle Boat Launch	See scenario 1	See scenario 1	See scenario 1	See scenario 1 Bel Marin Keys Public Dock Bel Marin Keys Yacht Club Caribe Isle Park Montego Park Calypso Bay Public Dock Bahama Reef Boat Launch Del Oro Park	See scenarios 1 & 5
Black Point	Black Point Boat Launch[M]	See scenario 1	See scenario 1	See scenario 1	See scenario 1	See scenario 1

RECREATION

	Near-term		Medium-term		Long-term	
	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
No. Novato					Rush Creek [M] Deer Island [M]	See scenario 5
Sta. Venetia	Santa Margarita Island [M] Santa Venetia Marsh [M]	See scenario 1	See scenario 1	See scenario 1	Pueblo Park[M] Adrian Rosal Park[M] Castro Park[M] Candy's Park[M]	See scenarios 1 & 5
Strawberry	Brickyard Cove Community Park Community Park Boat Launch Strawberry Point Tidal Area [M] Strawberry Point Park Aramburu Island [M]	See scenario 1	See scenario 1	See scenario 1	See scenario 1	See scenario 1
St. Vincent's	John F. McInnis Park [M]	See scenario 1	See scenario 1	See scenario 1	See scenario 1	See scenario 1
Tiburon	Paradise Beach Park [M]	See scenario 1	See scenario 1	See scenario 1	See scenario 1	See scenario 1

Source: MarinMap, CoSMoS

RECREATION

Beaches

Beaches are used for wildlife viewing, sunbathing, and accessing bay waters for swimming, kayaking, paddle boarding, and fishing. Sea level rise could inundate existing beaches and increase rates of shoreline erosion. This could potentially force beach recreation opportunities inland where beaches are not impeded by development, roads, or bluffs.[120] Beaches commonly used for recreation that could be vulnerable to sea level rise and storms include:

- Schoonmaker Beach, Sausalito,
- Swedes Beach, Sausalito,
- Tiffany Beach, Sausalito,
- Private beaches in Tiburon,
- Paradise Beach, Unincorporated Tiburon,
- Larkspur Landing Beach,
- Pt. San Quentin Beach (private),
- Marin Rod & Gun Club, San Rafael,
- McNear's Beach, Pt. San Pedro,
- Brick Yard Beach, San Rafael,
- China Camp State Park Beaches, and
- McInnis Beach, San Rafael.

Narrow Tiffany and Swede beaches in Sausalito. Credit: Sausalito

120 Feagin, R.A., D.J. Sherman, and W.E. Grant. 2005. Coastal erosion, global sea-level rise, and the loss of sand dune plant habitats. Frontiers in Ecology and the Environment 7:359-364.

Estuaries, Wetlands, & Marshes

Primary recreational activities in estuarine areas such as the shoreline areas of Richardson's Bay, San Pablo Bay, and the San Francisco Bay, are hiking, kayaking, paddle boarding, boating, bird watching, fishing, swimming, and other passive forms of recreation. Without a comparable increase in land elevation from sediment delivery, these recreational areas could flood.[121,122] Like beaches, estuaries can be prevented from moving landward when bordering development or cliffs. Vulnerable estuaries, wetlands, and marshes include:

- Bothin Marsh, Mill Valley,
- Santa Venetia Marsh,
- Shorebird Marsh, Corte Madera,
- Pt. Tiburon Marsh, and
- San Pablo Bay Wildlife Area, in the Bay off St. Vincent's.

Freshwater Resources

In scenario 5, with 60 inches of sea level rise, saltwater can travel miles inland up to, especially in Corte Madera Creek and the Petaluma River. This could significantly alter existing habitat and wildlife viewing opportunities, and may require adapting to create new opportunities. Creeks passing through parks that could be impacted by sea level rise include:

- Arroyo Corte Madera del Presidio,
- Baccaglio Basin Drainage,
- Castro Ditch,
- Corte Madera Channel,
- Corte Madera Creek,
- Corte Madera Outfall Channel,
- Coyote Creek,
- Estancia Ditch,
- Gallinas Creek,
- Glen Creek,
- Glenwood Creek,
- Greenbrae Creek,
- High Canal,

121 Largier, J.L., B.S. Cheng, and K.D. Higgason, editors. 2010. *Climate Change Impacts: Gulf of the Farallones and Cordell Bank National Marine Sanctuaries*. Report of a Joint Working Group of the Gulf of the Farallones and Cordell Bank National Marine Sanctuaries Advisory Councils.

122 Ackerly, D. D., R. A. Ryals, W. K. Cornwell, S. R. Loarie, S. Veloz, K. D.Higgason, W. L. Silver, and T. E. Dawson. 2012. *Potential Impacts of Climate Change on Biodiversity and Ecosystem Services in the San Francisco Bay Area*. California Energy Commission. Publication number: CEC-500-2012- 037.

- Larkspur Creek,
- Low Canal,
- Lynwood Slough,
- Mahon Creek
- Marin City Stormwater Pond Channel,
- Meadow Way Creek,
- Miller Creek,
- Nyhan Creek,
- Petaluma River,
- Reed Creek,
- Rush Creek,
- Ryan Creek,
- Salt Works Canal,
- San Rafael Canal,
- Sunny Oaks Drainage,
- Alto Shopping Center, and
- Wolfe Grade Creek.

Federal Parks

The National Park Service released *Adapting to Climate Change in Coastal Parks: Estimating the Exposure of Park Assets to 1 m of Sea-Level Rise*.[123] Note that the National Parks report uses a different methodology than this Assessment to determine vulnerability. While outside of the study area for this report, these federal park lands draw tourists and residents to and through Marin's bay area. Their report finds that high exposure to sea level rise could impact 43 assets valued at $57,870,724 and several recreational and habitat areas in the Marin County portion of the Golden Gate National Recreation Area.

Bay

Several open water recreation activities begin and end on the shoreline. While activities themselves will likely continue despite sea level rise, the facilities to serve these water based activities may need to adjust. These facilities include piers, harbors, marinas, boat launches, and fishing piers. Boating facilities using float systems for the docks and piers versus hydraulic lifts will fare better. Piers that are too short can be replaced, and ideally any project in the near future would incorporate a few extra feet above the current standard to be prepared for uncertainties in the future. A few of these facilities depend on jetties or break walls to protect the boats within them. These structures may also need to have elevation added to withstand higher tides. Jetties are also prone to subsidence and erosion.

- Arques Shipyard and Marina,
- Buck's Landing,
- Cass Gidley Marina,
- Clipper Yacht Harbor,
- Hi-Tide Boat Sales & Services,
- Loch Lomond Marina,
- Lowrie Yacht Harbor,
- Marin Yacht Club,
- McNear Public Fishing Pier
- Marina Plaza Harbor,
- Paradise Cay Yacht Harbor,
- Pelican Yacht Harbor,
- Petaluma River Public Fishing Access,
- Richardson Bay Marina,
- San Rafael Yacht Club,
- San Rafael Yacht Harbor,
- Sausalito Marine,
- Sausalito Yacht Harbor,
- Schoonmaker Point Marina, and
- Travis Marina.

According to Buck's Landing asset managers, monthly high tides that extend above the boat launch could cause up to a 75 percent reduction in capacity.[124]

[123] McDowell Peek, Katie, R. S. Young, R. L. Beavers, C. Hawkins Hoffman, B. T. Diethorn, S. Norton. *Adapting To Climate Change in Coastal Parks: Estimating the Exposure of Park Assets to 1 m of Sea-Level Rise.* Natural Resource Technical Report NPS/NRSS/GRD/NRR—2015/916. http://www.nature.nps.gov/geology/coastal/coastal_assets_report.cfm.

[124] Marin County Parks Asset Manager Interview

RECREATION

Mill Valley/Sausalito Multi-modal Pathway. Dec. 2014 King Tides. Credit: DPW

Mill Valley/Sausalito Multi-modal Path through Bothin Marsh. Dec. 2015. Credit: J Poskazner

Richardson's Bay Shoreline seating area. Dec. 2014 King Tide. Credit: DPW

RECREATION

Sporting Facilities

In addition to the passive recreation, several sites offer sporting facilities such as soccer fields, baseball diamonds, tennis courts, and other features. These facilities typically have electronic centers to control lighting that could be vulnerable. In most cases, only portions of a park are impacted. At McInnis Park the miniature golf, batting cages, driving range, and restaurant are not vulnerable. However, the entrance to the facility is compromised in the long-term and the creek side soccer fields are impacted earlier. Other parks in this category include:

- Swede's Beach, Sausalito,
- Dunphy Park, Sausalito,
- Gabrielson Park, Sausalito,
- Marinship Park, Sausalito,
- Piper Park baseball, soccer, and cricket fields, Larkspur,
- Mc Near's pool, tennis courts, and volley ball courts, Pt. San Pedro,
- Tiburon tennis courts,
- Mill Valley Recreation Center ball fields,
- Corte Madera's Town Park facilities,
- Albert Park, San Rafael, where the minor league baseball team plays,
- Pickleweed Park and Children's Center,
- Belvedere Community Center basketball courts and park, and
- A small piece of the Strawberry Recreation District baseball field could be vulnerable

Bikeways and Trails

Several residents and visitors use the extensive bike and trail systems on a year around basis. The most well-known is the Bay Trail, a regionally managed asset that travels along the majority of the shoreline. The trail is vulnerable in low-lying locations; however, several elevated locations are overtopped by 3 feet of sea level rise and higher. Another well-traveled trail is the Mill Valley-Sausalito Pathway. This pathway is already in a tidal zone and experiences seasonal flooding. The areas just inland from the trail floods at high tides at about 4.5 feet NGVD about 20 to 30 times every year. In the near future, flooding could reduce travel capacity significantly during high tides and increase maintenance needs. The Corte Madera Creek and Charles F. McGlashan Pathways are also vulnerable to sea level rise. In addition, bike travel along roads is vulnerable when the roads could be vulnerable. To see list of potentially vulnerable roads, refer to the Transportation Profile.

Map 38. Marin County Area Bay Trail

RECREATION

Private Recreation

Several of the previous shoreline recreation activities are available and enhanced by private service providers. These include hotels, boat suppliers, surfing schools, restaurants, markets, tours, and several could be vulnerable to sea level rise. Of the 35 or so hotels in eastern Marin, fifteen could be vulnerable to regular high tides and storms. Seaplane Adventures is also a unique asset that will likely need to adjust to higher waters. Other major examples of areas featuring private recreational assets include:

- Marin Country Mart shops and dining (access issues only),
- Shelter Bay shops and dining, Mill Valley,
- Downtown Tiburon shops and dining,
- Tam Junction shops and dining,
- Sausalito shops and dining,
- Downtown San Rafael shops and dining, and
- Mt. Tam Racquet Club, Larkspur.

Vulnerable hotels include:

- Embassy Suites by Hilton, Santa Venetia,
- Acqua Hotel, Mill Valley,
- Water's Edge Hotel, Tiburon,
- The Lodge, Tiburon,
- Best Western Corte Madera,
- Marin Suites Hotel, Corte Madera,
- Extended Stay America, San Rafael,
- Travel Lodge, San Rafael,
- North Bay Inn, San Rafael,
- Motel 6, San Rafael,
- Holiday Inn Express, Mill Valley,
- America's Best Value Inn & Suites (access issues only), Mill Valley,
- Travelodge Mill Valley/Sausalito,
- Hotel Sausalito, and
- The Inn Above Tide, Sausalito

Table 44 lists some potentially vulnerable recreational assets at mean higher high water (MHHW) for each sea level rise scenario. Many recreational assets are shoreline based or water features. Some assets are only vulnerable to saltwater flooding in long-term scenario 6. These include Larkspur's Niven Park, Tiburon's tennis courts.

Table 44. Example Vulnerable Recreation Assets Ranked by Onset and Flooding at MHHW

Location	Asset	Near-term	Medium-term	Long-term
		Scenario 1	Scenario 3	Scenario 5
Sausalito	Swedes Beach	Floods at existing high tides		
Sausalito	Tiffany Beach	Floods at existing high tides		
Novato	Scottsdale Marsh	Floods at existing high tides		
Tamalpais Valley	Bothin Marsh	Floods at existing high tides		
Unincorporated Tiburon	Paradise Beach Park	Floods at existing high tides		
Sausalito	GG Sausalito Ferry	No data	No data	No data
State Park	Angel Island State Park	14'1"	14'10"	17'9"
San Rafael	Spinnaker Pt. open space	10'3"	11'1"	25'4"
Tiburon	Pt. Tiburon Shoreline Park	8'	8'8"	11'6"
Pt. San Pedro	China Camp State Park	7'6"	8'1"	18'4"
San Rafael	John F. McInnis Park	7'6"	8'6"	10'6"
Larkspur	Piper Park	7'2"	7'11"	10'8"
Santa Venetia	Santa Venetia Marsh	7'	7'10"	9'11"
San Pablo Bay	San Pablo Bay Wildlife Area	6'9"	7'2"	19'
Santa Venetia	Santa Margarita Island	5'8"	6'8"	8'8"
Sausalito	Arques Shipyard and Marina	5'7"	8'6"	21'9"
Sausalito	Marina Plaza Harbor	5'7"	8'6"	21'9"
San Rafael	Starkweather Shoreline Park	5'4"	6'	16'3"
Larkspur	Bay Trail	0-5'4"	0-6'	0-8'6"
Bel Marin Keys	Del Oro Park	5'2"	5'8"	8'9"

RECREATION

Location	Asset	Near-term	Medium-term	Long-term
		Scenario 1	Scenario 3	Scenario 5
Sausalito	Dunphy Park	5'1"	5'8"	13'8"
Bel Marin Keys	Cavalia Cay Park	5'1"	5'8"	8'9"
Bel Marin Keys	Dolphin Isle Boat Launch	5'1"	5'8"	8'9"
San Rafael	Pickleweed Park	5'	5'8"	8'9"
Tiburon	Downtown shops & restaurants	0-5'	6"-3'11"	1'4"-12'9"
Larkspur	Cal Park Wetlands	4'10"	5'3"	8'2"
Bel Marin Keys	Bahama Reef Boat Launch	4'6"	5'2"	8'1"
Waldo Point	Richardson Bay Marina	4'5"	7'4"	18'7"
Larkspur	Bon Air Landing Park	4'4"	5'	8'6"
Pt. San Pedro	Mc Nears Beach Park	4'4"	5'9"	8'
Belvedere	Corinthian Yacht Club	4'	4'3"	11'
Sausalito	Shops & restaurants	3'6"	4'6"	11'6"
San Rafael	Open space off Bay Way	3'2"	3'11"	6'10"
Tiburon	Mc Kegney Green	3'1"	5'7"	15'3"
Tiburon	Richardson Bay Lineal Park	0-3'	1"-3'7"	1"-15'
Larkspur	Remillard Park	2'11"	3'6"	6'2"
Black Point	Black Point Boat Launch	2'8"	3'10"	7'
San Rafael	Bay Trail	0-2'3"	0-3'	0-10'3"
Belvedere	San Francisco Yacht Club	2'2"	3'6"	8'10"
San Rafael	San Rafael Yacht Harbor	1'2"	4'	10'4"
Almonte	Seaplane Adventures	9"	2'	5'
San Rafael	Lowrie Yacht Harbor	2"	9"	3'7""
Tiburon	The Cypress Garden Park	7"	1'4"	4'4"
San Rafael	Hi-Tide Boat Sales	6"	3'4"	8'5"
Corte Madera	Corte Madera Creek Path	4"	1'11"	6'10"
Sausalito	Sausalito Yacht Harbor	4"	1'	3'
Paradise Cay	Paradise Cay Yacht Harbor	2"	1'6"	3'10"
San Rafael	Marin Yacht Club	1"	1'6"	3'9"
Tiburon	Blackie's Pasture	0-9"	5'4"	12'9"
Tamalpais Valley	Tam Junction shops & restaurants	0-8"	7"-2'	1'5"-5'3"
Corte Madera	San Clemente Park	No data		
San Rafael	Open Space 025		9'2"	12'2"
San Rafael	Beach Park		8'11"	11'10"
Mill Valley	Bayfront Park		8'3"	4'-11'6"
Mill Valley	Bay Trail		0-8'	3"-12'5"
Almonte	Charles F. McGlashan Path		7'6"	10'8"
Sausalito	Schoonmaker Beach		7'2"	10'1"
Strawberry	Brickyard Cove		6'11"	9'11"
Corte Madera	Hal Brown Park		6'3"	9'2"
San Rafael	Peacock Gap Neighborhood Park		6'3"	9'
Strawberry	Strawberry Recreation District Boat Launch		5'11"	8'11"
Strawberry	Greenwood Cove area community park		5'4"	10'
Corte Madera	Shorebird Marsh		5'3"	10'9"
Strawberry	Strawberry Point Tidal Area		5'1"	8'1"

RECREATION

Location	Asset	Near-term	Medium-term	Long-term
		Scenario 1	Scenario 3	Scenario 5
Strawberry	Strawberry Point Park		4’10”	9’2”
Strawberry	Seminary Marsh area community park		4’4”	8’1”
San Rafael	Loch Lomond Marina		3’7”	9’7”
Corte Madera	Bay Trail		0-3’4”	0-8’6”
Sausalito	Schoonmaker Point Marina		3'3"	8'2"
Sausalito	Clipper Yacht Harbor		2’5”	6’3”
San Rafael	San Rafael Yacht Club		2’2”	5’7”
Bel Marin Keys	Montego Park		2’	5’4”
Sausalito	Cass Gidely Marina		2’	3’2”
San Rafael	Downtown shops & restaurants		1”-1’3”	3”-3’3”
San Rafael	Pickleweed Park facilities		1’2”	3’
Larkspur	Hamilton Park		10”	3’9”
Mill Valley	Shelter Bay		2”-9”	6”-1’10”
Novato	Bay Trail		0-8”	0-12’7”
Corte Madera	Bay Trail County Rte 17			13’4”
Corte Madera	Higgins Dock			11’10”
Novato	South Hamilton Park			11’6”
Novato	Deer Island			10’10”
Novato	Hamilton Amphitheater Park			10’6”
Corte Madera	Madera Gardens Lagoons			10’4”
San Rafael	Gallinas Creek			10’2”
Novato	Hamilton Airport Park			10’
Corte Madera	Town Park			9’10”
San Rafael	Albert Park			9’3”
Novato	Rush Creek			8’10”
Sausalito	Turney Street Boat Ramp			8’8”
Mill Valley	Sycamore Park			8’6”
Larkspur	Heatherwood Park			8’2”
Novato	Slade Park			8’
Novato	Hamilton Community Center			8’
Novato	Future Hamilton Rec. Area			7’6”
Corte Madera	Susan Marker Trail			1’2”-7’6”
Bel Marin Keys	Caribe Isle Park			7’4”
Bel Marin Keys	Calypso Bay Public Dock			7’4”
Bel Marin Keys	Bel Marin Keys Dock			7’4”
Bel Marin Keys	Bel Marin Keys Yacht Club			7’4”
Santa Venetia	Castro Park			6’11”
Novato	Bahia Mini Parks			6’9”
Santa Venetia	Candy's Park			6’3”
Santa Venetia	Adrian Rosal Park			5’10”
Belvedere	Mini Park			5’3”
San Rafael	Canal/ Shoreline Park			5’1”
Santa Venetia	Pueblo Park			4’11”
Tiburon	Zelinsky Park			4’10”
Tiburon	Pt. Tiburon Marsh			4’4”
Belvedere	Community Center			4’4”
San Rafael	Schoen Park			4’2”

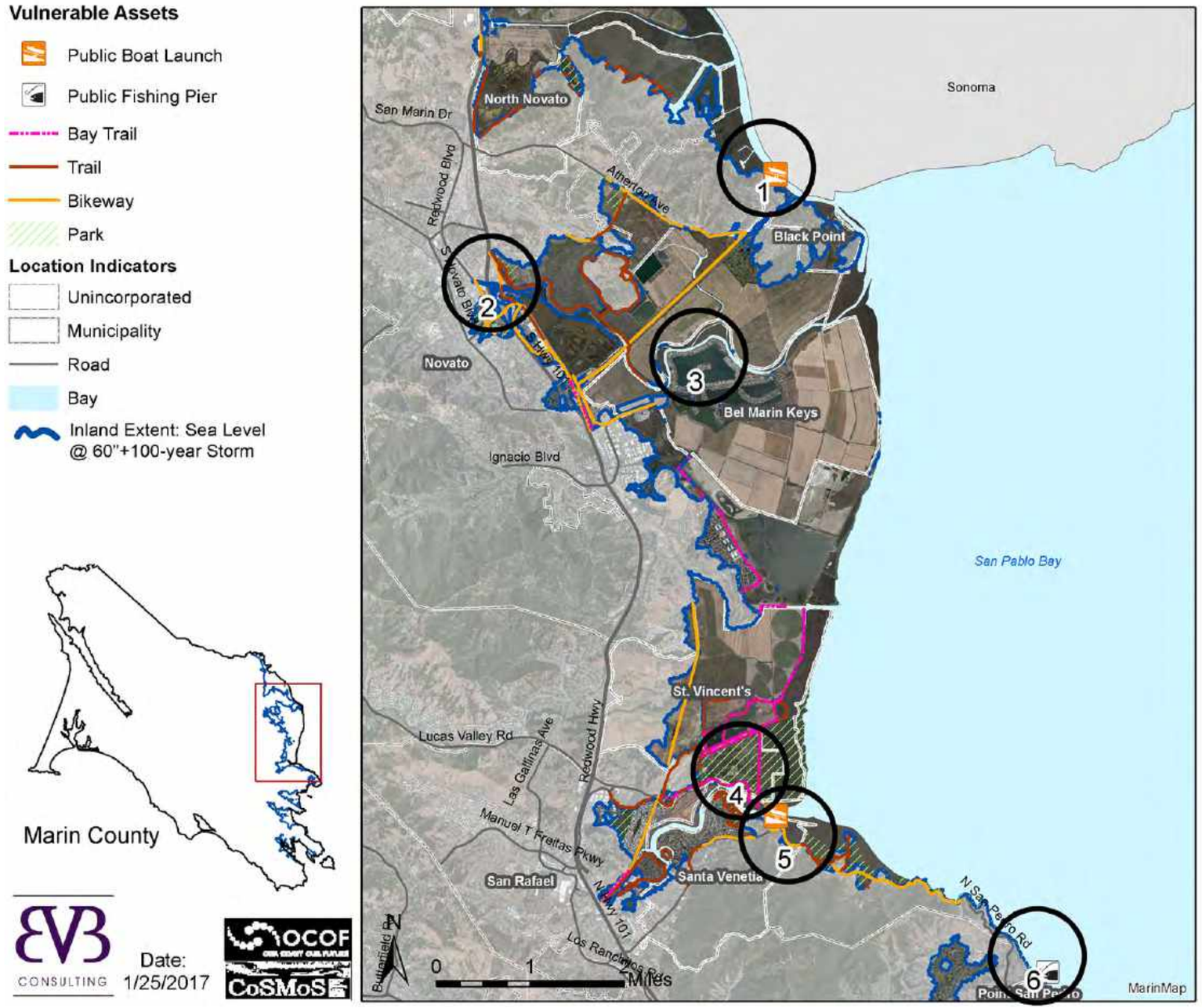
RECREATION

Location	Asset	Near-term	Medium-term	Long-term
		Scenario 1	Scenario 3	Scenario 5
Mill Valley	Freeman Park			4’1”
Strawberry	Baseball diamonds			3’10”
Mill Valley	Mill Valley Rec Center			3’6”
Corte Madera	Ring Mountain			3’6”
Mill Valley	Hauke Park			3’4”
Tiburon	Bay Trail			6”-3’
Corte Madera	Skunk Hollow Park			3’
Sausalito	Yee Tock Chee Park			2’11”
Sausalito	Bay Trail			7”-2’3”
Tiburon	Bel Aire Park			2’4”
Larkspur	Bon Air Landing Park			2’4”
Fort Baker	Travis Marina			4’10
Black Point	Golf Course			No data
Santa Venetia	Buck's Landing	No data		
Sausalito	Pelican Yacht Harbor	No data		
Larkspur	Marin Country Mart	Access issues only		

Source: MarinMap, CoSMoS

RECREATION

Map 39. Northern Study Area Vulnerable Recreation Assets



1: Black Point

2: Scottsdale Marsh

3: Bel Marin Keys

4: McInnis Park

5: Buck's Landing

6: McNears Beach Park

Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data providers here in, make no warranties of the accuracy or completeness of maps and data. Maps are representational and subject to future revision. Local site conditions must be examined. Commercial use is prohibited.

RECREATION

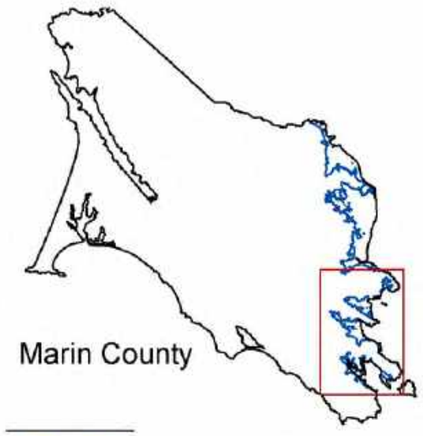
Map 40. Southern Study Area Vulnerable Recreation Assets

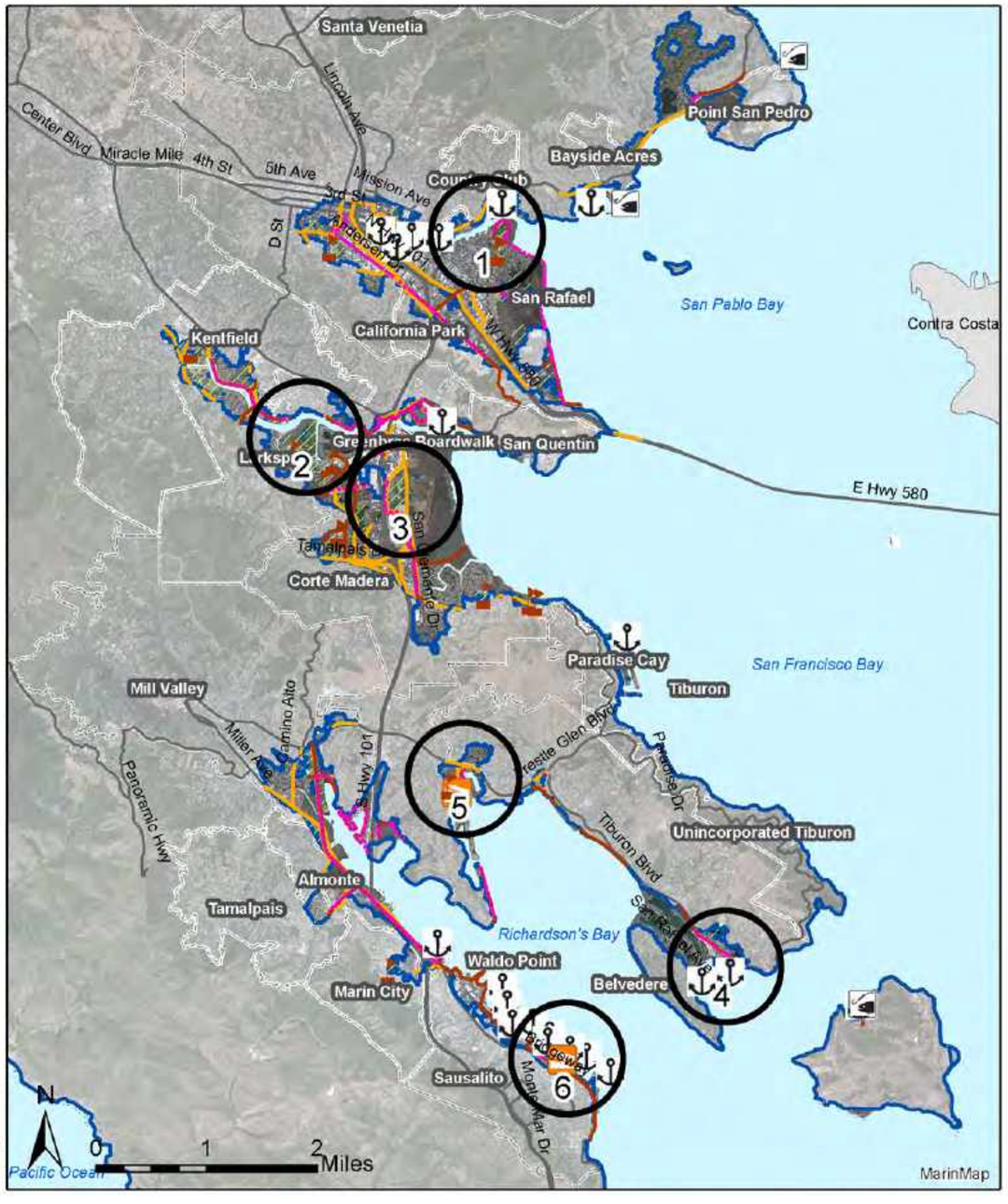
Vulnerable Assets

- School
- Public Boat Launch
- Public Fishing Pier
- Marina
- Bay Trail
- Trail
- Bikeway
- Park

Location Indicators

- Unincorporated
- Municipality
- Road
- Bay
- Inland Extent: Sea Level @ 60"+100-year Storm





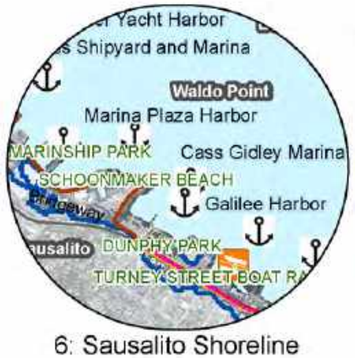
1: San Rafael Canal

2: Corte Madera Creek

3: Corte Madera Marsh

4: Belvedere/Tiburon

5: Strawberry



6: Sausalito Shoreline

Date: 4/1/2017

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RECREATION

Other Considerations

Economic
Active and passive recreation on and along Marin's shoreline are critical economic contributors to the regional economy that could be negatively impacted with rising seas. Several assets are national and regional draws. If roads, regional airports and transit service is disrupted these visitors may not be able to travel. This would greatly impact the tourist economy. Moreover, creating new spaces would require significant funding from taxes and user fees.

Environmental
Creating new access and activity areas could have serious temporary and long-term environmental impacts. Several species require buffers between their habitats and human activity, especially for breeding and nesting. Allowing human activity in new areas could greatly impact wildlife roosting and feeding habitats.

Social Equity
Beaches, estuaries, wetlands, and marshes provide unique low cost opportunities for wildlife viewing, shoreline access, and scenic enjoyment that could be lost to sea level rise.[125] The losses could be felt unequally across income levels because as free or low cost public access points are lost to the rising sea there could be less capacity to accommodate lower income households. This impact could also be experienced differently across geographies where reaching recreation opportunities is already hindered or could become hindered in the future. Those who fish for sustenance at bayside fishing piers, such as McNears Beach Park pubic fishing pier, could be disproportionately impacted and experience food insecurity.

Management
Protecting public access to natural resources and wildlife is a state and local priority. However, as Marin residents' daily lives become more and more vulnerable, preserving recreation opportunities could become a lower priority. National priorities could also affect Marin public lands and sanctuaries under federal jurisdiction.

[125] BCDC Vulnerability Assessment.

The Countywide Plan and local general plans seek to preserve recreational opportunities for residents and visitors, and to maintain and expand opportunities for public access. The County of Marin's Baylands district provides for open space, outdoor recreation, and other open lands, including areas suited for park and recreational purposes, access to beaches, and areas that link major recreation areas.

In addition, public trust lands include submerged land and tidelands below the mean high tide line in areas that do not contain tidal marsh and up to five feet above mean sea level in areas of tidal marsh. The Bay Conservation Development District (BCDC) retains development permit authority over:

- The Bay itself (all areas that are subject to tidal action, including sloughs, from the south end of the Bay to the Golden Gate to the Sacramento River,
- A shoreline band of land extending inland for 100 feet from the shoreline of the Bay,
- Select salt ponds,
- Select managed wetlands, and
- Certain waterways consisting of all areas that are subject to tidal action on named tributaries that flow into the Bay.

As sea level rise advances, the boundary of public trust lands would also move inland.

Paddle boarder on Miller Avenue near Bothin Marsh. Credit: Unknown

EMERGENCY SERVICES

Asset Profile: Emergency Services

Marin's Bay communities are susceptible to earthquakes, tsunamis, fires, and more. Sea level rise could create additional hazardous conditions and impede emergency response. In fact, the primary vulnerability in the emergency services sector is continued safe and timely access to people in need. In addition to this, several service providers could face additional threats from sea level rise.

Sheriff

The primary issue with the Sherriff would likely be access to places in need of services during storms. In addition, the Marine Patrol keeps Rescue Boat 1 moored at Richardson Bay Marina, at 100 Gate 6 Road, Sausalito. Rescue Boat 2 on a trailer at Loch Lomond Marina in San Rafael. These facilities are on the water and are thus vulnerable to storm damage at any given time. Loch Lomond Marina main jetty wall could be overtopped by tidal flooding by near-term scenario 1. Interior portions of the marina may be less vulnerable than the model estimates due to recent construction elevating the site. Richardson Bay Marina is vulnerable to tidal flooding on the jetties, or pathways to the boat slips, by near-term scenario 1 and is nearly entirely compromised by long-term scenario 5.

Fire Protection & Emergency Medical

Fire protection districts can provide a variety of services including ambulance, rescue and first aid, land clearing, fire prevention ordinances, and public education. Losing vehicular access is the main vulnerability for all of the fire districts in the area. Several fire stations could experience direct impacts: Station 54 in San Rafael, Tiburon, Station 13 in Corte Madera, and Station 2 in Novato could be vulnerable to sea level rise and storms. Fire Station 54 in San Rafael is on Castro Street in the Canal Neighborhood, the most diverse, disadvantaged, and severely impacted neighborhood in the study area. Southern Marin Fire Protection maintains a boat at the Pelican Yacht Harbor in Sausalito. This facility could expect tidal flooding reach the parking lot by long-term scenario 5.

IMPACTS AT-A-GLANCE: SCENARIO 6

Tens of thousands of residents, millions of visitors

Corte Madera Fire Station 13 San Rafael Fire Station 54 Novato Fire Station 2 Tiburon Fire Station CHP headquarters Two rescue boats Emergency Access Routes Hydrants Emergency water Supplies	Property Owners Office of Emergency Services Fire Departments County Sheriff CHP Municipal Police EMT providers

San Rafael Fire Station No. 54 is vulnerable. Credit: SRFD

Rescue Boat Liberty. Southern Marin Fire District. Credit: SMFD

Storm surges in scenario 6 almost reach Southern Marin Fire District Headquarters and station 14 in Corte Madera. Stations 52 and 55 in San Rafael could also face access issues. Finally, disruptions in water supply and corroding of reserve tanks could compromise fire service. This is primarily a concern in the northern half of the study area where NMWD has reserve emergency water tanks.

Local Police

Very few facilities are impacted directly. However, the Central Marin Police Authority building, serving San Anselmo, Corte Madera and Larkspur could become an island as the lands around it flood in the long-term. Flooding south of the station on Doherty Drive, in Larkspur, is already an issue during high tides and storms. The increased saltwater on roads around the station could lead to faster corrosion of the patrol SUVs. The Sausalito Police Department's two boats, Marine 1, berthed at Schoonmaker Marina, and Marine 2, berthed at the US Army Corps of Engineer's dock in Sausalito could also be vulnerable to storms damage and access to the boats could be difficult if tides are too high. If the marina facilities float systems are not adequately elevated to handle higher tides, the boats could be held under water.

California High Patrol (CHP)

Other than access issues, the Marin CHP Headquarters on San Clemente Drive in Corte Madera could face flooding impacts as early as scenario 3 in the medium-term. The building itself already experiences subsidence of the fill below. When the site starts to experience regular flooding, increased corrosion could damage patrol cars more quickly. The property also has fuel tanks at-grade and two stormwater pumps that could become burdened. The auto shop with lift equipment, computer electronic systems, evidence room, and reports and sensitive paper data would be impacted if flood waters reach into the facility.

Emergency Shelters

Several schools and churches double as emergency shelters because they have capacity to house many people, offer refrigeration for medications, and have backup generators. The facilities that could be vulnerable under these scenarios include:

- Bahia Vista Elementary School, San Rafael,
- Army Corps of Engineers Bay Model Visitor's Center, Sausalito,
- Belvedere City Community Center,
- Corte Madera Community Center,
- Henry Hall Middle School, Larkspur,
- Kent Middle School, Kentfield (storm surge only),
- Mill Valley Middle School,
- MLK Gym Sausalito Parks and Recreation, Marin City (storm surge only),
- Neil Cummins Elementary School, Corte Madera,
- Pickleweed Park Facilities, San Rafael,
- St. Andrews Presbyterian Church, Marin City (storm surge only),
- Strawberry Point Elem School,
- Strawberry Recreation Center (storm surge only),
- Tamalpais High School, Mill Valley (access only),
- Westminster Presbyterian Church, Strawberry,
- Belvedere City Hall, and
- Tiburon Town Hall.

Other

Lastly, the emergency fuels reserves at Larkspur Landing are also vulnerable to sea level rise. Some of this fuel is used for day to day operations; however, the majority of the fuel is the North Bay emergency reserve. If high enough tides overtop the berm and get trapped in the fuel farm containment area, where two tanks store nearly 400,000 gallons of diesel fuel the saltwater could accelerate corrosion. Not only is this region wide resource threatened, the bay could be contaminated with fuel and other chemicals. Finally, for all of these services, if these public servants are unable to access their job sites, they would not be able to perform their duties in times of need and could leave communities at a loss.

Table 45 lists some of the potentially vulnerable emergency service assets related assets in the study area. This list measures onset and tidal MHHW. And the maps on the following pages highlight where vulnerable emergency facilities exist. The areas in the call out circles enable the reader the see areas that are difficult to see on the large scale map. The circles do not indicate that these areas are more vulnerable than others along the shoreline.

EMERGENCY SERVICES

Several facilities may only be impacted during long-term scenario 6, indicating that they could experience storm surge flooding. These assets include:

- Belvedere Community Center
- Southern Marin Fire Station, Sausalito
- St. Andrews Presbyterian Church, Marin City
- Strawberry Point Elementary School
- Strawberry Recreation Center
- Corte Madera Fire Station 13
- Novato Fire Protection Administrative Services, and
- Kent Middle School, Kentfield.

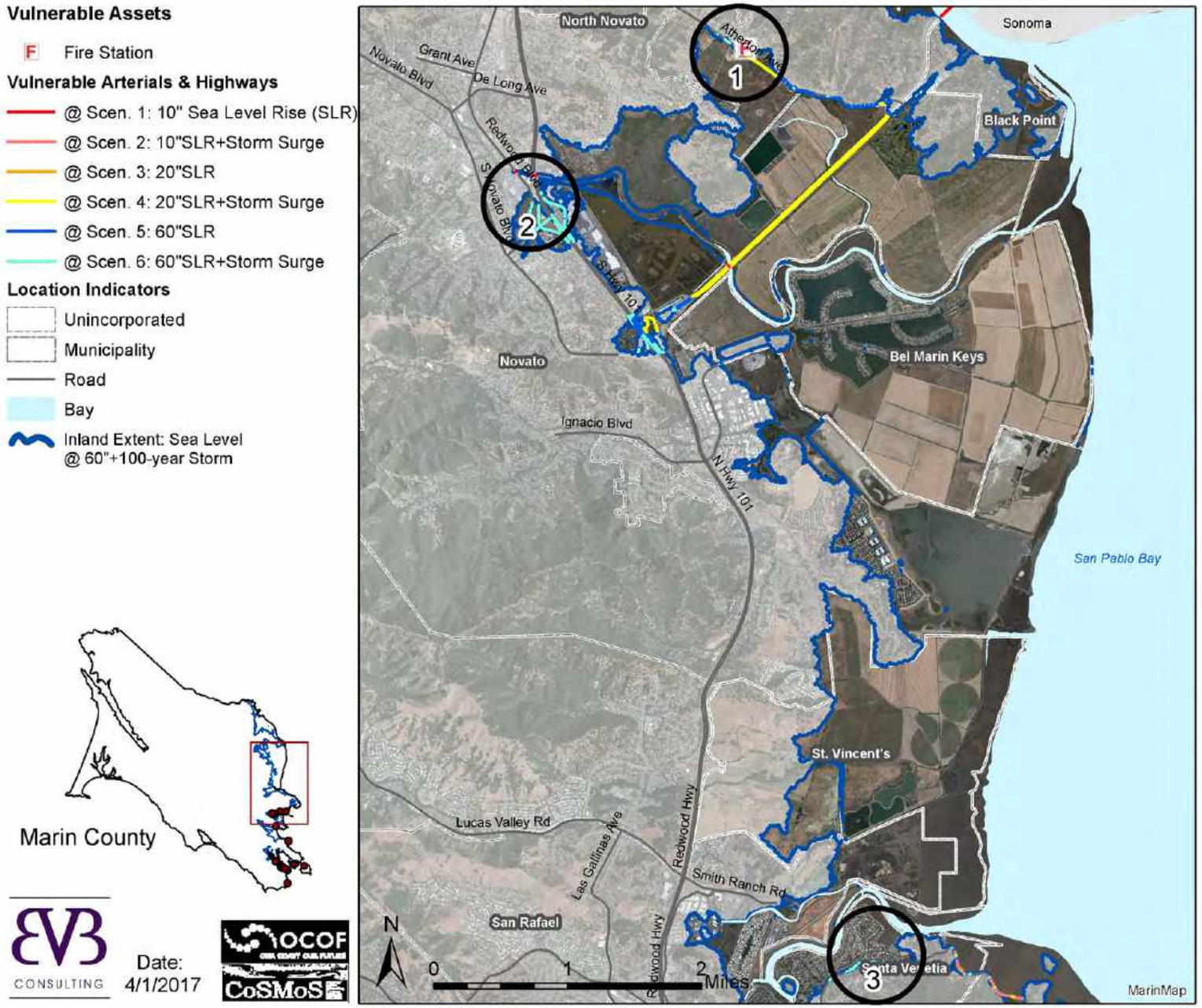
Table 45. Example Emergency Service Assets Ranked by Onset and Flooding at MHHW

Location	Asset	Near-term	Medium-term	Long-term
		Scenario 1	Scenario 3	Scenario 5
San Rafael	Fire Station No. 54	1'6"	2'7"	6'7"
San Rafael	Bahia Vista Elementary School	8”	2’3”	4’8”
Corte Madera	Neil Cummins Elementary School		2’5”	6’6”
San Rafael	Pickleweed Community Center		1’2”	3’
Tiburon	Fire Station		1’	2’6”
Larkspur	Henry Hall Middle School,		6”	1’2”
Novato	Fire Station 62		5"	1'
Mill Valley	Mill Valley Rec Center			3’10”
Waldo Point	Sheriff Water Rescue	Moored in Richardson’s Bay		
Sausalito	Police Rescue Boat	Moored in Richardson’s Bay		
Corte Madera	Recreation Center			Access Issues
San Rafael	Fire Station No. 52			Access Issue
San Rafael	Fire Station No. 55			Access Issue

Source: MarinMap, OCOF Exposure and Flood Depth data, Asset Manager Interviews

EMERGENCY SERVICES

Map 41: Northern Study Area Vulnerable Emergency Service Assets



1: Atherton Avenue @ Olive St.

2: U.S. Hwy. 101 @ Rowland Blvd.

3: N. San Pedro Rd.

Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data providers here in, make no warranties of the accuracy or completeness of maps and data. Maps are representational and subject to future revision. Local site conditions must be examined. Commercial use is prohibited.

EMERGENCY SERVICES

Map 42: Southern Study Area Vulnerable Emergency Service Assets

Vulnerable Assets

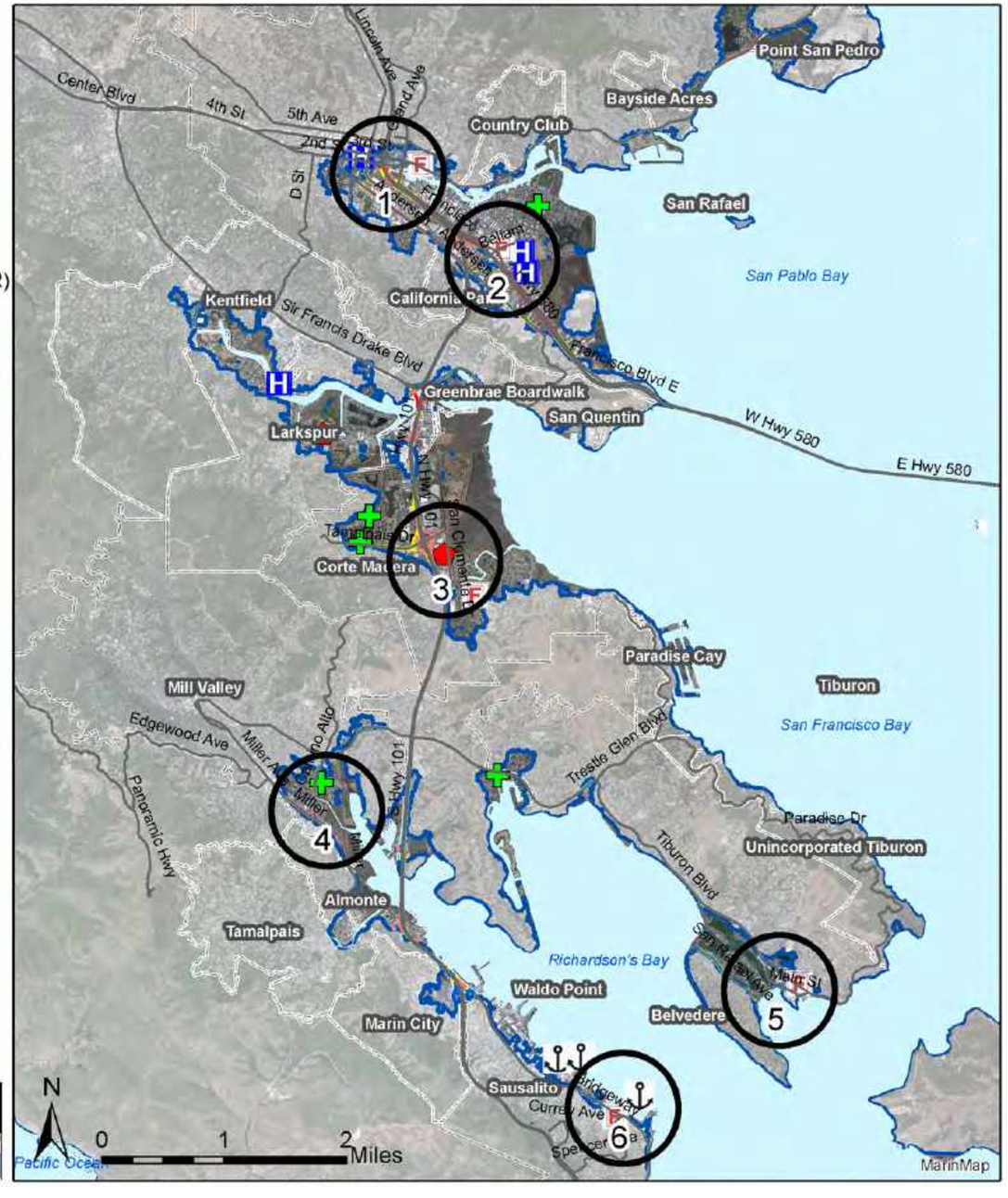
- F Fire Station
- Emergency Shelter
- Law Enforcement
- H Medical Facility
- Marina

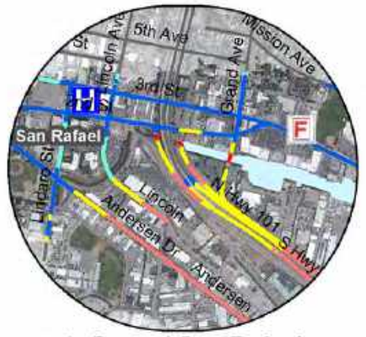
Vulnerable Arterials & Highways

- @ Scen. 1: 10" Sea Level Rise (SLR)
- @ Scen. 2: 10"SLR+Storm Surge
- @ Scen. 3: 20"SLR
- @ Scen. 4: 20"SLR+Storm Surge
- @ Scen. 5: 60"SLR
- @ Scen. 6: 60"SLR+Storm Surge

Location Indicators

- Unincorporated
- Municipality
- Road
- Bay
- Inland Extent: Sea Level @ 60"+100-year Storm





1: Central San Rafael

2: Canal Area

3: San Clemente Dr.

4: Miller Ave. @ Camino Alto

5: Belvedere/ Downtown Tiburon

6: Pelican Yacht Harbor

Date: 2/15/2017

Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data providers here in, make no warranties of the accuracy or completeness of maps and data. Maps are representational and subject to future revision. Local site conditions must be examined. Commercial use is prohibited.

EMERGENCY SERVICES

Other Considerations

Economic
Lack of emergency services or access for emergency services could lead to injury or death, which could result in costly medical and end of life expenses and cause financial complications for dependents of the victims.

Environmental
Lack of fire services or access could prevent adequate protection of homes or entire communities. Wildfire may be able to consume greater acreages if local and fire roads are compromised. If the emergency fuel tanks are compromised due to sea level rise or storms, the bay could become contaminated as well.

Social Equity
Losing public emergency services could impact all residents of and visitors to the potentially flooded areas. However, certain demographic factors may increase an individual's vulnerability in the face of an emergency. The Association of Bay Area Governments identifies several indicators that reduce a community's ability to prepare for, respond to, and recover from major disasters. These include:

- Low educational attainment
- Transit dependence (persons without vehicles)
- Non-English speakers
- Young children and aging adults
- Significant housing cost burden
- Household income
- Home ownership.[126]

Loss or compromised emergency services could be more devastating to communities with higher populations that fall into these demographic categories, such as Marin City or the Canal neighborhoods in San Rafael. In fact, the Castro Street Fire Station that serves the neighborhood could flood tidally itself in the near-term, and access from the next closest fire stations could be blocked entirely at high tide in the medium-term, compounding this area's vulnerability.

Management
Protecting emergency services will require coordination amongst federal, state, county and local agencies. Sea level rise planning efforts should collaborate with Local Hazard Mitigation Plans and the Office of Emergency Services to ensure emergency response systems and ammenities are planned with the consideration of sea level rise.

The Marin County Sheriff's Department established the Office of Emergency Services (OES) to coordinate efforts to develop disaster-resistant communities and to educate residents on emergency preparedness. In the event of a major emergency or disaster, the OES has established a fully functional centralized Emergency Operations Center (EOC). The County maintains an Emergency Operations Plan to provide preparation and agency response to disasters that threaten the health or property of residents and businesses. Simultaneously, the plan recognizes that in the first 72 hours following a major event, community members must be self-sufficient.

In addition, the Marin County Local Hazard Mitigation Plan (LHMP) was developed to meet the requirements of the Disaster Mitigation Act of 2000 and maintain eligibility for certain FEMA hazard mitigation programs. Strategies focus on safety and protection during earthquakes, fires, floods, and other disasters with high priority mitigation projects identified. The LHMP is currently being updated with an effort to reflect the full scope of hazard issues including climate change impacts.

Relevant programs of the Marin Countywide Plan and local general plans include: maintain effective communication systems, maintain adequate response resources, distribute public information, conduct disaster awareness efforts, promote community involvement, locate emergency facilities appropriately, promote agency emergency planning, and develop evacuation plans.

[126] Bay Conservation and Development Commission and Association of Bay Area Governments. *Creating Safe Growth Strategies for the San Francisco Bay Area.* 2015

CULTURAL RESOURCES

Asset Profile: Cultural Resources

Marin County is rich with history. Miwok Native Americans inhabited the area for thousands of years and around 600 identified village sites remain throughout the county.[127] In the early 1800's, Mexican governors of Alta California issued 21 land grants and founded the Mission San Rafael Arcángel as a hospital to treat Native Americans dying of introduced diseases.[128] The Gold Rush increased demand for beef and dairy, leading migrants to settle in Marin, establishing ranches and businesses.[129] New ferries, trains, and bridges enabled more access allowing bayside communities to become commercial fishing, water based recreation and vacation hubs, as well as neighborhoods for commuters working in San Francisco[130]. Many of Marin's Bayside communities have maintained their historic characters and downtowns with architectural styles including Shingle Style, Arts and Crafts, Mission Revival, Italianate, and Modern. Julia Morgan, Bernard Maybeck, Willis Polk, Frank Lloyd Wright, and Joseph Eichler are amongst the renowned architects who built in Marin County.[131] The following are key sea level rise vulnerabilities related to cultural resources:

- Tidal and storm surge flooding can destroy bayside archaeological sites and/or compromise data acquisition.
- Historic buildings along Marin's shoreline could be vulnerable to tidal and storm surge flooding, including homes and businesses in Larkspur, Sausalito, Belvedere, Tiburon, San Rafael, and Novato.
- Several publicly accessible sites within state or federal parkland could be vulnerable. Failure to protect these sites could lead to economic and intrinsic losses.
- Additional vulnerabilities lie in lack of comprehensive data on Marin's archaeological resources. Because the shoreline is only partially surveyed, potential losses in unmapped areas cannot be fully assessed.

IMPACTS AT-A-GLANCE: SCENARIO 6

More than 90 historic buildings in private ownership	**Archaeological Resources**
6 National Register of Historic Places Sites	**Public Sites in State and Federal Parkland**
Lack of comprehensive surveys	**State Parks National Park Service Local jurisdictions Marin County Property Owners Graton Rancheria Federated Indians**

Downtown Sausalito Historic District is a social and economic hub. Credit: Marin County CDA

[127] Wikipedia, Marin County California. Last updated July 3, 2016. en.wikipedia.org/wiki/Marin_County,_California#History
[128] Futcher, Jane. 1981. Marin, The Place, The People.
[129] Ibid.
[130] Marin County Community Development Agency. 2007. Marin Countywide Plan.
[131] Ibid.

CULTURAL RESOURCES

Vulnerable Assets

Cultural resources can be defined as "physical evidence or place of past human activity: site, object, landscape, structure; or a site, structure, landscape, object or natural feature of significance to a group of people traditionally associated with it."[132] Cultural resources analyzed in this assessment are archaeological sites and locally, state, and federally recognized historical structures.

Key resources include historic districts in Sausalito, Belvedere, Tiburon, San Rafael, Hamilton in Novato, and China Camp State Park. Often hubs for local businesses and heritage tourism, historic districts can play an important role in community economic development and sustainability. Historic sites may contribute to local sense of place, community character, and cultural identity. Historical sites can serve as museums or interpretive centers for educational purposes. Environmentally, the continued use of older buildings is generally much more energy efficient than new construction, thus helping to reduce greenhouse gas emissions.[133] Archaeological sites can provide scientific data such as plant and animal species that thrived under past climactic conditions which could useful in informing future natural resource management plans.

Historic buildings are physically vulnerable to flooding just like any other building (see Table 23). However, additional considerations for historic buildings include:

- Direct/Tangible:
  - o Increased sensitivity due to age/condition leading to more severe physical damage to building fabric.[134]
  - o Damage or destruction to character defining features
  - o Damage or destruction of historic artifacts within the building
- Direct/Intangible: Irreplaceable loss of cultural heritage from deterioration/destruction of building or artifacts contained within building [135]
- Indirect/Tangible: Loss of tourism revenue[136]
- Indirect/Intangible: Loss of sense of place. [137]

Due to available information, this Profile focuses on direct/tangible losses, primarily structural damage to historic buildings. Tourism revenue is not available for all of the sites therefore; indirect/tangible losses cannot be fully assessed. Additionally, while losing these sites would likely have negative cultural identity and sense of place impacts, quantifying the loss is a challenge with no known US precedents, and is beyond the scope of this report.

A handful of the vulnerable historic sites including, China Camp State Park's Shrimp Shed, Marinship's Bay Model Visitor Center and Hamilton Army Air Field Fire House museum collections are open to the public. National Park Service's 2016 *Cultural Resources Climate Change Strategy* compiles possible types of impacts to museum collections from increased flooding, inundation, increased storm surge, shoreline erosion and more, and consequently, the collections could face increased rusting, corrosion, rot, mold, mildew, infestation, swelling, direct damage, or destruction.[138]

To date, Marin County's Architectural Commission has identified only one historic structure,[139] though it is outside the study area for this assessment.

Archaeological Sites

The State of California recognizes 630 archaeological sites in Marin County including, permanent Miwok settlements, seasonal camps, hunting camps/special use sites, and petroglyphs. The Anthropological Studies Center at Sonoma State University is inventorying additional sites in anticipation of sea level rise and erosion. The blue lines depicted in Map 43 represent sixty-nine miles of surveyed public lands, and eight miles that are partially surveyed. Much of the southern Marin shoreline is not applicable for the survey, as depicted in red. The marshlands in Corte Madera and Larkspur, China Camp State Park, and St. Vincent's spanning up to Bel Marin Keys could feature archeological sites.

[132] National Park Service website. Last updated July 22, 2016. www.nps.gov/acad/learn/management/rm_culturalresources.htm

[133] National Trust for Historic Preservation. 2011. The Greenest Building: Quantifying the Environmental Value of Building Reuse.

[134] Stephenson, V. and D'Ayala, D. A New Approach to Flood Vulnerability Assessment for Historic Buildings in England (2014), 1036.

[135] ibid

[136] ibid

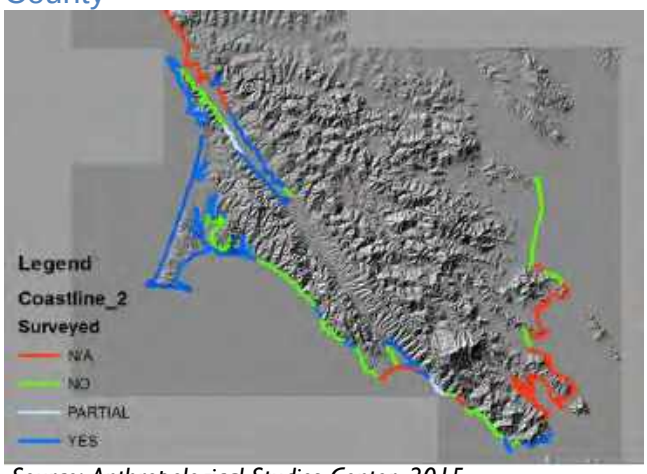
[137] ibid

[138] ibid, 22-23

[139] Bill Kelley and Marty Zwick (Marin County Architectural Commission), personal communications July 2016.

CULTURAL RESOURCES

Map 43. Archaeological surveying in Marin County



Source: Anthropological Studies Center, 2015

Table 46. Number of Known Vulnerable Archeological Sites

Near-term	3
Medium-term	5
Long-term	19

Source: Marin County CDA

Based on the County's limited available spatial data, 19 sites could be vulnerable spanning all of the scenarios. Most of the sites are at or near the edge of the Bay. Vulnerable sites include permanent settlements represented by shell mounds or middens associated with marshes and other locations at or near the edge of the bay where shellfish/marine resources were available. Most of the sites are subject to tidal flooding at MHHW, with an additional handful subject to temporary flooding from seasonal storm surges. In addition to total submersion, sites could be vulnerable from direct physical flood damage, destruction/loss of artifacts, post-flood subsidence, changes in pH, disturbance during flood clean-up, and more.[140] Specific locations of archaeological sites are confidential.

Sites located along sheltered bays may be protected from destructive storm surges; however, once a site becomes submerged, data recovery through "wet site archeology" becomes more difficult, dangerous, and costly.[141] Therefore, it is important to conduct cultural resource surveys prior to inundation to document what will be lost.[142] At this time, without certified and dedicated staff or financial resources, Marin County's capability to conduct a comprehensive vulnerability assessment of archaeological sites is limited.

Fort Baker

National Register of Historic Places

Vulnerable Resources: Marine Hoist and Dock, Refueling Dock and Marine Railway

Scenarios: All

Flood Depths: 0-7'10''+100-year storm surge

Primary Building Materials: Concrete, Wood, Steel

Fort Baker was acquired by the Federal Government in 1866 and served as an Army Post until the mid-1990s when it became part of the Golden Gate National Recreation Area. Two structures, the Marine Hoist and the Refueling Dock and Marine Railway (replacement value of $2,142,003[143]) the low lying area looking out to Horseshoe Bay could be vulnerable to flood depths of more than 4 feet in the near-term and nearly 8 feet with storm surge waters in the long-term.

Horseshoe Cove and Fort Baker (circa 1950s) Credit: Golden Gate National Recreation Area Park and Archives Record Center

[140] Rockman, Marcy, Marissa Morgan, Sonya Ziaja, George Hambrecht, Alison Meadow. 2016. *Cultural Resources Climate Change Strategy.* Cultural Resources, Partnerships, and Science and Climate Change Response Program, National Park Service, 22-23

[141] ibid, pg. 69.
[142] ibid, pg. 70
[143] 2016 dollars

In the long-term flooding could impact Bridgeway and Downtown Historic District buildings lining its west side. Credit: Marin County CDA

Sausalito
National Register of Historic Places (Downtown Historic District)
National Park Service Certified Historic District
City of Sausalito Historic Resources Inventory Listing
Vulnerable Resources: 26 National register district contributing sites, 17 noteworthy structures, 2 landmark buildings
Scenarios: All
Flood Depths: 09'04''+100-year storm surge
Primary Building Materials: Wood, concrete, brick, stucco, concrete

Prior to development of the Golden Gate Bridge, Sausalito was an important hub for rail, car, and ferry traffic. During World War II, the city developed rapidly as a shipbuilding center. The Downtown Historic District centers on a ferry terminal with service to San Francisco, and remains an important area for commerce, and as a popular visitor destination. The district is a National Park Service Certified Historic District.[144]

Sea level rise is projected to inundate parts of Sausalito's Downtown Historic District in the near-term, with storms expanding the vulnerable area and exacerbating impacts. By long-term scenario 6, 26 sites could be vulnerable.

Both water and land routes to Sausalito's Downtown Historic District could be vulnerable in the near-term. GGF's Sausalito Ferry could experience inundation at MHHW in the near-term. In the long-term, parts of Bridgeway could be tidally flooded, and impacts will worsen with storms.

In other parts of Sausalito, a handful of private properties on the city's Historic Resources Inventory could also be vulnerable at varying scenarios. Sausalito's Ark Row District includes seven noteworthy properties, vulnerable to more than six feet of water at MHHW in the near-term, and more than nine feet of water at MHHW in the long-term. An additional ten other properties could be vulnerable in the long-term, including the original firehouse (eight of the ten only subject to storm surges). Lastly, two of Sausalito's landmark buildings, Castle by the Sea and the Ice House, could be vulnerable to a 100-year storm surge in the long-term.

Marinship, Sausalito
Potential National/State Register Sites
Vulnerable Resources: 10 potential historic resources
Scenarios: All
Flood Depths: 2'1'' - 2'8''+100-year storm surge; flood depth data limited
Primary Building Materials: Concrete, wood, stucco, steel

The former Marinship yard, an approximately 210-acre site, was one of six Emergency Shipyards in the San Francisco Bay Area established during World War II. Marinship was built on bay fill, and some areas, such as Heath Way, have experienced approximately five feet of subsidence since 1943 based on photographic records.[145] In 2010, the Marinship Historic Context Statement inventoried and recorded every major World War II era building and structure. The effort concluded:

- Marinship retains a higher degree of architectural integrity then any of the other Bay Area World War II emergency shipyards,
- Eight surviving buildings could form a California Register eligible district in the southernmost portion of the district,
- Two sites are individually eligible for the National Register of Historic Place, and
- Four sites are individually eligible for the California Register of Historic Places.

Since the report was released, the WWII machine shop has received National Historic Landmark

[144] Office of Historic Places, accessed July 14, 2016. http://ohp.parks.ca.gov/?page_id=27283

[145] Robin Petravic (Heath Ceramics), personal communications. July 2016.

designation. The site is slated for renovation and repair. The remaining sites can be considered potential historic resources.

In the near term, shipways that are part of Building 23, the Marinship Shipways and Offices, could be vulnerable to 10 inches of sea level rise. In the long-term, two buildings, the Marinship Maintenance Garage and the Marinship Mold Loft and Yard Office, could be vulnerable to tidal flooding at depths deeper than two feet. Both buildings were erected in 1942 with cinderblock construction and could be vulnerable to standing water. Recently added to the National Register for historic places, the machine shop is also vulnerable and will be undergoing renovations.

Seven other properties could be vulnerable to the 100-year storm surge in long-term scenario 6 including Building 29 and Marinship Warehouse. This building serves as the Bay Model Visitors Center, and houses the US Army Corps of Engineers Bay Model, a working hydraulic scale model of the SF Bay-Delta completed in 1957.[146]

Belvedere
Historic Resource Inventory database and local register
Vulnerable resources: *1 California Register of Historic Places site, 4 additional locally registered historic sites*
Scenarios: All
Flood Depths: 6''- 3'2'' + 100-year storm surge
Primary Building Materials: Wood

Gate 5 Road in Marinship. Jan. 2004. Credit: R. Petrav

[146] US Army Corps of Engineers Bay Model. Last updated August 18, 2016. en.wikipedia.org/wiki/US_Army_Corps_of_Engineers_Bay_Model

Originally a fishing community, Belvedere was settled in the late 19th century and incorporated in 1896.[147] Vulnerable historic resources in Belvedere include:

- Properties on Beach Road, along the northwest edge of Belvedere Cove are vulnerable in the near term. Some of these properties were designed by well-known architect Albert Farr including, the Farr cottages/Farr apartments and the Belvedere Land Company. The China Cabin is also located here. This saloon was once housed by the S.S. China, built in 1866 to carry passengers from San Francisco to Asia.[148]
- The Belvedere Presbyterian Church/City Hall/Community Center.

The 1905 Belvedere Land Company building, designed by Albert Far.[149]

[147] Belvedere, CA. Last updated January 9, 2017. en.wikipedia.org/wiki/Belvedere,_California
[148] Belvedere-Tiburon Landmarks Society, China Cabin. Accessed January 18, 2017. landmarkssociety.com/landmarks/china-cabin/
[149] Albert L. Farr. Last updated October 10, 2016. en.wikipedia.org/wiki/Albert_L._Farr

Tiburon

Local Historic Inventory for Downtown Tiburon/List of Buildings Included and Eligible for California State Historic Building Code
National Register of Historic Places (Peter Donahue Building)
Vulnerable Resources: 21 buildings
Scenarios: All
Flood Depths: 1'4'' - 8'6''+100-year storm surge
Primary Building Materials: Wood

Vulnerable historic sites include more than 20 buildings along upper and lower Main Street. Built in the 1920s, original uses included saloons, apartments, a bank, hotel, grocery store, and butcher. Then and now, commercial uses provide commuters and visitors using the Tiburon Ferry Terminal with shops and restaurants. Several lower Main Street sites could be subject to tidal inundation in the near-term. Upper Main Street sites are subject to storm surge flooding in the long-term.

Just beyond downtown, the wood framed San Francisco and North Pacific Railroad Station House-Depot, or the Peter Donahue Building could be vulnerable to the 100-year storm surge. The building is listed on the National Register of Historic Places as the old station house at the ferry railroad terminus[150] and is the only surviving dual use terminal west of the Hudson River. The building now houses the Tiburon Railroad and Ferry Depot Museums. On the bottom floor is scale model of Tiburon circa 1900-1910.

Road access would be drastically compromised including permanent flooding of Main Street and Tiburon Blvd., the main thoroughfare connecting Tiburon with Highway 101. Water access would also be compromised, as the Tiburon Ferry buildings, land, and docks could be flooded in the near-term.

Tiburon once served as the southern terminus of the Northwestern Pacific Railroad. Credit: Photographer on San Francisco and North Pacific Railroad Station House-Depot National Register of Historic Places Nomination Form

Tiburon's Main Street commercial buildings date back to the early 1900s, and are adjacent to the ferry terminal. Credit: Marin County CDA

Angel Island

California State Landmark
National Register of Historic Places (Immigration Station)
Vulnerable Resources: Ferry terminal (access, non-historic)
Scenarios: All
Flood Depths: 0- 6'9''+100-year storm surge

Historically, Angel Island was best known for its immigration station, sometimes referred to as the "Ellis Island of the West." From 1910-1940, hundreds of thousands of immigrants, often from China and Japan, were detained on the island,

[150] Arnett, Victoria Mason. 1994. National Register of Historic Places Form - San Francisco and North Pacific Railroad Station House/Depot.

sometimes for months as part of immigration control. Now, the island is a popular destination with a variety of outdoor recreational activities and interpretation throughout its historical buildings.

Angel Island's historic structures are generally at higher elevations and therefore not vulnerable to sea level rise. However, the Angel Island ferry is vulnerable in the near-term, with flood depths increasing in the medium- and long-term scenarios. If the ferry terminal floods it could cause a reduction or loss in important tourism revenue needed to sustain the historic buildings.

Larkspur
Larkspur Historic Resources Inventory
Vulnerable Resources: 6 homes
Scenarios: All
Flood Depths: 1'1'' - 6'8''+100-year storm surge
Primary Building Materials: Wood

Six vulnerable historic homes lie along Boardwalk One, the only remaining boardwalk of four with arks, or small canal homes, accessed by boardwalks above the marshland.

San Rafael
San Rafael Historical/Architectural Survey & Historic Properties List
Vulnerable Resources: 1 Landmark, 1 District, at minimum 2 potentially historic areas, at minimum 4 potentially historic buildings
Scenarios: 2, 3, 4, 5, 6
Flood Depths: *0 to 6'+100-year storm surge*
Primary Building Materials: Wood, Brick

San Rafael's exposed historic resources could be vulnerable to both tidal flooding and 100-year storm surge flooding from San Rafael Creek, generally in close proximity to US Highway 101. Resources include the Litchfield Sign (local landmark), the French Quarter, two potentially historic areas, Ritter Street and Gerstle Park (partial), and four potentially historic structures.

China Camp State Park
National Register of Historic Places
Vulnerable Resources: Shrimp Shed and 305' Pier
Scenarios: All
Flood Depths: 0-10'0''+100-year storm surge
Primary Building Materials: Wood
Historic American Landscape Survey: *Underway*

China Camp was once home to Miwok Indians. The site contains a shellmound from their settlements here. This site is also the only remaining historic Chinese-American shrimp village in the Bay Area. In the late 1800's, China Camp housed around 500 residents, many from Canton, who made a living in shrimp harvesting. Several of the historic structures are intact and a seventy-five acre district encompassing them was added to the National Register of Historic Places in 1979. Finally, a Historic American Landscape Survey is underway to document the site's historic resources.[151]

Larkspur's Boardwalk #1 with canal homes accessed via boardwalks. Credit: Marin County CDA

San Rafael's French Quarter Historic District. Credit: Marin County CDA

[151] Patillo, C. *China Camp HALS*. Last updated July 1, 2012. http://halsca.blogspot.com/2012/07/china-camp-hals.html

Vulnerable structures at China Camp include the wood-framed shrimp shed and 305 foot pier along its waterfront. Flood depths could reach up to 10 feet of tidal water potentially drowning the pier and damaging both resources. The Shrimp Shed currently serves a visitor center with interpretive panels and artifacts educating the public on the early immigrant history, traditional fishing practices and more. These historic artifacts could also be damaged as the building is flooded. Erosion could further exacerbate impacts to the site, damaging cultural landscape features such as the beach itself. Furthermore, North San Pedro Road Camp floods at king tides, compromising public and maintenance access. This would worsen with higher sea levels.

China Camp drying grounds. 1889. Credit: Wikipedia.

King Tide floods N. San Pedro Road in China Camp. Nov. 2015. Credit: Marin County CDA

Hamilton Army Air Field
National Register of Historic Places
Vulnerable Resources: 8 buildings, 1 structure, 1 object
Scenarios: 5, 6
Flood Depths: 2'5''-10'4''+100-year storm surge
Primary Building Materials: *Concrete, Stucco*
Historic American Building Survey: *CA-2398*

In the 1930's, the 1,779 acre Hamilton Army Air Field was constructed as headquarters for the First Wing of the Air Force, one of only three such bases in the nation.[152] The site was transferred to the US Navy, Army, and Coast Guard in 1974, and is now part of Novato. The National Register of Historic Places Registration Form identifies 3 areas of the historic district.[153] Of the three areas, Area C could be subject to average higher high tide flood depths of 2'5'' to 10'4'' by long-term scenario 5. All ten of its resources could flood, including:

- Double hangars- 3 identical H-shaped buildings with a central shop and hangars on either end,
- Air Corps shops and hangar #9: Identical exterior to other hangar buildings, with half of its interior designed as a shop,
- Flagpole- 75 foot metal flagpole with historic plaque,
- Headquarters building- T-shaped with central two-story section and one-story wings,
- Non-Commissioned Officers' Barracks- 3 H-shaped 3-story buildings, and
- Electrical transformer vault.

Additionally, the Hamilton Field History Museum housed in the historic 1934 firehouse directly adjacent to Area C is also exposed by long-term scenario 5. The museum opened in 2010 to collect, preserve, exhibit, and interpret Hamilton field and Hamilton air force base history.

Table 47 highlights the vulnerable cultural resource assets and ranks them by onset and flood depth at MHHW. In addition to these sites, a few others could be vulnerable under long-term scenario 6 sea level rise conditions with a 100-year storm surge. These are:

[152] Maniery, M.L., and C.L. Baker. 1998. National Register of Historic Places Registration Form – Hamilton army Air Field Discontiguous Historic District.
[153] Ibid.

- Sausalito, two landmark buildings,
- Belvedere Presbyterian Church/Belvedere City Hall/Community Center, and
- Tiburon Railroad Station House-Depot.

Hamilton Field's Headquarters now serves as the Novato Arts Center. Credit: Marin County CDA

CULTURAL RESOURCES

Table 47. Vulnerable Cultural Resource Assets Ranked by Onset and Flooding at MHHW

Location	Asset	Near-term	Medium-term	Long-term
		Scenario 1	Scenario 3	Scenario 5
Confidential locations	Archaeological sites	3 sites	5 sites	14 sites @ 1'11''-10'8''
Belvedere	Four Waterfront Properties along Beach Road	6''	1'3''	3'0''–3'2''
Sausalito	Ark Row District	3'6''-6'2''	3'1''-6'10''	6'1''-9'5''
Tiburon	Main Street	2 buildings @ 7'3''-7'4'	6 buildings @ 6'8''-7'11''	11 buildings @ 1'4''-8'6''
Pt. San Pedro	China Camp Historic District*	0-7'3''	0-7'8''	0-10'0''
Larkspur	Boardwalk One	1'1''-3'1''	1'10''-3'10''	4'7''-6'8''
Fort Baker*	National Recreation Area	0-4'5''	0'-5'2''	0-7'10''
Angel Island	Angel Island* Ferry Terminal	0-'3''	0-11''	0-6'9''
Sausalito	Downtown Historic District*	4 sites	4 sites	4 sites @ 0-9'4'' (22 sites w/ storm surge)
San Rafael	The Litchfield Sign	w/ storm surge	3'3''	6'0''
San Rafael	The French Quarter District			2'2''-2'4''
San Rafael	2 potentially historic areas and at minimum 4 additional potentially historic structures			0-2'11''
Sausalito	Noteworthy structures outside the Downtown Historic District			2 sites @ 1'4''-6'1'' (8 sites w/ storm surge)
Sausalito	Marinship potential resources	1 resource		2 resources @ 2'1''-2'8'' (7 resources w/ storm surge)
Novato	Hamilton Army Air Field* Area C			2'5''-0'4''

**indicates listing on National Register of Historic Places*

Source: MarinMap; CoSMoS, Marin County CDA; City of Sausalito, Historic Resource Inventory Listing, Marinship Historic Context Statement; Local Historic Inventory for Downtown Tiburon; China Camp National Register of Historic Places Inventory – Nomination Form; Update of the Historic Resources Inventory (Larkspur); Fort baker, Barry and Cronkhite National Register of Historic Places Inventory – Nomination Form; Sausalito Historic District National Register of Historic Places Inventory – Nomination Form; City of Sausalito, Historic Resource Inventory Listing; Historic Properties List (San Rafael); San Rafael Historical/Architectural Survey; Marinship Historic Context Statement; National Register of Historic Places Registration Form – Hamilton Army Air Field Discontiguous Historic District; City of Belvedere General Plan Update – Cultural Resources.

Other Considerations

Economic

Historic preservation has proven to be an effective tool for small business sustainability, community development, renewal, and revitalization, heritage tourism development, and more.[154] Several of Marin's vulnerable historical areas house important local businesses. Loss or deterioration of these resources could have negative economic impacts. Additionally, Marin's historic sites contribute to the county's unique charm and character, adding to the appeal for tourism, and visitor spending, sales tax, and transient occupancy tax. In some cases, historic sites adjacent to the Bay may serve as shoreline armoring or buffer storm impacts helping to protect lands and properties inland, thus helping to prolong their continued economic use.

Environmental

In addition to providing valuable information on cultural history, archaeological resources can be important information sources on natural history. Through analysis of elements such as pollen, seeds, shells, and bones, archaeological data can reveal the plants and animals that thrived during past climactic periods (e.g., the mid Holocene) with land and water temperatures comparable to potential future conditions with climate changes, including secondary impacts, such as, increased ocean acidification.[155] Such data could be applied for future ecosystem restoration and management plans.

In addition to allowing communities to remain intact, continued use of older buildings has environmental benefits. Retrofitting existing buildings through elevation and flood proofing can extend their lives in the face of SLR and increased storms, thus avoiding the immediate need for new construction. Building reuse is almost always less environmentally taxing then new construction, and it can take 10 to 80 years for a new building that is 30% more energy efficient than an average performing existing building to overcome negative climate impacts from construction.[156]

[154] Rypkema, Donovan D., 2005. The Economics of Preservation: A Community Leader's Guide.

[155] Newland, Michael (Sonoma State Anthropological Studies Center). 2015. Personal Communications

[156] National Trust for Historic Preservation. 2011. The Greenest Building: Quantifying the Environmental Value of Building Reuse.

Social Equity

In addition to losing valuable historic information about the region, the loss of archaeological sites can have significant sense of place impacts, particularly for Native American's who consider the sites sacred, While documenting the sites can help preserve some of the valuable historical information, the loss of these irreplaceable resources could represent an unprecedented loss to history and culture with no established processes to mitigate their disappearance.

Social equity is important in the field of historic preservation. Both China Camp and Angel Island hold stories of historically marginalized Asian immigrants. Preservation of these irreplaceable sites is important to ensure they remain in the collective memory and contribute to a more inclusive understanding of local and national history.

Several of the public historic sites offer educational experiences that can be enjoyed by many people regardless of socioeconomic circumstances and age. China Camp, the San Francisco Bay Model, and Fort Baker can all be accessed for relatively low costs adding to their appeal for families with children. These costs could increase if the sites have to undergo improvements to prevent or recover from flooding.

Management

The loss of archaeological sites can present management challenges including the need for increased documentation and protection of sites, particularly those of high intrinsic value. Close coordination with Native American groups will be critical to ensure that adaptation strategies protect vulnerable archaeological sites.

Little guidance exists to inform the challenge of adapting historic sites in the face of sea level rise. Elevation may be structurally feasible, but could have negative integrity impacts. Levees and seawalls could have negative impacts to the cultural landscape. Relocation could remove sites from the historic districts or contexts. Such strategies may therefore not be allowed under current local design review guidelines.

Section 106 of the National Historic Preservation Act of 1966 requires federal agencies to take into account project impacts on historic properties. This includes projects located on federal properties or using federal funding. Under Section 106, any

alterations would need to be consistent with the Secretary of the Interior's Standards for the Treatment of Historic Properties. Adaptation strategies that have negative impacts on historic integrity, introduce incompatible elements, change the use or setting, or relocate landward are amongst the types of projects that would likely be deemed adverse effects.[157] Neglect and deterioration can also be adverse effects[158] that merit consideration as sea level rise and increased storms could exacerbate the deterioration of historic properties if not properly managed for.

[157] Advisory Council on Historic Preservation. 2015. Protecting Historic Properties: A Citizen's Guide to Section 106 Review.
[158] Ibid.

CULTURAL RESOURCES

Map 44: Northern Study Area Vulnerable Cultural Resource Assets

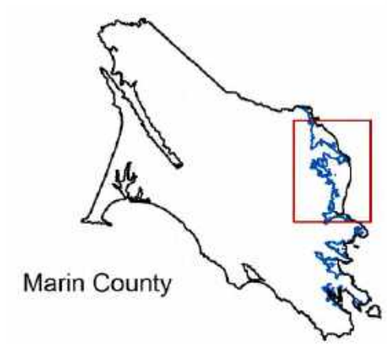
Vulnerable Historic Buildings

- Scen. 1: 10" Sea Level Rise (SLR)
- Scen. 2: 10" SLR+Storm Surge
- Scen. 3: 20" Sea Level Rise
- Scen. 4: 20" SLR+Storm Surge
- Scen. 5: 60" Sea Level Rise
- Scen. 6: 60" SLR+Storm Surge

Location Indicators

- Municipality
- Major Road
- Inland Extent: Sea Level @ 60"+100-year Storm

Archaeological resources may be present. Source: MarinMap; CoSMoS, Marin County CDA; China Camp National Register of Historic Places Inventory – Nomination Form; National Register of Historic Places Registration Form – Hamilton Army Air Field Discontiguous Historic District;



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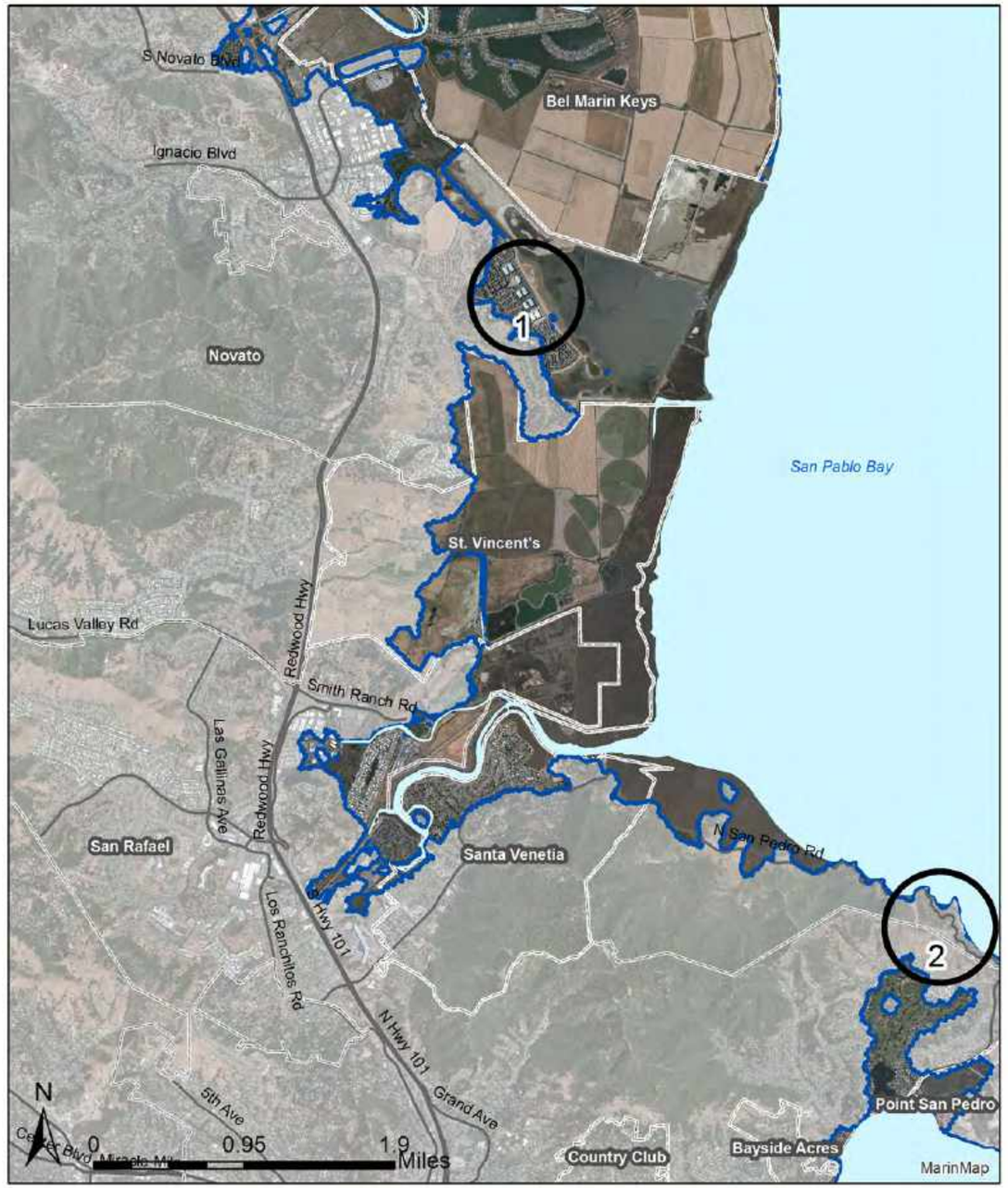


1: Hamilton Army Air Field

2: China Camp State Park

Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data providers here in, make no warranties of the accuracy or completeness of maps and data. Maps are representational and subject to future revision. Local site conditions must be examined. Commercial use is prohibited.

CULTURAL RESOURCES

Map 45: Southern Study Area Vulnerable Cultural Resource Asset

Vulnerable Historic Buildings

- Scen. 1: 10" Sea Level Rise (SLR)
- Scen. 2: 10" SLR+Storm Surge
- Scen. 3: 20" Sea Level Rise
- Scen. 4: 20" SLR+Storm Surge
- Scen. 5: 60" Sea Level Rise
- Scen. 6: 60" SLR+Storm Surge

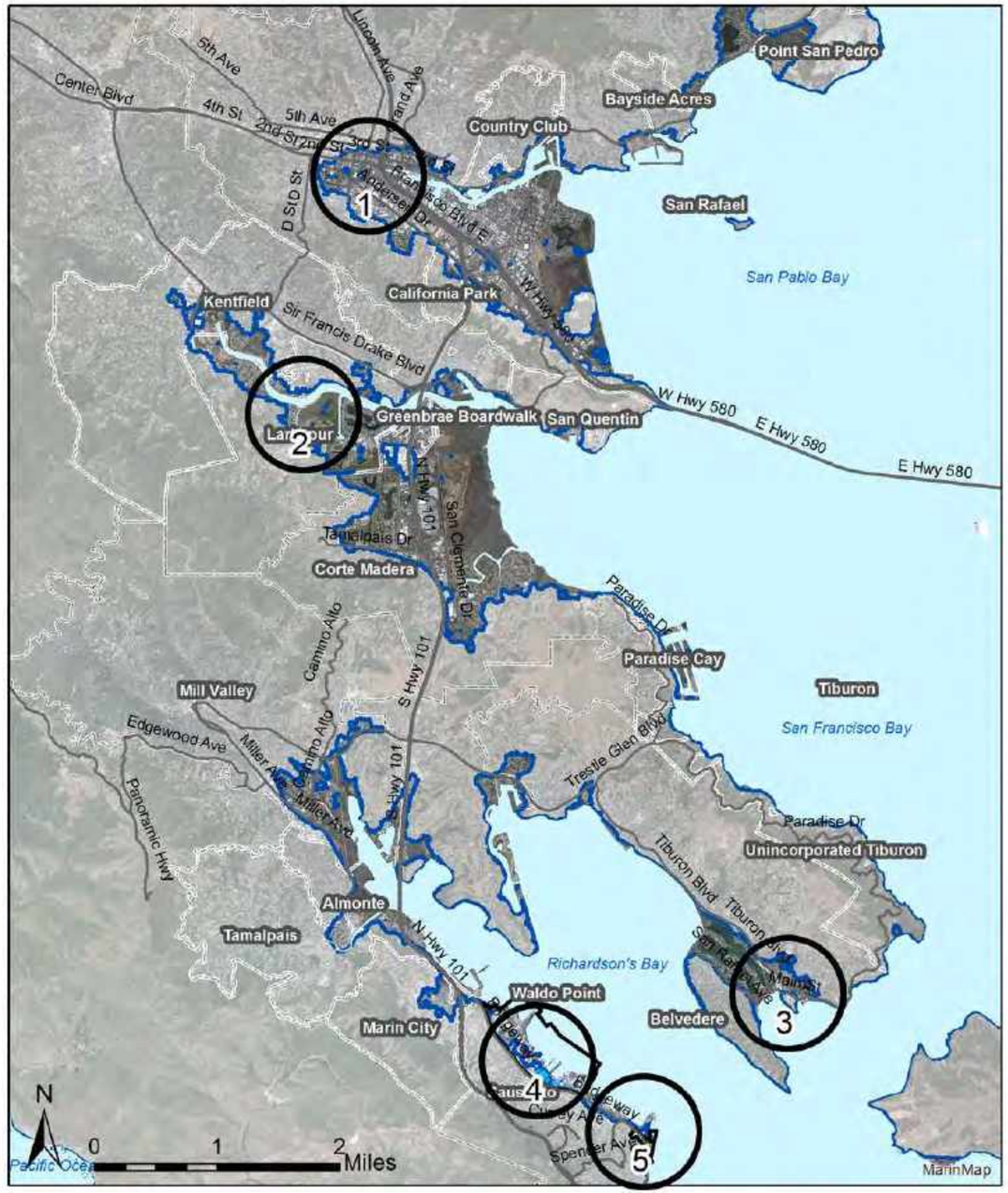
Location Indicators

- Municipality
- Major Road
- Inland Extent: Sea Level @ 60"+100-year Storm

Archaeological resources may be present.

Source: MarinMap; CoSMoS, Marin County CDA; City of Sausalito, Historic Resource Inventory Listing, Marinship Historic Context Statement; Local Historic Inventory for Downtown Tiburon; Update of the Historic Resources Inventory (Larkspur); Sausalito Historic District National Register of Historic Places Inventory – Nomination Form; City of Sausalito, Historic Resource Inventory Listing; Historic Properties List (San Rafael); San Rafael Historical/Architectural Survey; Marinship Historic Context Statement; City of Belvedere General Plan Update – Cultural Resources

Date: 2/17/2017



1: San Rafael

2: Larkspur

3: Tiburon-Belvedere

4: Marinship

5: Sausalito Downtown Historic District

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BayWAVE COMMUNITY PROFILES

SAUSALITO

Municipality Profile: Sausalito

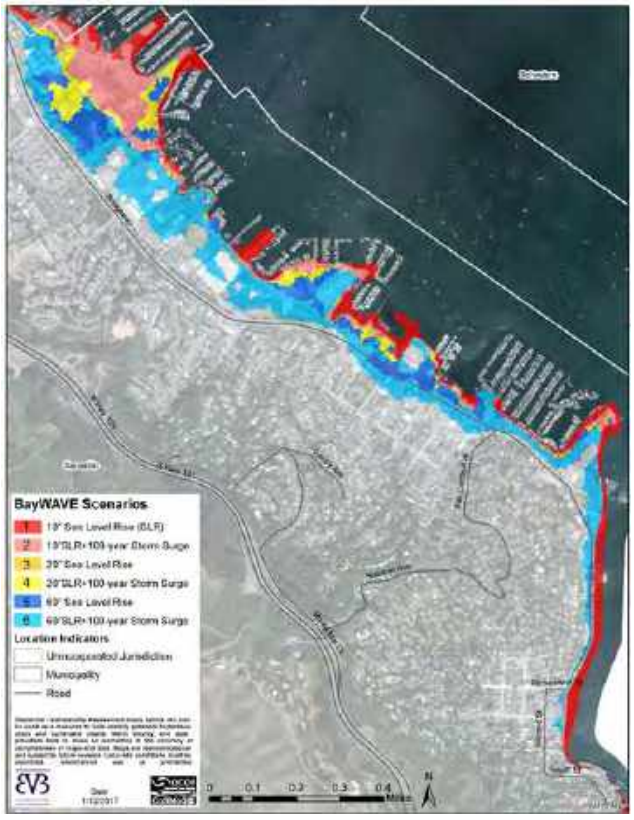
Sausalito, the southernmost community on the Marin shoreline, is situated just across the Golden Gate Bridge from San Francisco, along Richardson's Bay. In the near-term, twenty-six acres could be exposed to sea level rise. In the long-term, 84 acres could be exposed to sea level rise; and150 acres could be exposed with an additional 100-year storm surge. The following assets in the low lying areas primarily east of Bridgeway may be vulnerable to storm surges and sea level rise:

- Northerly access to Sausalito could be blocked in the Waldo Point community. Shifting highway access to the narrow windy hillside roads.
- The Marinship area in northern Sausalito is built on fill and is vulnerable to subsidence and flooding. This is the primary employment area.
- Shoreline homes in Old Town could be impacted by erosion, storm surges, and high tides.
- Bridgeway leading to Old Town is vulnerable in the long-term. The main wastewater force main leading to Sausalito Marin City Sanitary District treatment plant is under this roadway.
- Swede's and Tiffany beaches, and all other shoreline parks, could be vulnerable in the near-term.
- The Golden Gate Ferry's Sausalito Ferry landing is vulnerable in the near-term.
- The fire rescue boat in a vulnerable marina could also be impacted in times of need.
- Several shoreline restaurants, hotels, and business could be vulnerable to flooding in the near-term.
- Inflow and infiltration of tide waters into underground pipes could increasingly burden the wastewater treatment facilities.
- Several small shoreline parks and festival areas at Schoonmaker Point could flood, degrading public facilities and impeding public use.
- Several residents live in boats in marinas and unauthorized boats out in Richardson's Bay that are especially vulnerable during storms and could be vulnerable to damage at the marina's that host them.
- Tens of historic sites could be vulnerable across the BayWAVE scenarios.

IMPACTS AT-A-GLANCE: SCENARIO 6

150 acres	7,000+ people
265 living units	18 commercial parcels
3.5 miles of roads	
Extreme event impacts already occur	Property Owners City of Sausalito SMCSD Southern Marin Fire District GG's Sausalito Ferry
$400 million in assessed property value, $61,000 in single-family home market value[159]	

Map 46. Sausalito BayWAVE Scenarios



[159] 2016 dollars

SAUSALITO

Vulnerable Assets

Land

Sausalito is primarily built out and land locked by Richardson's Bay and the Marin Headlands. Most of the development is elevated on a hillside, however, the narrow strip of low-lying land near the shoreline is where most of the city's employment, tourist, cultural, bay access, and maritime assets are located.

Acres

Because of Sausalito's hilly nature, very little acreage could be flooded relative to the total area of the city, and to other communities in the study area. In near-term scenario 1, ten inches of sea level rise could flood 26 acres during average high tide several times a month. These 25 acres are dispersed along the shoreline and account for two percent of all acreage in Sausalito. An additional 100-year storm surge could double the acreage, though the added area would face temporary flooding only. In medium-term scenario 3, ten more aces and one additional percentage of the community could be exposed. With a storm surge these numbers could rise to 65 acres for five percent of the community. In long-term scenario 5, size percent of the community or 84 acres could expect tidal exposure. These and another 65 acres could face 100-year storm surge flooding as well.

Parcels

Land is divided into parcels for ownership and development purposes. Parcels are assigned land uses and tend to stay true to that designation, though many sites could feature multiple uses, such as commercial with housing included. Examining parcels can provide a window into how many land uses and human activities may be vulnerable.

The parcels that could flood tidally in the near-term are in the Marinship neighborhood, and extend all along the shoreline to Old Town Sausalito. Several of the parcels along the shoreline already extend into water by design. In the near-term 40 parcels could face tidal flooding. A 100-year storm surge at this sea level could temporarily flood another 20 or so parcels, and flood the first 40 parcels even more.

Table 48. Sausalito Exposed Acres

Scenarios		Acres	
		#	%
Near-term	1	26	2
	2	52	4
Medium-term	3	35	3
	4	65	5
Long-term	5	84	6
	6	149	11

Source: MarinMap, CoSMoS

Table 49. Sausalito Vulnerable Parcels

Scenarios		Parcels	
		#	%
Near-term	1	40	1
	2	61	2
Medium-term	3	48	1
	4	68	2
Long-term	5	88	3
	6	358	11

Source: MarinMap, CoSMoS

In the medium-term, 8 or so more parcels in Marinship and along the shoreline could flood in each scenario. In long-term scenario 5, around three percent of parcels in Sausalito could face tidal inundation, and an additional 100-year storm surge on top of five feet of sea level rise could flood an another 8 percent of Sausalito parcels. Overall, 11 percent of parcels could face storm surge flooding.

Vulnerable parcels account for nearly ten percent of all commercial parcels, though less than one percent of percent of residential parcels in the community. Note, however, a few of the marinas along the Bay allow people to live on their boats in slips. While these are not residential parcels, these are residential spaces that could be highly vulnerable during storm surges especially. Commercial buildings include a grocery store, offices, restaurants, and professional practices. Industrial operations are generally related to boating and craftsmanship.

More concerning is that Sausalito could lose 41 percent of industrial parcels to tidal flooding and an additional 20 percent to 100-year storm surge

flooding in the long-term. Twenty to 30 percent of industrial parcels could suffer 100-year storm surge impacts before this time. This, while only a few parcels is a significant contribution to the city's employment base. Note that while several places along the shoreline have armoring, they may not be adequate to hold back the potential flood waters. The only historic landfill site in Sausalito is Dunphy Park. The park could become completely covered with high tide waters at a sea level rise of 60 inches.

Buildings

The Sausalito Bayfront is highly developed with industrial and maritime oriented businesses, facilities, and residences. Buildings in the Marinship neighborhood are likely to flood as are, bay front homes on pilings in Old Town. The properties could be susceptible to undercutting from strong wave activity during storms, and from consistently higher high tides. In addition, Marinship and a few other sites along the shore were filled prior to construction and are prone to subsidence. The flooded buildings account for a small percentage of the building in the community.

In the near-term, 21 buildings could be compromised to flooding, however, a 100-year storm surge at this increased sea leave could flood nearly 115 buildings with bay water. In the medium-term scenario 3 and 4, 67, and 133 buildings respectively could experience flooding. In the long-term, five percent, or about 150 buildings could be subject of tidal flooding on a monthly basis, while an additional five percent could experience storm surge flooding. While, these numbers are relatively low compared to many communities in the study area, the Sausalito shoreline is one of the biggest destinations in the county and its loss would have significant impacts on the economy and culture of Marin County residents and visitors. In fact, several of the vulnerable buildings are part of Sausalito's Historic Downtown and are irreplaceable. To learn about these assets see the Cultural Resources Profile.

Table 53 divides potentially vulnerable buildings by the amount of water they could be flooded with at MHHW. For example, this table shows how many buildings flooded in scenario 1 could flood with one, two, or ten feet of water at the average highest high tide. A 100-year storm surge combined with these sea levels could add one to three feet of water on top of these levels.

Table 50. Sausalito Vulnerable Residential and Commercial Parcels

Land Use	Scenarios					
	1		3		5	
	Near-term		Medium-term		Long-term	
	#	%	#	%	#	%
Residential	9	0	11	0	12	0
Commercial	4	2	6	3	18	10
Industrial	3	21	8	30	41	62

Source: MarinMap, CoSMoS

Table 51. Sausalito Vulnerable Land Uses

Land Use	Scenarios					
	1		3		5	
	Near-term		Medium-term		Long-term	
	#	Ac.	#	Ac.	#	Ac.
Commercial Improved	3	0.6	5	3	16	14
Commercial Unimproved					2	0.12
Industrial Improved	2	1	5	2	24	17
Industrial Unimproved					4	1
Single-family Attached					3	0.03
Single Family Residential Improved	6	0.4	8	1	9	1
Tax Exempt	25	7	26	7	30	11

Source: MarinMap, CoSMoS

Table 52. Sausalito Vulnerable Buildings

Scenarios		Buildings	
		#	%
Near-term	**1**	21	1
	2	113	4
Medium-term	**3**	67	2
	4	133	4
Long-term	**5**	154	5
	6	299	10

Source: MarinMap, CoSMoS

In scenario 1, about ten buildings are could face three feet or shallower depths, and ten could be

vulnerable to waters over three feet, with most vulnerable to over six feet to seven feet. In the medium-term, several buildings are expected to flood with up to two feet of water, with ten more that could be flooded with three feet of water. About twice as many buildings could be vulnerable to over three feet of water than in the near-term. In the long-term, over fifty buildings could be vulnerable to less than or equal to 3 feet of water, and seventy buildings could be vulnerable to more than three feet of water. Across all of the scenarios, a small percentage of the buildings stock could face tidal flooding; however, these buildings are a significant portion of the city's commercial and industrial base.

Table 54 estimates damage costs using FEMA tagging designations for buildings and their contents. This analysis assumes every vulnerable building experiences the same level of damage under scenario 6 conditions. At minor levels of damage, up to $5 million[160] in damages could occur. If all of the buildings impacted under scenario 6 were to become unusable, over $200 million in assessed structural value could be lost.[161]

The maps on the following pages illustrate vulnerable buildings by scenario. The areas in the call out circles enable the reader the see areas that are difficult to see on the large scale map. The circles do not indicate that these areas are more vulnerable than others along the shoreline.

The Spinnaker. Sausalito. Credit: E. Snow

Table 53. Number of Sausalito Vulnerable Buildings by Flood* Level at MHHW

Flood Depth (feet)	Scenarios		
	1	3	5
	Near-term	Medium-term	Long-term
0.1-1		2	3
1.1-2	2	19	20
2.1-3	6	9	32
3.1-4	2	5	22
4.1-5		3	32
5.1-6	1	3	6
6.1-7	6	8	7
7.1- 8	2	4	3
8.1-9	2	2	5
9.1- 10		0	3
10.1+		4	9

** Flood depth data is not available for every vulnerable building. Buildings that already exist beyond mean sea level are not included.*

Source: MarinMap, CoSMoS

Table 54. Sausalito Vulnerable Buildings FEMA Hazus Storm Damage Estimates in Long-term Scenario 6

Buildings in Scenario 6	299
Yellow Tag-Minor Damage **$5,000 minimum**	$1,495,000
Orange Tag- Moderate Damage **$17,001 minimum**	$5,083,299
Red Tag-Destroyed **Assessed structural value**	$228,617,482

Source: MarinMap, CoSMoS; 2016 dollars

[160] 2016 dollars
[161] 2016 dollars

Map 47. Sausalito Vulnerable Buildings

Vulnerable Assets

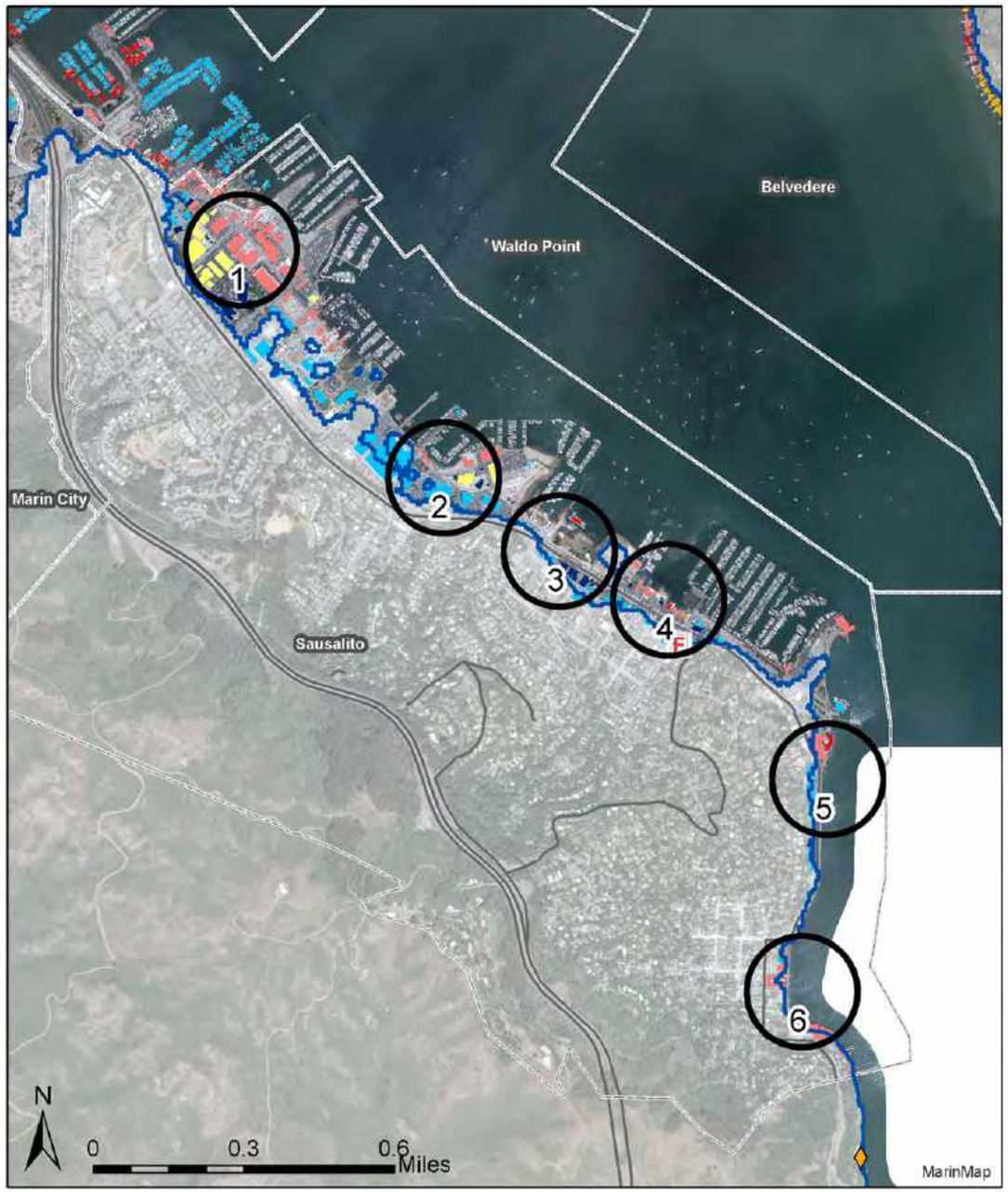
- Fire Station
- District Office

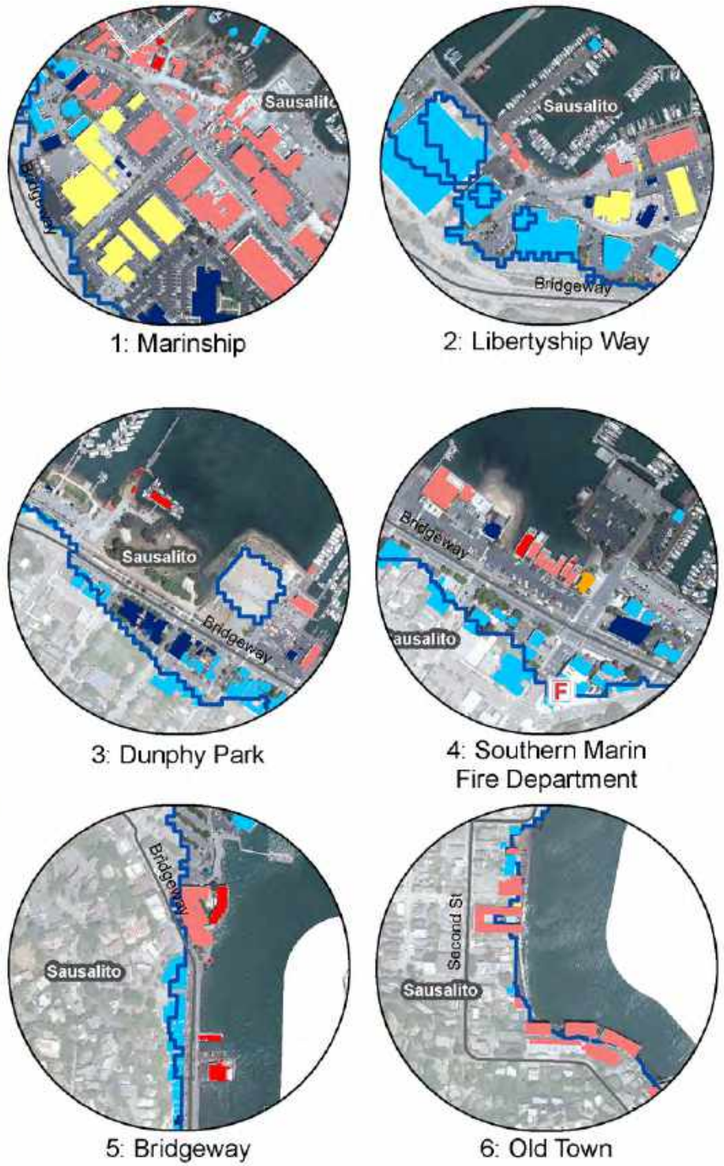
Vulnerable Buildings

- Scen. 1: 10" Sea Level Rise (SLR)
- Scen. 2: 10" SLR+Storm Surge
- Scen. 3: 20" Sea Level Rise
- Scen. 4: 20"SLR+Storm Surge
- Scen 5: 60" Sea Level Rise
- Scen. 6: 60"SLR+Storm Surge

Location Indicators

- Unincorporated
- Municipality
- Road
- Inland Extent: Sea Level @ 60"+100-year Storm





EVB CONSULTING

Date: 1/15/2017

OCOF CoSMoS

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SAUSALITO

Transportation

In near-term scenario 2, sea level rise with a 100-year storm surge, several streets in the Marinship area could flood more frequently than they already do causing reduced access to jobs and businesses there. In this time period with a 100-year storm, about one half of a mile could flood temporarily. By the medium-term, streets near Dunphy Park could become vulnerable. By this time, about 1.14 road miles could expect tidal impacts. With a 100-year storms surge coincidence, nearly one mile could experience bay surge flooding. In the long-term, Bridgeway could be vulnerable in the low lying areas downtown and along the southern shoreline. In addition, Johnson Street, where the Fire Station No. 1 is located, and Litho Street could be vulnerable. Overall, these roads miles add up to nearly one and one half of a mile. An additional two miles, and several other roads in the downtown area could be flooded by 60 inches with the 100-year storm surge.

Golden Gate Transit routes 2, 4, 10, 17, 22, 70, 80, 91, and 92 could be impeded by tidal and storm surge flooding along the vulnerable roadways. Floodwaters could reach the following stops:

- Bridgeway and Napa St.,
- Bridgeway and Pine St.,
- Bridgeway and Turney St., and
- Bridgeway and Ensign St.

In addition to roads, the Sausalito/Mill Valley Path and Bay Trail could be vulnerable to sea level rise in the Marinship and downtown areas. While these pathways could likely withstand low levels of irregular flooding, frequent flooding could prevent travel by foot, bike, or other non-motorized vehicles. This could have significant impacts on commuting and safe public access to recreational opportunities in the area.

Finally, though likely able to adjust in the near- and medium terms, several marinas, boat launches, boat slips, and other boating facilities could be flooded out during storms and eventually, tidal waters. During storms, the boats themselves could also be damaged. A significant vulnerable water transportation facility is the GGF Sausalito Ferry to and from San Francisco. The GGF Sausalito Ferry operates on a float system, and could likely withstand sea level impacts into the latter half of the century. However, the land the dock connects to and the parking lot could be flooded with deep water at MHHW in the near-term. Impacts to this facility would affect commuting and tourism. The following marine facilities are in the exposed area:

- Sausalito Shipyard and Marina, including residents,
- Cass Gidley Marina (public),
- Five Star Yacht,
- Liberty Ship Marina,
- Marina Plaza Harbor,
- Pelican Yacht Harbor,
- Bridgeway Marina,
- Sausalito Yacht Harbor, and
- Schoonmaker Point Marina.

Boats in Marina. Sausalito. Credit: City of Sausalito Photo Gallery.

Sausalito Yacht Club. Credit: E. Snow

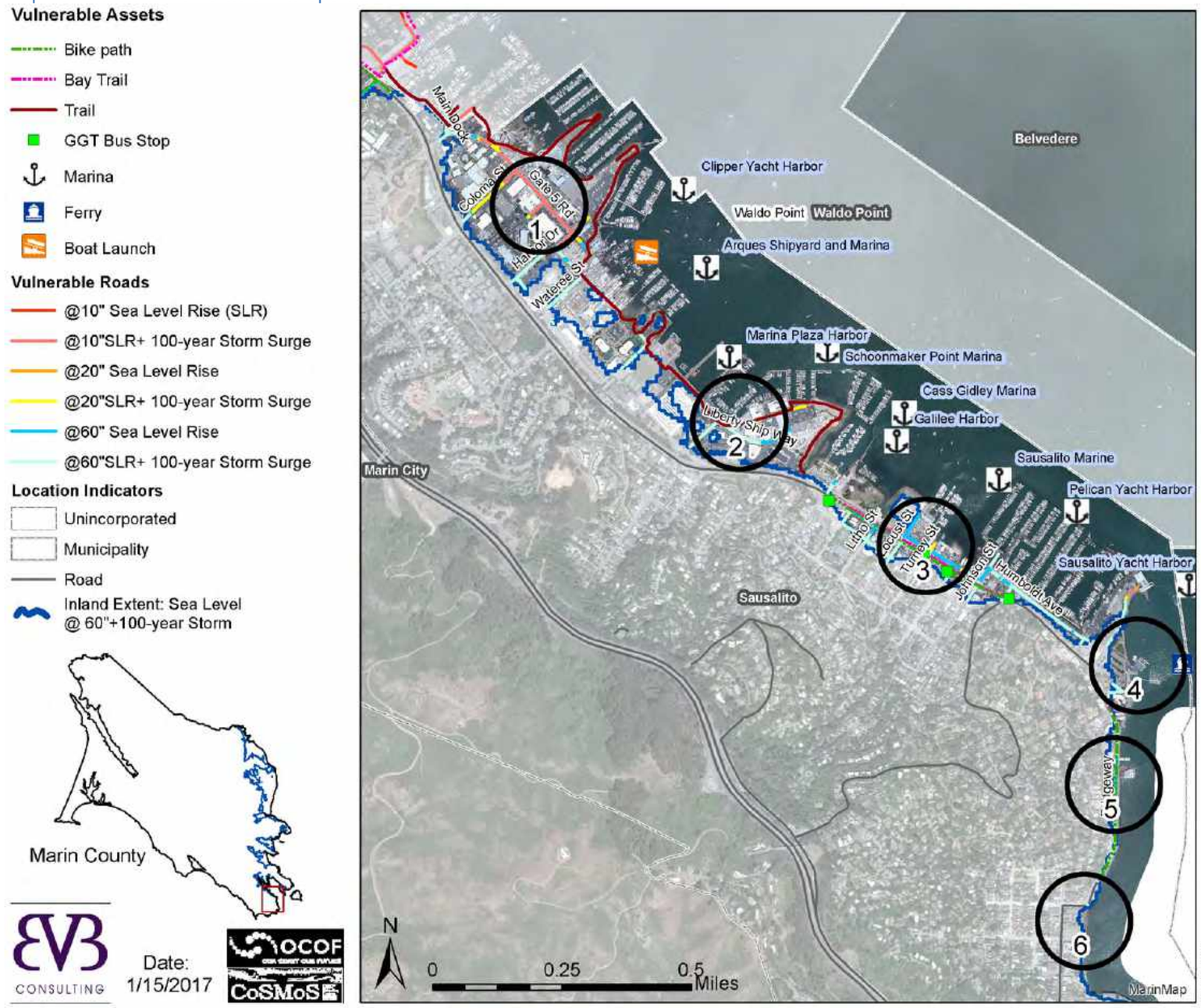
Table 55. Sausalito Transportation Routes Vulnerable to Sea Level Rise and a 100-year Storm Surge

Near -Term		Medium -Term		Long -Term	
Scenario 1	**Scenario 2**	**Scenario 3**	**Scenario 4**	**Scenario 5**	**Scenario 6**
None	**0.5 miles**	**0.14 miles**	**0.8 miles**	**1.4 miles**	**3.5 miles**
	Anchor Street [P] Coloma St [L] Gate 5 Rd [L, P] Harbor Dr [L] Heath Wy [L] Liberty Ship Wy [P] Spinnaker Dr [P] Varda Landing Rd [P]	Roads in scenario 2	Roads in scenario 2 Humboldt Ave [L, P] Turney St [L]	Roads in scenarios 1-4 Bridgeway [L] Johnson St [L] Litho St [L] Locust St [L] N Bridge Blvd [L] Napa St [L] Road 3 [P]	Roads in scenarios 1-5 Bay St [P] Bee St [L] Caledonia St [L] El Portal St [L] Ensign St [L] Marina Plaza [P] Marinship Wy [L, P] Napa St [L] Pine St [L] Princess St [L] Richardson St [L] San Carlos Ave [L] Tracy Wy [L] Wateree St [P]

M = Marin County; C = State of California; L = Local Municipality; P = Private. Source: MarinMap, CoSMoS

The maps on the following pages illustrate vulnerable transportation features. The areas in the call out circles enable the reader the see areas that are difficult to see on the large scale map. The circles do not indicate that these areas are more vulnerable than others along the shoreline.

Map 48. Sausalito Vulnerable Transportation Assets



1: Northern Marinship

2: Southern Marinship

3: Bridgeway

4: Golden Gate Ferry.

5: Bridgeway

6: Old Town

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Utilities
Individual buildings that flood could face on site electrical, potable water, stormwater, and wastewater issues. If these sites, especially those closest to the shoreline, become regularly inundated, services could be permanently cut off.

These properties could also become sources of excess water into the pump stations for flood control and the waste treatment system. This could place a burden on the equipment, chemical use, and energy conservation.

Potential Sausalito Marin City Sanitary District (SMCSD) vulnerabilities impacting all residents in Sausalito are:

- The Main Street pump station and pipeline. The pipeline collects and transports 95 percent of the effluent brought to the treatment plant and borders the shoreline under a vulnerable portion of Bridgeway.
- The Locust Street pump station could become burdened with tidal water infiltration.
- The Anchor Street pump station could become burdened.
- The pump station, 500 block of Bridgeway could become burdened, and controls across the street near the Trident Restaurant could be flooded.
- The Drake pump station could become burdened with tidal water infiltration.
- The Gate 5 Road pump stations could become increasingly burdened by tidal water infiltration and could also be vulnerable to subsidence.
- The access hatches along effluent pipes extending into Richardson's Bay could be overtopped frequently preventing employee access.
- The below grade electrical motors at the treatment plant could be flooded in the long-term at high tides with a 100-year storm surge.

In addition, Sausalito is vulnerable to issues common to all of the communities such as:

- Underground pipes face compounding pressure forces from water and the road,
- Road erosion and collapse with underlain pipes,
- Increasing saltwater inflow and infiltration causing inefficiencies in wastewater treatment,
- Continuously subsiding soils or fill, and
- Escalating activity, capacity demands, energy consumption, and wear and tear on pump stations in stormwater and wastewater systems,
- Aging individual site connections for water, sewer, and electrical, and
- Flood waters interrupting access for employees to reach work sites.

Available PG&E data did not reveal any major gas and electric assets that could be vulnerable in the study area. The same may be true for potable water infrastructure. Digitized geographic stormwater data was not available at the time of this assessment. Wastewater data is provided on Map 49.

Working Lands
Fishing habitats and facilities could be impacted. See the transportation section for a list and map of marinas and boat launches in Sausalito.

Natural Resources
Beaches are among the most vulnerable habitats, susceptible to higher tides, flooding, erosion, and sand shift.[162] Swede's and Tiffany beaches are very narrow with minimal habitat value and no opportunity to migrate landward. Beaches and rocky areas are home to many seabirds and several unique fish species swim just off shore.

A 2008 study found that Richardson's Bay supports extensive beds of eelgrass. [163]Eelgrass was observed in the open water immediately northeast of Dunphy Park and Cass Gidley Marina and within the Richardson Bay Navigation Channel.[164] Eelgrass beds are among the most productive aquatic ecosystems known. Eelgrass beds are recognized by both federal and state agencies as sensitive and essential habitat for Pacific salmon and

[162] Hutto, S.V., K.D. Higgason, J.M. Kershner, W.A. Reynier, D.S. Gregg. 2015. Climate Change Vulnerability Assessment for the North-central California Shoreline and Ocean. Marine Sanctuaries Conservation Series ONMS-15-02. US Department of Commerce, National Oceanic and Atmospheric Administration, Office of National Marine Sanctuaries, Silver Spring, MD.
[163] Merkel & Associates, Inc. May 2008. Baseline Eelgrass Study, San Francisco Bay, California. Prepared for Marin Baylands Advocates/Audubon Society, May 5, 2008
[164] These features are not mapped. Their absence does not indicate a lack of vulnerability, rather a lack of digitized data.

groundfish.[165] Eelgrass beds are much larger and closer to shore than the mapped habitats on Map 52.

The longfin smelt is the only listed species recorded in this area. The smelt is listed as threated on the California list and a candidate on the federal list. The largest longfin smelt population occurs in the San Francisco Estuary and Sacramento-San Joaquin Delta. This species occupies bay waters throughout summer and moves into lower reaches of rivers in fall to spawn. Other important fish species sensitive to changes in environmental conditions that could occur in Richardson's Bay are:

- Chinook salmon
- Delta smelt:
- Green sturgeon
- Pacific herring, and
- Steelhead.

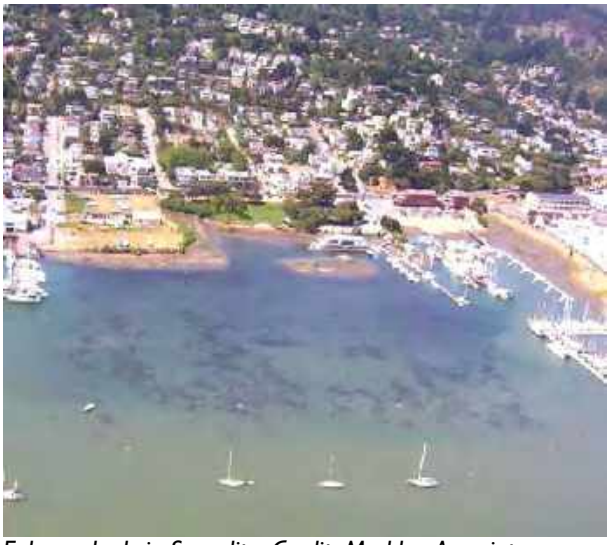
Listed bird species that could be found in or moving through the Sausalito shoreline are the Ridgway's rail and the Western snowy plover. The Ridgway's rail is one of the largest rails in North America. The Ridgway's rail is very secretive and occurs primarily in salt and brackish marshes with pickleweed and cordgrass. Richardson's Bay is known to support a small number of Ridgway's rails.[166] The Western snowy plover is a small shorebird that nests on and near the shores of the San Francisco Bay and may forage in Richardson's Bay. Other unique and valuable bird species common in the area are:

- California brown pelican,
- California least tern,
- Double-crested cormorant,
- San Francisco common yellowthroat, and
- San Pablo (Samuels) song sparrow.

Additional migratory birds are reported and some may occur within the project site on a regular basis or on occasion (e.g., Allen's hummingbird, marbled godwit, Nuttall's woodpecker, western grebe).

[165] NOAA Fisheries West Coast Region. 2014. The Importance of Eelgrass. Updated fall 2014. http://www.westcoast.fisheries.noaa.gov/stories/2014/04_11072014_eelgrass_mitigation.html. Accessed 1/18/17

[166] Wood, J., L. Salas, N. Nur, M. Elrod, J. McBroom. 2013. Distribution and population trends for the Endangered California Clapper Rail. State of the Estuary Conference, 26 October 2013, Oakland, CA.



Eelgrass beds in Sausalito. Credit: Merklen Associates

And while not listed as threatened or endangered, a unique and valuable species that travels through the San Francisco Bay is the Southern sea otter, also known as the California sea otter. These mammals are, are among the smallest of marine mammals and may live for 15-20 years in the wild. Insects, such as the Monarch butterfly, could also be vulnerable to impacts to their habitats. To learn more about these species, see the Natural Resources Profile.

Lastly, special status plants with habitats that are expected to be vulnerable to sea level rise are:

- Franciscan thistle,
- Hairless popcornflower.
- Marin western flax,
- Oregon polemonium,
- Point Reyes salty bird's-beak,
- Tiburon buckwheat,
- Tiburon paintbrush, and
- White-rayed pentachaeta.[167]

Recreation

Based on the CoSMoS model results, beaches and shoreline parks could disappear in the near to medium-terms. A few shoreline hotels, restaurants, and other guest serving facilities could also face higher tides. Turney Street Boat Ramp, the only public boat launch on Richardson's Bay, and other

[167] Prunuske Chatham, Inc. March 2016. Draft Biological Resources Assessment: Dunphy Park Improvement Project Sausalito, Marin County.

private marinas could also become compromised more frequently during high tides, especially by long-term scenario 5. Nearly all of the shoreline trails, including the Bay Trail and bicycle trails could also flood out and require increased maintenance from repeated saltwater exposure.

In the long-term flooding could impact Bridgeway and historic buildings lining its west side. Credit: Marin County CDA

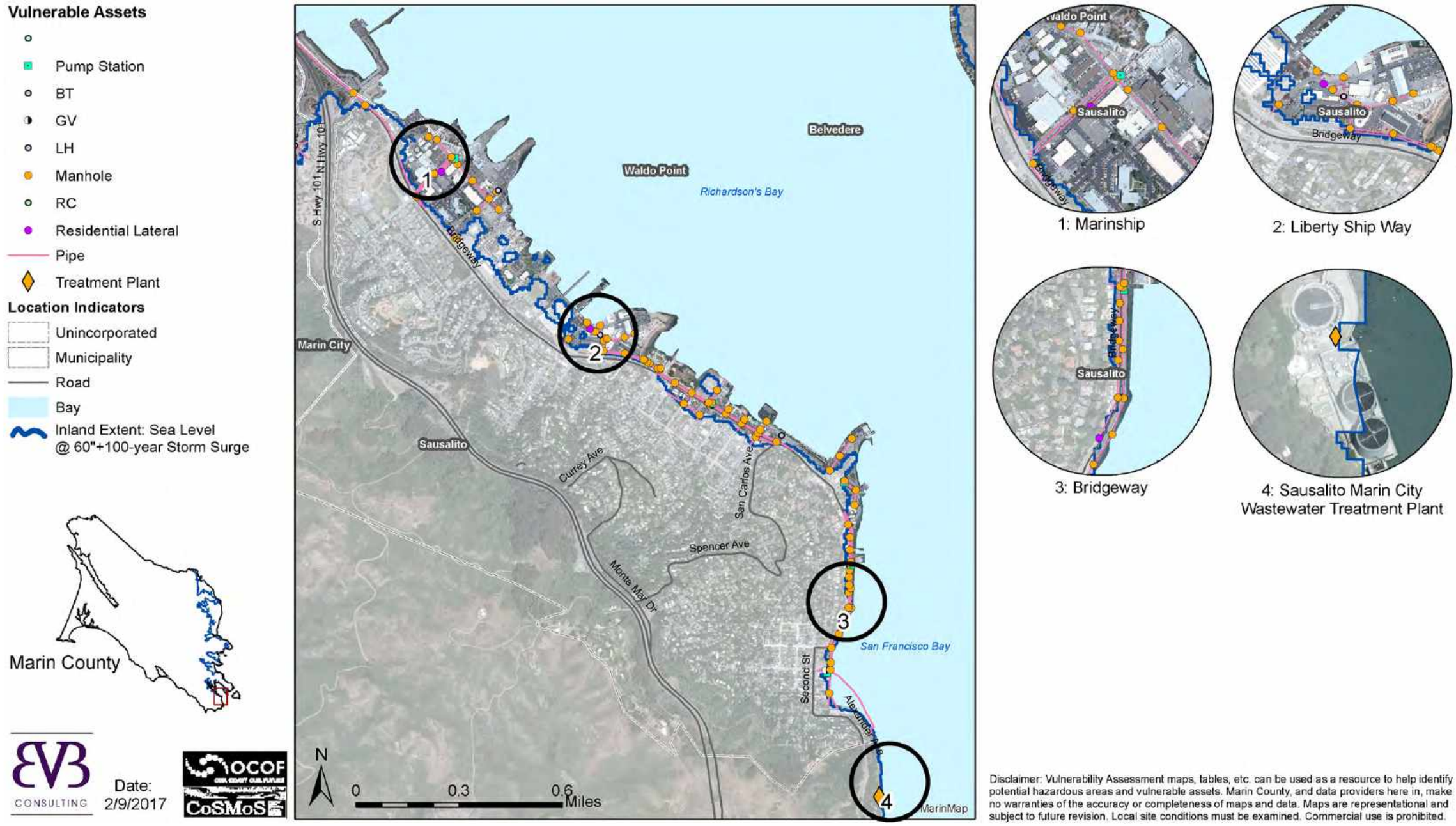
Emergency Services

Access for emergency services to the Marinship area and other shoreline areas east of Bridgeway are the primary concern for police, fire, and ambulatory services. The Southern Marin Fire Rescue boat Liberty could also be vulnerable during severe storms and impacted by disrupted marina function. This would also be true for Sausalito Police Department's two boats, Marine 1, berthed at Schoonmaker Marina, and Marine 2, berthed at the US Army Corps of Engineer's dock. Fire Station 1 and the Sausalito Police Department station could expect 100-year storm surge impacts by the end of the century, and access issues east of Bridgeway sooner. Finally, according to local asset managers, the Army Corps of Engineers facility off Bridgeway and Liberty Ship Way also serves as an emergency shelter. The large facility hosts the Bay Model Visitors Center and serves as the Navigation Branch for the M/V Raccoon and M/V John A.B. Dillard, Jr. at its dock in Sausalito.[168]

The maps on the following pages illustrate vulnerable utility, natural resource, recreation, emergency and historic features. The areas in the call out circles enable the reader the see areas that are difficult to see on the large scale map. The circles do not indicate that these areas are more vulnerable than others along the shoreline.

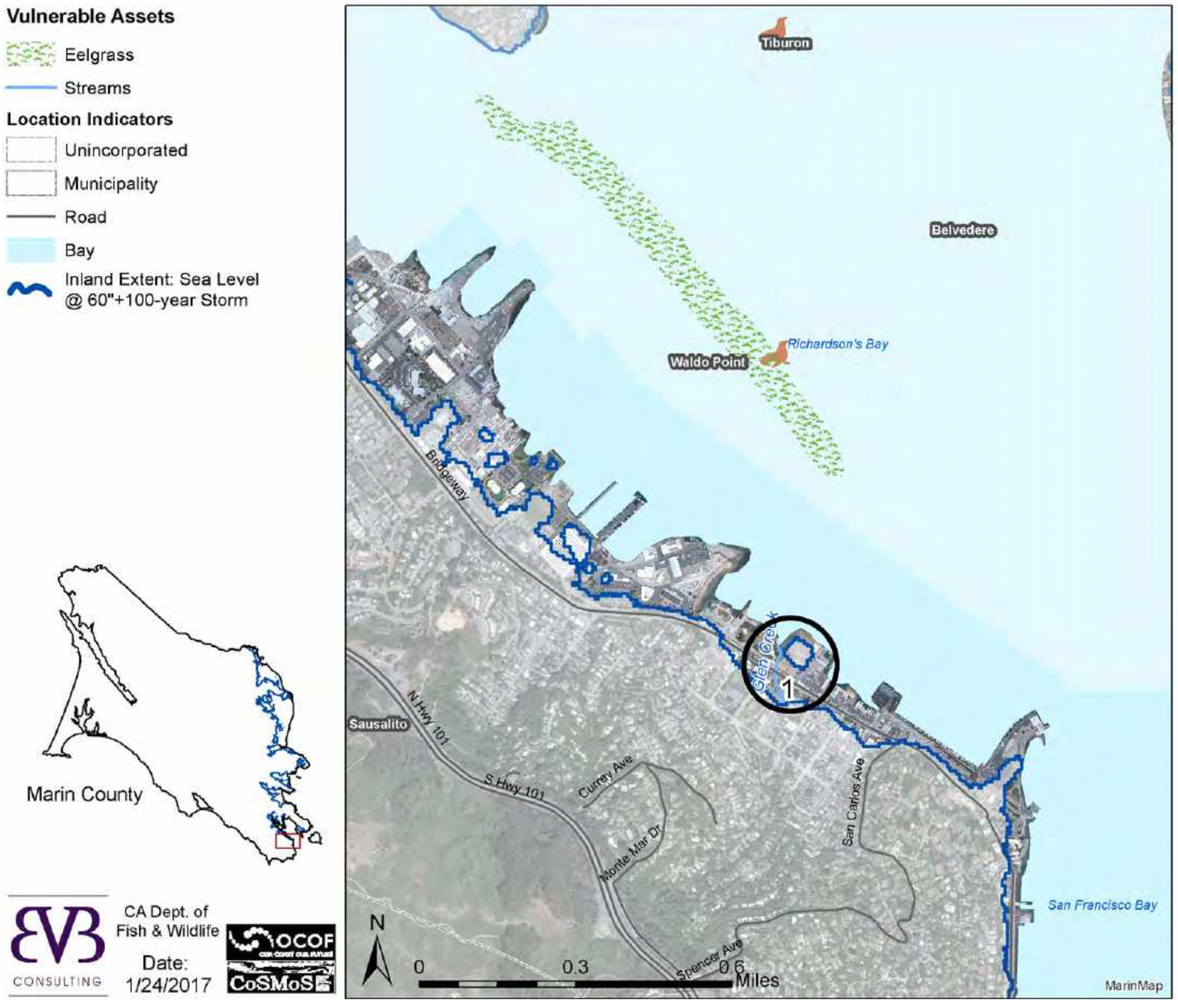
[168] J. Goldman. Dec. 20, 2016. Personal Communication. B. Van Belleghem

Map 49. Sausalito Vulnerable Wastewater Assets



Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data providers here in, make no warranties of the accuracy or completeness of maps and data. Maps are representational and subject to future revision. Local site conditions must be examined. Commercial use is prohibited.

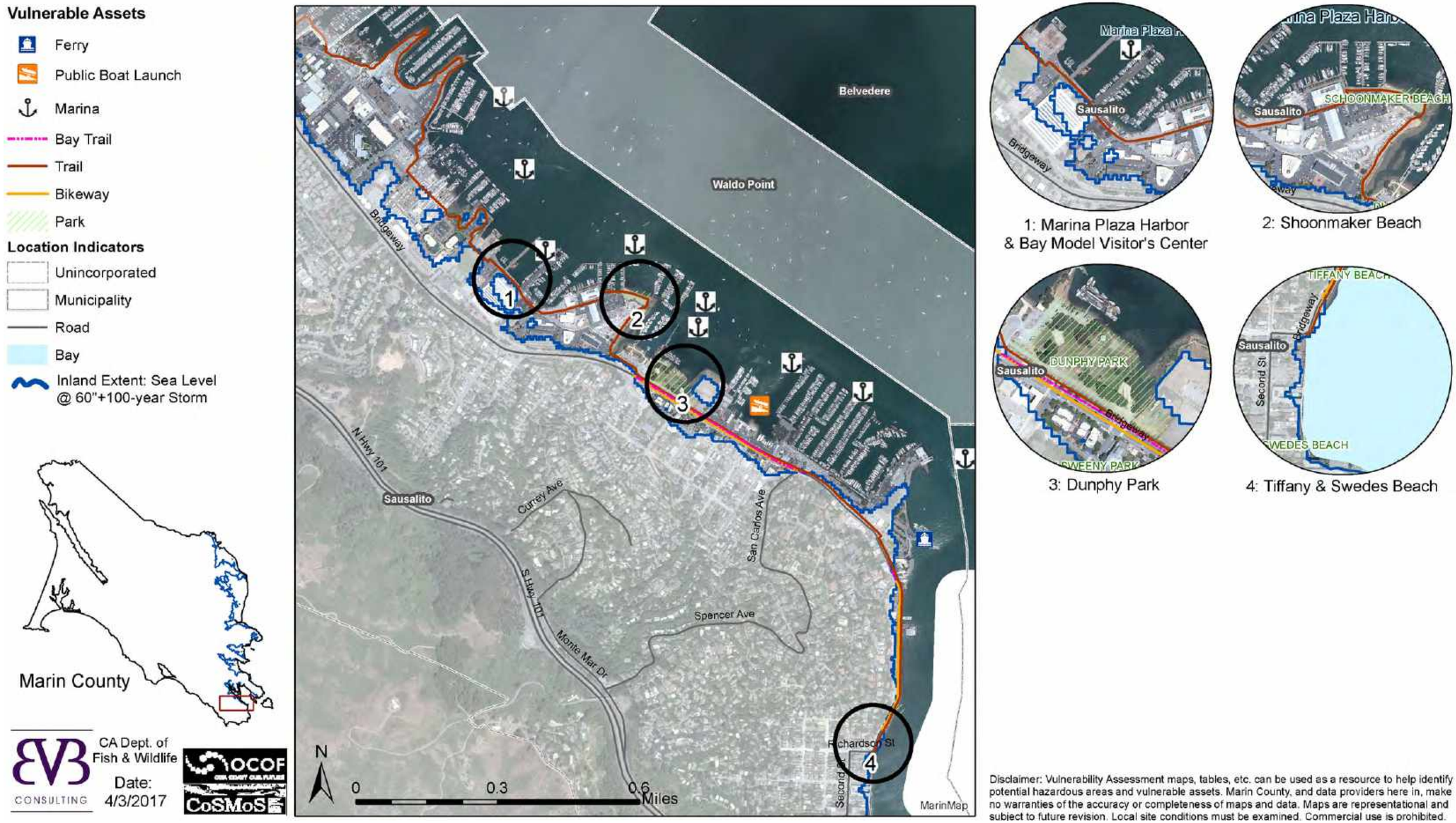
Map 50. Sausalito Vulnerable Natural Resource Assets



1: Glen Creek

Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data providers here in, make no warranties of the accuracy or completeness of maps and data. Maps are representational and subject to future revision. Local site conditions must be examined. Commercial use is prohibited.

Map 51. Sausalito Vulnerable Recreation Assets



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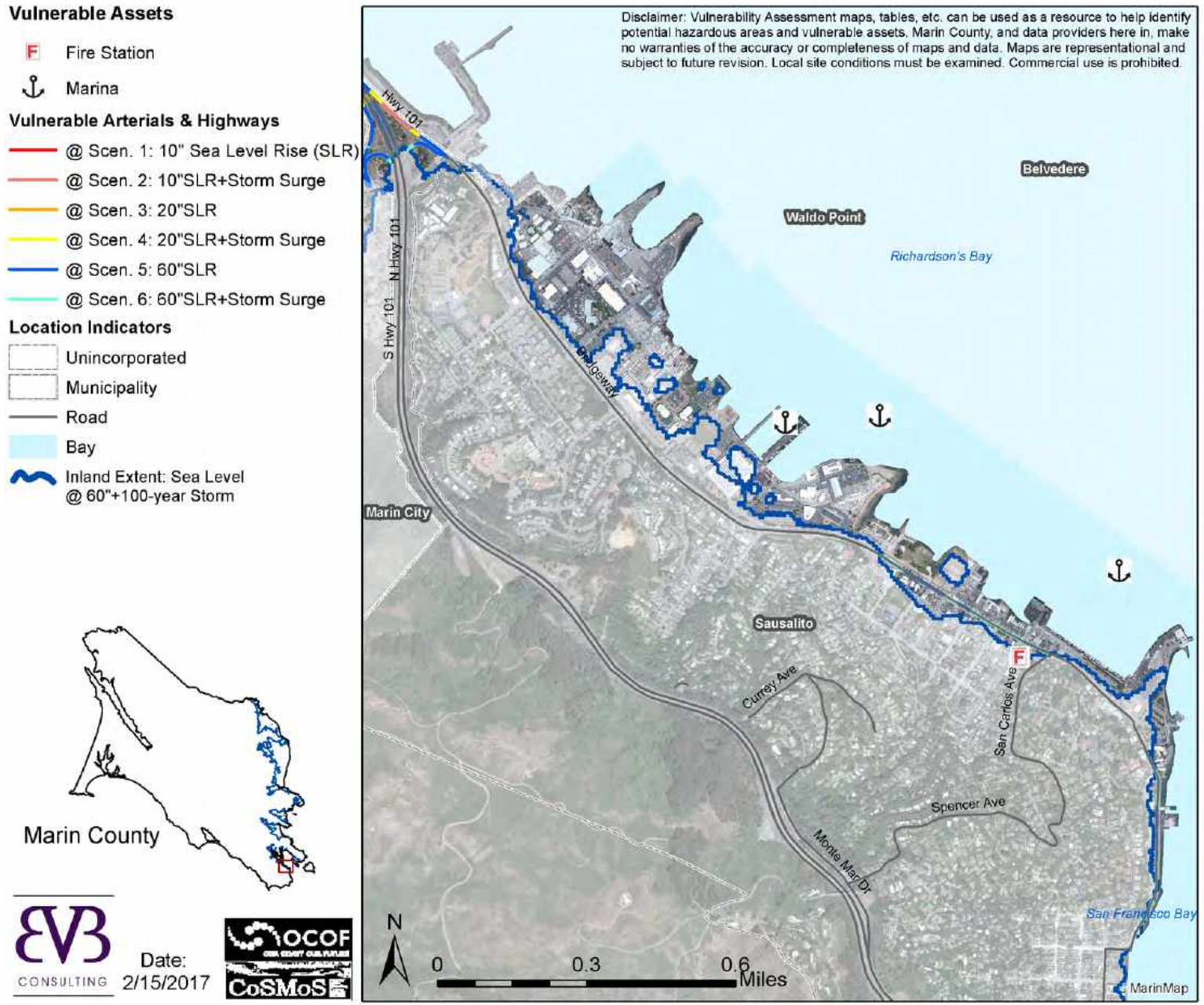
Map 52. Sausalito Vulnerable Emergency Service Assets



Map 53. Sausalito Vulnerable Cultural Resource Assets

Vulnerable Historic Buildings

- Scen. 1: 10" Sea Level Rise (SLR)
- Scen. 2: 10" SLR+Storm Surge
- Scen. 3: 20" Sea Level Rise
- Scen. 4: 20" SLR+Storm Surge
- Scen. 5: 60" Sea Level Rise
- Scen. 6: 60" SLR+Storm Surge

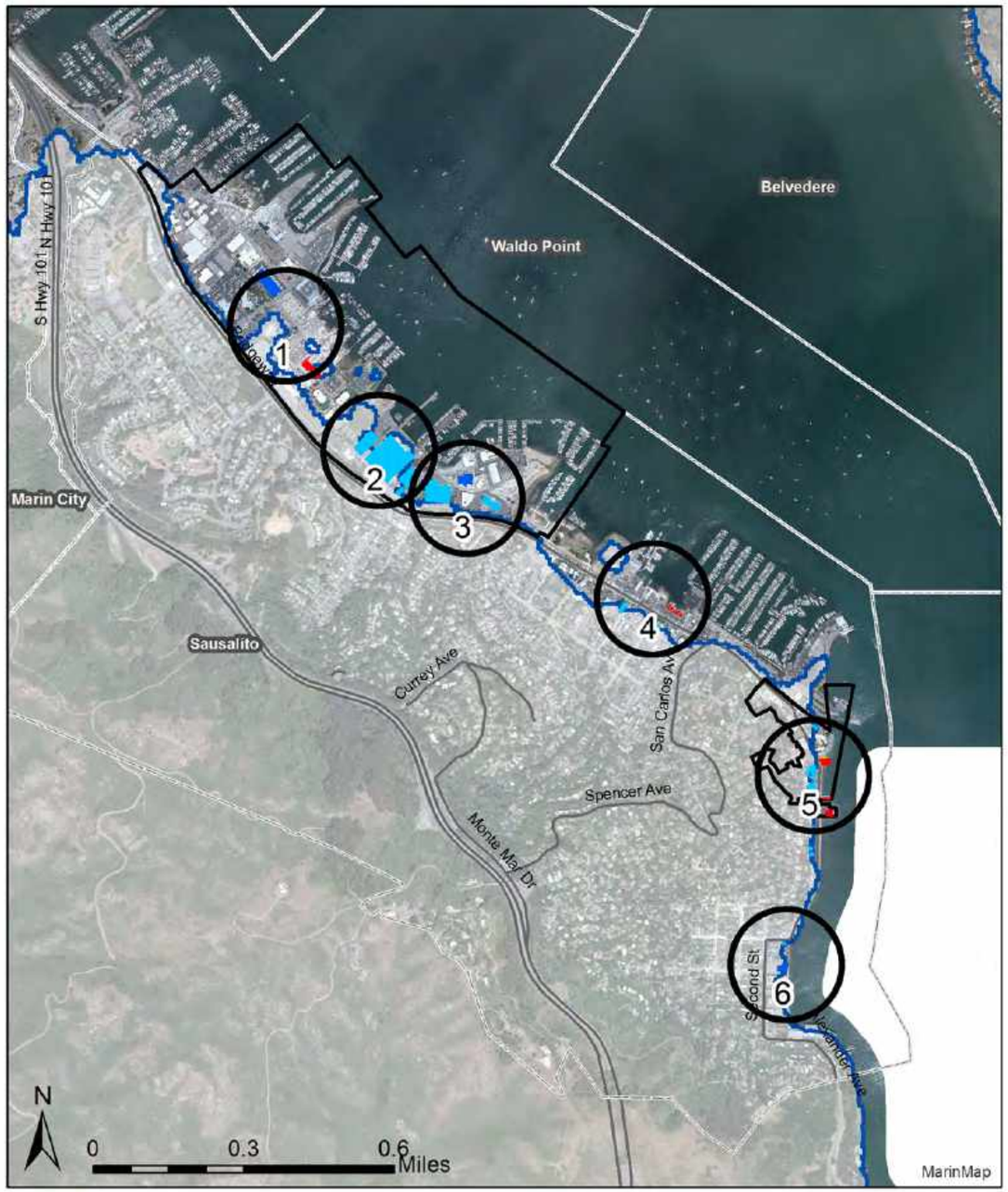
Location Indicators

- Municipality
- Major Road
- Inland Extent: Sea Level @ 60"+100-year Storm

Source: Marin Map, CoSMoS, City of Sausalito, Historic Resource Inventory Listing, Marinship Historic Context Statement.

Archaeological resources may be present.

Date: 2/17/2017



1: Northern Marinship

2: Central Marinship

3: Southern Marinship

4: Ark Row District

5: Downtown Historic District

6: Old Town

Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data providers here in, make no warranties of the accuracy or completeness of maps and data. Maps are representational and subject to future revision. Local site conditions must be examined. Commercial use is prohibited.

Cultural Resources
Vulnerable Resources: 26 National register district contributing sites, 17 noteworthy structures, 2 landmark buildings
Scenarios: All
Flood Depths: 09'04''+100-year storm surge
Primary Building Materials: Wood, concrete, brick, stucco, concrete

Both water and land access routes to Sausalito's historic properties could be vulnerable in the near-term. The historic GGF Sausalito Ferry landing could face inundation in the near-term. In the long-term, parts of Bridgeway could be tidally flooded, and impacts could worsen with storms.

A handful of private properties, including two major districts (Downtown Historic District and Ark Row District) on the city's Historic Resources Inventory could also be vulnerable across the BayWAVE scenarios. Sausalito's Ark Row District includes seven noteworthy properties that could be flooded with more than six feet of tidewaters in the near-term, and nine feet in the long-term. An additional ten other properties could be vulnerable in the long-term, including the original firehouse, with eight of the ten only subject to storms. Additionally, two of Sausalito's landmark buildings, Castle by the Sea and Ice House, could be vulnerable to a 100-year storm surge in scenario 6.

Marinship
Vulnerable Resources: 10 potential historic resources
Scenarios: All
Flood Depths: 2'1'' - 2'8''+100-year storm surge; flood depth data limited
Primary Building Materials: Concrete, wood, stucco, steel

The former Marinship yard, an approximately 210-acre site, was one of six Emergency Shipyards in the San Francisco Bay Area established during World War II. Marinship was built on bay fill, and some areas, such as Heath Way, have experienced approximately five feet of subsidence since 1943 based on photographic records.[169] In 2010, the Marinship Historic Context Statement inventoried and recorded every major World War II era building and structure. The effort concluded:

- Marinship retains a higher degree of architectural integrity then any of the other Bay Area World War II emergency shipyards,
- Eight surviving buildings could form a California Register eligible district in the southernmost portion of the district,
- Two sites are individually eligible for the National Register of Historic Place, and
- Four sites are individually eligible for the California Register of Historic Places.

Since the report was released, the WWII machine shop has received National Historic Landmark designation. The site is slated for renovation and repair. The remaining sites can be considered potential historic resources.

In the near term, shipways that are part of Building 23, the Marinship Shipways and Offices, could be vulnerable to 10 inches of sea level rise. More detailed analysis would be necessary to fully evaluate structural integrity impacts that could occur.

In the long-term, two buildings, the Marinship Maintenance Garage and the Marinship Mold Loft and Yard Office, could be vulnerable to tidal flooding at depths deeper than two feet. Both buildings were erected in 1942 with cinderblock construction and could be vulnerable to standing water. The Mold Loft could be eligible for the California Register, and the Maintenance garage could support a California register-eligible district.

Seven other properties could be vulnerable to the 100-year storm surge by the long-term scenario including Building 29, the Marinship Warehouse. This building now serves as the Bay Model Visitors Center which houses the US Army Corps of Engineers Bay Model, a working hydraulic scale model of the SF Bay-Delta, completed in 1957.[170] The model is no longer used for research, but open to the public for educational purposes.

Downtown Historic District
The Downtown Historic District is a National Register of Historic Places and on the City of Sausalito Historic Resources Inventory Listing. Overall, there

[169] Robin Petravic (Heath Ceramics), personal communications. July 2016.

[170] US Army Corps of Engineers Bay Model. Last updated August 18, 2016. en.wikipedia.org/wiki/U.S._Army_Corps_of_Engineers_Bay_Model

are 26 National Register District contributing sites, that could experience over nine feet of sea level rise flooding and additional storm surge flooding in the long-term.

Sausalito was an important hub for rail, car and ferry traffic before the Golden Gate Bridge was constructed. During World War II, the city developed rapidly as a shipbuilding center. The Downtown Historic District centers on a ferry terminal with service to San Francisco, is an important area for commerce, and a popular visitor destination. The district is a National Park Service Certified Historic District.[171]

Sea level rise is projected to inundate parts of Sausalito's historic district in the near-term, with storms expanding the vulnerable area and exacerbating impacts. By the long-term scenario with a 100-year storm surge, 26 National Register District contributing sites could be vulnerable. Further analysis could determine specific vulnerability to each building based on location, flood depth, height above grade, materials, etc.

Archaeological Resources
Archaeological resources may be present in the exposure zones.

Table 56 lists example vulnerable assets in Sausalito by onset and flood depth at MHHW. Maps throughout the profile illustrate the developed and natural assets vulnerable to sea level rise and the 100-year storm surge. A 100-year storm surge could add an additional 1 to 3 feet of water to these properties. Note also, above average high tides could impact more properties than accounted for in this analysis.

Table 56. Example Sausalito Vulnerable Assets by Onset and Flooding at MHHW

Asset	Scenarios		
	1	3	5
	Near-term	Medium-term	Long-term
Sausalito Ferry Facilities	No data		
Swedes Beach	Flooded at existing high tides		
Tiffany Beach	Flooded at existing high tides		7'
Marinship Neighborhood	0-13'	4"-14'2"	11"-36'
Marina Plaza Harbor	5'7"	8'6"	21'9"
Dunphy Park	5'1"	5'8"	13'8"
Shops and restaurants	3'6"	4'6"	11'6"
Sausalito Yacht Harbor	4"	1'	3'
Mill Valley/ Sausalito Pathway		0-8'5"	1"-11'8"
Schoonmaker Beach		7'2"	10'1"
Schoonmaker Point Marina		3'3"	8'2"
Clipper Yacht Harbor		2'5"	6'3"
Gate 5 Road		0-2'2"	10"-4'10"
Cass Gidley Marina		2'	3'2"
Turney Street Boat Ramp			8'8"
Yee Tock Chee Park			2'11"
Bay Trail			7"-2'3"
Bridgeway			7"-2'

Source: MarinMap, OCOF, Asset Manager Interviews

[171] Office of Historic Places, accessed July 14, 2016. http://ohp.parks.ca.gov/?page_id=27283

MILL VALLEY

Community Profile: Mill Valley

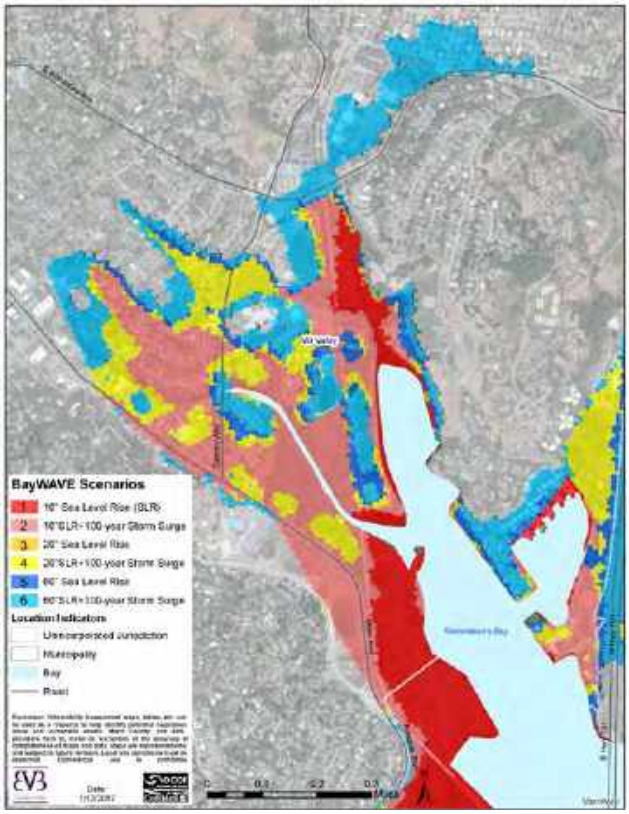
Just north east of Sausalito is Mill Valley. Mill Valley borders Richardson's Bay and extends into the narrow valley. While only a small area of the community could flood tidally, several key access routes and public facilities used by entire communities are in the exposed low lying areas surrounding the Bay. Key issues in Mill Valley are:

- Miller Avenue could be flooded in the near-term. This area already experiences seasonal flooding that extends to Tamalpais High School fields.
- Homes and businesses along and near Shelter Cove, Hamilton Drive, and the Frontage Road could expect near-term flooding impacts.
- The Redwoods, a retirement community, is exposed and completely surrounded, and therefore vulnerable in the medium-term.
- Sanitary Association of Southern Marin (SASM) treatment plant, serving six sanitary districts and 30,000 people, including Mill Valley residents, could expect flooding impacts between the medium and long-term scenarios.
- The Mill Valley-Sausalito Path could flood a majority of the year during average high tides in the medium-term.
- Mill Valley Middle School could expect sea level rise impacts to the grounds, and could expect flood waters reach the buildings with the 100-year storm coincidence.
- Bothin Marsh habitat could transition to mudflats without adequate sediment supply because the marsh does not have options for inland migration.
- Mill Valley Recreation Center fields could be vulnerable to sea level rise in the long-term. A 100-year storm surge could impact nearly the whole site.
- Camino Alto, between Miller and Blithedale Avenues, and the neighborhood north of it, could expect flooding in the long-term.

IMPACTS AT-A-GLANCE: SCENARIO 6

1,000+ living units	13,500+ people
273 acres exposed	25 commercial parcels
5.6 miles of roads	
Storm and tidal impacts already occur	
Nearly $550 million of assessed property value and $830 million in single-family market value vulnerable[172]	Property Owners SASM City of Mill Valley Mill Valley School District

Map 54. Mill Valley Sea Level Rise and 100-year Storm Surge Scenarios



[172] 2016 dollars

MILL VALLEY

Vulnerable Assets

Mill Valley's most vulnerable assets are Miller Avenue, Shelter Bay area, the Sanitary Association of Southern Marin (SASM) treatment plant, and Bothin Marsh. However, by the long-term both the western and northern access routes in to the community could be vulnerable to flooding during a 100-year storm surge. Combined with existing storm water issues, storm impacts from rain and from the bay, or even a king tide, could have devastating impacts on natural and built assets in low-lying areas closest to the shoreline.

Land

Much like other communities in the region, Mill Valley has extensive development upland in the valley and along the valley hillsides. Thus, developable Bayfront land is minimal and intensely utilized. In addition, Mill Valley is fronted with Bothin and Sutton Marshes that serve valuable ecological and physical buffering functions. The areas contribute greatly to the acreage counted.

Acres

In near-term scenario 1, 44 acres of mostly marsh and water's edge land could be vulnerable to monthly tidal flooding at MHHW. In near-term scenario 2, a 100-year storm could flood these and sixty more acres, amounting to 3 percent of Mill Valley's land area. In medium-term scenario 3, roughly 20 more acres could anticipate tidal flooding, and nearly triple this could anticipate storm surge flooding in scenario 4. By the long-term, tidal flooding could extend beyond the marshes and their borders into developed areas. In scenario 5, 190 acres, or 6 percent of acres in the community may be exposed to tidal flooding. In scenario 6, with the additional 100-year storm surge, these 190 acres, plus nearly 100 more could experience storm surge exposure. This indicates that ten percent of the Mill Valley's land area could be exposed to five feet of sea level rise and a 100-year storm surge.

Parcels

Land is divided into parcels for ownership and development purposes. Parcels are assigned land uses and tend to stay true to that designation, though many sites could feature multiple uses, such as commercial with housing included. Examining parcels can provides estimate of how many land uses and human activities may be vulnerable.

Table 57. Mill Valley Exposed Acres by Scenario

Scenarios		Acres	
		#	%
Near-term	1	44	1
	2	103	3
Medium-term	3	62	2
	4	183	6
Long-term	5	190	6
	6	273	9

Source: MarinMap, CoSMoS

Table 58. Mill Valley Vulnerable Parcels by Scenario

Scenarios		Parcels	
		#	%
Near-term	1	80	1
	2	195	3
Medium-term	3	80	1
	4	338	6
Long-term	5	361	6
	6	741	13

Source: MarinMap, CoSMoS

Sutton Marsh habitat and Mill Valley Recreation Center. Credit: Marin County DPW

MILL VALLEY

Table 59. Mill Valley Vulnerable Residential and Commercial Parcels

Land Use	Scenarios					
	1		3		5	
	Near-term		Medium-term		Long-term	
	#	%	#	%	#	%
Residential	74	1	169	1	308	6
Commercial	3	1	3	1	25	10

Source: MarinMap, CoSMoS

Table 60. Mill Valley Vulnerable Parcels by Land Use

Land Use	Scenarios					
	1		3		5	
	Near-term		Medium-term		Long-term	
	#	Ac.	#	Ac.	#	Ac.
Commercial Improved	3	14	3	14	19	27
Commercial Unimproved					6	9
Exemption Improved					4	14
Multi-Family Residential Improved					1	0.13
Single Family Attached	73	1	71	1	184	3
Single Family Residential Improved					122	17
Single Family Residential Unimproved	1	3	1	3	1	3
Tax Exempt	1	6	3	8	21	63

Source: MarinMap, CoSMoS

In scenario 1, exposed acreage is divided into 80 vulnerable parcels. These parcels are essentially all parcels that directly border the water's edge. These consist of several large publically owned parcels and smaller residential parcel. A small number of commercial parcels are impacted. With a 100-year storm surge, scenario 2, 195 parcels, or three percent of all parcels in Mill Valley could be vulnerable to storm surge flooding. In medium-term scenario 4, up to six percent of parcels could be vulnerable to storm surge flooding. These parcels are also likely to experience tidal flooding impacts by long-term scenario 5. Over twice this amount may experience 100-year storm surge flooding by scenario 6.

As shown in Table 59 and Table 60, by land use, less than 1 percent of residential and commercial parcels could experience flooding in the near- and medium-terms. The primary vulnerable land use is tax exempt, or publicly owned. These include parkland, two schools, and a waste water treatment facility. In the long-term, however; several hundred residential parcels, accounting for six percent of all residential parcels in Mill Valley, could be vulnerable to tidal impacts. Residential parcels include the Redwoods retirement community, homes on the Shelter Bay inlet, and homes north or Camino Alto at roughly Sycamore Avenue By this time 25 commercial parcels, 10 percent of commercial parcels in Mill Valley, along Camino Alto and Redwood Highway Frontage Road could also experience tidal flooding.

In long-term scenario 6, even more homes north of Camino Alto could flood, as could the shopping centers east of Blithedale Avenue. With a 100-year storm surge in scenario 6, nearly fifteen percent of residential parcels, and one-third of the commercial parcels could be vulnerable to temporary flooding. Commercial properties that could experience flooding are the Mill Valley Shopping Center in the long-term and the Alto Shopping Center in the long-term with a 100-year storm surge, scenario 6.

Buildings

Many of the vulnerable parcels contain one or more buildings. Flooding to buildings and their contents could result in significant amounts of building and material damage, or worse loss. Relative to other East Marin communities, Mill Valley has a low number of buildings vulnerable to sea level rise and a 100-year storm surge. However, several areas already vulnerable to stormwater backups could expect these conditions to worsen with added saltwater.

Table 61 summarizes the vulnerable buildings in the study area. As shown, in the near-term, a few buildings could expect tidal flooding. In scenario 2, ten inches of sea level rise with a 100-year storm surge; more than 200 buildings could be vulnerable. With respect to sea level rise, the medium-term is similar to the near-term; however, the 100-year storm surge could impact more than a 100 more buildings. In the long-term, the same buildings impacted in scenario 4, could now experience tidal flooding at MHHW. These buildings account for roughly five percent of Mill Valley's building stock. In the long-term with a 100-year storm surge, these figures nearly double over scenario 5 figures to over 500 buildings. Most of these buildings are on residential parcels, though Mill Valley Middle School, the SASM treatment plant, the Mill Valley Recreation Center, and Tamalpais High School are also vulnerable. Vulnerable residential parcels now include homes in the southern end of the Sycamore neighborhood. In addition, buildings in the commercial center buildings along Camino Alto and East Blithedale could face storm flooding.

Most of Mill Valley's buildings are wood-framed. While it is unclear how many buildings are older than 30 years, many in the low-lying areas are. Newer buildings typically have drilled piles 20-30 feet deep with reinforced steel cages and concrete to connect the homes to the foundation. This feature can help buildings withstand lateral forces from wind and water. However, even if buildings remain structurally intact, utility-related equipment could be vulnerable. Moreover, material and content damage from water and salt could occur.

Table 62 divides the vulnerable buildings into flood depth intervals, showing how many buildings could be flooded with one, two or ten feet of tidal flooding during MHHW. This analysis reveals that flood depths are shallow through medium-term. However, by the long-term, nearly 250 buildings could flood with three feet of water, and seventy could be impacted by more than three to five feet of water.

Table 63 estimates costs using FEMA tagging designations for damage to buildings and their contents. This analysis focuses on scenario 6 sea level rise and storm surge conditions, the worst case storm scenario analyzed. If every vulnerable building experienced minor levels of damage, up to $9 million[173] in damages could occur. If all of the buildings impacted under scenario 6 were to become unusable, over $300 million in assessed structural value could be lost.[174] Reality would likely reflect a mix of damage levels. The deterioration and destruction of Mill Valley's commercial and public buildings would have significant impacts on the local economy and sense of place. Having to rebuild or repair buildings after flooding can be traumatic and costly for tax paying residents and business owners.

Table 61. Mill Valley Vulnerable Buildings

Scenarios		Buildings	
		#	%
Near-term	1	5	0
	2	207	3
Medium-term	3	7	0
	4	325	5
Long-term	5	329	5
	6	536	8

Source: MarinMap, CoSMoS

Table 62. Mill Valley Vulnerable Buildings' Average Flood Depth MHHW Estimates

Flood Depth (feet)		Scenarios		
		1	3	5
0.1-1	#		1	32
1.1-2	#		1	96
2.1-3	#			127
3.1-4	#			59
4.1-5	#			12

Source: MarinMap, CoSMoS

** Flood depth data is not available for all exposed assets.*

[173] 2016 dollars
[174] 2016 dollars

Table 63. Mill Valley Vulnerable Building's FEMA Hazus Damage Cost* Estimates for Long-term Scenario 6

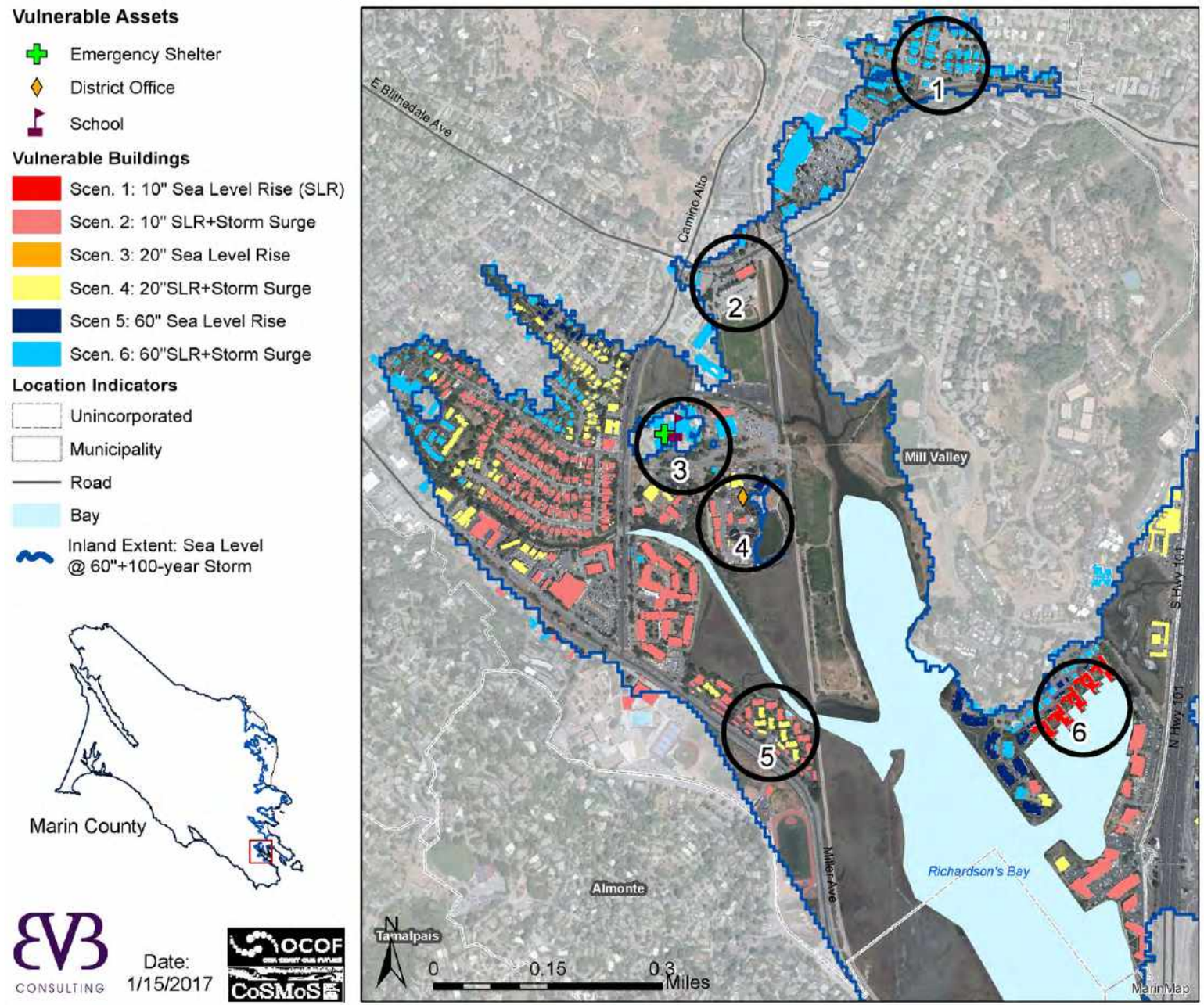
Buildings Scenario 6	536
Yellow Tag: Minor Damage **$5,000 minimum**	$2,680,000
Orange Tag: Moderate Damage **$17,001 minimum**	$9,112,536
Red Tag: Destroyed **Assessed structural value**	$300,215,511

*Source: MarinMap, CoSMoS. *2016 dollars*

The maps on the following pages illustrate vulnerable buildings by scenario. The areas in the call out circles enable the reader the see areas that are difficult to see on the large scale map. The circles do not indicate that these areas are more vulnerable than others along the shoreline.

MILL VALLEY

Map 55. Mill Valley Vulnerable Buildings



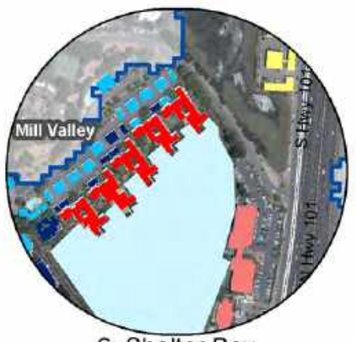
1: E. Blithdale Avenue

2: E. Blithdale Ave. @ Bike Path

3: Mill Valley Middle School

4: SASM Wastewater Treatment Plant

5: Mill Creek Meadows



6: Shelter Bay

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MILL VALLEY

Mill Valley-Sausalito Path. Credit: J. Poskazner

Transportation

Miller Avenue is the only southwestern access road to Mill Valley, and is vulnerable in the near-term. In fact, this area already experiences seasonal flooding that extends into Tamalpais High School athletic fields, especially combined with rain events. Portions of the road are on a narrow strip of land between businesses, the hillside, and Richardson's Bay, offering little room for inland relocation. Moreover, Miller Avenue is connected to the freeway system through Shoreline Highway in the frequently flooded Manzanita area in Almonte. Miller Avenue serves high school students, commuters, service providers, and suppliers that would face difficulties making it through the narrow corridor when flooded.

The Mill Valley/Sausalito Path for non-vehicular traffic faces a similar fate, though likely sooner due to its marshland location. In addition, the Redwood Highway Frontage Road along U.S Highway 101 southbound is vulnerable in the near-term. In the long-term, Camino Alto, between Miller and Blithedale Avenues**,** could be vulnerable to tidal flooding, as could several smaller neighborhood streets to the north, though with the 100-year storm surge, this area could be impacted temporarily in the medium-term. Blithedale Avenue could expect minor high tide flooding by scenario 5, with more severe flooding with a 100-year storm surge.

Transit routes 4, 8, 17, and 22 could expect tidal and/or temporary storm surge flooding and result in a reduction in service during average high tides at the following Golden Gate Transit bus stops:

- Miller Ave. and Reed St.,
- E Blithedale Ave. and Lomita Dr.,
- E Blithedale Ave. and Roque Moraes Dr.,
- Miller Ave. and Camino Alto, and
- Miller Ave. and Almonte Blvd.

The maps on the following pages illustrate vulnerable transportation features. The areas in the call out circles enable the reader the see areas that are difficult to see on the large scale map. The circles do not indicate that these areas are more vulnerable than others along the shoreline.

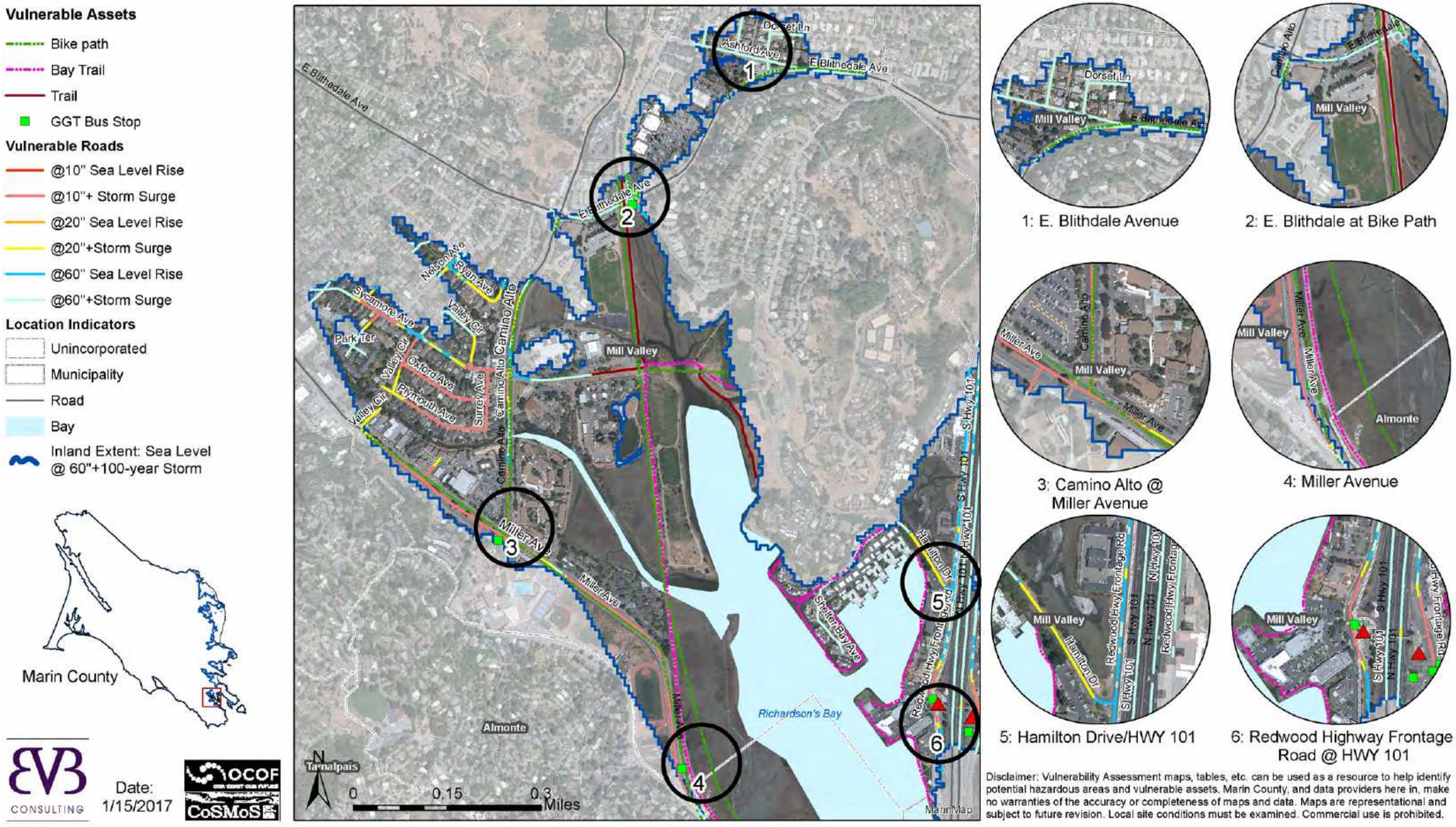
Table 64. Mill Valley Vulnerable Transportation Routes

Near-term		Medium-term		Long-term	
Scenario 1	**Scenario 2**	**Scenario 3**	**Scenario 4**	**Scenario 5**	**Scenario 6**
None	**1.5 miles**	**None**	**2 miles**	**3 miles**	**6 miles**
	Redwood Hwy L Camino Alto L Amicita Ave L Gomez Way P Miller Ave L Nelson Ave L Oxford Ave L Park Ter P Plymouth Ave L Frontage Rd L Surrey Ave L Sycamore Ave L Tamalpais Commons Ln P Valley Cir L		Roads in scenario 2 Hamilton Dr L Ryan Ave L	Roads in scenarios 2 and 4 E Blithedale Ave L Plymouth Cir L Roque Moraes Dr L	Roads in scenarios 2, 4, and 5 Ashford Ave L La Goma St L Leyton Ct L Lomita Dr L Matilda Ave L Meadow Rd L Nelson Ave L Shelter Bay Ave L Somerset Ln L

M = Marin County; C = State of California; L = Local Municipality; P = Private. Source: MarinMap, CoSMoS

MILL VALLEY

Map 56. Mill Valley Vulnerable Transportation Assets



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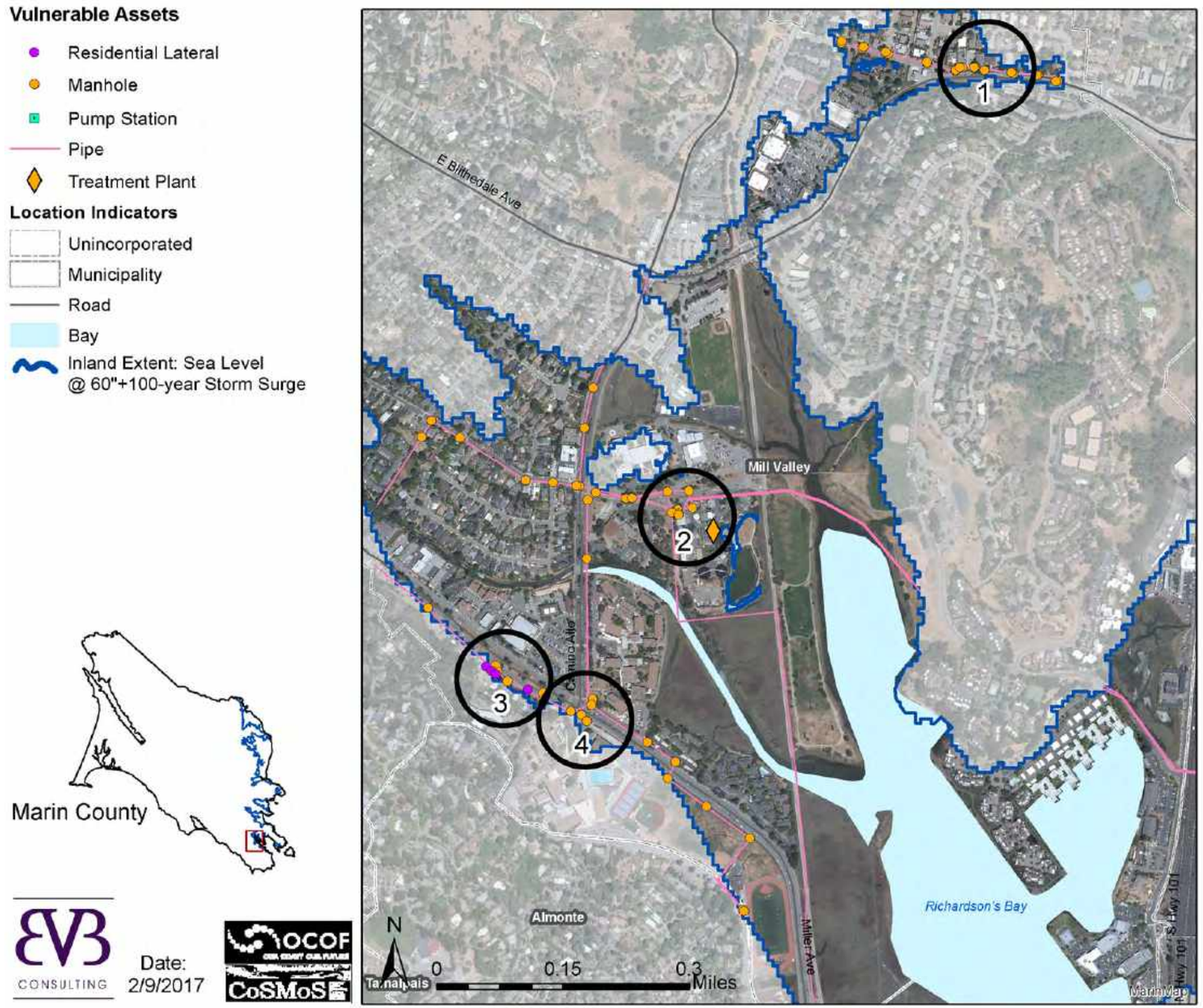
MILL VALLEY

Map 57. Mill Valley Vulnerable Sanitary Sewer Assets



1: E. Blithdale Ave.

2: SASM

3: Miller Ave.

4: Miller Ave. @ Camino Alto

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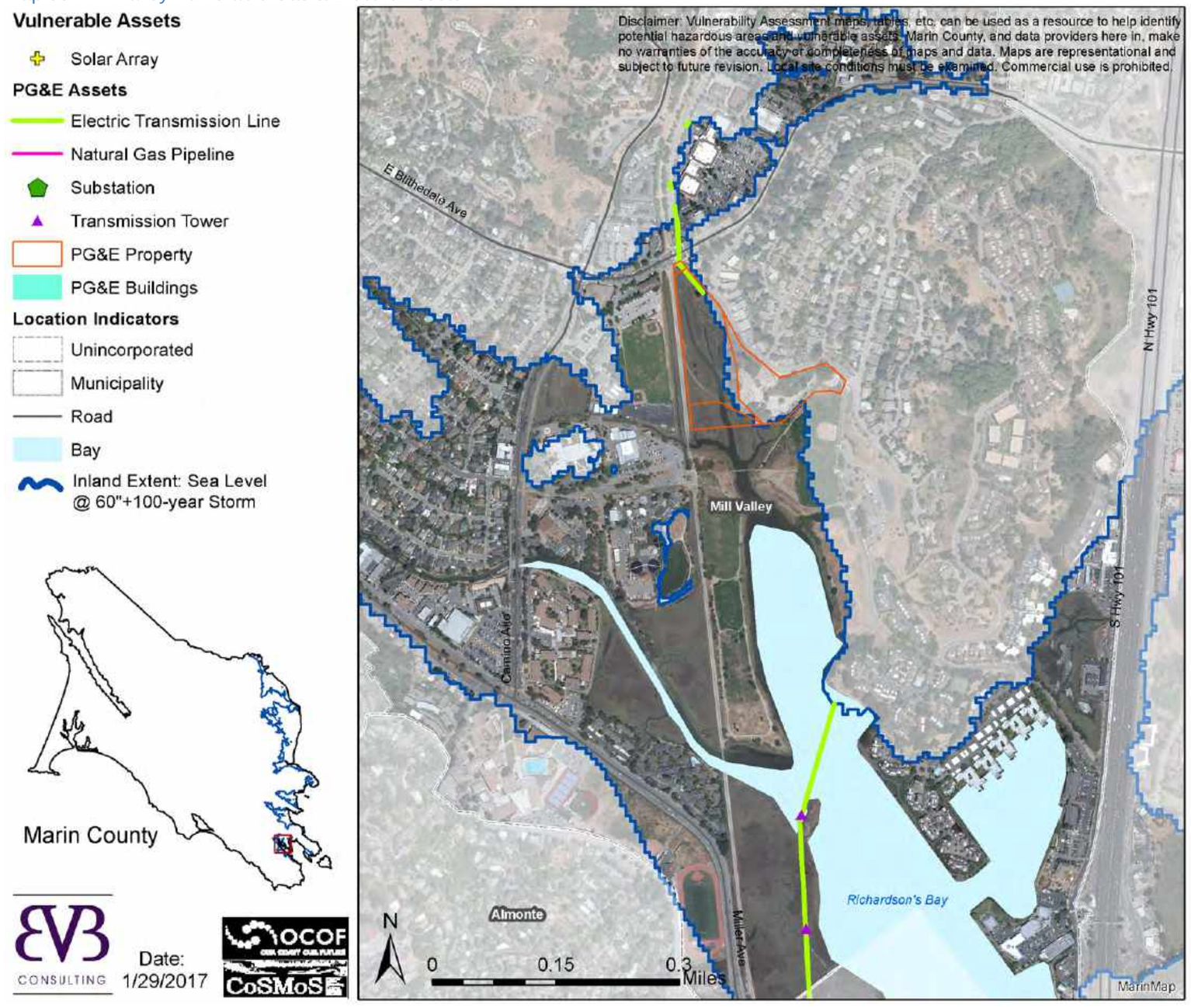
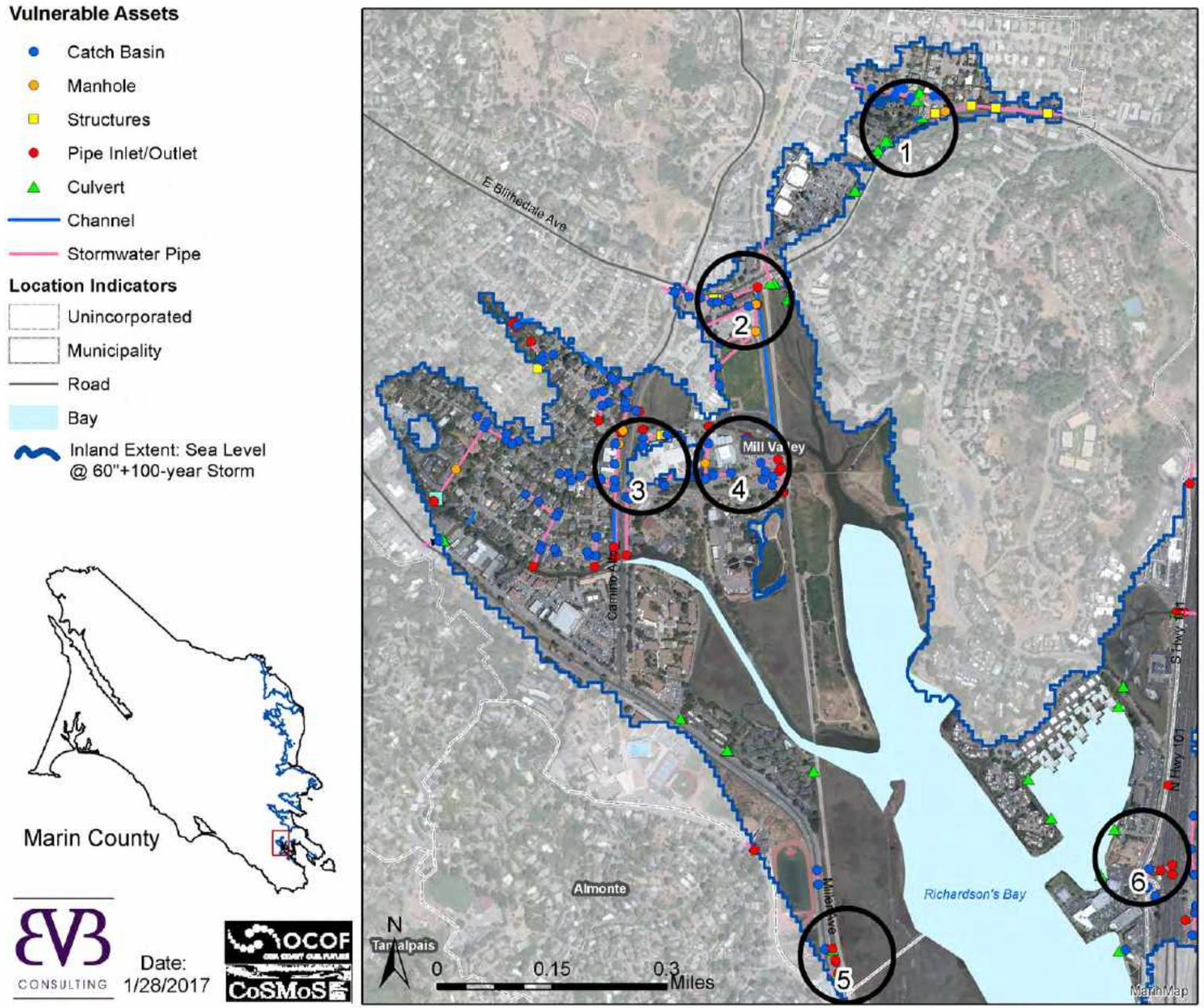
Map 58. Mill Valley Vulnerable Gas & Electric Assets



MILL VALLEY

Map 59. Mill Valley Vulnerable Stormwater Assets



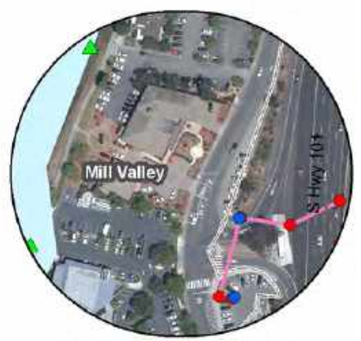
1: E. Blithdale Avenue

2: E. Blithdale Avenue @ Camino Alto

3: Camino Alto @ Sycamore Ave.

4: Sycamore Ave. @ Mill Valley/Sausalito Bike Path

5: Miller Avenue



6: Redwood Highway Frontage Rd.

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Utilities
The key vulnerable utility asset is the SASM treatment plant. This plant serves tens of thousands of people at their homes, business, and places of study, work, and worship. If the treatment plant is compromised, even dry hillside homes could suffer breakdowns in the system if no action is taken to protect or relocate the plant. For more information on SASM vulnerabilities see the Utilities Profile.

Other concerns include those common to other communities, such as:

- Underground pipes face compounding pressure forces from water and the road,
- Road erosion and collapse with underlain pipes,
- Saltwater inflow and infiltration causing inefficiencies in wastewater treatment,
- Continuously subsiding soils or fill, and
- Escalating activity, capacity demands, energy consumption, and wear and tear on pump stations in stormwater and wastewater systems,
- Aging individual site connections for water, sewer, and electrical, and
- Flood waters interrupting access for employees to reach work sites.

The maps on the previous pages illustrate vulnerable utility features. The areas in the call out circles enable the reader the see areas that are difficult to see on the large scale map. The circles do not indicate that these areas are more vulnerable than others along the shoreline.

Natural Resources
Bothin Marsh and its smaller connected marshes, such as Sutton Marsh, and Shelter Bay habitats could be vulnerable to sea level rise in the near-term. The habitat serves for bird, rodent, insect, and water loving species. Factors that could impact the habitat are increased salinity, higher water levels, increased erosion, and road and building barriers to inland migration.

The longfin smelt and Ridgway's Rail are the listed species recorded in Bothin Marsh. The smelt is listed as threated on the California list and a candidate on the federal list. The largest longfin smelt population occurs in the San Francisco Estuary and Sacramento-San Joaquin Delta. This species occupies bay waters throughout summer and moves into lower reaches of rivers in fall to spawn. Other important fish species sensitive to changes in environmental conditions that could occur in Richardson's Bay are:

- Chinook salmon
- Delta smelt:
- Green sturgeon
- Pacific herring, and
- Steelhead.

The Ridgway's rail is one of the largest rails in North America. The Ridgway's rail is very secretive and occurs primarily in salt and brackish marshes with pickleweed and cordgrass. Rails were detected in Bothin Marsh Preserve, Mill Valley.[175] The Western snowy plover is a small shorebird that nests on and near the shores of the San Francisco Bay and may forage in Richardson's Bay. Other unique and valuable bird species common in the area are:

- California brown pelican,
- California least tern,
- Double-crested cormorant,
- San Francisco common yellowthroat, and
- San Pablo (Samuels) song sparrow.

Insects, such as the Monarch butterfly, could also be vulnerable to impacts to their habitat. Finally, numerous special status plants with habitats that are expected to be vulnerable to sea level rise are:

- Franciscan thistle,
- Hairless popcornflower,
- Marin western flax,
- Oregon polemonium,
- Point Reyes salty bird's-beak,
- Tiburon buckwheat,
- Tiburon paintbrush, and
- White-rayed pentachaeta.[176]

To learn more about these species, see the Natural Resources Profile.

[175] Wood, J., L. Salas, N. Nur, M. Elrod, J. McBroom. 2013. Distribution and population trends for the Endangered California Clapper Rail. State of the Estuary Conference, 26 October 2013, Oakland, CA.
[176] Prunuske Chatham, Inc. March 2016. Draft Biological Resources Assessment: Dunphy Park Improvement Project Sausalito, Marin County.

MILL VALLEY

Recreation
The vulnerable Mill Valley marshes are a popular recreational destination for locals and visitors alike. This loss could have negative effects on the sense of place and local economy. The Mill Valley-Sausalito pathway through the marshes could be flooded out more often and degraded more quickly. Strong enough storm waters could even damage the wooden pathways structural integrity. Capacity reductions would impact bikers, skaters, runners, and walkers of all ages.

The Mill Valley Recreation Center could expect impacts to the ball fields and some ancillary buildings from long-term sea level rise. A 100-year storm could flood out the majority of the property and access could be compromised. The primary buildings are elevated beyond MHHW; however, by the end of the century, they could be impacted by the highest high tides, especially during and immediately following a rain event.

In addition, the guest serving Acqua Hotel on Shelter Bay and the Travel Lodge may be vulnerable in the long-term, and nearby restaurants may be vulnerable in the medium-term.

Emergency Services
The primary concern for Mill Valley emergency services is vehicular access to and through flooded areas in emergencies. Delayed service could lead to worse injury or worse, loss of life.

Cultural Resources
Mill Valley's inventoried historic assets are located outside of the exposure zones.

Example assets are presented Table 65 and described in the subsequent sections. A 100-year storm surge would add an additional 1 to 3 feet of water to these properties. Note also, above average high tides could impact more properties than accounted for in this analysis. The maps on the following pages illustrate vulnerable natural resource, recreation, emergency and historic features. The areas in the call out circles enable the reader the see areas that are difficult to see on the large scale map. The circles do not indicate that these areas are more vulnerable than others along the shoreline.

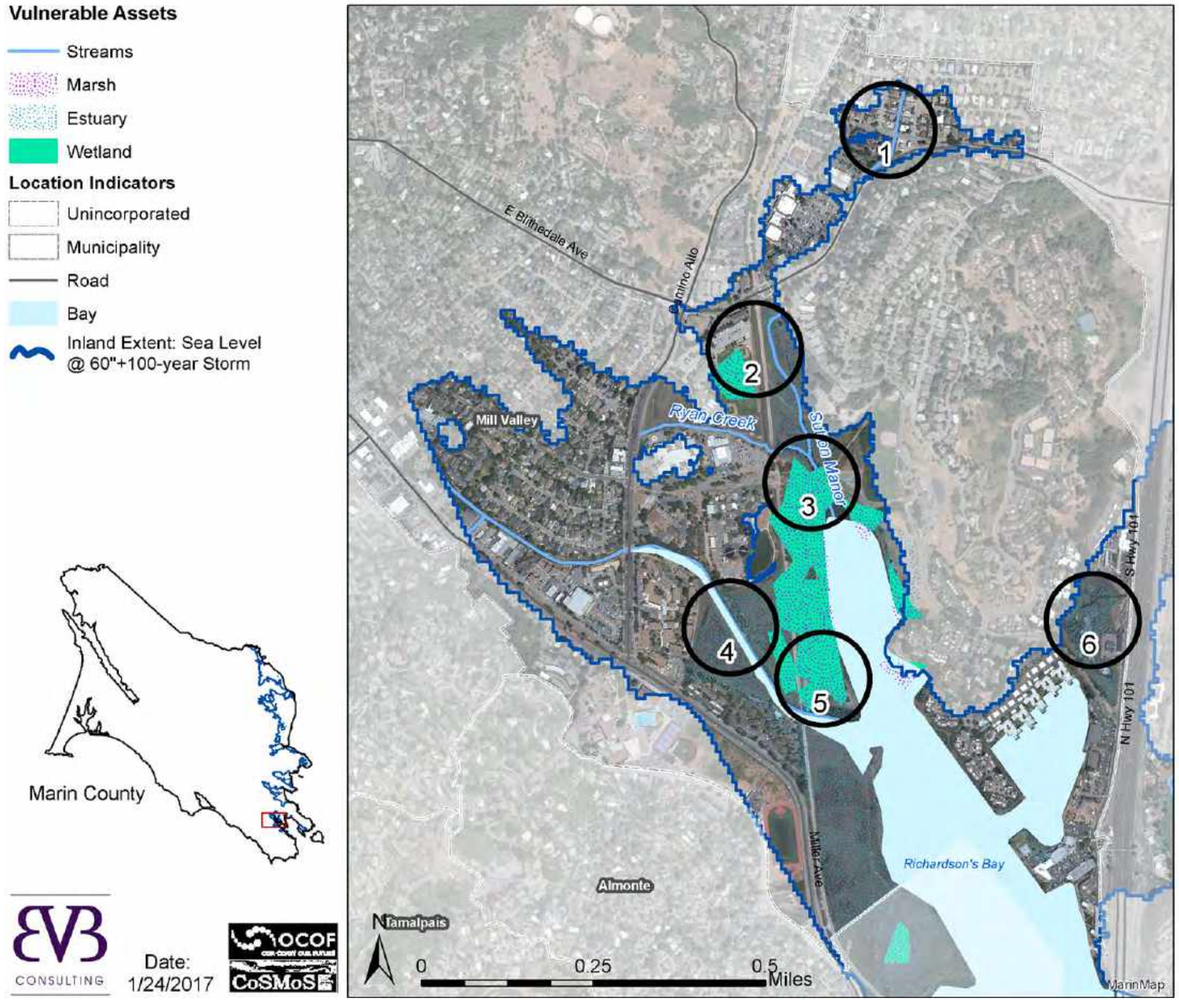
Table 65. Example Mill Valley Assets Vulnerable to Sea Level Rise by Onset and Flood Depth at MHHW

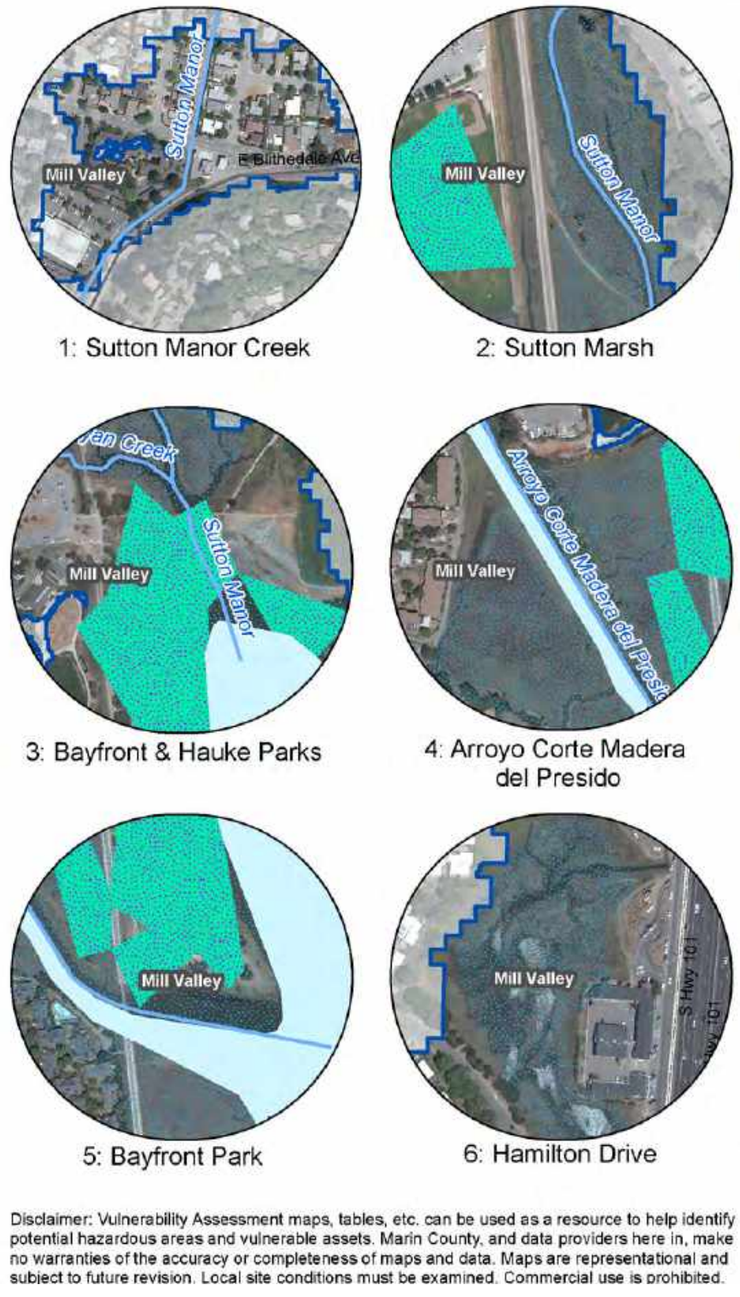
Asset	Scenarios		
	Near-term	Medium-term	Long-term
	1	3	5
Hwy 101 commercial	0-4”	9”-1’3”	2’-3’2”
Mill Valley/ Sausalito Pathway		0-8’5”	1”-11’8”
Bay Trail		0-8’	3”-12’5”
Mill Valley Shopping Center		1’2”-7’	6”-2’6”
Sycamore neighborhood		2”-2’2”	4”-4’7”
Miller Avenue		0-1’7”	2’-4’8”
SASM treatment plant		6”-11”	1’2”-2’5”
Shelter Bay neighborhood		2”-9”	6”-1’10”
The Redwoods		7”	1’7”
Sycamore Ave			0-4’7”
Camino Alto (between Miller and Blithedale Avenues)			2”-3’6”
Mill Valley Middle School temp buildings			1’2”
E. Blithedale Avenue			1”
Tamalpais High fields	No data		
Bothin Marsh	Floods at existing high tides		
Arroyo Corte Madera Del Presidio	Water resource		

Source: MarinMap, CoSMoS

MILL VALLEY

Map 60. Mill Valley Vulnerable Natural Resource Assets





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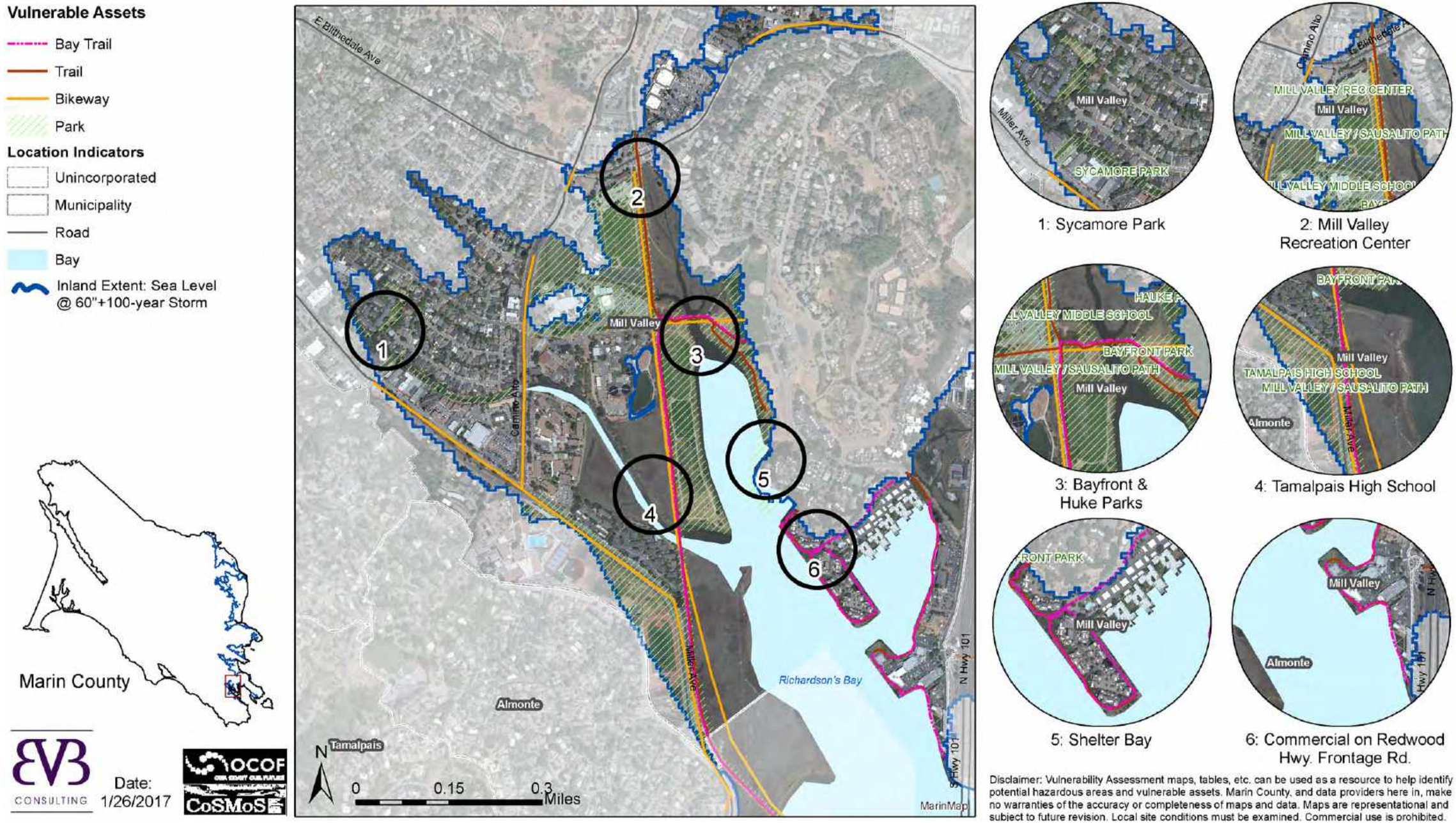
MILL VALLEY

Map 61. Mill Valley Vulnerable Recreation Assets



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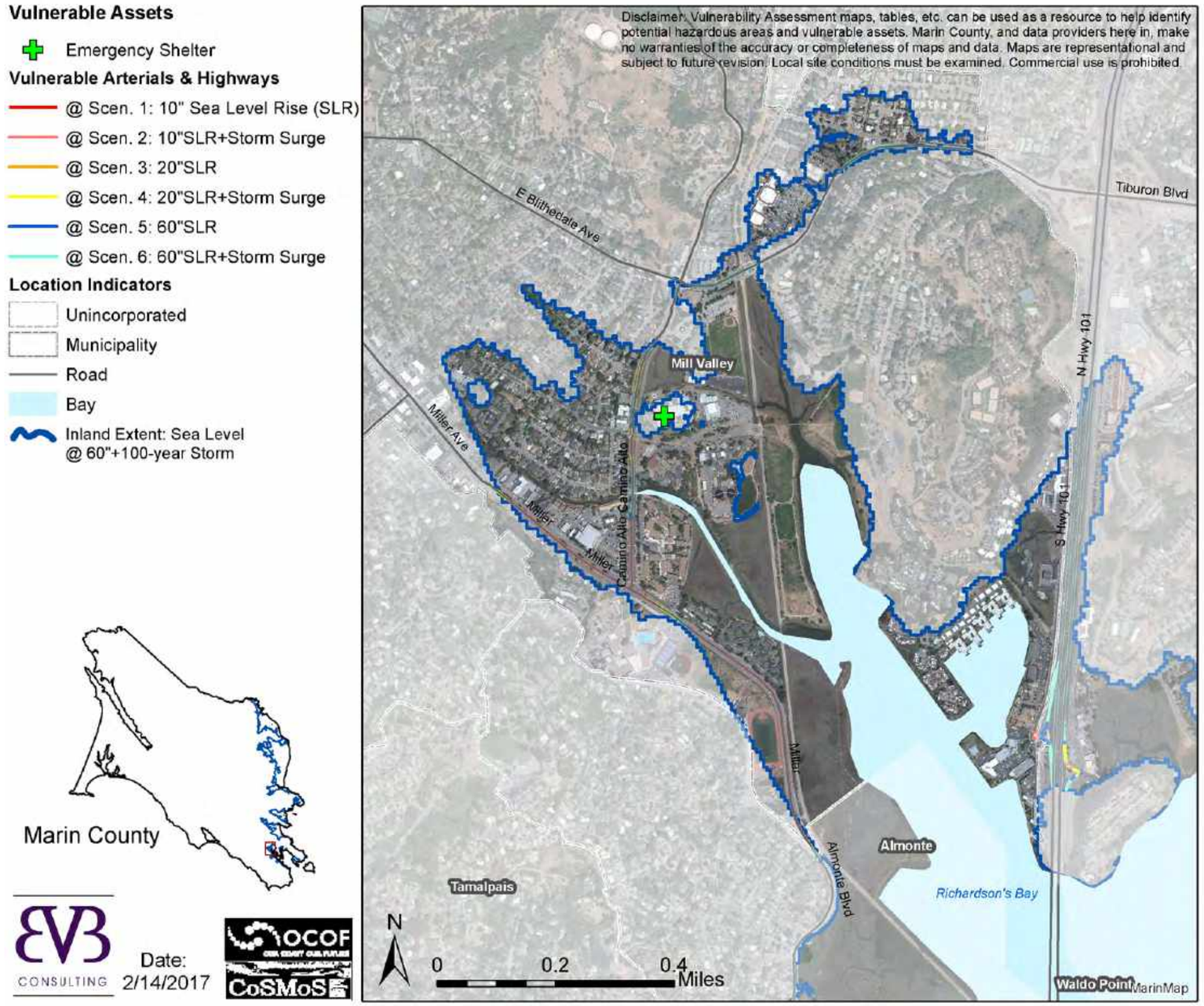
MILL VALLEY

Map 62. Mill Valley Vulnerable Emergency Services



BELVEDERE

Community Profile: Belvedere

Belvedere is a unique shoreline community, because it used to be an island before fill was used to create the lagoon, or flats, neighborhood. The primary impacts here are to housing. In the near-term, 24 acres could be exposed to sea level rise. By the long-term, 169 acres could be exposed to sea level rise and 180 acres could be exposed with an additional 100-year storm surge. Key sea level rise vulnerabilities include:

- San Rafael Avenue could be impacted after the medium-term, cutting off the first access point to the community.
- Shoreline homes along West Shore and Beach Roads could expect impacts to utilities in the near and medium-terms, and potential structural impacts to any in water structures during storms, especially in the long-term.
- Homes in the flats would be vulnerable to sea level rise flooding if the levees are overtopped. Note that the homes on the lagoon could also flood, however the model may overestimate the flooding intensity. These homes are also vulnerable to worsening subsidence.
- The Belvedere Corp Yard could be vulnerable to storm surge flooding in the near-term and tidal flooding in the long-term.
- The City Hall, Community Center, and Police Department share the same buildings that could expect impacts in the long-term, especially during storms. The park facility and roads fronting the building could expect flood waters sooner, creating potential access issues.

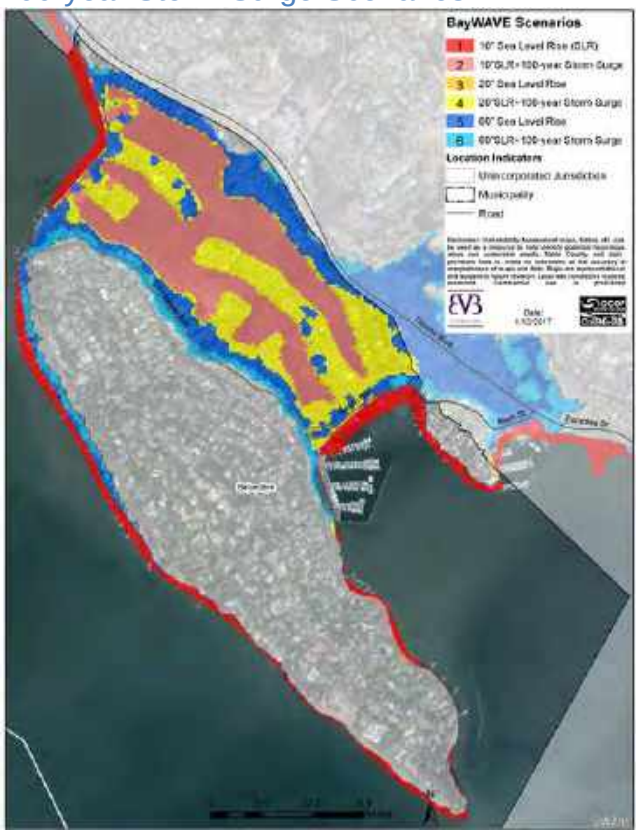
Vulnerable Assets

The assets most vulnerable to sea level rise and storm surges in Belvedere are single-family residential homes and San Rafael Avenue. With respect to the impacts to lagoon side homes, it is important to note that the CoSMoS model treats the tide gate closing the lagoon from incoming tide waters as open. This assumption may overestimate flooding levels and prematurely estimate onset of flooding. The following sections detail these vulnerabilities.

IMPACTS AT-A-GLANCE: SCENARIO 6

550 living units	2,000+ people
180 acres exposed	4 commercial parcels
3.7 miles of roads	
Seasonal storm flooding already occurs	
$8.6 million in assessed property; $1.4 billion in single-family housing market value[177]	Property Owners City of Belvedere

Map 63. Belvedere Sea Level Rise and 100-year Storm Surge Scenarios



Source: MarinMap, CoSMoS. Credit: BVB Consulting LLC

[177] 2016 dollars

BELVEDERE

Belvedere Lagoon homes. Credit: Wiki Commons

Table 66. Belvedere Exposed Acres

Scenarios		Acres	
		#	%
Near-term	1	24	2
	2	85	6
Medium-term	3	24	2
	4	130	9
Long-term	5	169	12
	6	180	12

Source: MarinMap, CoSMoS

Table 67. Belvedere Vulnerable Parcels

Scenarios		Parcels	
		#	%
Near-term	1	51	5
	2	56	6
Medium-term	3	52	5
	4	210	21
Long-term	5	356	36
	6	495	50

Source: MarinMap, CoSMoS

Land

Belvedere was an island until it was connected to Tiburon with fill on bay mud. Because of this several homes in the lagoon neighborhood could be vulnerable to subsidence and several have sunk below mean sea level. Much of this area is protected from the Bay by a levee wall on the north and a wall with tides gates to the south. The tide gates allow water into a central lagoon. Note that the CoSMoS model treats these gates open, when city engineers have the ability to close the gates to reduce tidal influences on the internal lagoon.

Acres

Belvedere is essentially two hill side and top neighborhoods and a lagoon neighborhood. The first acreages claimed by tidal waters are those along the bluff side of Belvedere Island. In time, the lagoon area and the area extending into Tiburon could face tidal and storm surge flooding.

In near-term scenario 1, two percent, or 24 acres of Belvedere could face tidal flooding at MHHW. Flooded acreage could more than triple with the onset of a 100-year storm surge. The same acreage could be vulnerable in the medium-term as the near-term due to sea level rise alone. A 100-year storm surge could impact almost ten percent of the acre sin Belvedere. In long-term scenario 5 and 6, less than 200 acres, or 12 percent of Belvedere could be vulnerable to sea level rise and a 100-year storm surge, including the entire lagoon neighborhood.

Parcels

This land area is divided into parcels. Most parcels in the community are residential in use; however, a few commercial and public parcels are also vulnerable. As shown in Table 67, in the near-term, 51 water's edge parcels on Belvedere and Corinthian Islands could be vulnerable to sea level rise, as are a few on the southern end of the Belvedere lagoon. A significant jump in parcels could flood in the medium-term with a 100-year storm surge, when levee protecting the lagoon neighborhood are overtopped. In long-term scenario 5, sea levels are high enough at mean higher high water to over top the levee walls and flood most of the lagoon area, amounting to more than 30 percent of the parcels there. With a 100-year storm nearly every parcel in low-lying Belvedere could flood, accounting for a striking half of all parcels in the community.

BELVEDERE

Table 68 shows that over 30 percent of residential and commercial parcels in Belvedere could be vulnerable to sea level rise. The majority of these properties are in the low lying lagoon area. Thirty percent of residential parcels would be a considerable loss of over 300 parcels. Most of these parcels are single family residential. Some multi-family parcels could be vulnerable as well.

Table 68. Belvedere Vulnerable Residential and Commercial Parcels

Land Use	Scenarios					
	Near-term		Medium-term		Long-term	
	1		3		5	
	#	%	#	%	#	%
Residential	46	5	47	5	324	37
Commercial					4	33

Source: MarinMap, CoSMoS

Table 69. Belvedere Vulnerable Parcels by Land Use

Land Use	Scenarios					
	1		3		5	
	Near-term		Medium-term		Long-term	
	#	Ac.	#	Ac.	#	Ac.
Commercial Improved					4	3
Common Area					10	64
Exemption Improved					2	0.4
Residential	46	10	47	10	324	70
Multi-Family Improved	3	2	3	2	14	12
Single Family Attached					4	0.1
Single Family Improved	40	8	41	8	303	57
Single Family Unimproved	3	0.3	3	0.4	3	0.5
Tax Exempt	5	1	5	1	16	3

Source: MarinMap, CoSMoS

Buildings

The most vulnerable buildings are in the flats, or lagoon area, and those directly above the bay on the bluff edge on West Shore Road and Beach Road. Some may extend over the water on piers or feature overhanging decks. According to Belvedere managers, some of these homes have vents and other utility lines under the homes that could be vulnerable to increased saltwater exposure. In the low-lying areas, homes in the area could be vulnerable in the medium to long-term time horizon if the levees are overtopped and the lagoon is left under tidal influence. Even if the lagoon is managed well enough to keep those homes bordering it dry, these homes may become isolated if tidewaters overtop the levees lining San Rafael Avenue and Beach Road, or Tiburon's downtown streets. Looking at the CoSMoS model interactive map, the levees surrounding the lagoon area are topped at 3 feet of sea level rise, though significant impacts could occur between scenarios 3 and 5. In the lagoon area, many of the original homes were, or are being, replaced with newer construction.

In addition, the city corporation yard is vulnerable in the medium-term to low levels of flooding and over one foot of flooding at MHHW in the long-term. The remaining community center, police department, and city hall, which share a building, could expect impacts during storms to the surrounding property, face access issues in the medium-term, and flood with up to four feet of tide waters by scenario 5.

As seen in Table 70, in the near-term, 32 buildings could be compromised. The number of buildings impacted by 20 inches of sea level rise doubles, and nearly three times as many are impacted by the 100-year storm surge in scenarios 2 and 4. In the long-term, from sea level rise alone, around 400 buildings could be vulnerable to sea level rise.[178] Table 71 divides the vulnerable buildings by flood depth in one-foot intervals, showing how many buildings could flood with one, two, or ten feet of salt water at MHHW. A 100-year storm surge would add 1 to 3 feet of water.

[178] The CoSMoS model may over predict flooding in the lagoon system. The model treats the lagoon as tidal, when, in fact, the lagoon water levels are managed through tide gates for seasonal water fluctuations.

BELVEDERE

Table 70. Belvedere Vulnerable Buildings

Scenarios		Buildings	
		#	%
Near-term	1	32	2
	2	84	5
Medium-term	3	65	4
	4	90	5
Long-term	5	423	24
	6	470	27

Source: MarinMap, CoSMoS

Table 71. Belvedere Tidal MHHW Flood Depth* Estimates for Vulnerable Buildings

Flood Depth (feet)	Scenarios		
	Near-term	Medium-term	Long-term
	1	3	5
0.1-1	10	6	8
1.1-2	14	16	31
2.1-3	13	14	65
3.1-4	5	10	52
4.1-5	3	2	89
5.1-6	2	3	124
6.1-7		1	46
7.1-8			5
8.1-9			1
9.1-10			1

**Flood depth data is not available for all exposed assets.*
Source: MarinMap, CoSMoS

Table 72. Belvedere Vulnerable Buildings FEMA Hazus Damage Cost Estimates in Long-term Scenario 6

Buildings Scenario 6	470
Yellow Tag-Minor Damage **$5,000 minimum**	$2,350,000
Orange Tag: Moderate Damage **$17,001 minimum**	$7,990,470
Red Tag-Destroyed **Assessed structural value**	$356,209,805

Source: MarinMap, CoSMoS
**2016 dollars*

In near-term scenario 1, of the buildings with an associated flood depth, ten buildings could expect 1 foot of flooding. If a building is elevated from the ground by more than this amount the floor boards of the building may remain dry, however, any equipment, and the property in general, would be wet and could be damaged on a regular basis. Thirty buildings could face flood levels of over one to three feet, and an addition al ten could experience up to six feet of flood water. In the medium-term, most buildings could flood with more than 1 foot to three feet of salt water, with 20 buildings experiencing flooding deeper than three feet up to seven feet. In long-term scenario 5, flooding could exceed seven feet and reach up to 10 feet at MHHW. Roughly 300 buildings could expect saltwater flooding over three feet up to seven feet. About 100 buildings could anticipate less than three feet of saltwater flooding at MHHW. Tidal flooding at these levels may require a dramatic shift in use and design is use of the properties is still desired moving forward.

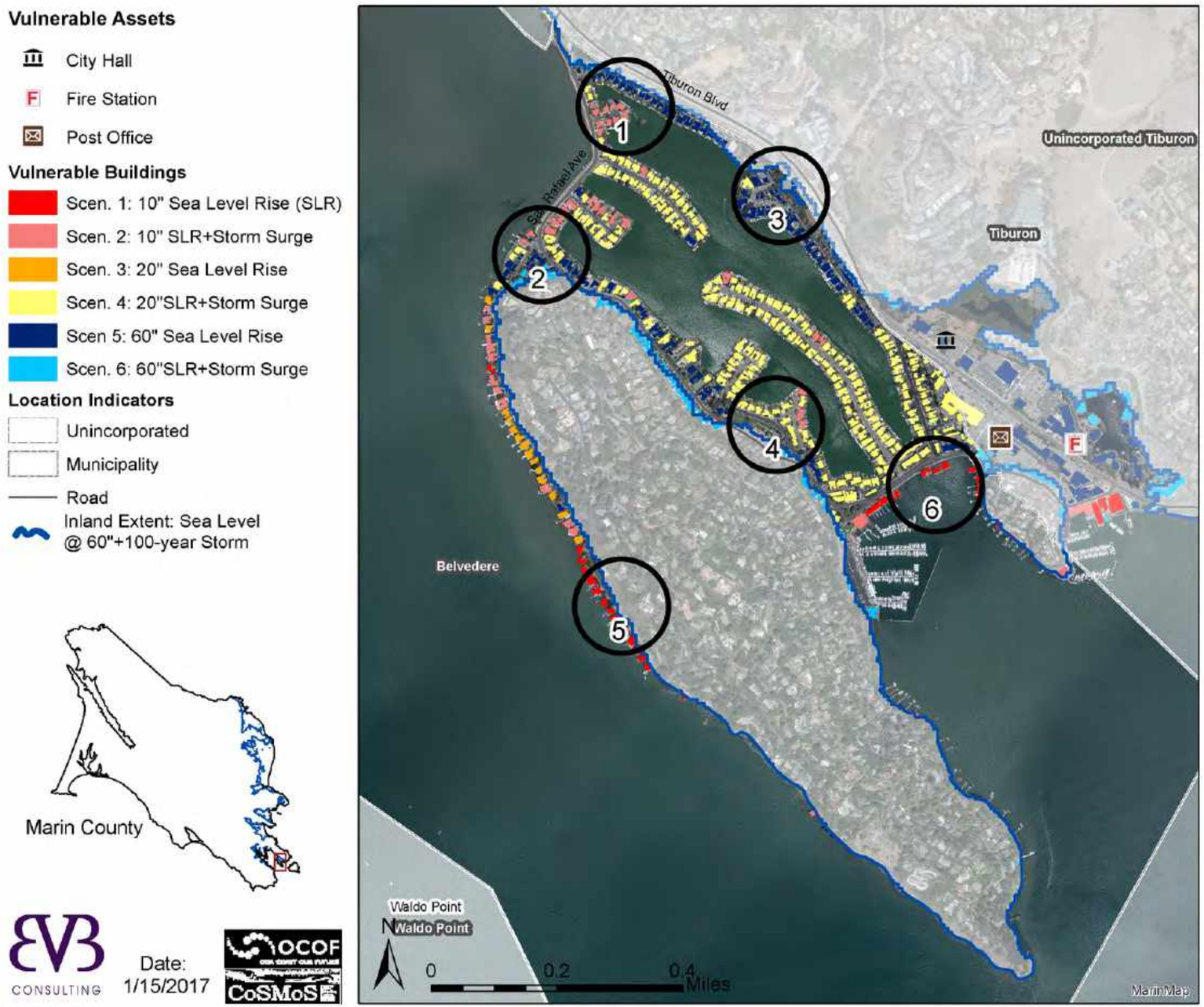
Applying the FEMA post-storm damage tagging levels described in the Buildings Profile reveals that minor damage to all of the buildings flooded in scenario 6, the worst case scenario, could add to $8 million.[179,180] If total destruction were to occur for each building vulnerable to five feet of sea level rise and a 100-year storm, over $356 million in assessed building value[181,182] could be lost in a storm. Reality will likely reflect a mix of these damage levels. These figures are summarized in Table 72.

If sea level rise occurs at these levels much a Belvedere's lagoon area could be lost to sea. This would also present major complications for those who travel through the lagoon neighborhood on San Rafael Avenue to get to their homes or jobs on Belvedere Island. The maps on the following pages illustrate vulnerable buildings by scenario. The areas in the call out circles enable the reader the see areas that are difficult to see on the large scale map. The circles do not indicate that these areas are more vulnerable than others along the shoreline.

179 ArcGIS. FEMA Modeling Task Force (MOTF)-Superstorm Sandy Impact Analysis. Last update June 22, 2015. http://www.arcgis.com/home/item.html?id=307dd522499d4a44a33d7296a5da5ea0
180 2016 dollars
181 Market value is typically higher than assessed value.
182 2016 dollars

BELVEDERE

Map 64. Belvedere Vulnerable Buildings

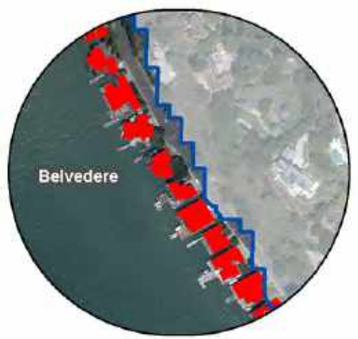


1: Entry to Belvedere

2: San Rafael Ave. @ Westshore Rd.

3: Homes on Eastern Lagoon

4: Community Center & Park



5: Westshore Rd.

6: Beach Rd. & Corinthian Hill

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BELVEDERE

Transportation

The primary access road to Belvedere, San Rafael Avenue, is vulnerable to overland flooding after three feet of sea level rise. The levee lining the shoreline here may protect the avenue from sea level rise for a couple decades; however, when combined with storm surges, the armoring could be compromised sooner. The lagoon area roads may experience increasing subsidence issues in addition to, and even before, flooding. In time, several additional roads in the lagoon area could be impacted by high tides on a regular basis. If the low lying roads are compromised, people who live in the homes on Belvedere Island could become isolated or prevented through travel for several hours several days a month.

Table 73 lists roads and trails that could be vulnerable to sea level rise and a 100-year storm surge. Golden Gate Transit route 8 along Beach Road, and along its route connecting to Belvedere, could experience service reductions during high tides and/or a 100-year storm at the following stops:

- Beach Rd. and San Rafael Ave, and
- Beach Rd. and Juanita Ln.

If public transportation gets cut off because roads are inundated, people who travel through or to the area for work would be cut off. Similarly, people with mobility or health constraints will be affected.

Water transportation for recreational purposes is a major use of the San Francisco Yacht Club Marina off Belvedere Island. As sea level rises, the facility may need to make some adjustments or relocate. Several private piers and docks could also be damaged in storms and/or may need to be elevated.

The maps on the following pages illustrate vulnerable transportation features. The areas in the call out circles enable the reader the see areas that are difficult to see on the large scale map. The circles do not indicate that these areas are more vulnerable than others along the shoreline.

San Francisco Yacht Club facing Corinthian Hill in Belvedere. Credit: F .Higgins

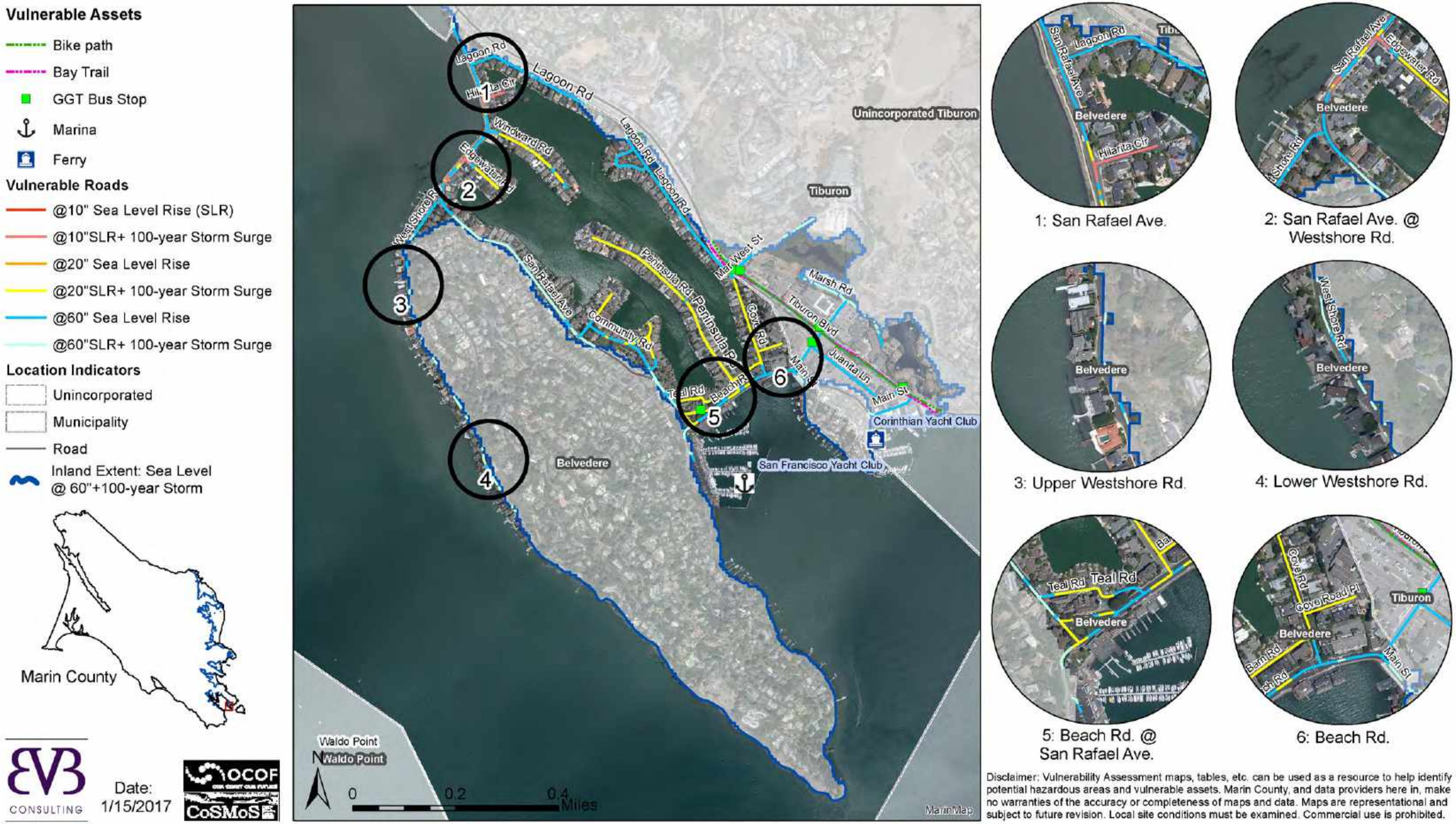
Table 73. Belvedere Roads Vulnerable to Sea Level Rise and a 100-year Storm Surge

Near-term		Medium-term		Long-term	
Scenario 1	**Scenario 2**	**Scenario 3**	**Scenario 4**	**Scenario 5**	**Scenario 6**
None	**0.1** miles	**None**	**1.5** miles	**3** miles	**4** miles
	San Rafael Ave [L] Hilarita Cir [L] Edgewater Rd [L]		Roads in Scenario 2 Barn Rd [P] Beach Rd [L] Community Rd Cove Rd [L] Cove Road Pl [L] Leeward Rd [L] Mallard Rd [P] Peninsula Rd [L] Teal Rd [P] Windward Rd [L]	Roads in scenarios 2 and 4 Embarcadero Dr [P] Lagoon Rd [L] Maybridge Rd [L] West Shore Rd [L]	Roads in scenarios 2, 4, and 5 Bellevue Ave [L] Golden Gate Ave [L]

M = Marin County; C = State of California; L = Local Municipality; P = Private.
Source: MarinMap, CoSMoS

BELVEDERE

Map 65. Belvedere Vulnerable Transportation Assets



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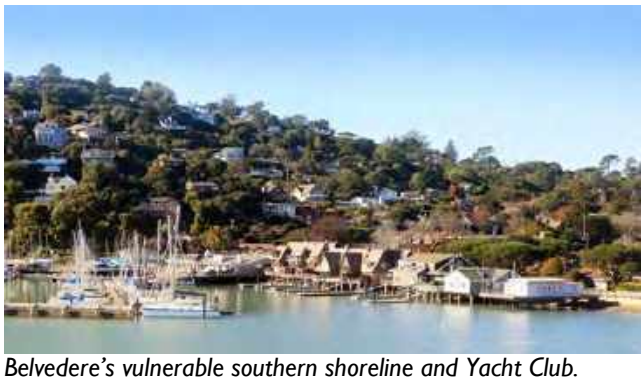
BELVEDERE



Belvedere's vulnerable southern shoreline and Yacht Club. Credit: WikiMedia

Utilities
Primary concerns include those common to other communities in the study area such as:

- Underground pipes face compounding pressure forces from water and the road,
- Road erosion and collapse with underlain pipes,
- Saltwater inflow and infiltration causing inefficiencies in wastewater treatment,
- Continuously subsiding soils or fill, and
- Escalating activity, capacity demands, energy consumption, and wear and tear on pump stations in stormwater and wastewater systems,
- Aging individual site connections for water, sewer, and electrical, and
- Flood waters interrupting access for employees to reach work sites.

Natural Resources
Much of Belvedere is developed with housing and boating facilities. Nevertheless, the Belvedere lagoon and Corinthian Bay provide ample bird and marine life habitat.

Just off the shores of Belvedere Island is a relatively large patch of eelgrass that serves as critical shallower water habitat. Eelgrass beds are recognized by both federal and state agencies as sensitive and highly valuable habitat for a suite of species. They are managed under the Magnuson-Stevens Fishery Conservation and Management Act. Eelgrass beds are listed as a Habitat Area of Particular Concern because they are susceptible to degradation, especially ecologically important, and/or located in an environmentally stressed area. As mean low tide rises, creating deeper waters in the bay, these plants could be denied the sunlight required to generate energy and sustain them. The loss of eelgrass beds would have significant ripple effects on other species in the Bay eco-system. Eelgrass beds are much larger and closer to shore than the mapped habitats on Map 69.

The longfin smelt is the only listed species recorded in this area. The smelt is list as threated on the California species list and a candidate for the federal list. The San Pablo Song sparrow, though not listed, is unique to the area, and has potential habitat in the vulnerable area.

Recreation
Access to the water could be compromised at the yacht club and private residential facilities. Trails around and leading to the area could also be compromised by flooding and erosion. Finally the Belvedere Community Center and Park could be vulnerable to sea level rise alone in the long-term, especially if the tide gates managing the lagoon water level fail.

Cultural Resources
Vulnerable resources: *1 California Register of Historic Places site, 4 additional locally registered historic sites*
Scenarios: All
Flood Depths: 6''- 3'2'' + 100-year storm surge
Primary Building Materials: Wood

Belvedere was first settled in the late 19th century as a fishing community, and incorporated in 1896.[183] Vulnerable historic resources in Belvedere include:

- Properties on Beach Road, along the northwest edge of Belvedere Cove are exposed, including several in the near term. A handful of these properties were designed by well-known architect Albert Farr including the Farr cottages/Farr apartments and the Belvedere Land Company. Additionally the China Cabin lies along this vulnerable waterfront stretch. This saloon was once housed by the S.S. China, built in 1866 to carry passengers from San Francisco to Asia, though the rest of the ship was burned for scrap metal.[184]
- The Belvedere Presbyterian Church/City Hall/Community Center.

[183] Belvedere, CA. Last updated January 9, 2017. en.wikipedia.org/wiki/Belvedere,_California
[184] Belvedere-Tiburon Landmarks Society, China Cabin. Accessed January 18, 2017. landmarkssociety.com/landmarks/china-cabin/

BELVEDERE

The 1905 Belvedere Land Company building reflects designer Albert Farr's signature style.[185] *Credit: Wikipedia*

Emergency Services

The largest threat to emergency services is lost emergency vehicle access to the community. High tides and storms could flood the roads in front of the police department and, in the long-term, up to four feet of flooding could impact the property and the vehicles. In addition, though technically in Tiburon, the Tiburon Fire Department serves Belvedere and could be blocked from providing service if roads are severely flooded or if the station itself is flooded.

Select assets are presented in Table 74. A 100-year storm surge would add an additional one to three feet of water to these properties. Note also, above average high tides could impact more properties than accounted for in this analysis. The maps on the following pages illustrate vulnerable utility, natural resource, recreation, emergency and historic features. The areas in the call out circles enable the reader the see areas that are difficult to see on the large scale map. The circles do not indicate that these areas are more vulnerable than others along the shoreline.

[185] Albert L. Farr. Last updated October 10, 2016. <en.wikipedia.org/wiki/Albert_L._Farr>

Map 66. Belvedere Vulnerable Cultural Resource Assets

Source: MarinMap, CoSMoS, City of Belvedere General Plan Update. Credit: Marin County CDA

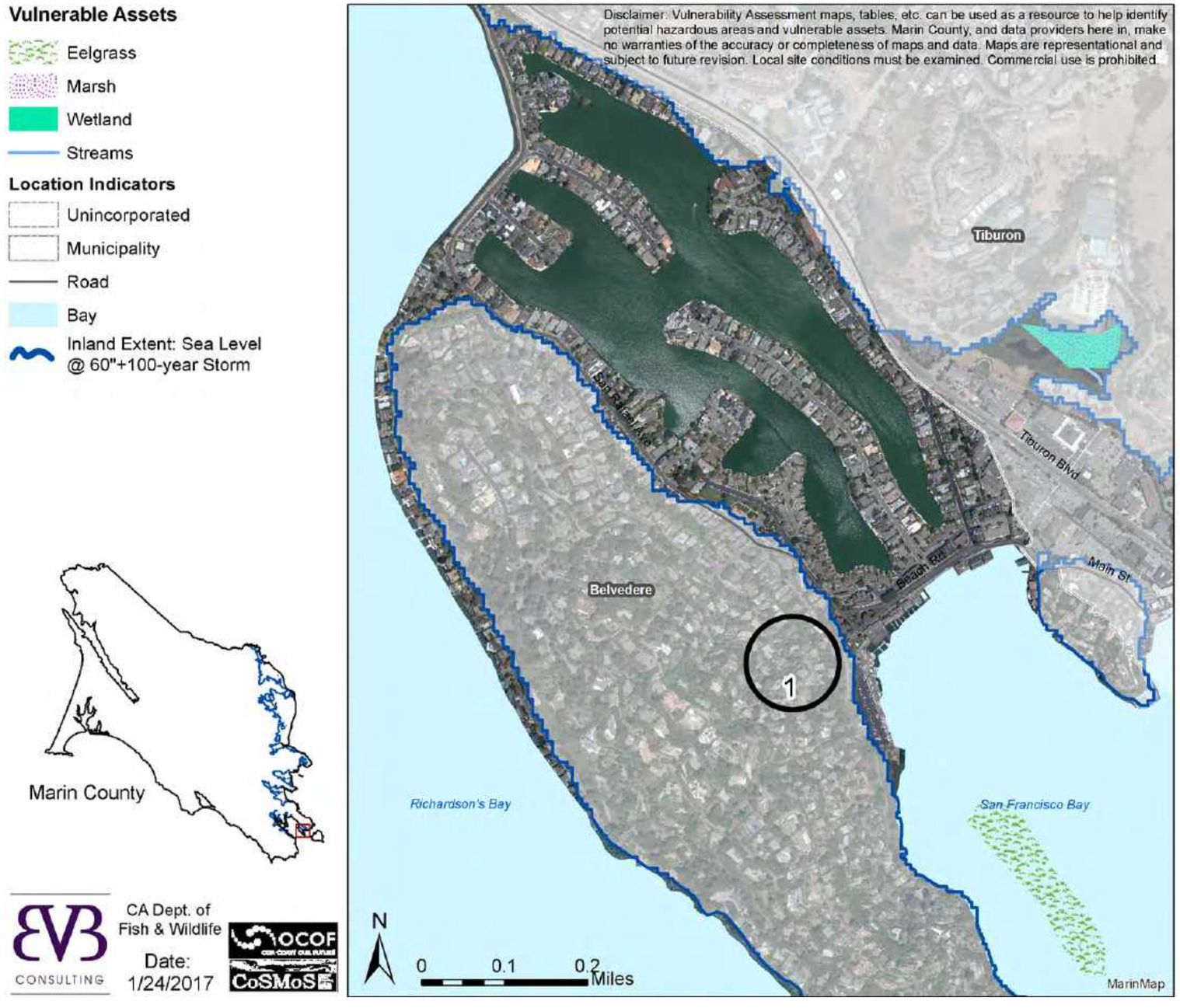
Table 74. Example Belvedere Vulnerable Assets by Sea Level Rise Onset and Flooding at MHHW

Asset	Scenarios		
	Near-term	Medium-term	Long-term
	1	3	5
Corinthian Hill homes	2'10'	3'2"	4'7"
West Shore Rd. homes	0-2'4"	2"-3'6"	5"-8'11"
SF Yacht Club	2'2"	3'6"	8'10"
Beach Rd. homes	6"	2'2"	4'
Lagoon homes		2"-3'	5"-7'9"
Corp Yard		4"	1'5"
San Rafael Ave.		0-3"	2"-4'3"
West Shore Rd.			2'3"-5'5"
Mini Park			5'3"
Beach Rd.			11"-5'
Community center city hall, & police			4'4"
Belvedere Lagoon	Saltwater resource		

Source: MarinMap, CoSMoS

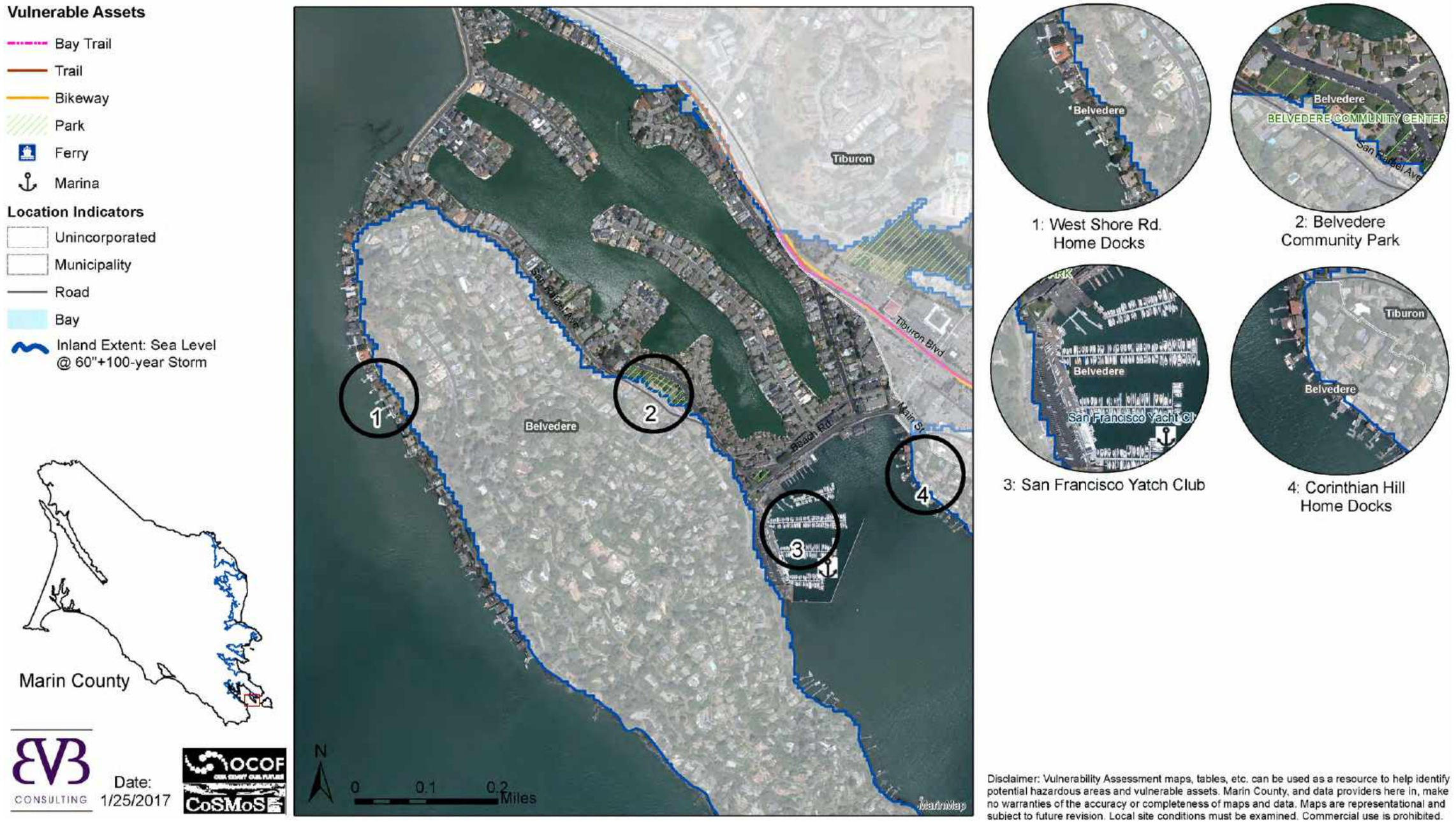
BELVEDERE

Map 67. Belvedere Vulnerable Natural Resource Assets



BELVEDERE

Map 68. Belvedere Vulnerable Recreation Assets



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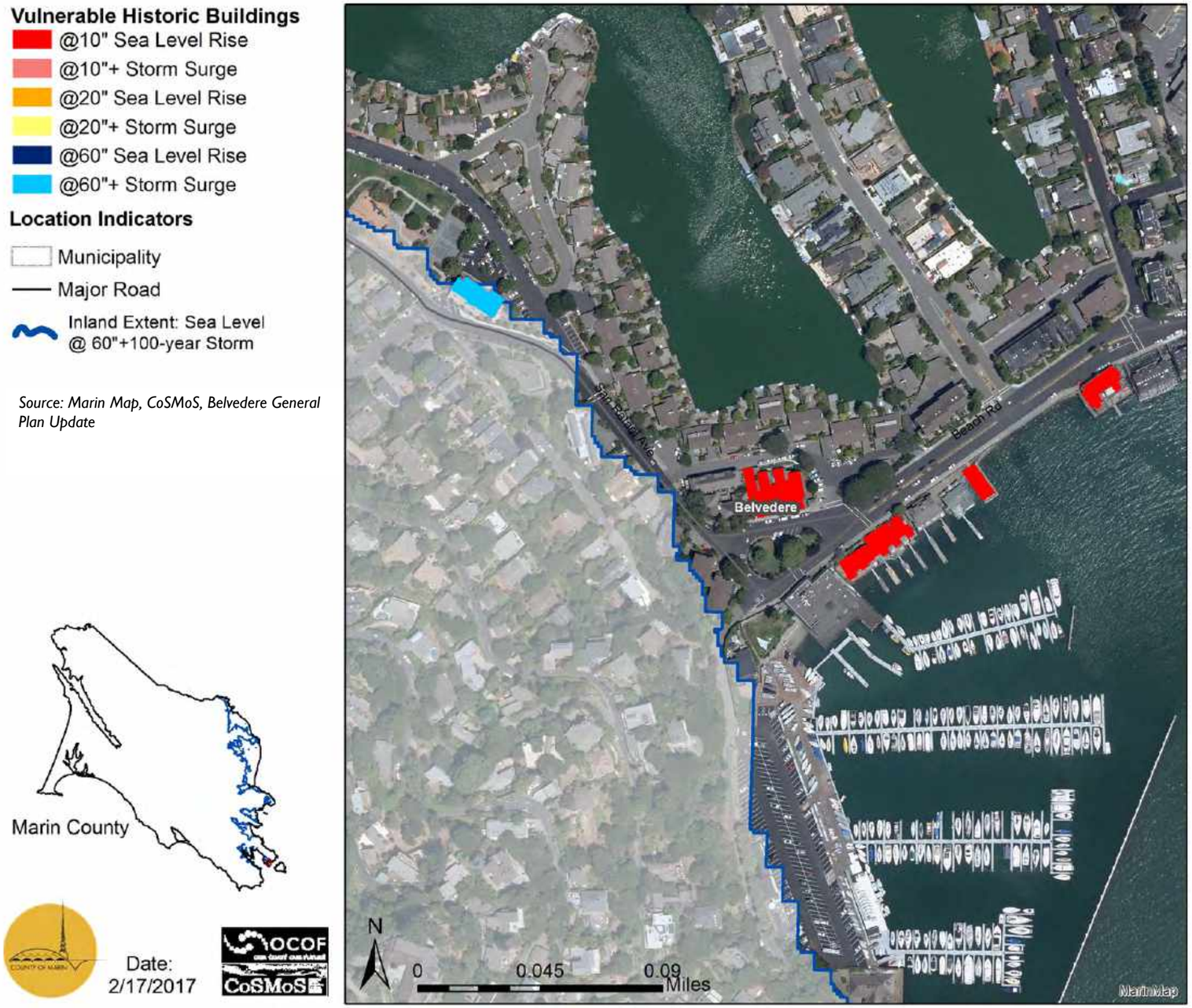
Map 69. Belvedere Cultural Resource Assets



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TIBURON

Community Profile: Tiburon

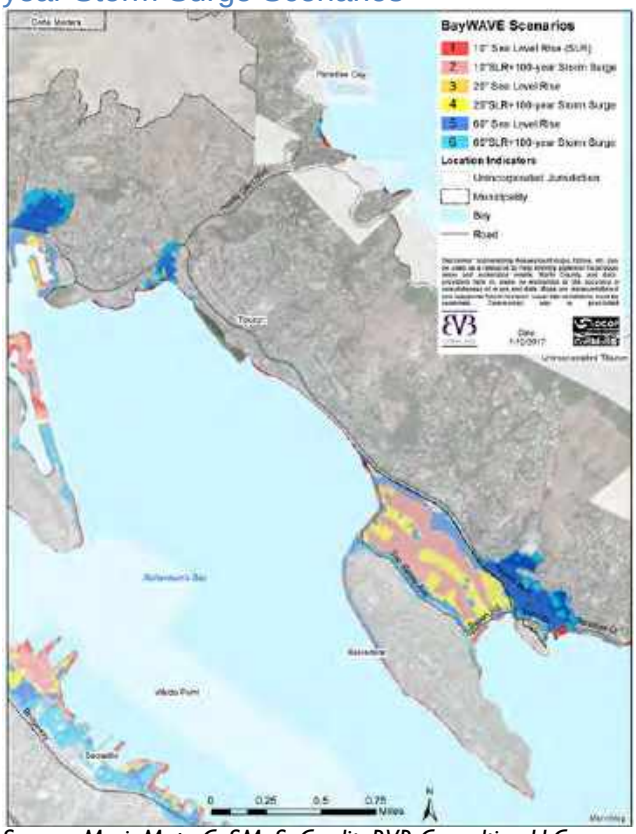
Tiburon is located along an extensive peninsula projecting into Richardson's and San Pablo Bays. The peninsula is generally steep with several areas of reinforced shoreline. However, the low-lying downtown Blackie's Pasture, and Cove areas could be vulnerable. Increased sea level rise and storm surges could significantly compromise this shoreline community in the following ways:

- Highly valued Main Street shoreline shops and restaurants could be vulnerable in the near-term.
- Homes along the interface of the bluffs and shoreline could be vulnerable to increased erosion and bluff collapse during storms.
- The Tiburon and Angel Island ferries may face complications with loading during extreme high tides, and may experience compromised American Disabilities Act (ADA) access.
- Vehicular access along Tiburon Blvd. could be compromised at the Cove Shopping Center and in downtown in the long-term.
- The Tiburon Fire Department, library, post office, and municipal facilities may be vulnerable to tidal flooding in the long-term.
- The Bay Trail and hotels downtown are compromised in the near-term.
- Corinthian Yacht Club facilities could be vulnerable to storm damage and flooding in the medium- to long-terms.
- The Cove Shopping Center is vulnerable in the long-term to sea level rise, though could suffer sooner from combinations of higher tides and stormwater.
- If US 101 is compromised, so is service and goods delivery to Tiburon businesses.
- Access to Tiburon from Corte Madera could also flood in the medium-term.
- Homes high in the hills could become isolated and cut off from necessities and the ability to leave the community, as alternative access routes are not available at this time.
- Several historic sites downtown and the old shipping terminal could flood with saltwater as early as the near-term.

IMPACTS AT-A-GLANCE

341 living units	8,500+ people
135 acres exposed	36 commercial parcels
2.4 miles of roads	
Storm and tidal impacts already occur	
Over $400 million in assessed value; nearly $600 million in single-family market family[186]	Town of Tiburon Property Owners Caltrans Marin DPW Ferry Services

Map 70. Tiburon Sea Level Rise and 100-year Storm Surge Scenarios



Source: MarinMap, CoSMoS. Credit: BVB Consulting LLC

[186] 2016 dollars

TIBURON

View of Corinthian Marina and Tiburon Ferry facilities from Shoreline Park. Credit: BVB Consulting LLC

Vulnerable Assets

Tiburon's most vulnerable assets are concentrated on the face of the peninsula, downtown, and the Cove. These areas feature housing and a number of business, civic, recreation, historic and visitor serving uses. These areas tend to draw millions of visitors a year and provide a significant amount of economic and cultural value to the community and Marin County.

Land

Low-lying land on Tiburon's steep peninsula are concentrated in small areas that ae highly developed and treasured. Bluff top parcels could expect negative impacts from storm surges that could cause the bluffs to collapse. Note that because significant amounts of development are in the uplands, the exposed land area is relatively small compared to the total area of Tiburon. Examining the exposed acreage and the vulnerable land uses on the exposed land provides a glimpse of what is at stake if actions to prepare for sea level rise are no taken.

Acres

In near- and medium-term scenarios 1, 2, 3, and 4, about fifty acres could be vulnerable. By the long-term, 106 acres could be vulnerable to sea level rise and 135 acres could be vulnerable with an additional 100-year storm surge. Despite the numeric jump, these figures account for less than one percent of Tiburon's land area.

Parcels

Table 76 shows how many parcels are in the exposed area of the community under the six BayWAVE scenarios. About 45 to 50 parcels could be vulnerable in the near- and medium-terms. IN the long-term, this number triples to 150 vulnerable parcels. An additional 100-year storm surge at five feet of sea level rise could triple this figure again, to and 450 flooded parcels.

Table 75. Tiburon Exposed Acreage

Scenarios		Acres	
		#	%
Near-term	1	48	0.3
	2	47	0.3
Medium-term	3	48	0.3
	4	49	0.3
Long-term	5	106	0.6
	6	135	0.8

Source: MarinMap, CoSMoS

Table 76. Tiburon Vulnerable Parcels at MHHW

Scenarios		Parcels	
		#	%
Near-term	1	46	1
	2	46	1
Medium-term	3	47	1
	4	49	1
Long-term	5	145	4
	6	442	12

Source: MarinMap, CoSMoS

Table 77. Tiburon Vulnerable Residential and Commercial Parcels

Land Use	Scenario					
	1		3		5	
	#	%	#	%	#	%
Residential	34	1	34	1	88	3
Commercial	4	7	5	9	36	64

Source: MarinMap, CoSMoS.

TIBURON

The Tiburon waterfront is vulnerable in the near-term. Source: Marin County CDA.

When taking a closer look at land use, a striking 65 percent of commercial properties could be vulnerable to long-term levels of sea level rise. In this scenario, tidal flooding could extend down Tiburon Boulevard. Additional stormwater from the hillsides would only exacerbate his flooding during storms. Reductions in service or loss due to building or inventory damage could have significant economic and employment repercussions for Tiburon. In earlier scenarios, roughly ten percent of commercial parcels could face tidal flooding at MHHW. While less than three percent of residential parcels in Tiburon could face tidal flooding, several downtown commercial buildings likely feature second story apartments.

Buildings

Many of Tiburon's Vulnerable parcels host buildings for commercial, residential, and public service activities. Compared to other communities in the study area, Tiburon has fewer buildings that could be vulnerable to sea level rise due to the bluff side development pattern. Nevertheless, these buildings provide much of Tiburon's historic and charming character.

Table 78. Tiburon Vulnerable Parcels by Land Use

Land Use	Scenarios					
	1		3		5	
	Near-term		Medium-term		Long-term	
	#	Ac.	#	Ac.	#	Ac.
Commercial Improved	4	1	5	1	32	18
Commercial Unimproved					4	1
Residential	34	10	42	10	87	19
Multi-Family Improved	12	3	12	3	12	3
Multi-Family Unimproved	2	0.5	2	0.5	4	0.5
Single Family Improved	13	6	13	6	62	15
Single Family Unimproved	7	0.5	7	0.6	7	0.6
Tax Exempt	8	18	8	18	20	36

Source: MarinMap, CoSMoS

Table 79. Tiburon Vulnerable Buildings

Scenarios		Buildings	
		#	%
Near-term	**1**	26	1
	2	42	1
Medium-term	**3**	42	1
	4	44	1
Long-term	**5**	153	4
	6	261	7

Source: MarinMap, CoSMoS

Table 79 shows how many buildings could be impacted under the six BayWAVE scenarios. The analysis shows that 20 to 50 buildings in the near- and medium-terms, and 150 buildings in the long-term are vulnerable to tidal flooding at MHHW. When a 100-year storm surge also occurs, 260 parcels would flood temporarily. The difference in scenario 6 parcel and building figures may be attributed to the nature of bluff side development, where the parcels could be impacted at the water's edge with the building safely elevated above and/or back from the edge.

In the downtown area, several of the buildings impacted first are restaurants that feed locals and

visitors, later the condos and other office facilities and housing just beyond the Tiburon Blvd. and Main Street intersection. Heading north along Tiburon Blvd. are several buildings, including CVS, Town Hall, Library, and other Tiburon offices that could expect tidal flooding in the long-term. Some of these buildings are newer construction and elevated with floating foundations designed to maintain stability of soggy soils. Because of this, these buildings may be able to withstand seasonal flooding; however, parking and access points could be compromised then and when tidal waters reach the area.

Housing is primarily impacted along the bluff edge around the peninsula. These properties may have docks and other structural components on the water that would be adjusted or lost first. Another batch of homes could suffer tidal impacts just east to the Cove Shopping Center in the long-term. The shopping center, which could expect over one foot of water in the medium-term and over 3 feet of water in the long-term, and the adjacent stretch of Tiburon Blvd. already face seasonal stormwater flooding. The site is equipped with a high capacity pump station to prevent flooding here. Additional tidal forces against the stormwater flow could burden the pump station and may result in more severe stormwater back-ups during high tides.

Table 80 divides the vulnerable buildings by how much water could fill the property, whether it is one, two, or ten feet of tidal waters at MHHW. In scenario 1, a few buildings downtown are flooded with seven to nine feet of water. In scenario 3, a few are flooded at low levels of flooding, and the buildings impacted in scenario 1 flood with deeper waters. In the long-term, scenario 5, nearly 100 buildings could be under three feet of flood waters, with a few buildings vulnerable to between three and six feet of flooding. The same buildings measured in scenario 1 remain under deep water at MHHW.

Table 81 outlines cost estimates for damage to buildings and their contents under scenario 6, the worst case storm surge scenario analyzed in this assessment. The analysis uses the FEMA damage tagging levels of yellow for minor damage of $5,000 and no more than $17,000 per building, orange for moderate damage of more than $17,000, and red for destroyed structures. Nearly $200 million of damage could occur if all vulnerable buildings in scenario 6 were to be destroyed in the long-term. This figure assumes all of the vulnerable buildings in scenario 6 experience one of the three damage levels, destroyed. Reality would likely reflect a mix of damage levels.

The maps on the following pages illustrate vulnerable buildings by scenario. The areas in the call out circles enable the reader the see areas that are difficult to see on the large scale map. The circles do not indicate that these areas are more vulnerable than others along the shoreline.

Table 80. Tiburon Vulnerable Buildings Average Flood Depth* Estimates at MHHW

Flood Depth (feet)		Scenario		
		1	3	5
0.1-1	#		1	22
1.1-2	#		0	34
2.1-3	#		1	37
3.1-4	#			18
4.1-5	#			4
5.1-6	#			1
6.1-7	#		1	1
7.1- 8	#	5	2	1
8.1-9	#		2	1
9.1- 10	#	1	2	2
10.1+	#			1

Source: MarinMap, CoSMoS

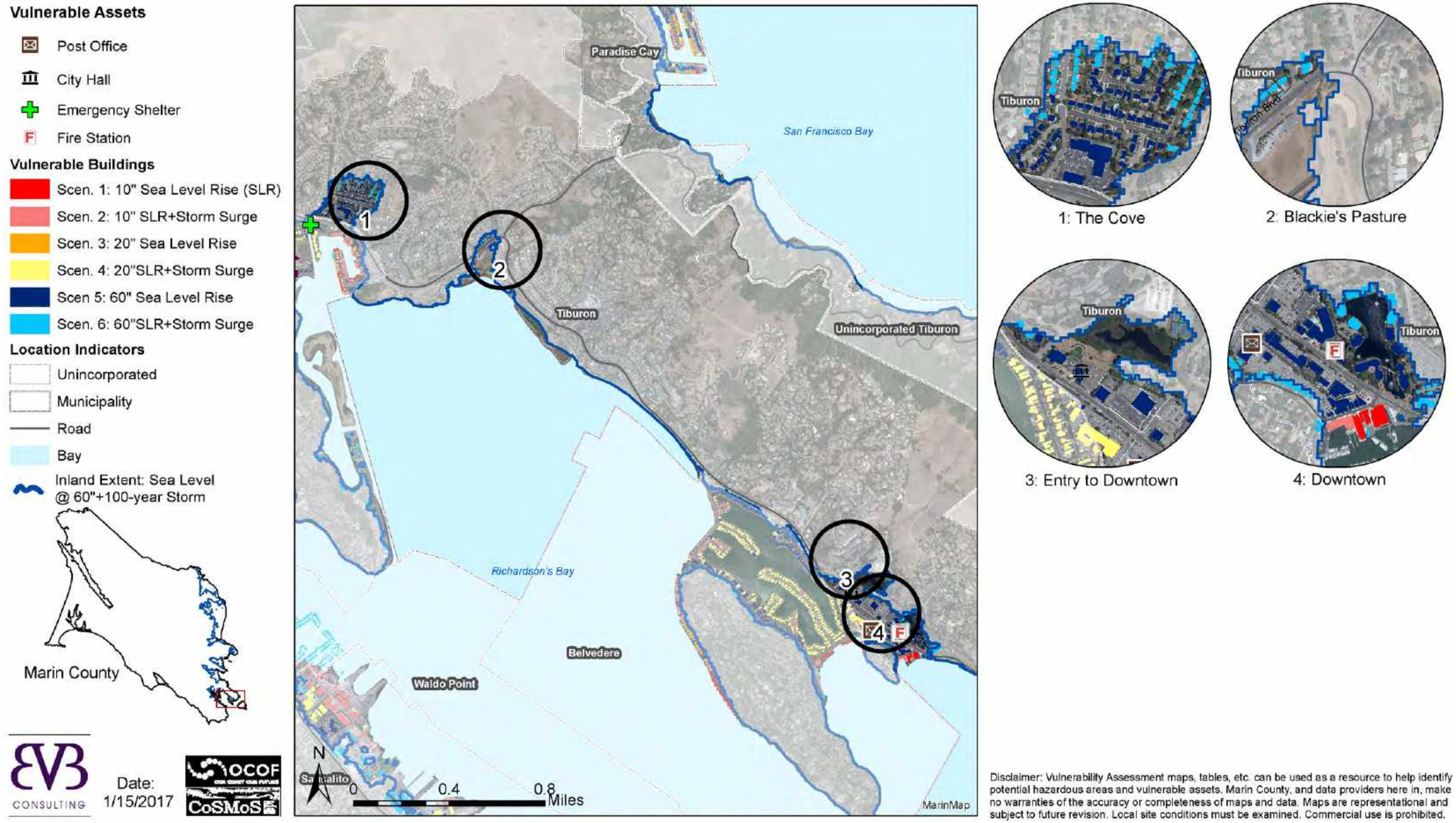
** Flood depth data is not available for all exposed areas and assets.*

Table 81. Tiburon Vulnerable Buildings FEMA Hazus Damage Estimates for Long-term Scenario 6

Buildings in Scenario 6	261
Yellow Tag-Minor Damage **$5,000 minimum**	$1,305,000
Orange Tag: Moderate Damage **$17,001 minimum**	$4,437,261
Red Tag-Destroyed **Assessed structural value**	$187,457,062

Source: MarinMap, CoSMoS

Map 71. Tiburon Vulnerable Buildings



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Transportation

The first road that could be impacted is Brunini Way in scenario 2. Additional roads downtown and west of Tiburon Boulevard may avoid impacts until after medium-term scenarios 3 and 4. Tiburon Boulevard could expect 100-year storm surge impacts in scenario 6 at Main Street, Paradise Drive, and the Cove. Tiburon Boulevard is the main access road to Tiburon. Paradise Drive offers a windy alternative; however, Paradise Drive faces its own flooding issues in Corte Madera. In addition to roads, the Bay Trail could expect flooding downtown and erosion along its course.

Roads could erode and deteriorate faster if they are repeatedly exposed to salt water. Vehicles can also be destroyed by salt water exposure. Temporary closures to the road and bicycle network could have significant impacts on commuting to and from the peninsula to US Highway 101, completing daily routines, recreational opportunities, and emergency vehicle access. Disruptions in the road network would disrupt Golden Gate Transit Route 8 service along Tiburon Boulevard and at the following stops:

- Tiburon Blvd. and Mar West St.,
- Tiburon Blvd. and Main St., and
- Tiburon Blvd. and Beach Rd.

If public transportation gets cut off because roads are inundated, people who travel through or to the area for work would be cut off. Similarly, people with mobility or health constraints will be affected.

Tiburon also features a robust boating center with the Corinthian Yacht Club, the Blue and Gold commuter ferry to San Francisco, and the Angel Island Ferry. These sites can typically adjust to higher tides, though they made need to be elevated. If the adjacent land severely floods, access to these water transportation features may not be available. This could significantly impact commuting to San Francisco via ferry, and travel to Angel Island. In addition, several private docks could be vulnerable in their current elevations. These facilities are anticipated to tolerate higher tides; however, storms are known to damage piers, docs, and other marina structures.

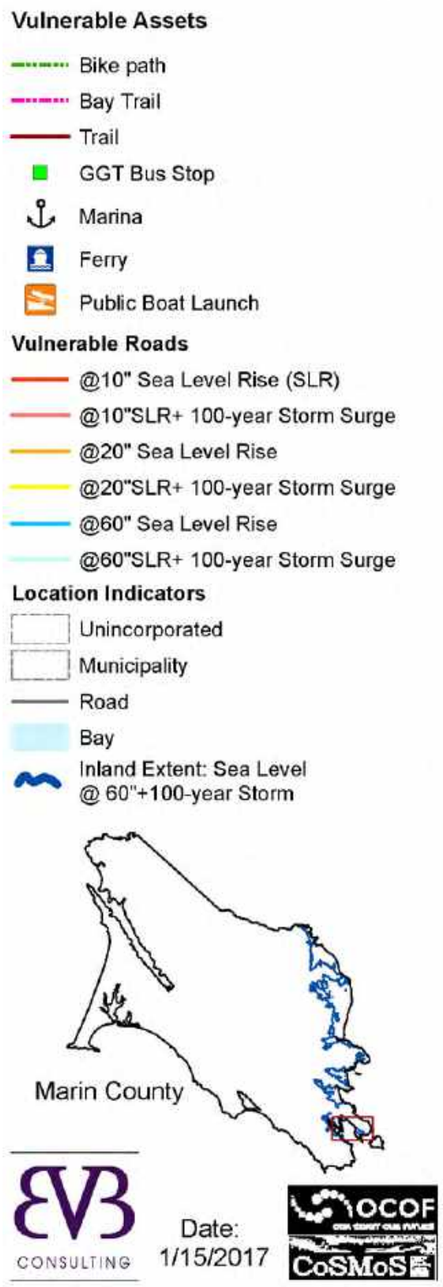
Table 82 lists Tiburon transportation routes by when they are exposed to salt water at MHHW. The maps on the following pages illustrate vulnerable transportation features. The areas in the call out circles enable the reader the see areas that are difficult to see on the large scale map. The circles do not indicate that these areas are more vulnerable than others along the shoreline.

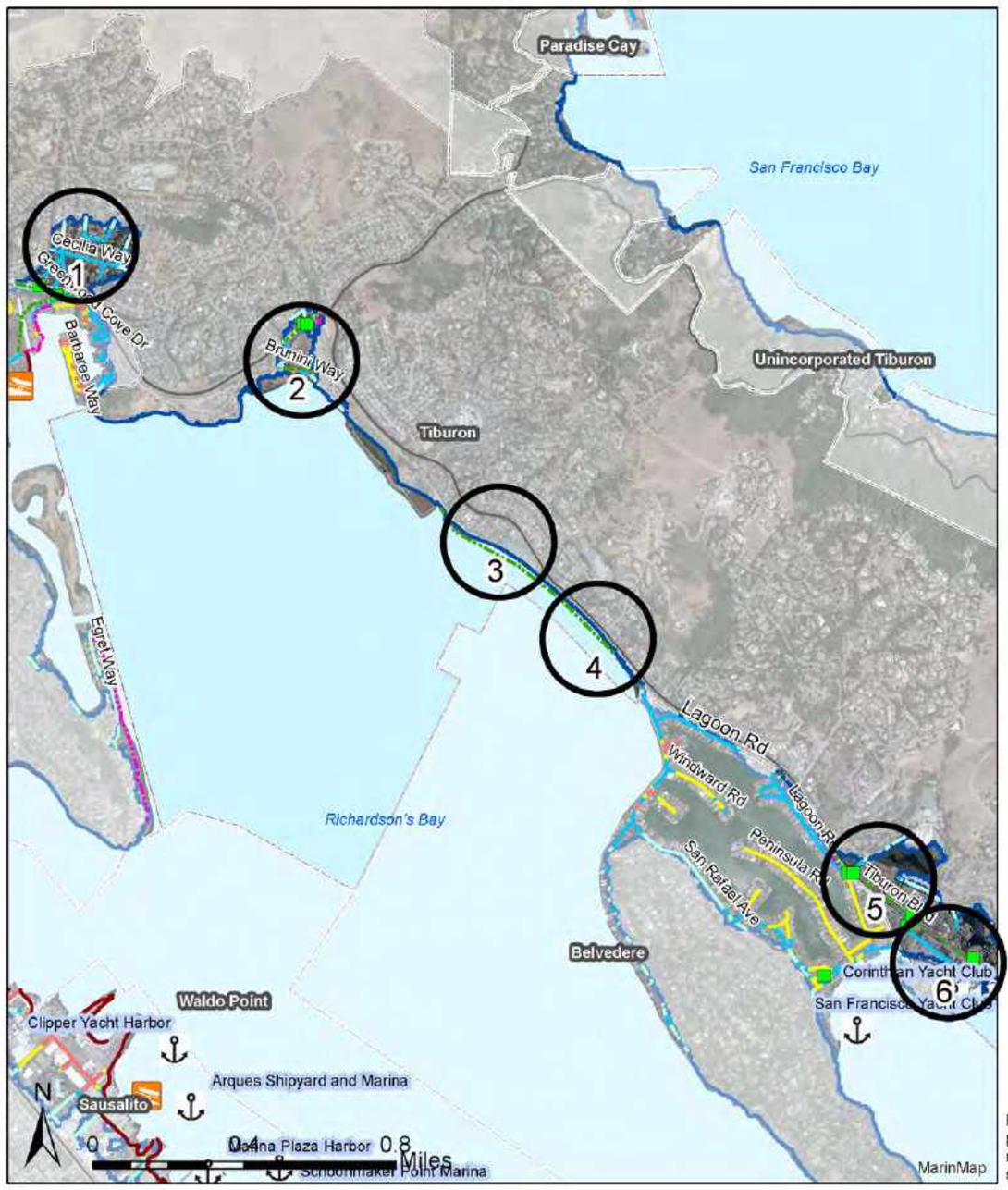
Table 82. Tiburon Vulnerable Transportation Assets

Near-term		Medium-term		Long-term	
Scenario 1	**Scenario 2**	**Scenario 3**	**Scenario 4**	**Scenario 5**	**Scenario 6**
None	0.01 miles	None	0.02 miles	1.5 miles	2.5 miles
	Brunini Wy [L]		Road from scenario 2	Road from scenarios 2 & 4 Beach Rd [L] Blackfield Dr [L] Blackies' Pasture Rd [L] Cecilia Wy [L] Claire Wy [L] Harriet Way [L] Juanita Ln [L] Lagoon Vista [P] Leland Wy [L] Main St [L] Mar West St [L] Marsh Rd [P] Pamela Ct [L] Paradise Dr [L, M]	Roads in scenarios 2, 4, & 5 Tiburon Blvd [C] Jefferson Dr [L] Washington Ct [L]

M = Marin County; C = State of California; L = Local Municipality; P = Private. Source: MarinMap, CoSMoS

Map 72. Tiburon Vulnerable Transportation Assets





1: Northern Marinship

2: Southern Marinship

3: Bridgeway

4: Golden Gate Ferry.

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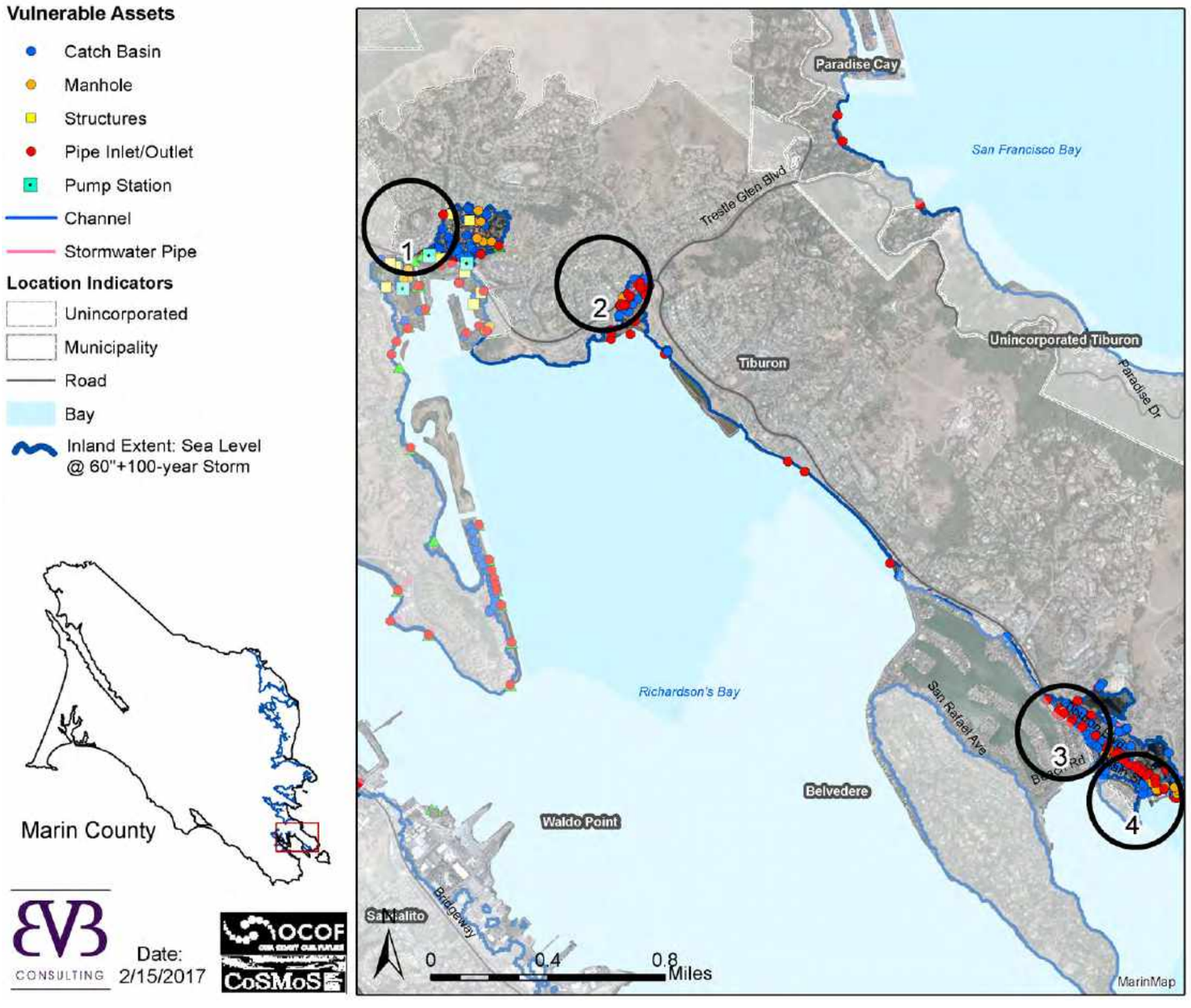
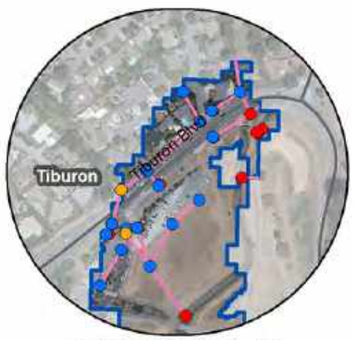
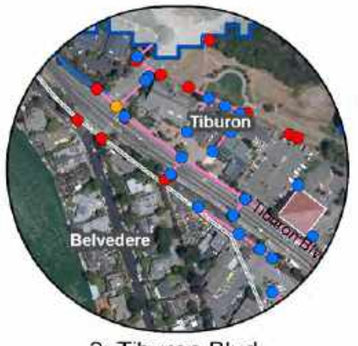
Map 73. Tiburon Vulnerable Stormwater Management Assets



1: Cove Shopping Center



2: Tiburon Blvd. @ Blackie's Pasture



3: Tiburon Blvd.

4: Tiburon Blvd. Downtown

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TIBURON

Pump station and overflow pond at the Cove Shopping Center. Credit: Marin County DPW

Utilities

Tiburon will likely face utility issues common in other shoreline communities in the study area, including:

- Underground pipes face compounding pressure forces from water and the road,
- Road erosion and collapse with underlain pipes,
- Saltwater inflow and infiltration causing inefficiencies in wastewater treatment,
- Continuously subsiding soils or fill, and
- Escalating activity, capacity demands, energy consumption, and wear and tear on pump stations in stormwater and wastewater systems,
- Aging individual site connections for water, sewer, and electrical, and
- Flood waters interrupting access for employees to reach work sites.

The smaller of two treatment plants in Sanitary District No. 5, the Paradise Cove Plant, would be impacted at scenario 6, 5 feet of sea level rise, plus 100-year storm surge. The main issues are worsening erosion and flooding at this site, saltwater intrusion for sewer lines along Tiburon Boulevard that run along the beach, a manhole at Beach Road and Tiburon Boulevard that already floods, and pump station electrical panels.

The primary treatment facility off Tiburon Boulevard could anticipate some flooding during storm surges in the parking lot. This flooding may also create access issues for employees and cause wear and tear on facility vehicles and equipment.

A majority of the pipes are original, and are planned for replacement, including the force main for Belvedere. All sewage is pumped from smaller pump stations to one main pump station and the 50-year old connecting pipe needs repair.[187]

The maps on the previous pages illustrate vulnerable utility features. The areas in the call out circles enable the reader the see areas that are difficult to see on the large scale map. The circles do not indicate that these areas are more vulnerable than others along the shoreline.

Natural Resources

The Tiburon Peninsula provides ample bird habitat, fishing, and other open water habitats. Small marshes also support wetland species. These habitats are very narrow and may already be drowned out at existing high tides. As sea level rises, these habitats could become dominated by standing water. Eelgrass is also a critical tidal habitat, typically in slightly deeper, saltier waters, associated with rocky ground. Eelgrass was observed off Tiburon Point off the high bluff extending into the San Francisco Bay. Eelgrass beds are recognized by both federal and state agencies as sensitive and highly valuable habitat for a suite of species. They are managed under the Magnuson-Stevens Fishery Conservation and Management Act. Eelgrass beds are listed as a Habitat Area of Particular Concern because they are susceptible to degradation, especially ecologically important, and/or located in an environmentally stressed area. As mean low tide rises closer to the bluff edge, these essential plants would be stressed by inadequate sunlight.

The longfin smelt is the only listed species recorded in this area. The smelt is list as threated on the California species list and a candidate for the federal list. The San Pablo Song sparrow is unique to the area and lives in potentially vulnerable habitat. In addition, the Tiburon Mariposa Lily at Ring Mountain could also be vulnerable to increased salinity.

Recreation

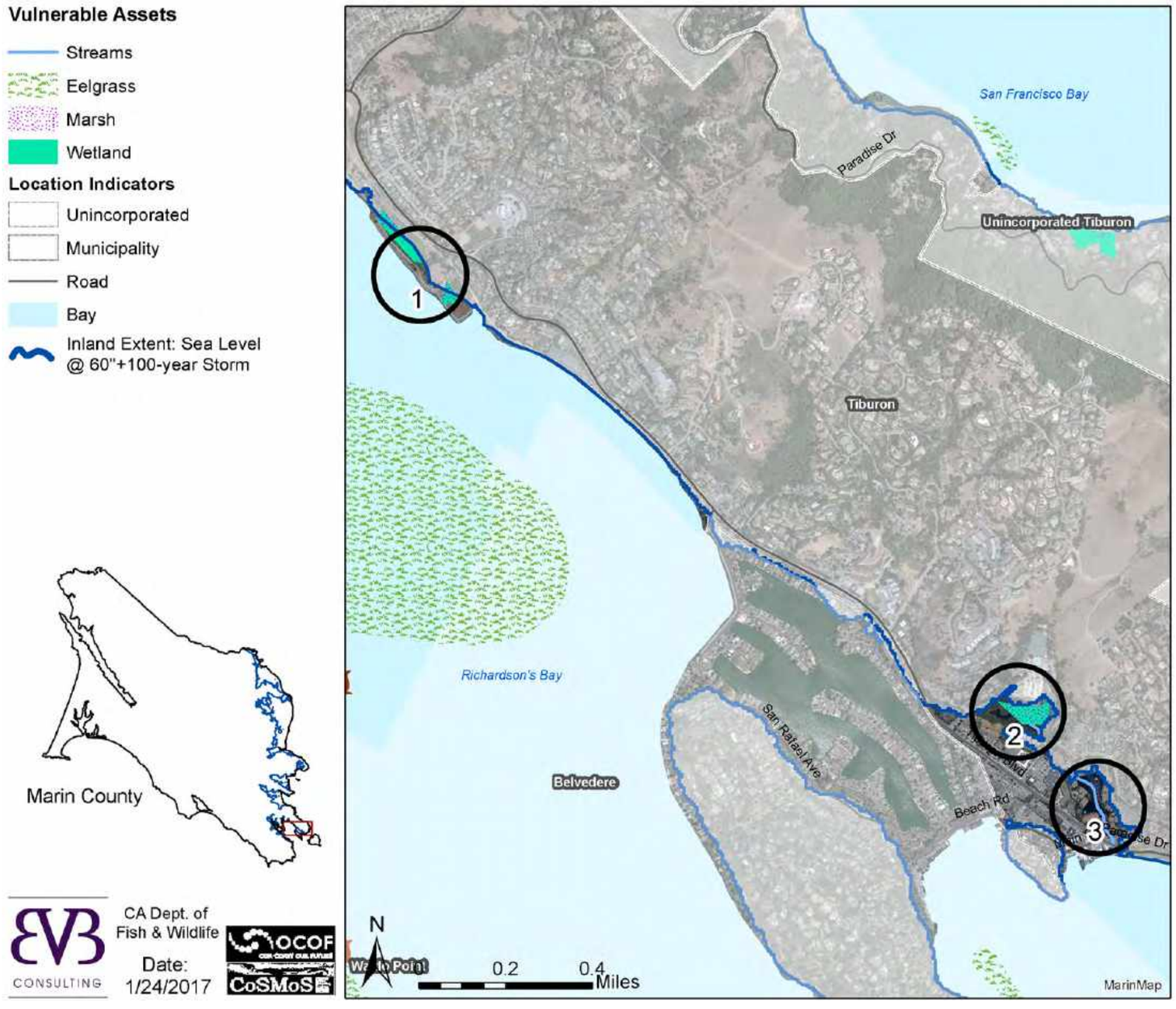
Tiburon is a destination for visitors via ferry, boat, bike, and car. The shoreline view of San Francisco, water bordering restaurants, and a walkable downtown, draw tourists from around the world to this small community. The main concern is reduced functionality of vulnerable transportation assets,

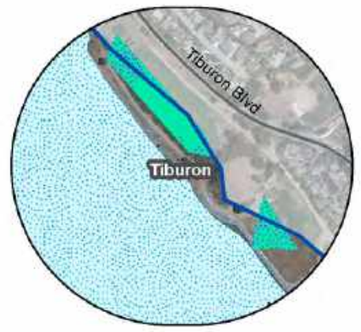
[187] Sea Level Rise Interview. Jan. 20, 2016. Sanitary District No. 5. Tony Rubio. Interviewed by C. Choo, Marin County Public Works.

including the Bay Trail and ferry service to San Francisco and Angel Island State Park. In addition, restaurants, hotels, and other visitor serving facilities on the shoreline could be vulnerable in the near-term. Potentially vulnerable hotels are the Water's Edge Hotel and the Lodge at Tiburon.

The maps on the following pages illustrate vulnerable natural resource, recreation, emergency and historic features. The areas in the call out circles enable the reader the see areas that are difficult to see on the large scale map. The circles do not indicate that these areas are more vulnerable than others along the shoreline.

Map 74. Tiburon Vulnerable Natural Resource Assets





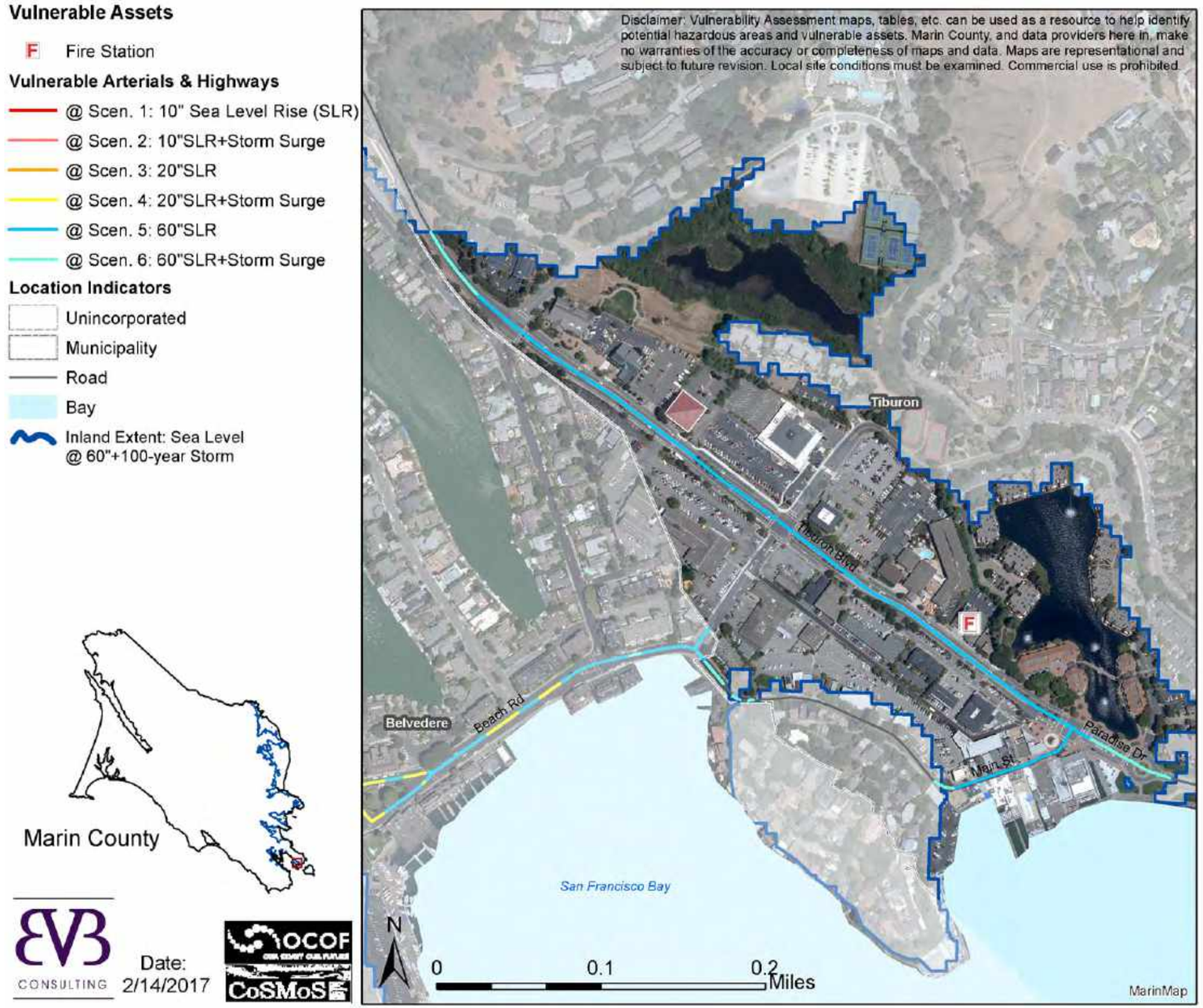
1: McKegney Field

2: Pt. Tiburon Marsh

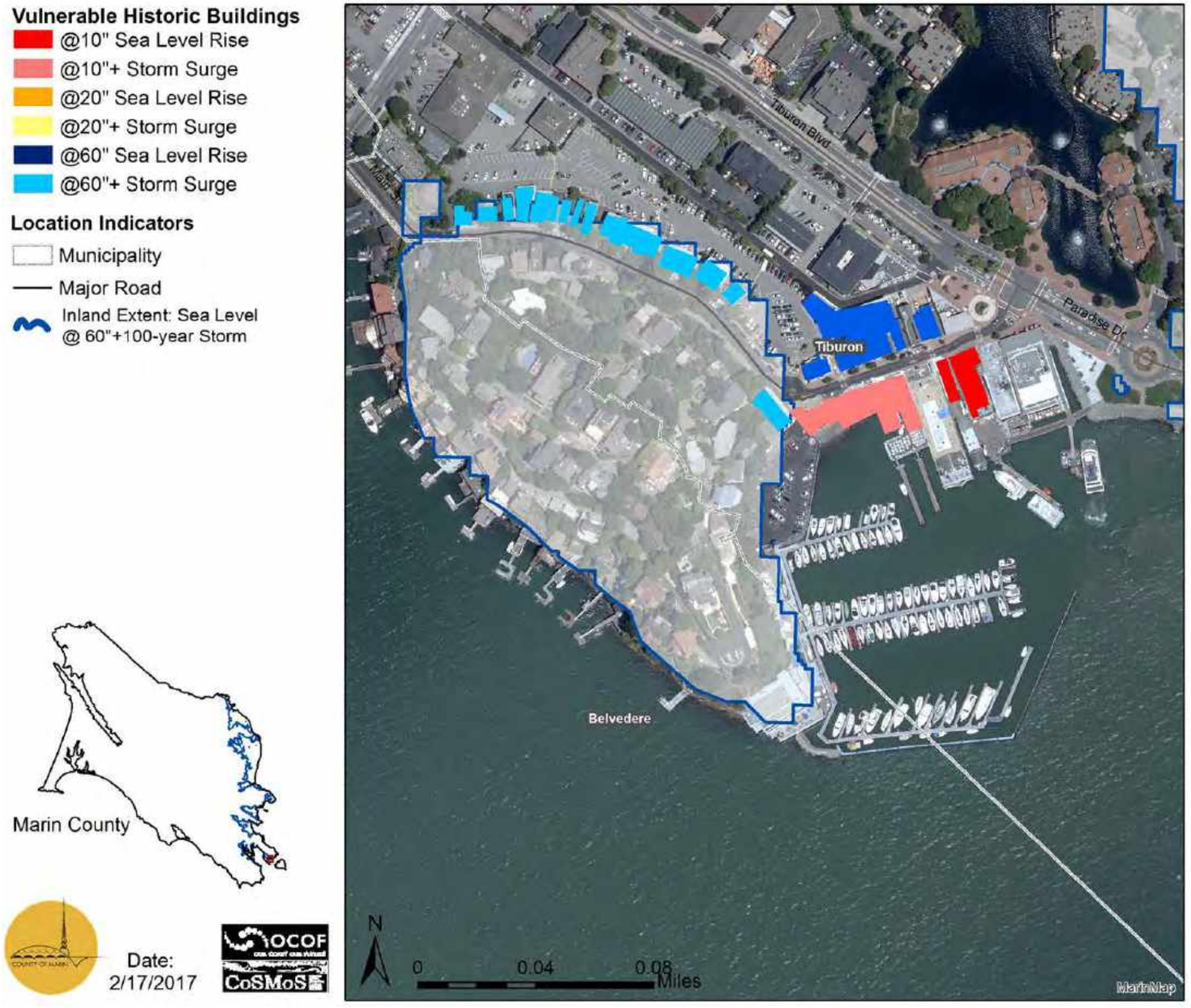
3: Lagoon Vista

Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data providers here in, make no warranties of the accuracy or completeness of maps and data. Maps are representational and subject to future revision. Local site conditions must be examined. Commercial use is prohibited.

Map 75. Tiburon Vulnerable Emergency Assets



Map 76. Tiburon Vulnerable Cultural Resource Assets



Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data providers here in, make no warranties of the accuracy or completeness of maps and data. Maps are representational and subject to future revision. Local site conditions must be examined. Commercial use is prohibited.

Tiburon's Main Street buildings date back to the early 1900s. Credit: Marin County CDA

Southern terminus of the Northwestern Pacific Railroad, Tiburon. Credit: San Francisco and North Pacific Railroad Station House-Depot National Register of Historic Places

Emergency Services

The Tiburon Fire Department could tidally flood in the long-term and experience restricted access throughout and out of downtown Tiburon. If Tiburon Boulevard is compromised, service up to the bluff may take longer. Service to the Cove area could be hindered by flooding on Tiburon Boulevard and within the Cove neighborhood itself.

Cultural Resources

Vulnerable historic buildings in Tiburon are the Peter Donahue Building on the National Register of Historic Places[188] and several others on the Local Historic Inventory for Downtown Tiburon. Vulnerable historic sites include over 20 buildings built in the 1920s along upper and lower Main Street. Then and now, commercial uses provide commuters and visitors using the Tiburon Ferry Terminal. Several lower Main Street sites could be subject to tidal inundation in the near-term. Upper Main Street sites are subject to storm surge flooding in the long-term. Just beyond the downtown, the San Francisco and North Pacific Railroad Station House-Depot, or the Peter Donahue Building, could be vulnerable to the 100-year storm surge in long-term scenario 6. Overall, these buildings could be vulnerable to over eight feet of tidal and storm surge flooding.

Table 83 lists example vulnerable assets in Tiburon by onset and flood depth. A 100-year storm surge would add an additional 1 to 3 feet of water to these properties. Note also, above average high tides, such as king tides, could impact more properties than accounted for in this analysis.

Table 83. Example Tiburon Vulnerable Assets by Onset and Flooding at MHHW

Asset	Scenarios		
	Near-term	Medium-term	Long-term
	1	3	5
Waterfront	9'2"	9'11"	12'9"
Pt. Tiburon Shoreline Park	8'	8'8"	11'6"
Ferry facilities	4'	5'	12'9"
Corinthian Yacht Club	4'	4'3"	11'
Richardson Bay Lineal Park	0-3'	1"-3'7"	1"-15'
Blackie's Pasture	0-9"	5'4"	12'9"
Cypress Garden Park	7"	1'4"	4'4"
Tiburon Blvd. shopping		4"-2'	1'-5'4"
Cove Shopping Center		1'8"	3'11"
Post office		1'6"	3'11"
Tiburon Fire Department		1'	2'6"
Town Hall		1'	2'2"
Town Library		1'	2'2"
Tiburon Blvd.			9"-5'
Zelinsky Park			4'10"
Pt. Tiburon Marsh			4'4"
Bay Trail			6"-3'
Main Street			4"-2'5"
Bel Aire Park			2'4"

Source: MarinMap, CoSMoS

[188] Arnett, V.M. 1994. National Register of Historic Places Form-San Francisco and North Pacific Railroad Station House & Depot.

CORTE MADERA

Community Profile: Corte Madera

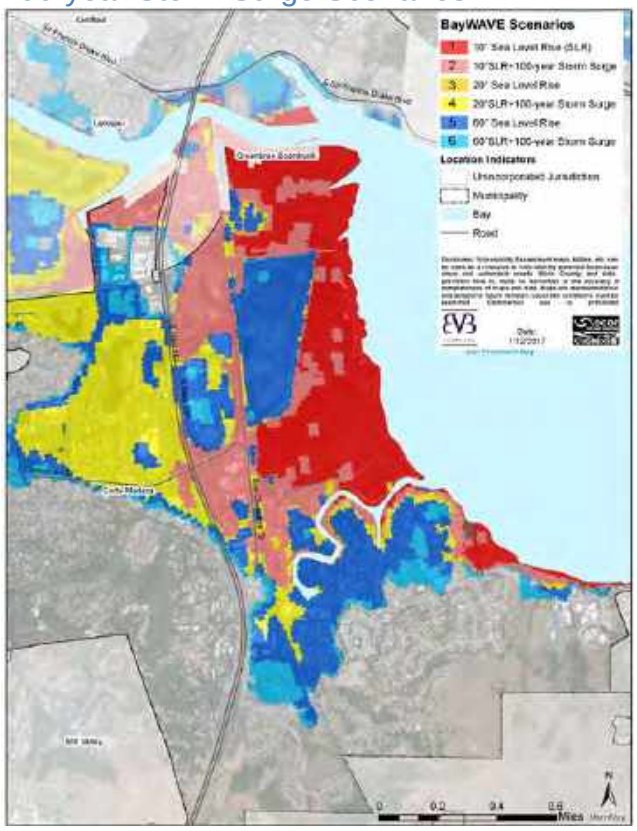
Corte Madera is a primarily residential community with several large commercial areas that take advantage of the highway corridor. These commercial areas serve the entire region and include outdoor malls, auto dealerships, restaurants, and other local business. In the near-term, 230 acres could be exposed to sea level rise. By the long-term, 906 acres could be exposed to sea level rise and 994 acres could be exposed with an additional 100-year storm surge. Key vulnerabilities in Corte Madera include:

- Homes along the tributaries to Corte Madera Creek may be vulnerable in the near-term.
- Commercial areas on Paradise Drive may be vulnerable to sea level rise in the near-term, and storm surges sooner.
- Segments of the 101 could be vulnerable to seasonal storm surges in the near-term, and sea level rise in the medium to long-terms. Access to the community from the US Highway 101 corridor may become increasingly difficult with chronic flooding.
- Marin Country Day School, Marin Montessori, Cove Elementary, and Neil Cummins elementary could be vulnerable across the scenarios.
- Mariner Cove and Marina Village are already susceptible to subsidence and could be vulnerable to sea level rise surface flooding in the near-term.
- Madera Gardens and the Corte Madera Town Center could be vulnerable to the 100-year storm surge in the medium-term, scenario 4, and sea level rise in the long-term, scenario 6.
- Stormwater pump stations could become tidally influenced and overburdened. If the pump station fails or capacity is exceeded, the surrounding neighborhoods could flood.
- Marsh land degradation or loss at the shoreline and Corte Madera Creek tributaries.
- The fire station on Paradise Drive could experience flooding impacts and access issues in the medium-term.
- Police serving the community are headquartered in Larkspur. Flooded roads could increase response times, and at worst, low lying areas become blocked to vehicles.
- California Highway Patrol (CHP) Marin headquarters is vulnerable to subsidence and sea level rise in the medium-term.

IMPACTS AT-A-GLANCE: SCENARIO 6

1,500+ living units	9,500+ people
994 acres exposed	79 commercial parcels
16 miles of roads	
Storm, tidal, and subsidence impacts already occur	Corte Madera Caltrans Central Marin PD Corte Madera Fire CHP Larkspur-Corte Madera School District HOAs Property Owners
$1.4 billion worth of assessed property value; assets vulnerable; $1.5 billion in single family market value[189]	

Map 77. Corte Madera Sea Level Rise and 100-year Storm Surge Scenarios



[189] 2016 dollars

CORTE MADERA

Housing at the end of Lucky Drive. Corte Madera. Credit: Marin County DPW

Vulnerable Assets

Corte Madera's most vulnerable assets in the near-term include commercial and residential south of US Highway 101 and along Corte Madera Creek. In the long-term, flooding could pass through the US Highway 101 corridor, flooding commercial development, and residential west of the highway.

Land

Corte Madera is one of the County's large municipalities and has relatively long length of shoreline that is protected by armoring with development not too far behind in most cases. Corte Madera also features productive tidal marshes that may help preventing major flooding before the medium-term. Note also, that Corte Madera city limits extend well into the upland valleys. However, unlike communities further south, Corte Madera has considerable low-lying areas, especially historic marshes filled for development.

Acres

In the near-term, 230 acres, or eight percent of Corte Madera, could be exposed to tidal flooding and another 200 acres could be exposed to storm surge flooding only. In Medium-term scenario 3, eleven percent of Corte Madera, or about 300 acres could be exposed to sea level rise tidal flooding at MHHW. With the additional 100-year storm surge in scenario 4, twice this area could face nuisance storm-surge flooding. In the long-term more than thirty percent of Corte Madera could be subject to MHHW tidal flooding and 100-year storm surge flooding.

Table 84. Corte Madera Exposed Acres

Scenarios		Acres	
		#	%
Near-term	1	230	8
	2	430	15
Medium-term	3	313	11
	4	640	22
Long-term	5	906	32
	6	994	35

Source: MarinMap, CoSMoS

Table 85. Corte Madera Vulnerable Parcels at MHHW

Scenarios		Parcels	
		#	%
Near-term	1	9	0
	2	201	6
Medium-term	3	68	2
	4	635	17
Long-term	5	1,104	30
	6	1,535	42

Source: MarinMap, CoSMoS

Parcels

Examining how this acreage is divided in to parcels for development and reservation, and what uses are on the land can provide a representation of the human activities that could be vulnerable in Corte Madera. In the near-term, few parcels could be vulnerable to tidal flooding; however, 200 could be vulnerable to 100-year storm surge flooding. In the medium-term, nearly 70 parcels could experience tidal flooding. Several of these are marshes and parklands, though some residential parcels off Lucky Drive could be vulnerable to flooding by this time period. A 100-year storm could flood, almost 20 percent of parcels with bay storm waters. In the long-term, more than 1,100 parcels may be subject to tidal and storm-surge flooding. These parcels constitute one-third of Corte Madera's parcels. With an addition 100-year storm surge, more than 40 percent of Corte Madera could be impacted by flooding. This level of flooding would be devastating to development and property owners.

CORTE MADERA

Table 86. Corte Madera Vulnerable Parcels by Land Use

Land Use	Scenarios					
	1		3		5	
	Near-term		Medium-term		Long-term	
	#	Ac.	#	Ac.	#	Ac.
Commercial Improved			4	3	70	95
Commercial Unimproved					8	3
Industrial Improved					5	8
Industrial Unimproved					3	5
Residential	3	1	57	28	944	152
Multi-Family Improved					3	1
Single Family Attached			2	25	66	3
Single Family Improved	2	0.6	55	9	871	147
Single Family Unimproved	1	0.4	2	0.4	4	1
Tax Exempt	3	237	4	274	52	472
Exemption Improved	1	3			10	10
Exemption Vacant	2	25	1	3	3	27

Source: MarinMap, CoSMoS

Table 87. Corte Madera Vulnerable Residential and Commercial Parcels

Land Use	Scenario					
	1		3		5	
	Near-term		Medium-term		Long-term	
	#	%	#	%	#	%
Residential	3	0	57	3	944	29
Commercial			4	3	79	66

Source: MarinMap, CoSMoS.

Across land uses, the majority of acreage in the near-term is dedicated to tax exempt lands, which are typically parks and open space, and this case, mostly marshes. Residential is also vulnerable in the Marina Village and Mariners Cove. In the medium-term, commercial parcels along San Clemente Drive could expect tidal impacts in the parking lots. In the long-term, all of the marshes are flooded, as are most of the neighborhoods east of Paradise Drive. These nearly 1,000 parcels account for thirty percent of Corte Madera residential parcels. The eighty parcels that could expect tidal flooding impacts on a regular basis account for seventy percent of commercial parcels in Corte Madera. This is a significant portion of commercial properties in the community. Moreover, these businesses serve as a regional center of commerce serving more than just the Corte Madera community. Several of the businesses also sell high value items, such as cars, furniture, and more. Of note, a few industrial use parcels could face tidal flooding.

Buildings

Buildings on the flatlands of Corte Madera were built on filled in marshes that extend to Kentfield, and are already vulnerable to subsidence. East of U.S> High 101, Mariner Cove is built on fill and is not levee protected. Marina Village is protected to the north by a levee. However, the eastern side of Marina Village is raised by fill and may be susceptible to sea level rise along San Clemente Creek first. Mariners Cove may be susceptible to sea level rise along San Clemente Creek as well. Further east along the roadway are commercial centers that are fronted by marsh lands tempered with an earthen levee used as a trail. These commercial areas, including Aegis Senior Living complex, may be vulnerable across all of the sea level rise scenarios, first impacting the low-lying car dealership area and spreading outwards.

In long-term scenario 5, the area north of US 101 including the Corte Madera Town Center, could also be impacted. While it is plausible this area could be reached by storms in the medium-term, long-term sea level rise could burden the area with regular tidal influences. Water could also impact the area north of the highway from the creek system and channels extending into the city. This area is also impacted by stormwater backups due to tidal influences that would worsen. In fact, this issue may have led to a two week shut down of half of Neil Cummings Elementary School.

Table 88. Corte Madera Vulnerable Buildings by Scenario

Scenarios		Buildings	
		#	%
Near-term	1	5	0
	2	255	7
Medium-term	3	138	4
	4	804	21
Long-term	5	1,283	33
	6	1,468	38

Source: MarinMap, CoSMoS

Table 89. Corte Madera Vulnerable Buildings Average Flood Depths* at MHHW

Flood Depth (feet)	Scenarios		
	Near-term	Medium-term	Long-term
	1	3	5
0.1-1	1	43	34
1.1-2	4	79	240
2.1-3	0	10	206
3.1-4		1	200
4.1-5		2	240
5.1-6			224
6.1-7			106
7.1- 8			15
8.1-9			1

Source: MarinMap, CoSMoS
**Flood depth data is not available for all exposed areas and assets.*

Table 90. Corte Madera Vulnerable Buildings' FEMA Hazus Storm Damage Cost* Estimates in Long-term Scenario 6

Number of Buildings in Scenario 6	1,468
Yellow Tag :Minor Damage $5,000	$7,340,000
Orange Tag: Moderate Damage $17,001+	$24,957,468
Red Tag-Destroyed Assessed structural value	$726,321,314

Source: MarinMap, CoSMoS
** 2016 dollars*

As seen in Table 88, in the near-term, buildings are not impacted until the 100-year storm surge condition is applied, amounting to 255 buildings. In the medium-term, nearly 140 buildings may be vulnerable to tidal flooding. And more than six hundred more buildings are vulnerable with the 100-year storm surge coincidence. These figures constitute one-fifth of the community's buildings. By scenario 5, nearly 1,300 buildings could expect tidal flooding impacts, and a few hundred more could be damaged from storm surge impacts.

Table 89 indicates how many buildings could fill with one, two, or ten feet of water when flooded due to sea level rise at MHHW. In the near-term, five vulnerable buildings could expect less than or equal to two feet of tide waters. This trend continues for the majority of the buildings in scenario 3 as well. In long-term scenario 5, 500 buildings could be flooded with up to three of saltwater. More than 650 buildings could be flooded with more than three feet and up to six feet of water, and about 125 buildings could be flooded with between six and nine feet of saltwater on a regular basis. These properties would be unusable in their current state.

Table 90 estimates costs using FEMA Hazus post-disaster damage tagging levels for buildings and their contents. These figures are based on scenario 6, the worst case scenario examined in this assessment. This analysis assumes every building experiences the same damage level, such that if all 1,500 buildings are yellow-tagged, up to $25 million in damages could incur. At the high end, more than $700 million[190] of structural damages could occur. Reality would likely reflect of mix of these damage levels.

The maps on the following pages illustrate vulnerable buildings by scenario. The areas in the call out circles enable the reader the see areas that are difficult to see on the large scale map. The circles do not indicate that these areas are more vulnerable than others along the shoreline.

[190] 2016 dollars

CORTE MADERA

Map 78. Corte Madera Vulnerable Buildings

Vulnerable Assets

- School
- Emergency Shelter
- Fire Station
- Law Enforcement

Vulnerable Buildings

- Scen. 1: 10" Sea Level Rise (SLR)
- Scen. 2: 10" SLR+Storm Surge
- Scen. 3: 20" Sea Level Rise
- Scen. 4: 20"SLR+Storm Surge
- Scen 5: 60" Sea Level Rise
- Scen. 6: 60"SLR+Storm Surge

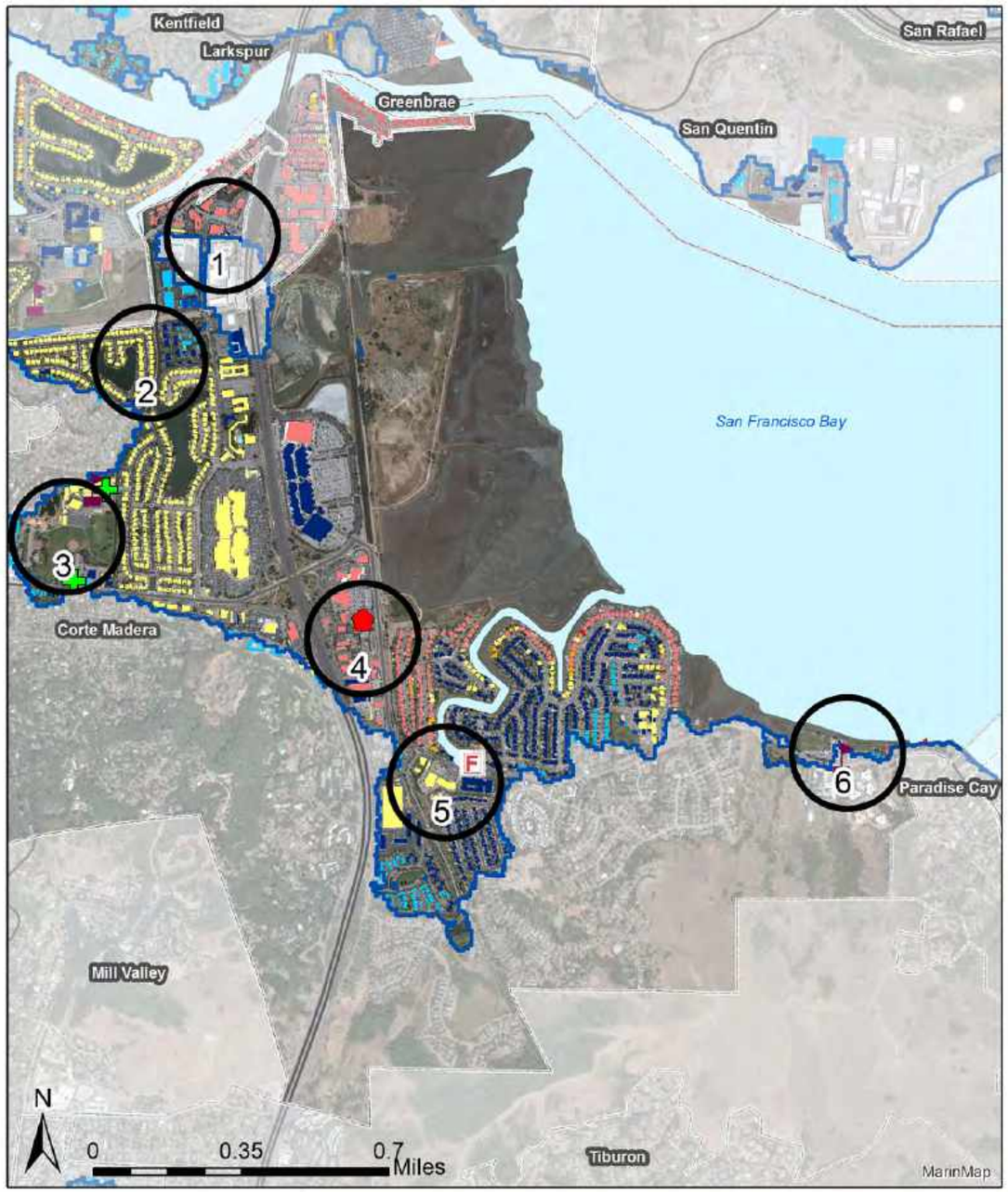
Location Indicators

- Unincorporated
- Municipality
- Road
- Bay
- Inland Extent: Sea Level @ 60"+100-year Storm

EVB CONSULTING

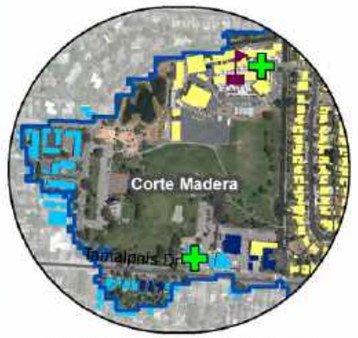
Date: 6/15/2017

OCOF CoSMoS



1: Lucky Drive

2: Madera Gardens



3: Neil Cummins School

4: San Clemente Drive

5: San Clemente Dr. @ Paradise Dr.

6: Paradise Drive

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Transportation

Nearly every road west of Highway 101 is vulnerable in the near- to medium-terms with a 100-year storm surge. By scenario 5, all of these roads and tens more on the east side of the US Highway 101 could expect tidal flooding. Several of the roads east of US Highway 101 are already, and will continue to be, vulnerable to subsidence. In addition, due to the orientation of the commercial sites, already stressed parking lots could experience impacts first.

Table 91 lists the vulnerable roads and trails in Corte Madera by onset. In near-term scenario 2, 3 miles of road could experience nuisance storm surge flooding. In medium-term scenario 3, 1 mile of road could experience tidal flooding. In scenario 4, this figure jumps to nine miles. This temporary flooding; however, may not be as problematic as roads that only experience may be able to tolerate short-term saltwater exposure. Finally, in the long-term 14 miles could experience tidal flooding, and two more could experience storm surge flooding. Fourteen miles of road closed down twice a day for several days a month several months of the year would be extremely burdensome for travelers. Especially considering the regional impacts of US Highway 101 flooding where it interchanges with Interstate 580.

Preliminary conversations with Caltrans indicate that Caltrans is well aware of the existing and arising concerns in the County.[191] According to Caltrans and the CoSMoS model shows flooding at low spots of US Highway 101 between Corte Madera and San Rafael. These low spots typically benefit from levees and pumps others operate to protect the larger area from flooding. These locations are south of Tamalpais Drive to Nellen Avenue, and from Corte Madera Creek to Lucky Drive.

Transit service along the vulnerable roads could also be compromised. Impacts to transit service could disproportionately impact low-income and Aegis residents. Both Golden Gate Transit and Marin Transit operate in the area. Golden Gate Transit routes 18, 22, 17, 24, 27, 36, 70, 71, 80, and 117 pass through the flooded area at the following stops:

- Paradise Dr. and El Camino Dr.,
- Paradise Dr. and Seawolf Passage,
- Paradise Dr. and Prince Royal Dr.,
- Doherty Dr. and Larkspur Plaza,
- Paradise Dr. and Madera Del Presidio Ave.,
- Paradise Dr. and Harbor Dr.,
- 33 San Clemente Dr.,
- Hwy 101 and Lucky Dr.,
- Hwy 101 and Tamalpais Dr., and
- Hwy 101 and Paradise Dr.

Marin Transit routes 113 and 117 also travel through the flooded areas with stops at:

- Tamal Vista Blvd. and Sandpiper Circle,
- Madera Blvd. and Monona Dr.
- Madera Blvd. and Mohawk Ave.,
- Paradise Dr. and Madera Del Presidio Ave.,
- Paradise Dr. and Harbor Dr.,
- Paradise Dr. and El Camino Dr.,
- Paradise Dr. and Seawolf Passage,
- Paradise Dr. and Robin Dr.,
- 33 San Clemente Drive,
- Tamal Vista Blvd. and Council Crest Dr., and
- Paradise Bus Pads.

Lost or compromised function of these ground transportation features could cut off access to Corte Madera, leading to negative economic impacts for local and regional businesses, emergency vehicle accessibility impacts, residents and commuters dependent on US Highway 101.

Trails along and through the marshes are also vulnerable in the near-term. These paths are typically on or near shoreline armoring. Several miles of bike path and sidewalk along the vulnerable roads are also vulnerable across all scenarios.

Corte Madera Creek at the end of Lucky Drive. Note the low-lying segment of US Highway 101 starts here. Credit. Marin County DPW

[191] Sea Level Rise Vulnerability Assessment Interview. Caltrans. April 30, 2015. J. Peterson. D. Fahey. Marin County Development Agency. BVB Consulting LLC.

CORTE MADERA

The maps on the following pages illustrate vulnerable transportation features. The areas in the call out circles enable the reader the see areas that are difficult to see on the large scale map. The circles do not indicate that these areas are more vulnerable than others along the shoreline.

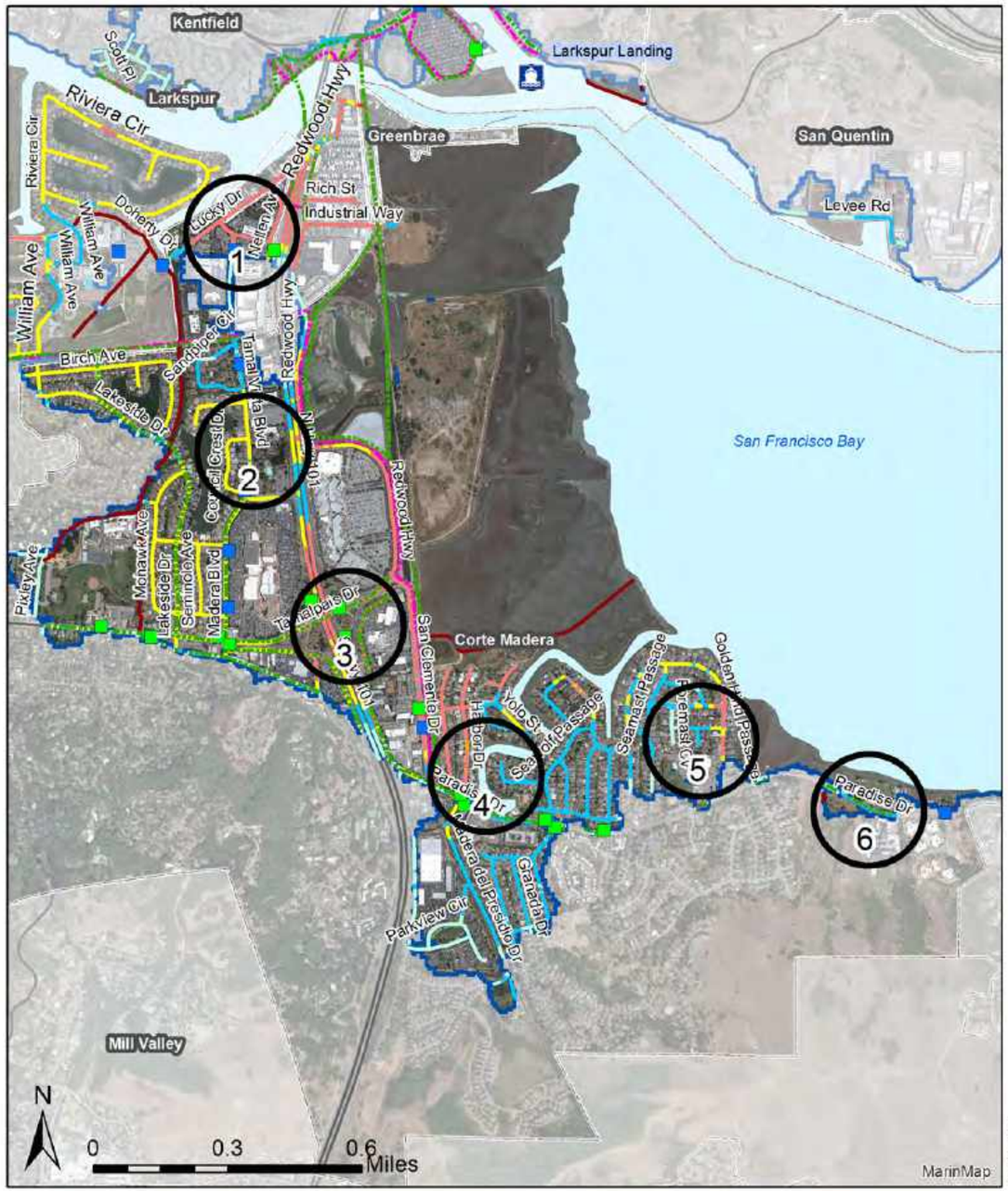
Table 91. Corte Madera Vulnerable Transportation Assets

Near-term		Medium-term		Long-term	
Scenario 1	**Scenario 2**	**Scenario 3**	**Scenario 4**	**Scenario 5**	**Scenario 6**
None	**3** miles	**1** mile	**9** miles	**14** miles	**16** miles
	Hwy 101[C] Redwood Hwy[L] Paradise Dr[L] Baja Ct[L] Casa Buena Dr[L] Channel Dr[L] Conow St[L] Ebbtide Passage[L] Echo Ave[L] Fifer Ave[L] Golden Hind Passage[L] Harbor Dr[L] Lucky Dr[L] Nellen Ave[L] San Clemente Dr[L] Tamal Vista Blvd[L] Tamalpais Dr[L] Yolo St[L]		Roads in scenario 2 Apache Rd[L] Arrowhead Ln[L] Birch Ave[L] Cheyenne Way[L] Chickasaw Ct[L] Council Crest Dr[L] Edgemar Way[L] Hickory Ave[L] Lakeside Dr[L] Madera Blvd[L] Madera del Presidio Dr[L] Meadowsweet Dr[L] Mohave Ct[L] Mohawk Ave[L] Monona Dr[L] Navajo Ln[L] Sanford St[L] Seamast Passage[L] Seminole Ave[L] Tradewind Passage[L]	Roads in scenarios 2 and 4 Diamond Head Passage[L] El Camino Dr[L] Estrada Ln[L] Flying Cloud Course[L] Foremast Cv[L] Granada Dr[L] Key Largo Course[L] Key Largo Cv[L] Lanyard Cv[L] Meadow Creek Dr[P] Morning Star Course[L] Pacific Queen Passage[L] Paloma Dr[L] Prince Royal Dr[L] Prince Royal Passage[L] Sandpiper Cir[P] Sandra Marker Trl[L] Seawolf Passage[L] Simon Ranch Rd[P] Spindrift Passage[L] Staghound Passage[L] Wornum Dr[L,C]	Roads in scenarios 2, 4, and 5 Ash Ave[L] Cay Passage[L] Chapman Dr[L] Council Crest Dr[L] Creekside Ct[P] Eastman Ave[L] Hickory Ave[L] Laurel Dr Parkview Cir[P] Pixley Ave[L] Redwood Ave Westward Dr[L]

M = Marin County; C = State of California; L = Local Municipality; P = Private. Source: MarinMap, CoSMoS

CORTE MADERA

Map 79. Corte Madera Vulnerable Transportation Assets



1: Lucky Drive

2: Tamal Vista Blvd.

3: U.S. Hwy. 101

4: San Clemente Dr. @ Paradise Dr.

5: Mariner's Cove

6: Paradise Drive

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Utilities

Corte Madera's Sanitary District No. 2 will likely face issues common in other shoreline communities in the study area, including:

- Underground pipes face compounding pressure forces from water and the road,
- Road erosion and collapse with underlain pipes,
- Saltwater inflow and infiltration causing inefficiencies in wastewater treatment,
- Continuously subsiding soils or fill, and
- Escalating activity, capacity demands, energy consumption, and wear and tear on pump stations in stormwater and wastewater systems,
- Aging individual site connections for water, sewer, and electrical, and
- Flood waters interrupting access for employees to reach work sites.

In addition, PG&E has a natural gas pipe line along US Highway 101, Paradise Drive, and Madera del Presidio Drive towards Paloma Drive. They also have transmission towers and lines that travel from Larkspur through the hills across the Corte Madera marshes.

Natural Resources

Corte Madera has a rich estuary and marsh system that support robust wildlife populations in the Corte Madera Ecological Reserve, Triangle Marsh, and the lagoon habitats. The marsh lands are extensive and may be able to withstand sea level rise impacts; however, because many sections abut levees, roads, or development, the marshes could get squeezed out in the long-term and turn to mud flats and open water.

The longfin smelt, Ridgway Rail, and Salt Marsh harvest mouse are the listed endangered species recorded in this area. The smelt is list as threated on the California species list and a candidate for the federal list. The Ridgway Rail and Harvest mouse are federally listed. The San Pablo Song sparrow, though not listed, is unique to the area and has potential habitat in the exposed area.

The Ridgway's rail is one of the largest rails in North America, very secretive, and primarily lives in salt and brackish marshes. The Corte Madera Ecological Reserve supports one of the densest populations of Ridgway's rails in the northern San Francisco Bay.[192]

Salt marsh harvest mice are endangered because of habitat loss, fragmentation, and alteration.[193] These mice are only found in the Bay area, including the marshes of Corte Madera; in the upper half of tidal salt marshes and the adjacent uplands during high tides.[194] Sea level rise would greatly impact this species, especially if the mouse's habitat is trapped by development. If high inundation rates occur in areas without upland habitat then reproduction could be reduced or eliminated.

Lastly, Chinook salmon, an endangered species, young use tidal marshes for cover and the feed as it out-migrates through the estuary. And steelhead trout, a special status species, use tidal marshes and creeks for foraging.[195]

Corte Madera Ecological Reserve. Credit: C. Kennard

[192] Goals Project. 2015. *The Baylands and Climate Change: What We Can Do*. Baylands Ecosystem Habitat Goals Science Update 2015 prepared by the San Francisco Bay Area Wetlands Ecosystem Goals Project. California State Coastal Conservancy, Oakland, CA. Pg. 168

[193] Shellhammer, H. 2000. Salt Marsh Harvest Mouse. Pp. 219 – 228 in Goals Project. 2000. Baylands Ecosystem Species and Community Profiles: Life history and environmental requirements of key plants, fish and wildlife. Prepared by the San Francisco Bay Area Wetlands Ecosystem Goals Project. P. R. Olofson, editor. San Francisco Bay Regional Water Quality Control Board, Oakland, California.

[194] Goals Project. 2015. *The Baylands and Climate Change: What We Can Do*. Appendix 5.1 Salt Marsh Harvest Mouse. Ecosystem Baylands Habitat Goals Science Update 2015 prepared by the San Francisco Bay Area Wetlands Ecosystem Goals Project. California State Coastal Conservancy, Oakland, CA.

[195] Marin Audubon Society. Personal Communication. March 10, 2017.

Recreation
The Bay Trail (County Route 17), Sandra Marker Tail, Corte Madera/Larkspur Bike Path, marsh land pathways, and private boating infrastructure could be vulnerable to sea level rise in the near-term. Additionally, on street bike paths and sidewalks are also compromised. This would greatly impact bicyclists that ride the Tiburon Peninsula. These activities will likely shift to accommodate the changing circumstances of travel. In addition, the Best Western and Marin Suites could be vulnerable.

Emergency Services
Three emergency shelters in Corte Madera may be vulnerable in scenario 6. Fire Station 13 off of Paradise Drive is vulnerable in the long-term to sea level rise and could experience access impacts even sooner. The Tamalpais Drive fire station just misses exposure under these average high tide scenarios. Access south of the facility could be compromised due to flooding. The police headquarters are technically in Larkspur; however, similar access issues could also arise here. When traveling to Corte Madera, that fastest route from the station is typically using US Highway 101, which could likely be flooded to some degree during high tides under all of the BayWAVE scenarios. This could increase response times, and at worst, prevent responses entirely. Finally, the California Highway Patrol Office is in the exposure zone. To learn more about the site's vulnerabilities see the Emergency Services Profile.

Cultural Resources
Corte Madera's inventoried historic assets are located outside of the flood area.

Table 92 lists these assets and others in order of onset and severity of flooding. A 100-year storm surge would add an additional 1 to 3 feet of water to these properties. Note also, above average high tides could impact more properties than accounted for in this analysis.

A few additional select assets could also be vulnerable in scenario 6 with the additional 100-year storm surge condition. These are:

- Marin Country Day School (emergency shelter),
- Holy Innocents Episcopal (emergency shelter), and
- Marin Lutheran Church (emergency shelter).

All three of these sites are existing emergency shelters that by the end of the century could be at the epicenter of emergency and unable to serve their function.

The maps on the following pages illustrate vulnerable utility, natural resource, recreation, emergency and historic features. The areas in the call out circles enable the reader the see areas that are difficult to see on the large scale map. The circles do not indicate that these areas are more vulnerable than others along the shoreline.

CORTE MADERA

Table 92. Example Corte Madera Vulnerable Assets by Sea Level Rise Onset and Flooding at MHHW

Asset	Scenarios		
	Near-term	Medium-term	Long-term
	1	3	5
Paradise Dr. commercial	0-1'2"	9"-3'3"	2'-8'4"
Marina Village	0-1'	4'-2'5"	11'-6'
Mariner Cove	0-1'	2"-2'	5'3"
CHP Headquarters	3"	2'4"	6'
Shorebird Marsh		5'3"	10'9"
Bay Trail		0-3'4"	0-8'6"
Madera Gardens.		9"-3'	2'-7'4"
Paradise Drive		0-2'5"	4"-9'
Neil Cummins Elementary		2'5"	6'6"
San Clemente Dr.		1'2"-2'3"	1'9"-7'4'
Tamalpais Dr.		0-2'	2"-7'6"
Corte Madera Town Center		2'	5'
Aegis Senior Living		1'9"	4'7"
Susan Marker Trail			1'2"-7'6"
Cove Elementary		11"	2'3"
The Village at Corte Madera		10"	2'
Higgins Dock			11'10"
Madera Gardens Lagoons			10'4"
Town Park			9'10"
Hwy 101 North bound			6"-7'8"
Redwood Hwy.			1'2"-6'8"
Hwy 101 South bound off ramp			1'-5'5"
Ring Mountain			3'6"
Skunk Hollow Park			3'
Marin Montessori			1'7"
Corte Madera Ecological Reserve	Floods at existing high tides		

Source: MarinMap, CoSMoS

CORTE MADERA

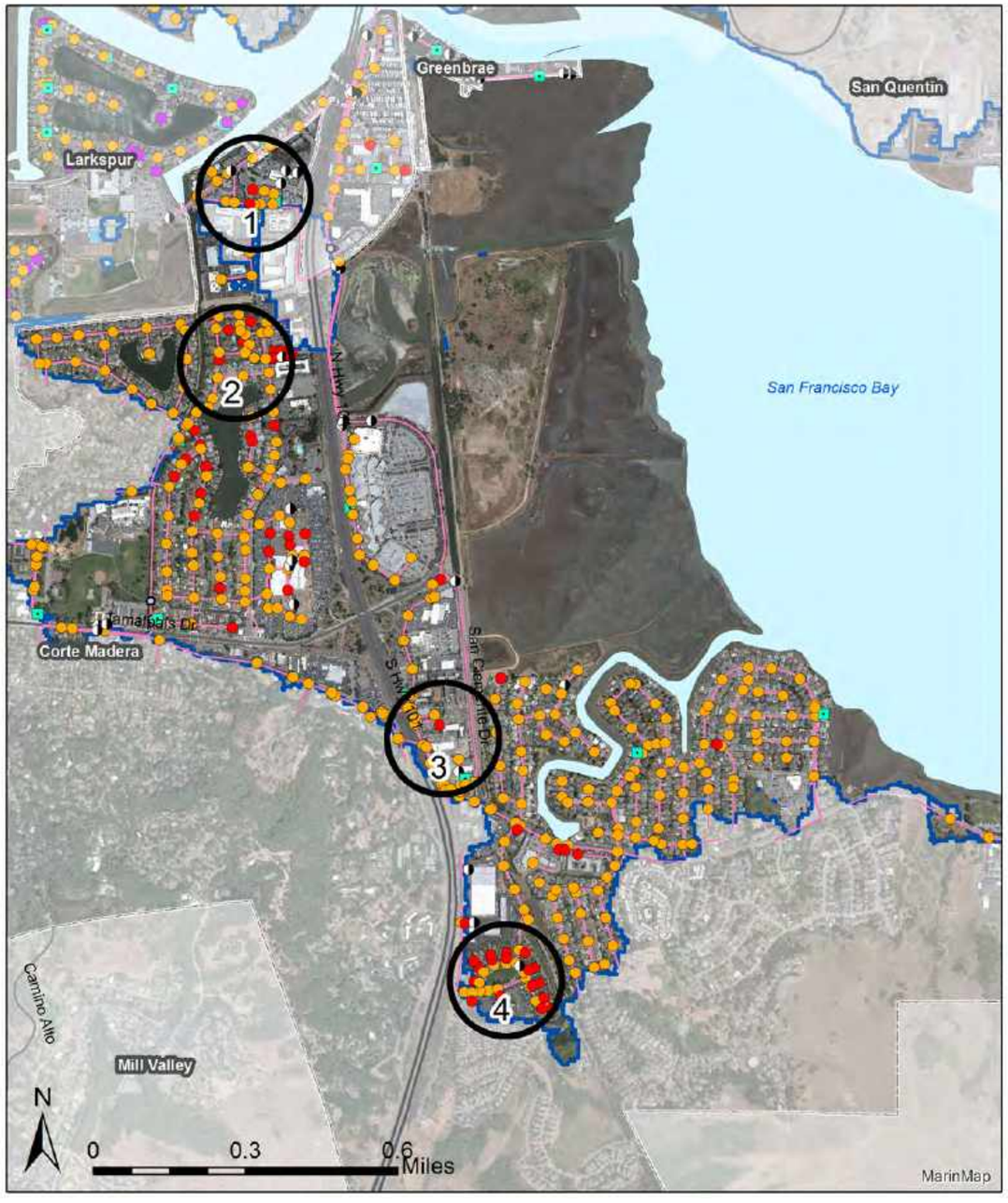
Map 80. Corte Madera Vulnerable Wastewater Utility Assets

Vulnerable Assets

- AP
- Pump Station
- Junction
- Outlet
- Manhole
- Pipe

Location Indicators

- Unincorporated
- Municipality
- Road
- Bay
- Inland Extent: Sea Level @ 60"+100-year Storm Surge

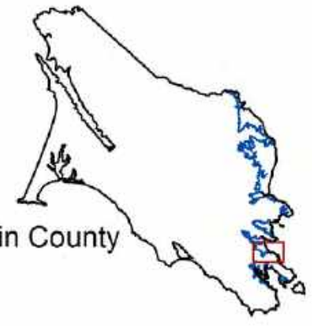


1: Lucky Dr.

2: Madera Gardens

3: San Clemente Drive

4: Madera del Presidio



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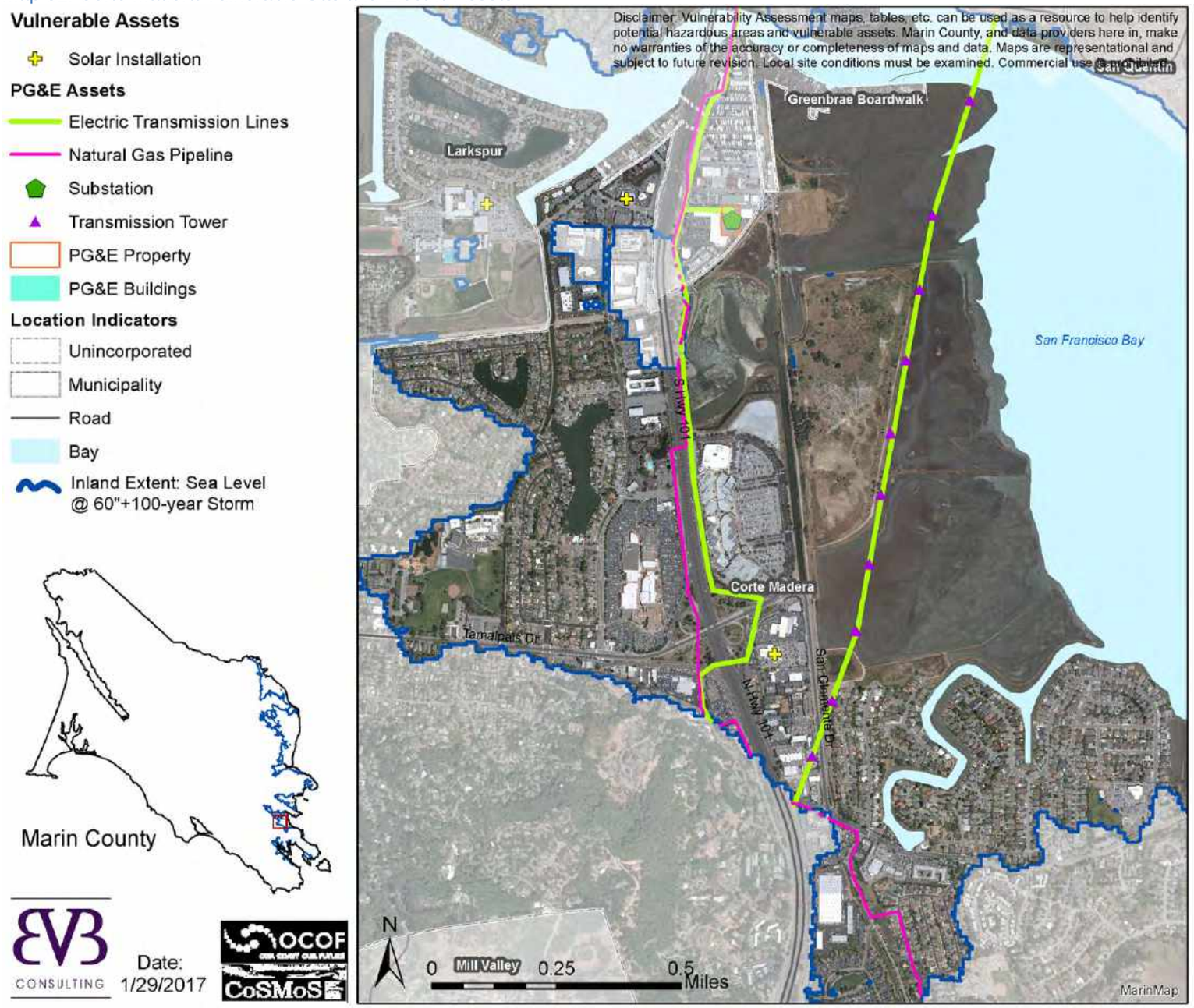
Date: 6/15/2017

OCOF CoSMoS

Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data providers here in, make no warranties of the accuracy or completeness of maps and data. Maps are representational and subject to future revision. Local site conditions must be examined. Commercial use is prohibited.

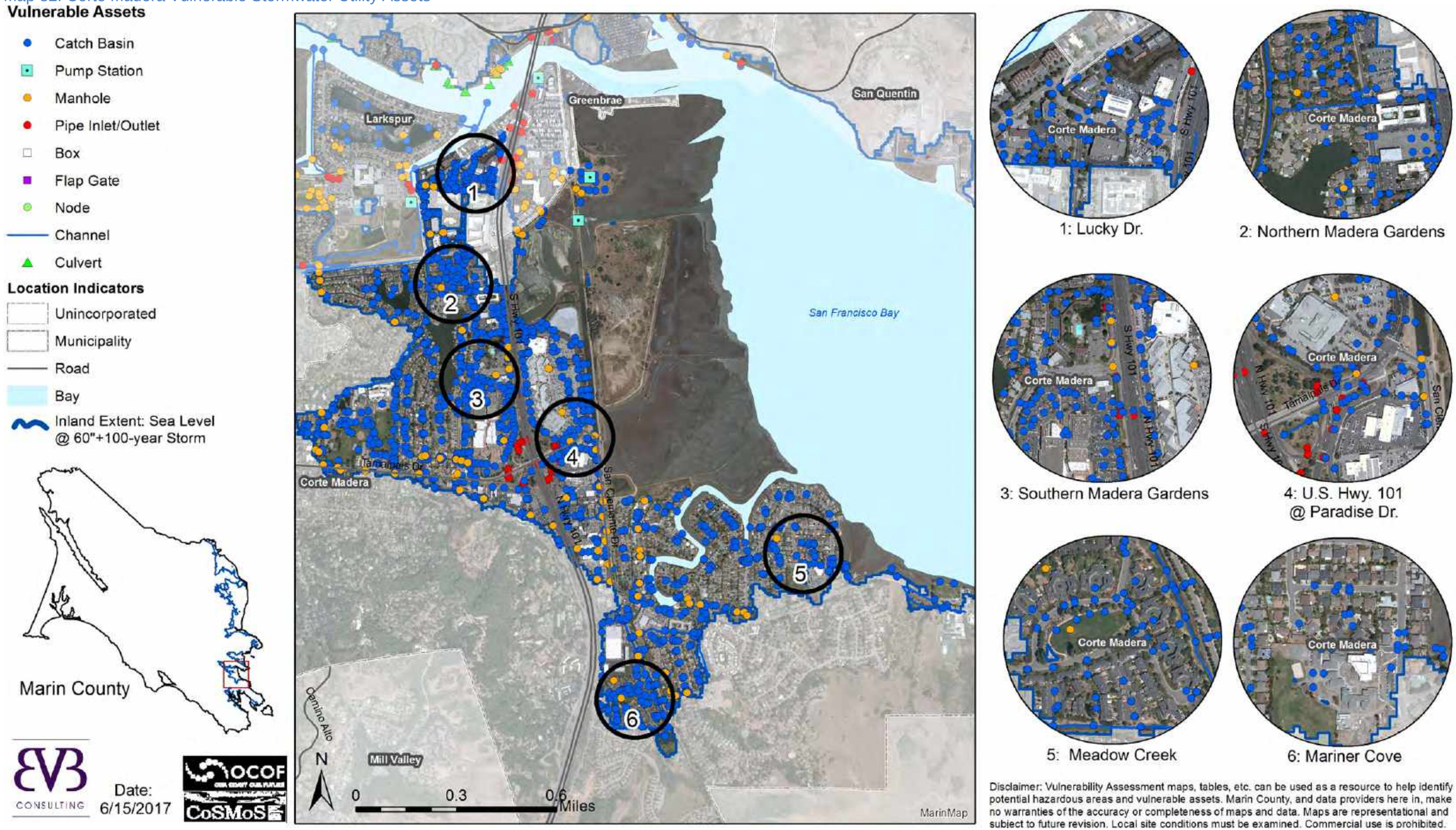
CORTE MADERA

Map 81. Corte Madera Vulnerable Gas and Electric Assets



CORTE MADERA

Map 82. Corte Madera Vulnerable Stormwater Utility Assets



Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data providers here in, make no warranties of the accuracy or completeness of maps and data. Maps are representational and subject to future revision. Local site conditions must be examined. Commercial use is prohibited.

CORTE MADERA

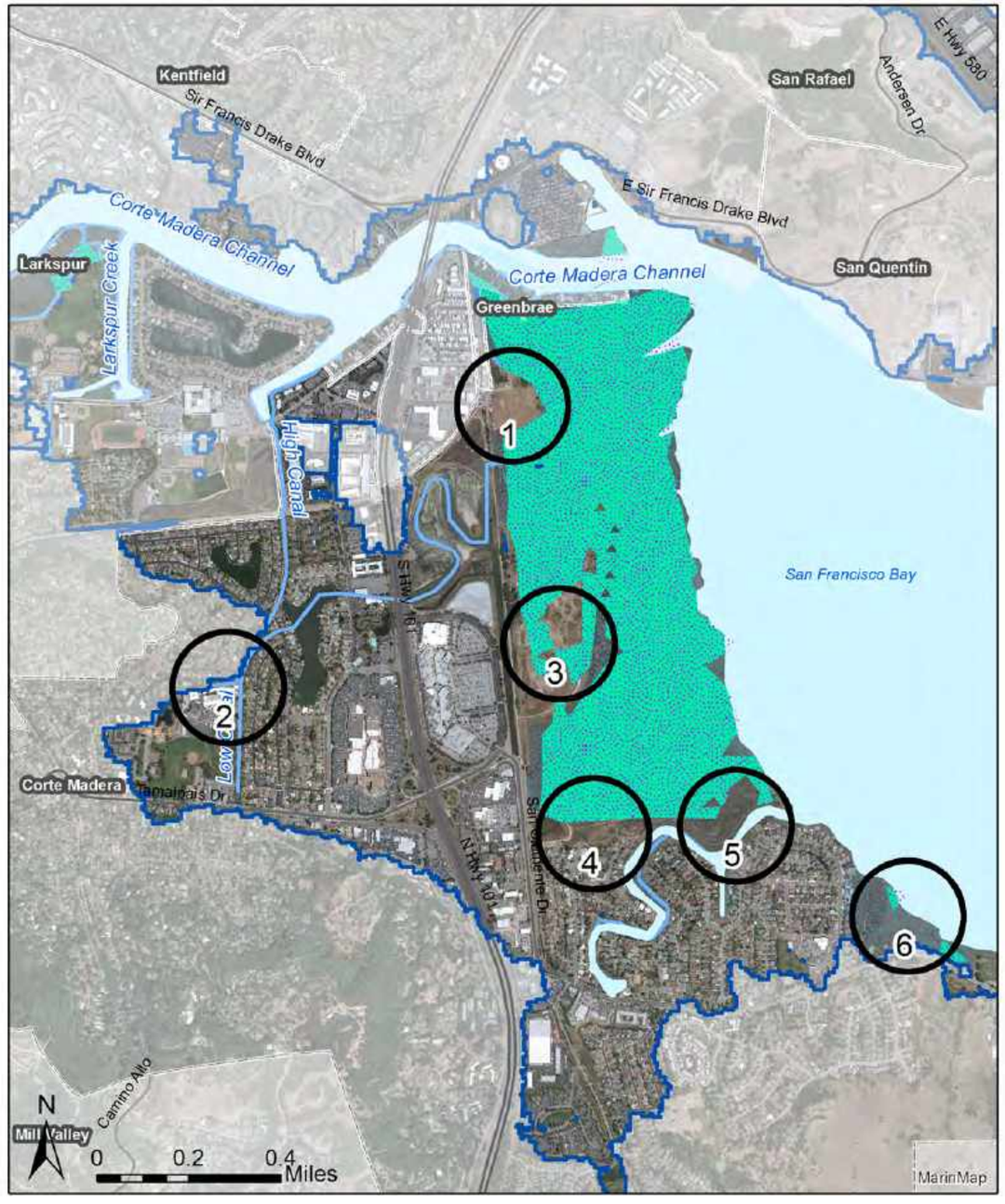
Map 83. Corte Madera Vulnerable Natural Resource Assets

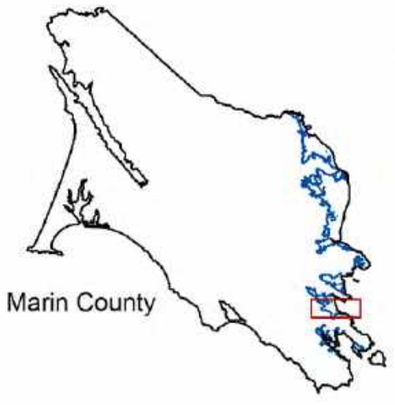
Vulnerable Assets

- Streams
- Marsh
- Estuary
- Wetland

Location Indicators

- Unincorporated
- Municipality
- Road
- Bay
- Inland Extent: Sea Level @ 60"+100-year Storm





1: Corte Madera Marsh @ Greenbrae Boardwalk

2: Corte Madera Marsh @ The Village

3: High & Low Canals

4: Corte Madera Marsh @ San Clemente Drive

5: San Clemente Creek

6: Triangle Marsh

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Date: 6/15/2017

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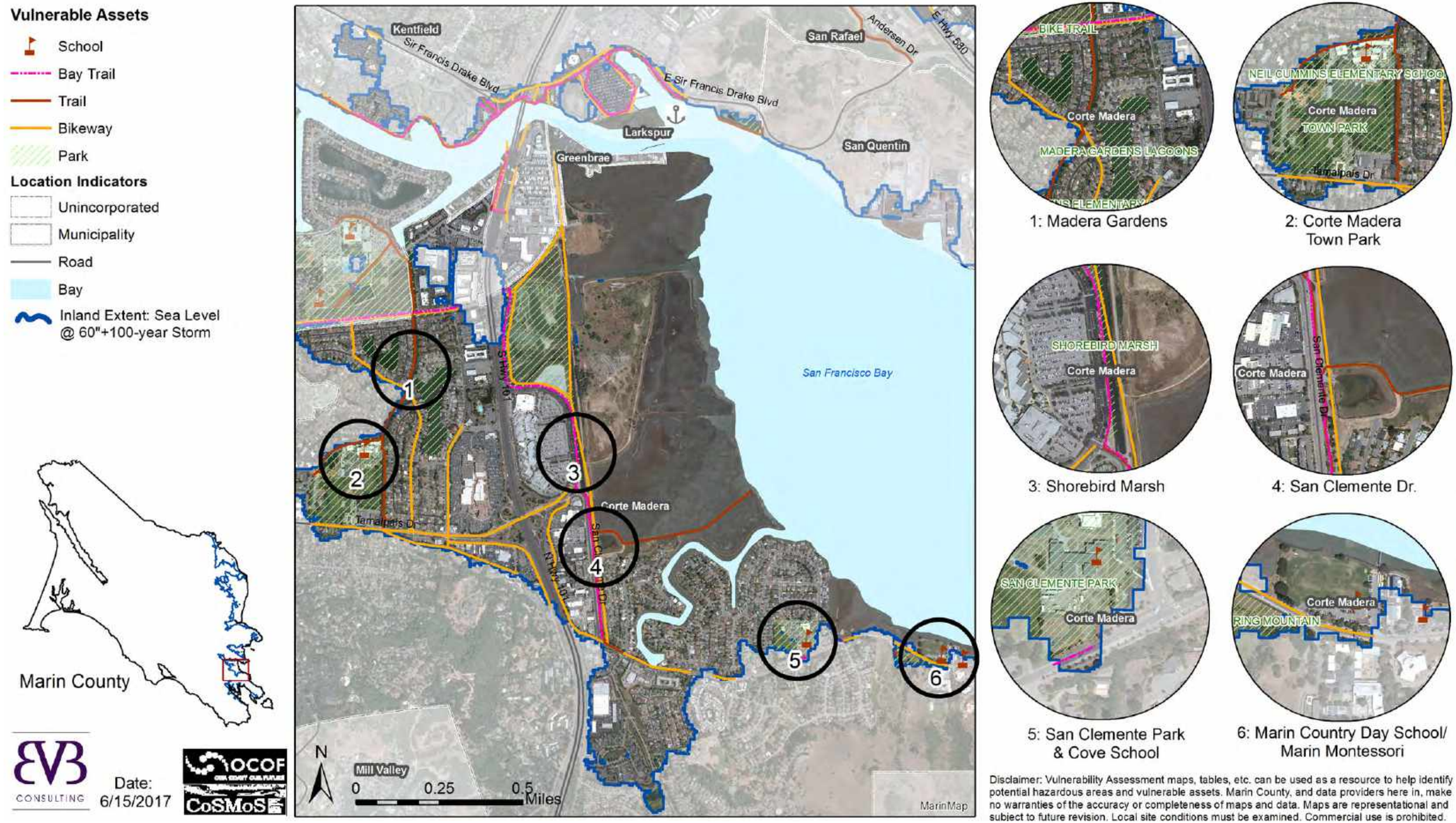
Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data providers here in, make no warranties of the accuracy or completeness of maps and data. Maps are representational and subject to future revision. Local site conditions must be examined. Commercial use is prohibited.

CORTE MADERA

Map 84. Corte Madera Vulnerable Recreation Assets



1: Madera Gardens

2: Corte Madera Town Park

3: Shorebird Marsh

4: San Clemente Dr.

5: San Clemente Park & Cove School

6: Marin Country Day School/ Marin Montessori

Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data providers here in, make no warranties of the accuracy or completeness of maps and data. Maps are representational and subject to future revision. Local site conditions must be examined. Commercial use is prohibited.

CORTE MADERA

Map 85. Corte Madera Vulnerable Emergency Service Assets

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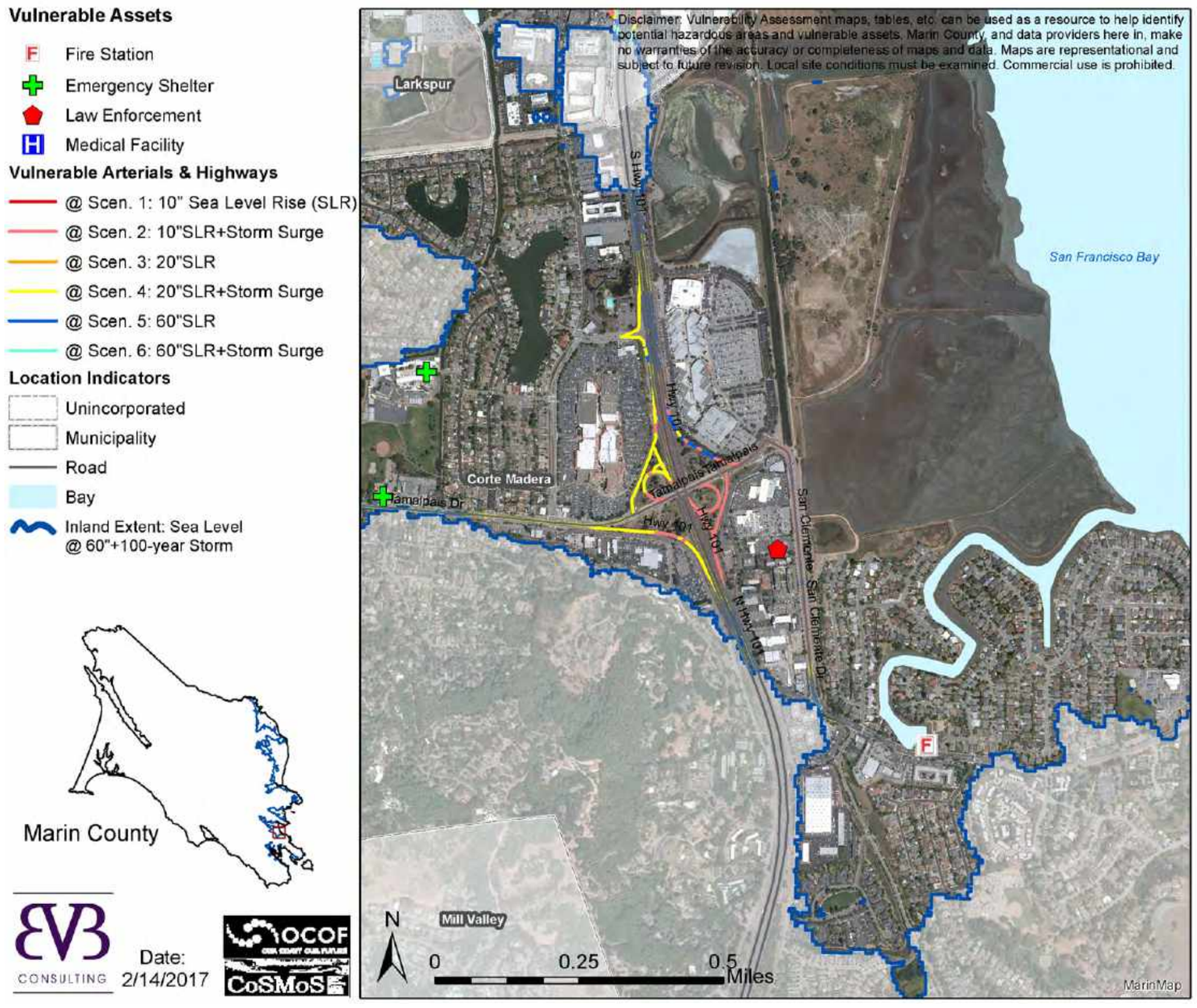


LARKSPUR

Community Profile: Larkspur

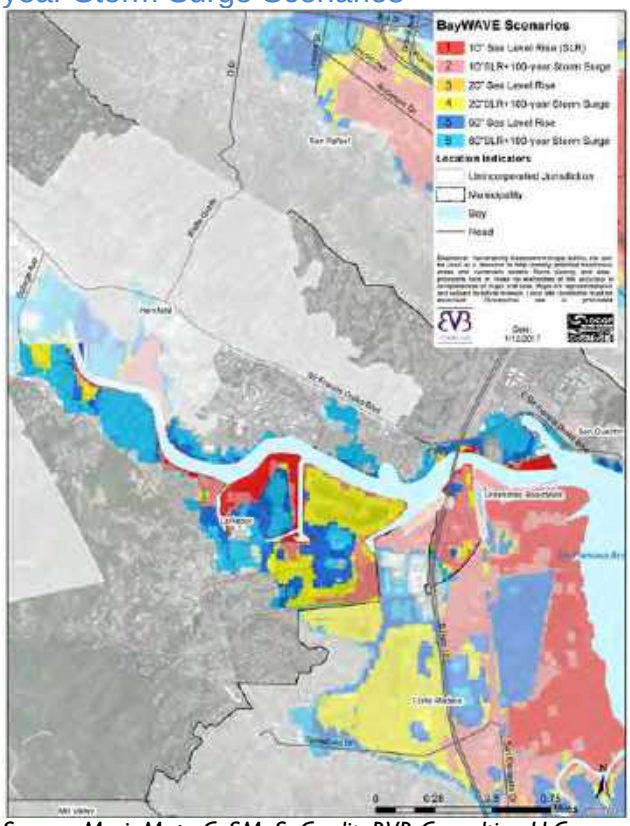
Larkspur borders both sides of Corte Madera Creek, sandwiched between the Town of Corte Madera and Wolfe Grade. The community is characterized by the creek, low-lying public lands, and uplands where downtown and additional hill side housing reside. Key issues include:

- The Golden Gate Bridge District's (GGBHTD) Larkspur site and hydraulic ferry facility may not be able to withstand near-term high tides.
- The several hundred thousand gallons of reserve fuel at the ferry facility could be vulnerable in the long-term.
- Housing along Corte Madera Creek canals, sloughs, and lagoons could be vulnerable in the near- to medium-terms. This includes, Boardwalk One, multi-family on Larkspur Plaza, the southern portion of Heatherwood Gardens, and housing west of S. Eliseo Drive. The elevated over marsh homes on Boardwalk One may be more adaptable than homes on solid foundations elsewhere.
- Industrial and commercial sites east of US Highway 101 could be vulnerable in the near-term with a storm surge, and to high tides in the medium-term along Redwood Highway.
- Riviera Circle homes could be vulnerable to sea level rise in the long-term, and storm surges and subsidence sooner.
- The Hillview neighborhood, while already vulnerable to stormwater back-ups, is vulnerable to sea level rise during a 100-year storm surge in the long-term, as is the Edgewater complex and buildings extending up Magnolia Avenue towards Kentfield.
- The Corte Madera/Larkspur Pathway could be compromised along Corte Madera Creek.
- Several schools along Doherty Drive could be vulnerable in the medium- to long-term.
- Stormwater infrastructure along the Corte Madera Creek, and its tributaries, could be burdened in the medium- to long-term.
- Access to and from Larkspur using US Highway 101 already floods during storms. The route is vulnerable to tidal flooding in the long-term.
- The Central Marin Police Department could be surrounded by flood waters.
- Piper Park, a historic land fill and current community sports facility and marsh habitat could be vulnerable in the long-term to sea level rise and 100-year storm surge.

IMPACTS AT-A-GLANCE: SCENARIO 6

1,200+ living units	12,000 people
544 acres exposed	27 commercial parcels
8.7 miles of roads	
Storm and tidal impacts already occur	
$2 billion in assessed property value; $1.2 billion in single-family market value[196]	Caltrans Property Owners Tamalpais Union School District GGBHTD

Map 86. Larkspur Sea Level Rise and 100-year Storm Surge Scenarios



Source: MarinMap, CoSMoS. Credit: BVB Consulting LLC

[196] 2016 dollars

LARKSPUR

Vulnerable Assets

Larkspur's most vulnerable assets interface with Corte Madera Creek and its tributaries as they enter San Francisco Bay. Some buildings on the creek already suffer from subsidence and have undergone repairs. The low lying area along Doherty Drive could be vulnerable by the long-term, and is highly susceptible to bay surges and stormwater flows.

Land

Much of Larkspur developed flat lands were marshy before the water was channeled and land filled. This area is vulnerable to flooding and subsidence. Larkspur Landing, a critical center for commuting and commerce, could also flood.

Acres

In the near-term, 132 acres, seven percent of Larkspur, could be exposed to tidal flooding. Ten percent of the community could be impacted by an additional 100-year storm surge. About another 100 acres could be exposed to storm surge flooding in medium-term scenario 4. In long-term scenario 5, nearly twenty percent of the community could expect tidal flooding, and 30 percent, or 544 acres, could be exposed with an additional 100-year storm surge. This third of the area of Larkspur is essential to accessing Larkspur, schooling, recreation, and emergency services.

Parcels

This acreage is broken in to parcels for ownership and development purposes. Parcels are also assigned land uses. Examining land uses can provide a representation of what types of human activities could be threatened by sea level rise and stormy seas. Nearly all land uses in the study area could face changing conditions that make their existing use infeasible and are therefore vulnerable. Without intervention, it is unlikely that parcels exposed to tidal flooding could sustain continued use, and even existing tidal marsh habitats could completely transition to mudflats and open water.

In near-term scenario1 almost 100 acres could face tidal flooding. More than twice that could experience storm surge flooding. Properties experiencing both would have an extremely difficult time recovering from soggy conditions. Around ten percent of Larkspur, or 445, acres, could flood in medium-term scenario 4. In long-term scenario 5, fifteen percent of the community along waterways large and small could experience tidal flooding. With and additional storm surge, one-third of the community could be under saltwater.

1973 Flood on US Highway 101 and fronting marshes. Larkspur. Credit: Marin County DPW

Table 93. Larkspur Exposed Acreage

Scenarios		Acres	
		#	%
Near-term	1	132	7
	2	202	10
Medium-term	3	147	7
	4	299	15
Long-term	5	379	19
	6	544	27

Source: MarinMap, CoSMoS

Table 94. Larkspur Vulnerable Parcels

Scenarios		Parcels	
		#	%
Near-term	1	90	2
	2	246	5
Medium-term	3	121	3
	4	445	10
Long-term	5	687	15
	6	1,216	27

Source: MarinMap, CoSMoS

LARKSPUR

Table 95. Larkspur Vulnerable Residential and Commercial Parcels

Land Use	Scenarios					
	Near-term		Medium-term		Long-term	
	1		3		5	
	#	%	#	%	#	%
Residential	67	2	99	2	586	15
Commercial			6	4	27	18
Industrial			4	30	12	100

Source: MarinMap, CoSMoS.

Table 96. Larkspur Vulnerable Parcels by Land Use

Land Use	Scenarios					
	1		3		5	
	Near-term		Medium-term		Long-term	
	#	Ac.	#	Ac.	#	Ac.
Commercial Improved			6	10	25	24
Commercial Unimproved					2	0.5
Exemption Improved					21	0.4
Industrial Improved			3	1	10	6
Industrial Unimproved			1	0.1	2	1
Residential	67	21	99	23	586	70
Mobile Home			6	0.03	50	0.3
Multi-Family Improved	6	1	6	1	12	4
Multi-Family Unimproved					1	0.3
Single Family Attached			7	0.1	244	3
Single Family Improved	60	20	69	22	276	62
Single Family Unimproved	1	0.3	2	0.5	2	0.5
Tax Exempt	12	17	15	17	34	84

Source: MarinMap, CoSMoS

The three most impacted uses in Larkspur are public land uses, such as schools, parks, and, emergency services, residential, and industrial land uses. Industrial parcels east of US Highway 101 on the shoreline already flood seasonally and could continue to suffer from storms over the next fifteen years. In medium-term scenario 3, the few industrial parcels impacted are one-third of the city's industrial base. By the long-term, all of Larkspurs industrial land could flood tidally at MHHW rendering the properties the very narrow land uses, and not likely the existing uses. Moreover, any industrial products and contaminates from machining or the gas station could input pollutants into the surrounding properties and the Bay waters.

Residential development along Corte Madera Creek could experience tidal flooding in the near- and medium terms. In the long-term, tidal flooding could impact fifteen percent of residential parcels in Larkspur. Multi-family parcels could also see flooding on Larkspur Plaza Drive. Fifty mobile homes, some of Marin's limited affordable housing, could flood tidally at MHHW in the long-term and face storm flooding in the medium-term.

Similar portions of commercial parcels could be vulnerable to tidal flooding as residential, though far less in number and acreage, with 27 parcels and 27 acres flooded in the long-term.

Buildings

Larkspur contains a high number of potentially vulnerable buildings relative to other communities in the study area. In the near-term, forty buildings, two percent of all buildings in Larkspur, could experience tidal flooding. Several hundred buildings could anticipate additional storm surge impacts. In the medium-term, more than 150 buildings could anticipate MHHW tidal flooding, and several hundred more could anticipate impacts during a 100-year storm surge. By long-term scenario 5, 802, or 20 percent of buildings, could experience tidal flooding at MHHW. With the additional 100-year storm surge, 1,160, or 28 percent of buildings could be vulnerable to five feet of sea level rise combine d with a 100-year storm surge. A thirty percent loss of buildings would significantly impact Larkspurs ability to recover from disastrous flooding at a community level.

All industrial buildings east of US Highway 101 could experience tidal and storm surge flooding. Housing

along Corte Madera Creek canals, sloughs, and lagoons could be vulnerable in the near- to medium-terms. These properties include Boardwalk One, multi-family units across the canal on Larkspur Plaza, the southern portion of the Heather Garden neighborhood, and some housing west of S. Eliseo Drive. The homes along Boardwalk One are elevated on piers, which may make them more adaptable in the near term. All housing west of S. Eliseo Drive could be vulnerable by the long-term to tidal exposure. Riviera Circle homes could be vulnerable to sea level rise in the long-term, and storm surges and subsidence sooner. The Hillview neighborhood already suffers from stormwater back-ups during high tides. However, from sea level rise alone, this neighborhood could be vulnerable to a 100-year storm surge in the long-term, as could the Edgewater complex and buildings extending up Magnolia Avenue towards Kentfield. Nevertheless, higher high tides would exacerbate stormwater back-ups, and consequently fresh water.

Several schools could face tidal and storm surge flooding. These areas are also already impacted by storm water flooding, which sea level rise will only worsen. Finally, the Central Marin Police Department could be surrounded by flood waters making it difficult for employees to reach and leave the facility.

Buildings in the flooded areas of Larkspur are wood framed structures. Newer buildings are elevated on fill and off the ground, however, homes older than twenty years old may not be. In addition, because many areas were built on filled in marsh, developments, such as the Riviera Circle neighborhood, are also vulnerable to subsidence as underlying soils liquefy.

Table 98 divides the vulnerable buildings by how much tidal saltwater they could flood with, whether it is one, two, or eight feet of saltwater that could come rushing in. In the near- and medium-terms the majority of buildings are flooded with three feet or less of water. In the long-term, more than 450 buildings re vulnerable to more than 3 feet of flooding at MHHW relegating these buildings, unless elevated or protected, unusable.

Table 97. Larkspur Vulnerable Buildings

Scenarios		Buildings	
		#	%
Near-term	1	40	1
	2	382	9
Medium-term	3	165	4
	4	670	16
Long-term	5	802	19
	6	1,160	28

Source: MarinMap, CoSMoS

Table 98. Larkspur Tidal MHHW Flood Depth Estimates for Vulnerable Buildings

Flood Depth (feet)	Scenarios		
	Near-term	Medium-term	Long-term
	1	3	5
0.1-1	17	35	37
1.1-2	17	44	63
2.1-3	22	33	98
3.1-4	1	9	228
4.1-5	0	0	121
5.1-6	1	1	107
6.1-7			31
7.1- 8			15

** Flood depth data is not available for all exposed areas and assets.*
Source: MarinMap, CoSMoS

Table 99. Larkspur Vulnerable Buildings FEMA Hazus Storm Damage Cost Estimates in Long-term Scenario 6

Number of Buildings in Scenario 6	1,160
Yellow Tag :Minor Damage $5,000 minimum	$5,800,000
Orange Tag: Moderate Damage $17,001 minimum	$19,721,160
Red Tag: Destroyed Assessed structural value	$1,496,649,606

Source: MarinMap, CoSMoS

Table 99 outlines cost estimates using FEMA Hazus tagging levels for damage to buildings and their contents under scenario 6, the worst case scenario analyzed in this assessment. If every vulnerable building were to be destroyed, nearly $1.5 billion in losses could occur. At yellow tag levels, a minimum of $5.8 million[197] in damages could occur. Reality would likely reflect a mix of damage levels and monetary figure between these.

The maps on the following pages illustrate potentially vulnerable buildings by scenario. The areas in the call out circles enable the reader the see areas that are difficult to see on the large scale map. The circles do not indicate that these areas are more vulnerable than others along the shoreline.

[197] 2016 dollars

LARKSPUR

Map 87. Larkspur Vulnerable Buildings

Vulnerable Assets

- School
- Emergency Shelter
- Fire Station
- Law Enforcement

Vulnerable Buildings

- Scen. 1: 10" Sea Level Rise (SLR)
- Scen. 2: 10" SLR+Storm Surge
- Scen. 3: 20" Sea Level Rise
- Scen. 4: 20"SLR+Storm Surge
- Scen 5: 60" Sea Level Rise
- Scen. 6: 60"SLR+Storm Surge

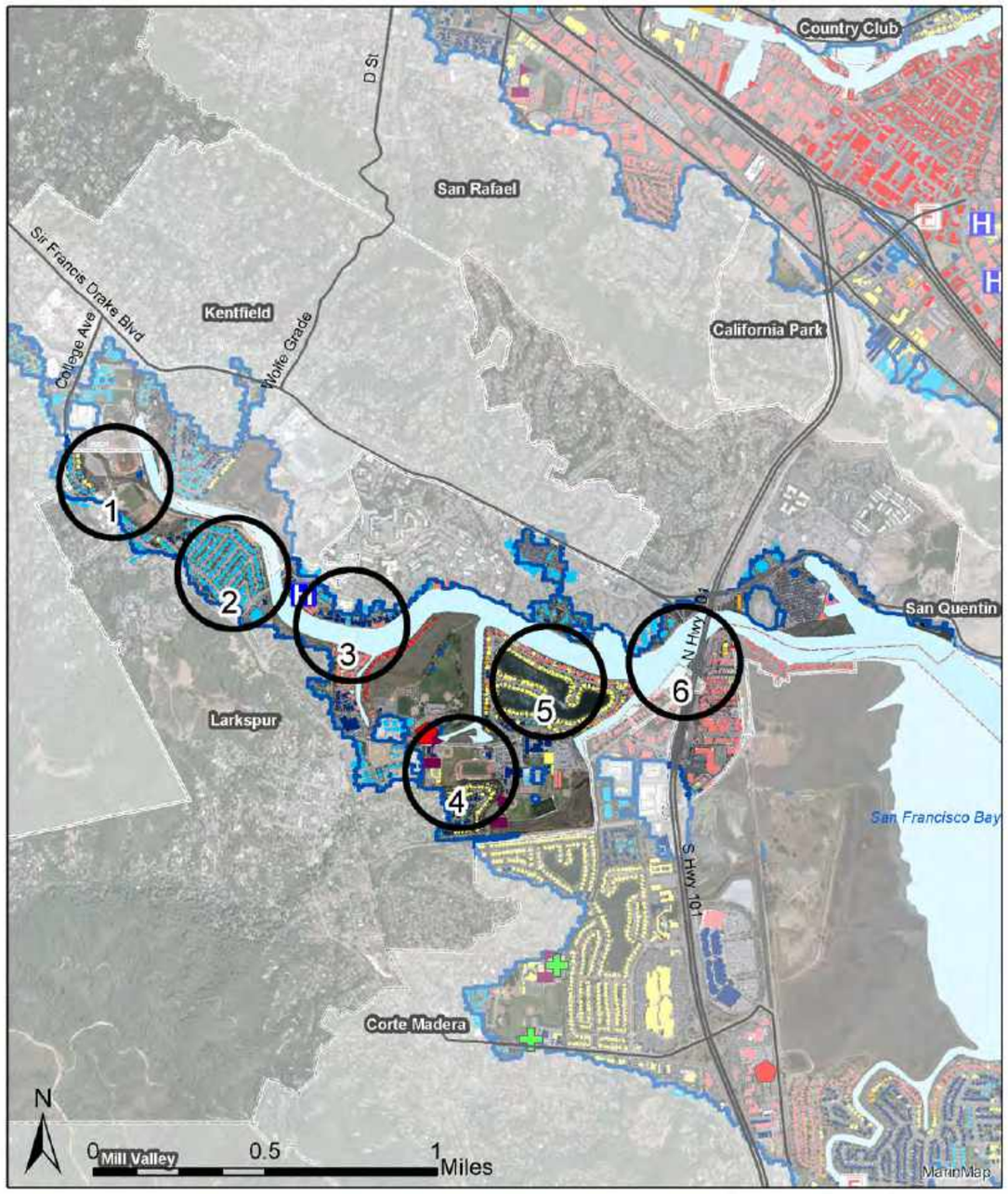
Location Indicators

- Unincorporated
- Municipality
- Road
- Bay
- Inland Extent: Sea Level @ 60"+100-year Storm

EVB CONSULTING

Date: 6/24/2017

OCOF CoSMoS



1: Magnolia Ave. @ College Ave.

2: Hillview Neighborhood

3: S. Eliseo/Boardwalk 1/ Larskpur Plaza Dr.

4: Redwood High School

5: Riviera Circle

6: Industrial east of U.S. Hwy. 101

Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data providers here in, make no warranties of the accuracy or completeness of maps and data. Maps are representational and subject to future revision. Local site conditions must be examined. Commercial use is prohibited.

Transportation

Southerly highway access to Larkspur could be compromised at Lucky Drive and Sir Francis Drake Boulevard US Highway 101 exits. Riviera Circle and Doherty Drive could anticipate storm impacts as early as scenario 2 and tidal flooding by the long-term and medium-term respectively. Floodwaters move up the creek and can reach into the neighborhoods, impacting streets in low elevation areas at Bon Air Road and west of Corte Madera Creek. Bon Air road is a critical route to area hospitals and has experienced flooding as recent as 2017 with up to one and one half feet of water at the Bon Air Bridge. These roads enable commuters, school children, and emergency vehicles to travel to, from, and within the community.

Preliminary conversations with Caltrans indicate that Caltrans is well aware of the existing and arising concerns in the County.[198] According to Caltrans and the CoSMoS model flooding occurs at low spots of US Highway 101 in Larkspur from Corte Madera Creek to Lucky Drive. These low spots typically benefit from levees and pumps others operate to protect the larger area from flooding.

Transit service along Marin Transit routes 17, 29, 113, 117, 119, and 228 and Golden Gate Transit routes 17, 18, 22, 24, 25, 27, 28, 29, 36, 37, 70, 71, 80, and 117 would be compromised if roads are flooded. Impacts to transit service could disproportionately impact low-income and mobility impaired residents. Stops that could be compromised include:

- Bon Air Rd.
- Doherty Dr. and Larkspur Plaza Dr.,
- Lucky Dr. and Riviera Cir.,
- E Sir Francis Drake Blvd. and Larkspur Landing,
- Redwood High School
- Sir Francis Drake Blvd. and McAllister Ave,
- Magnolia Ave. and Dartmouth Dr.,
- Magnolia Ave. and Frances Ave.,
- Magnolia Ave. and Estelle Ave.,
- Larkspur Ferry Terminal,
- Doherty Dr. and Larkspur Plaza,
- Hwy 101 and Lucky Dr., and
- E Sir Francis Drake Blvd. and Larkspur Landing.

The maps on the following pages illustrate vulnerable transportation features. The areas in the call out circles enable the reader the see areas that are difficult to see on the large scale map. The circles do not indicate that these areas are more vulnerable than others along the shoreline.

Golden Gate Ferry and Terminal. Credit: Marin County CDA

Lucky Dr at Doherty Drive. Redwood Highschool at King Tide. Jan. 21, 2015. Credit YESS Program, Redwood High School Students.

[198] Sea Level Rise Vulnerability Assessment Interview. Caltrans. April 30, 2015. J. Peterson. D. Fahey. Marin County Development Agency. BVB Consulting LLC.

LARKSPUR

Table 100. Larkspur Transportation Routes Vulnerable to Sea Level Rise and a 100-year Storm Surge

Near-term		Medium-term		Long-term	
Scenario 1	**Scenario 2**	**Scenario 3**	**Scenario 4**	**Scenario 5**	**Scenario 6**
0.5 miles	**1.5** miles	**0.5** miles	4 miles	**5** miles	9 miles
Hwy 101 [C] Redwood Hwy [L] Bon Air Rd [L]	Roads in scenario 1 Creekside Dr [P] Doherty Dr [L] Industrial Wy [L, P] Larkspur Plaza [L] Rich St [L, P] Riviera Cir Dr [L]	Roads in scenarios 1 and 2	Roads in scenarios 1-3 Corte del Coronado [L] Diane Ln [L] Liberty St [L] Midway Rd [L] Tulane Dr [L] Via la Brisa [L] William Ave [L]	Roads in scenarios 1-4 Sir Francis Drake Blvd [L, M, C] Camellia Cir [P] Heather Wy [L] Rose Ln [P] S Eliseo Dr [L] Stanford Ct [L]	Roads in scenarios 1-5 Barry Way [L, P] College Ave [L, M] Cornell Ave [L] Corte del Brayo Real [L] Creek View Cir [P] Cross Creek Pl [P] Dartmouth Dr [L] Elizabeth Cir [P] Estelle Ave [L] Frances Ave [L] Gregory Pl [P] Gretchen Pl [P] Harvard Dr [L] Laderman Ln [P] Larkspur Lndg Cir [L] Lupine Ct [P] Magnolia Ave [L] Murray Ave [L] Orchid Dr [P] Sandy Creek Wy [P] Scott Pl [P] Victoria Wy [L] Yale Ave [L]

M = Marin County; C = State of California; L = Local Municipality; P = Private. Source: MarinMap, CoSMoS

Map 88. Larkspur Vulnerable Transportation Assets

Vulnerable Assets

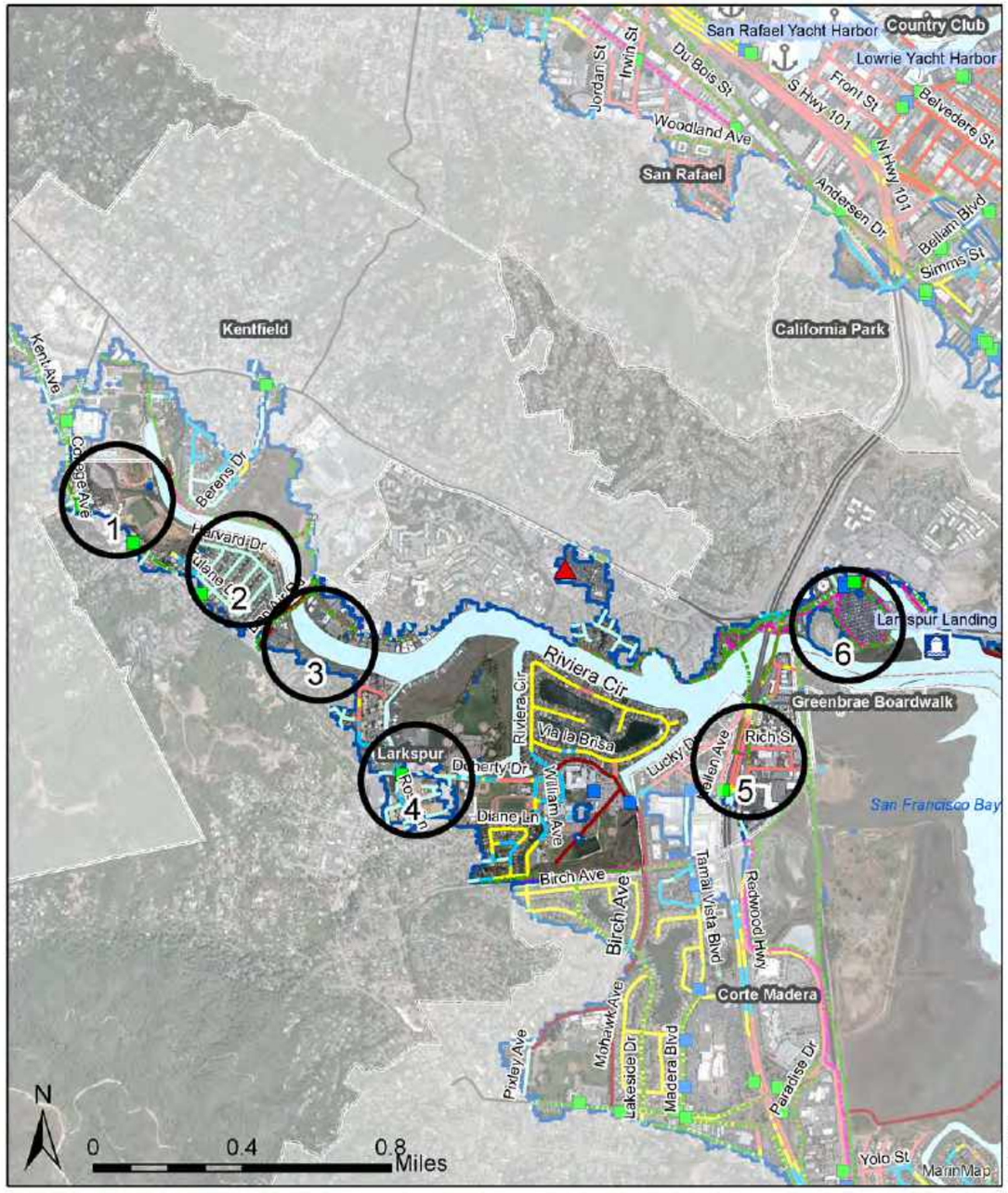
- Park & Ride
- Bike path
- Bay Trail
- Trail
- MT Bus Stop
- GGT Bus Stop
- Ferry

Vulnerable Roads

- @10" Sea Level Rise (SLR)
- @10"SLR+ 100-year Storm Surge
- @20" Sea Level Rise
- @20"SLR+ 100-year Storm Surge
- @60" Sea Level Rise
- @60"SLR+ 100-year Storm Surge

Location Indicators

- Unincorporated
- Municipality
- Road
- Bay
- Inland Extent: Sea Level @ 60"+100-year Storm



1: Magnolia Ave. @ College Avenue

2: Hillview Neighborhood

3: Bon Air Rd. @ S. Eliseo Dr.

4: Doherty Dr.

5: U.S. Hwy. 101 @ Corte Madera/Larkspur

6: Larkspur Landing

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Date: 3/29/2017

CoSMoS

Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data providers here in, make no warranties of the accuracy or completeness of maps and data. Maps are representational and subject to future revision. Local site conditions must be examined. Commercial use is prohibited.

Utilities
Larkspur could experience utility issues common in other shoreline communities in the study area, including:

- Underground pipes face compounding pressure forces from water and the road,
- Road erosion and collapse with underlain pipes,
- Saltwater inflow and infiltration causing inefficiencies in wastewater treatment,
- Continuously subsiding soils or fill, and
- Escalating activity, capacity demands, energy consumption, and wear and tear on pump stations in stormwater and wastewater systems,
- Aging individual site connections for water, sewer, and electrical, and
- Flood waters interrupting access for employees to reach work sites.

In addition, PG&E has a natural gas pipe line along US Highway 101 towards San Rafael and a substation bayside of Cost Plus World Market that could be vulnerable during a 100-year storm surge in the long-term, scenario 6, though may be less sensitive if all electrical components are adequately elevated off the ground.

Natural Resources
Marshes lining the Corte Madera Creek are narrow and bordered by development almost entirely, thus vulnerable to sea level rise. These marshes provide extensive habitat for birds, rodents, fish, reptiles, and amphibians. Changes in salinity in the creek and its tributaries may push freshwater and brackish animal and plant species upstream.

Found in Corte Madera, the smelt is list as threatened on the California species list and a candidate for the federal list. The Ridgway's Rail, tidewater goby, and harvest mouse are federally listed. The white-rayed pentachaeta is an endangered plant species in Corte Madera.

Recreation
The Corte Madera/Larkspur Path is vulnerable in the near-term at creek side segments. Private piers and docks could also be vulnerable. Boat launch sites for kayaking may need to adjust. Piper Park is also vulnerable in the long-term. This park features softball, soccer, and cricket accommodations that are used regionally. School sites off Doherty Drive used for recreation are vulnerable in the long-term.

Emergency Services
Access through low lying roads is the primary concern for Larkspur residents and businesses that need assistance or transport to Marin General Hospital and other medical facilities in the area. The Central Marin Police Department would become an island as surrounding areas flood. This department also serves Corte Madera and San Anselmo.

Cultural Resources
Six vulnerable historic homes along Boardwalk One are the only remaining homes of the four original communities of arks, or houseboats on cement pedestals in water accessed by boardwalks elevated above the marshland. Many of the homes have had alterations and additions compromising the original defining features, though still retain historical character through size, materials, scale, and color.[199]

Homes on Riviera Circle at King Tide. Jan. 21, 2015. Credit YESS Program, Redwood High School Students

[199] City of Larkspur. 2005. Historic Resources Survey Re-evaluation

LARKSPUR

Map 89. Larkspur Vulnerable Cultural Resource Assets

Source: CoSMoS, MarinMap, Larkspur Historic Inventory

Table 101 ranks vulnerable asset by onset and flood depth. A 100-year storm surge would add an additional 1 to 3 feet of water to these properties. Note also, above average high tides could impact more properties than accounted for in this analysis. The Larkspur Plaza shopping center could expect storm surge flooding in the long-term at the sourthern end of the propoerty. The maps on the following pages illustrate vulnerable utility, natural resource, recreation, emergency and historic features. The areas in the call out circles enable the reader the see areas that are difficult to see on the large scale map. The circles do not indicate that these areas are more vulnerable than others along the shoreline.

Boardwalk One homes on the left and multi-family affordable housing on the right on Marin Lagoon, Larkspur. Credit: Marin County DPW

Table 101. Example Vulnerable Larkspur Assets by Onset and Flooding at MHHW

Asset	Scenarios		
	Near-term	Medium-term	Long-term
	1	3	5
Larkspur Landing Beach	Floods at existing high tide		
Boardwalk 1	2”-3’	5-“3’10”	3’2”-6’5”
Piper Park	7’2”	7’11”	10’8”
Bay Trail @ Larkspur Landing	0-5’4”	0-6’	0-8’6”
Cal Park Hill @ Sir Francis Drake Blvd	4’10”	5’3”	8’2”
Edgewater Place marsh	4’4”	5’	8’6”
Remillard Park	2’11”	3’6”	6’2”
Corte Madera Creek Path	0-3”	1”-2’	0-6’9”
Industrial & commercial east of Hwy 101	0-1’9”	0-2’4”	2’2”-6’7”
Hal Brown Park		6’3”	9’2”
Golden Gate Mobile Homes		10”-3’	2’-7’5”
Ferry Terminal		1’-2’6”	2’7”-7’9”
Riviera Circle Homes		3”-2’	7”-5’3”
GGBHTD fuel reserve		1’7”	4’2”
Tamiscal High School		1’7”	2’11”
San Andreas High School		1’5”	3’8”

Asset	Scenarios		
	Near-term	Medium-term	Long-term
	1	3	5
Central Marin Police Department		2'7"	6'9"
Redwood High fields and lots		1'4"	3'4"
Hamilton Park		10"	3'9"
Doherty Dr		0-3"	05'5"
Heatherwood Park			8'2"
Heather Gardens neighborhood			7'
Hwy 101NB @ Lucky Dr			3'6"-5'3"
Redwood Hwy			4'2"-5'2"
Hwy 101SB off ramp @ Sir Francis Drake Blvd			2'3"-5'
Riviera Circle (street)			1'8"-4'9"
Multi-family on Larkspur Plaza Dr.			4'5"
PG&E Substation			4'
Sir Francis Drake Blvd @ Hwy 101			7"-2'9"
Bon Air Landing Park			2'4"
Hillview neighborhood			1'8"
Passport Health			6"
Henry Hall Middle School	Surrounded by saltwater		
Corte Madera Creek	Water resource		
Marin Country Mart	Access issues only		

Source: MarinMap, CoSMoS, Asset Manager Interviews

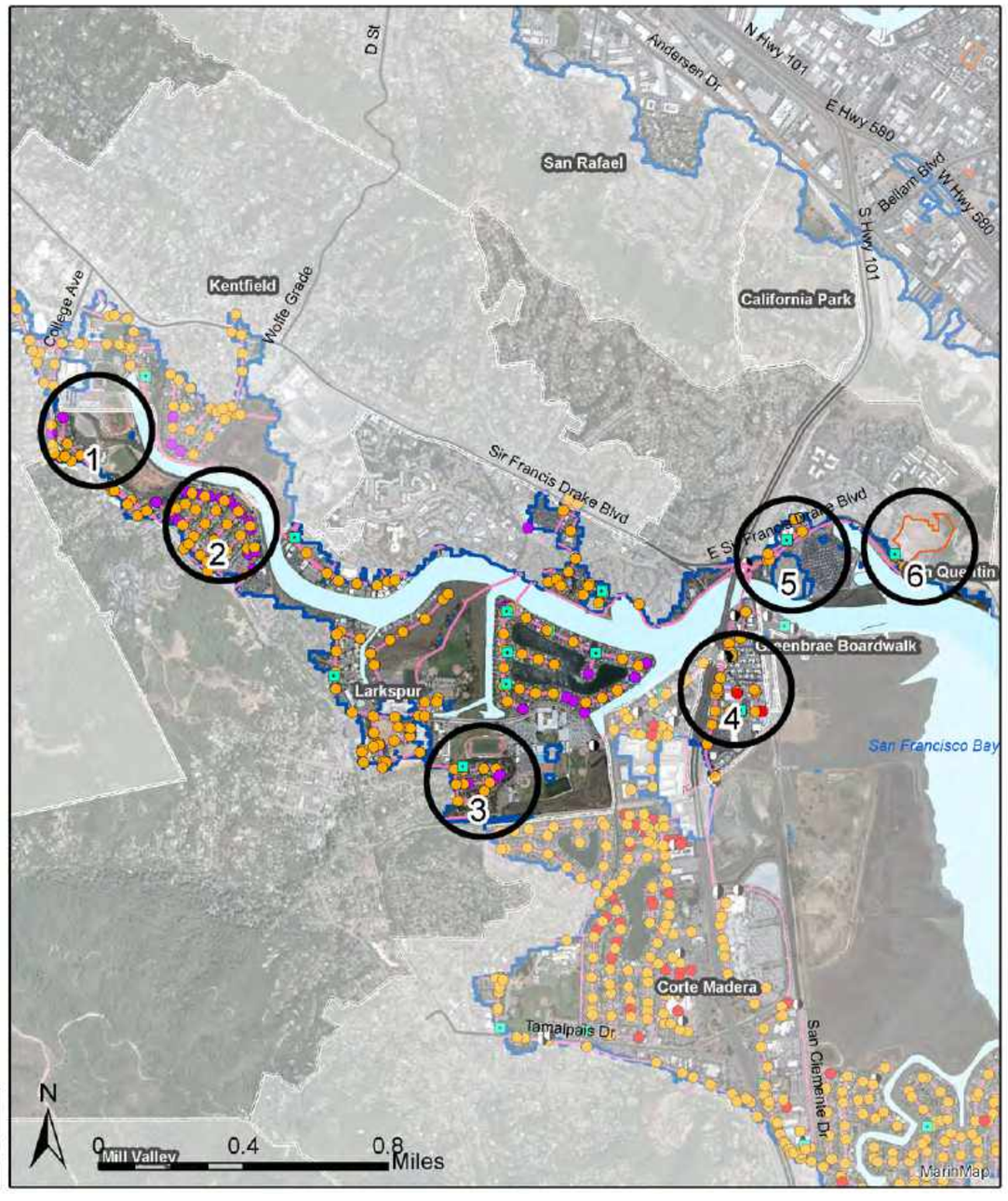
Map 90. Larkspur Vulnerable Wastewater Utility Asset

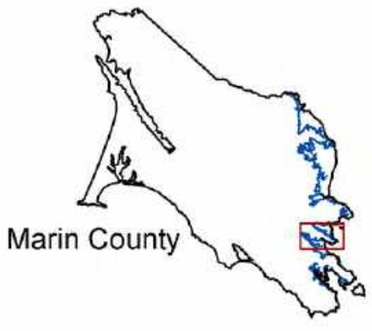
Vulnerable Assets

- Manhole
- Pump Station
- Residential Lateral
- Pipe
- Collector
- Junction

Location Indicators

- Unincorporated
- Municipality
- Road
- Bay
- Inland Extent: Sea Level @ 60"+100-year Storm Surge



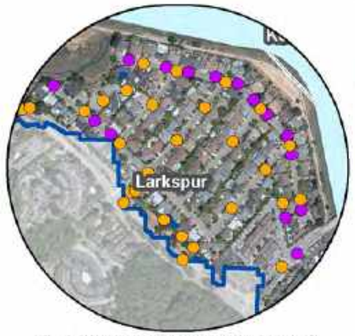


EVB CONSULTING

Date: 3/29/2017

OCOF CoSMoS

1: Magnolia Ave. @ College Ave.



2: Hillview Neighborhood

3: Heatherwood Neighborhood

4: Redwood Highway Frontage Rd.

5: Sir Francis Drake Blvd. @ U.S. Hwy. 101

6: Sir Francis Drake Blvd. @ Larkspur Landing Cir.

Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data providers here in, make no warranties of the accuracy or completeness of maps and data. Maps are representational and subject to future revision. Local site conditions must be examined. Commercial use is prohibited.

Map 91. Larkspur Vulnerable Gas and Electric Utility Assets

Vulnerable Assets

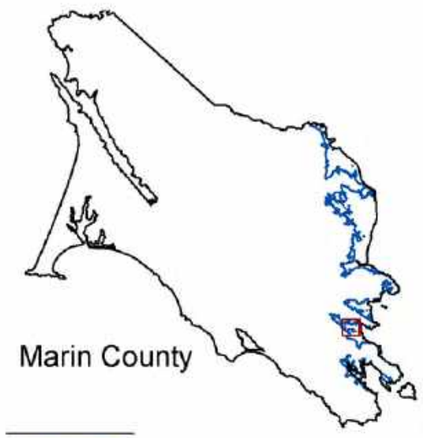
- Solar Installation

PG&E Assets

- Electric Transmission Lines
- Natural Gas Pipeline
- Substation
- Transmission Tower
- PG&E Property
- PG&E Buildings

Location Indicators

- Unincorporated
- Municipality
- Road
- Bay
- Inland Extent: Sea Level @ 60"+100-year Storm



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Date: 1/29/2017

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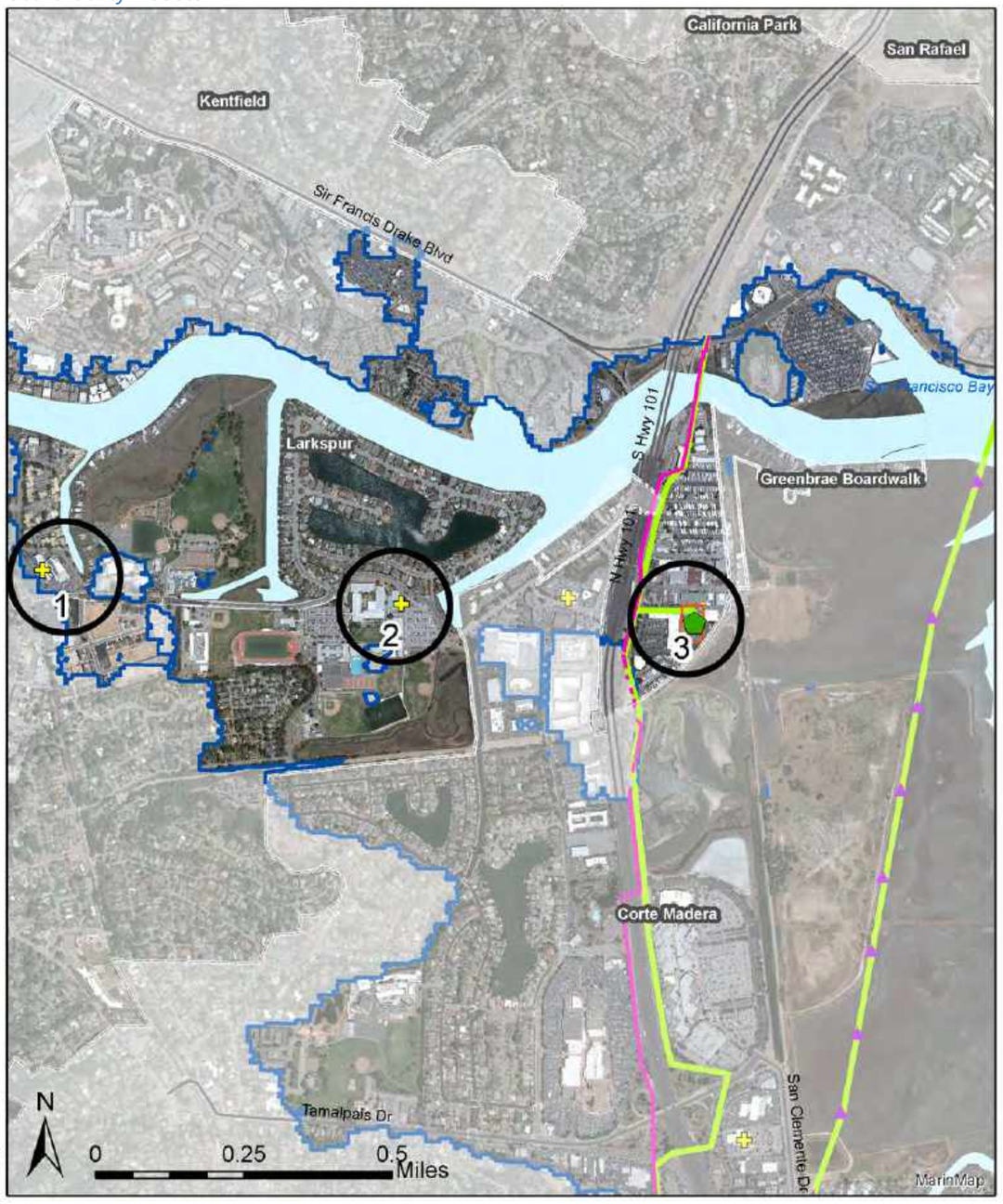

1: Athletic Club

2: Redwood High School

3: PG&E Substation

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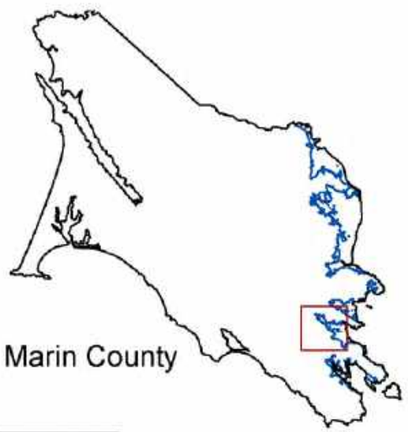
Map 92. Larkspur Vulnerable Stormwater Utility Assets

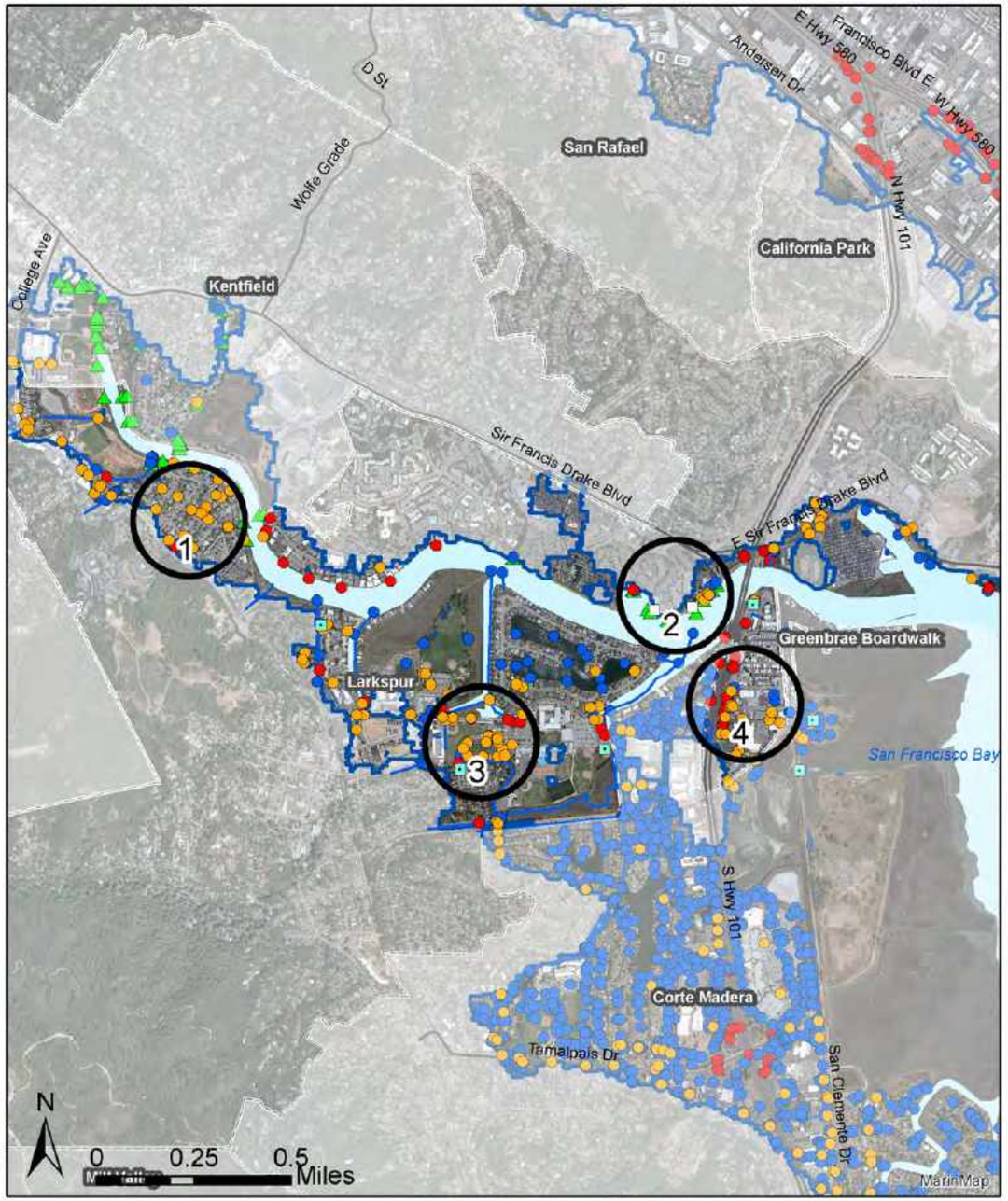
Vulnerable Assets

- Catch Basin
- Pump Station
- Manhole
- Pipe Inlet/Outlet
- Box
- Flap Gate
- Node
- Channel
- Culvert

Location Indicators

- Unincorporated
- Municipality
- Road
- Bay
- Inland Extent: Sea Level @ 60"+100-year Storm





1: Hillview Neighborhood

2: Bon Air Landing Park

3: Redwood Highschool

4: U.S. Hwy. 101 Corridor

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Date: 3/29/2017

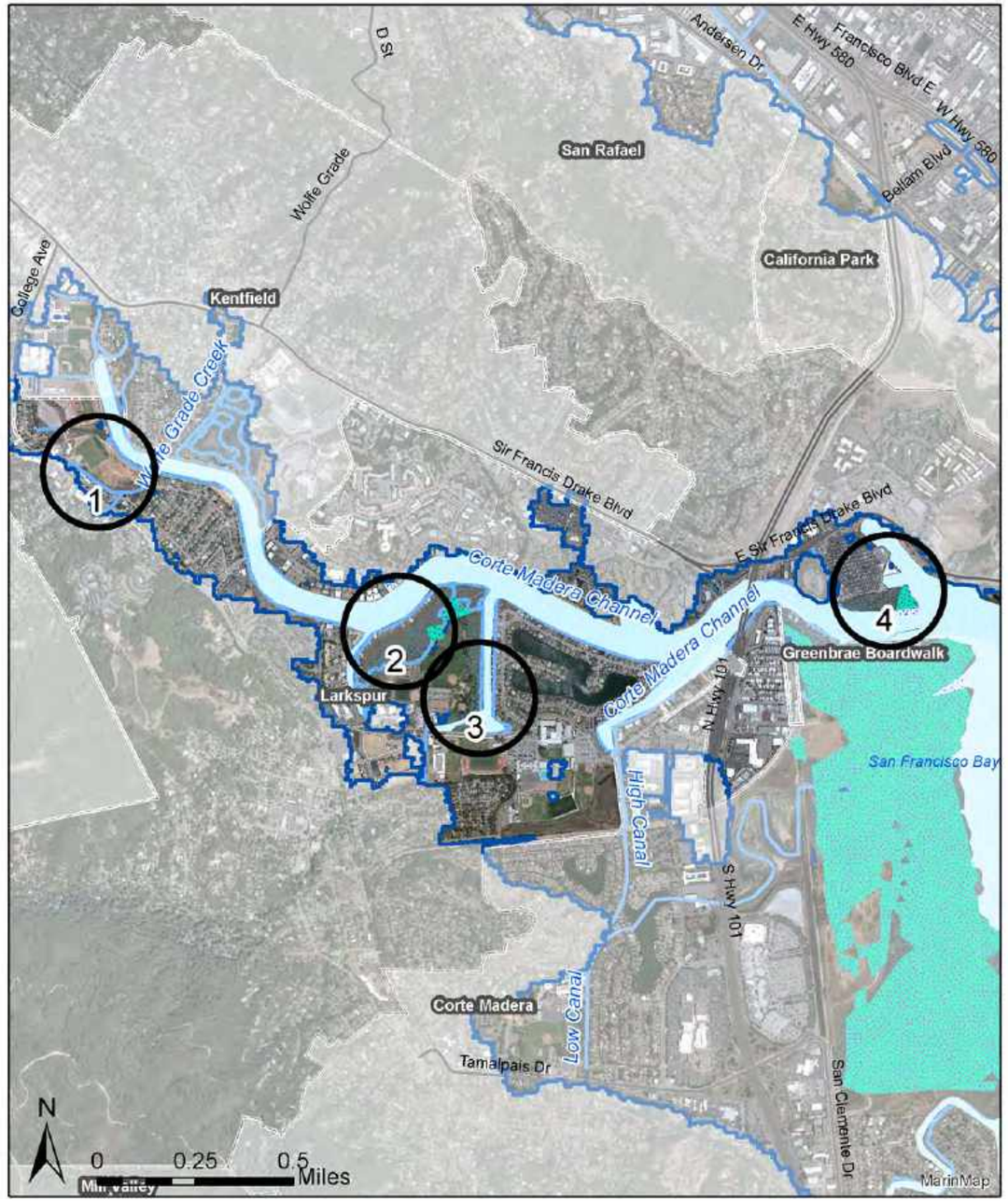
Map 93. Larkspur Vulnerable Natural Resource Assets

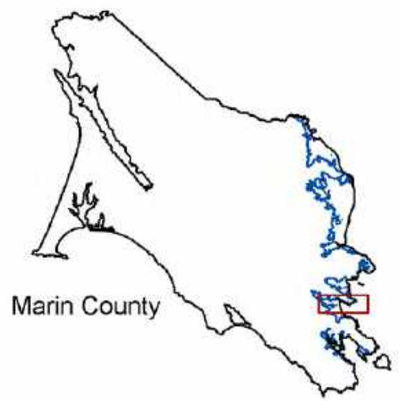
Vulnerable Assets

- Streams
- Marsh
- Estuary
- Wetland

Location Indicators

- Unincorporated
- Municipality
- Road
- Bay
- Inland Extent: Sea Level @ 60"+100-year Storm





1: Upper Corte Madera Creek

2: Boardwalk One

3: Piper Park

4: Larkspur Landing

Date: 3/29/2017

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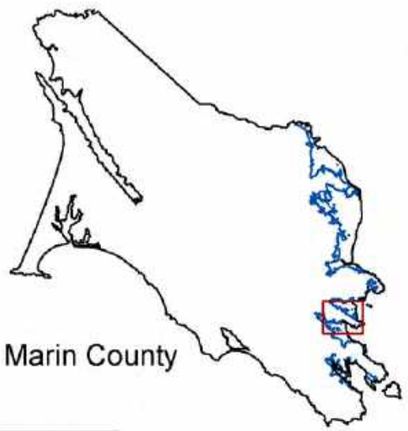
Map 94. Larkspur Vulnerable Recreation Assets

Vulnerable Assets

- School
- Bay Trail
- Trail
- Bikeway
- Park

Location Indicators

- Unincorporated
- Municipality
- Road
- Bay
- Inland Extent: Sea Level @ 60"+100-year Storm



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Date: 1/25/2017

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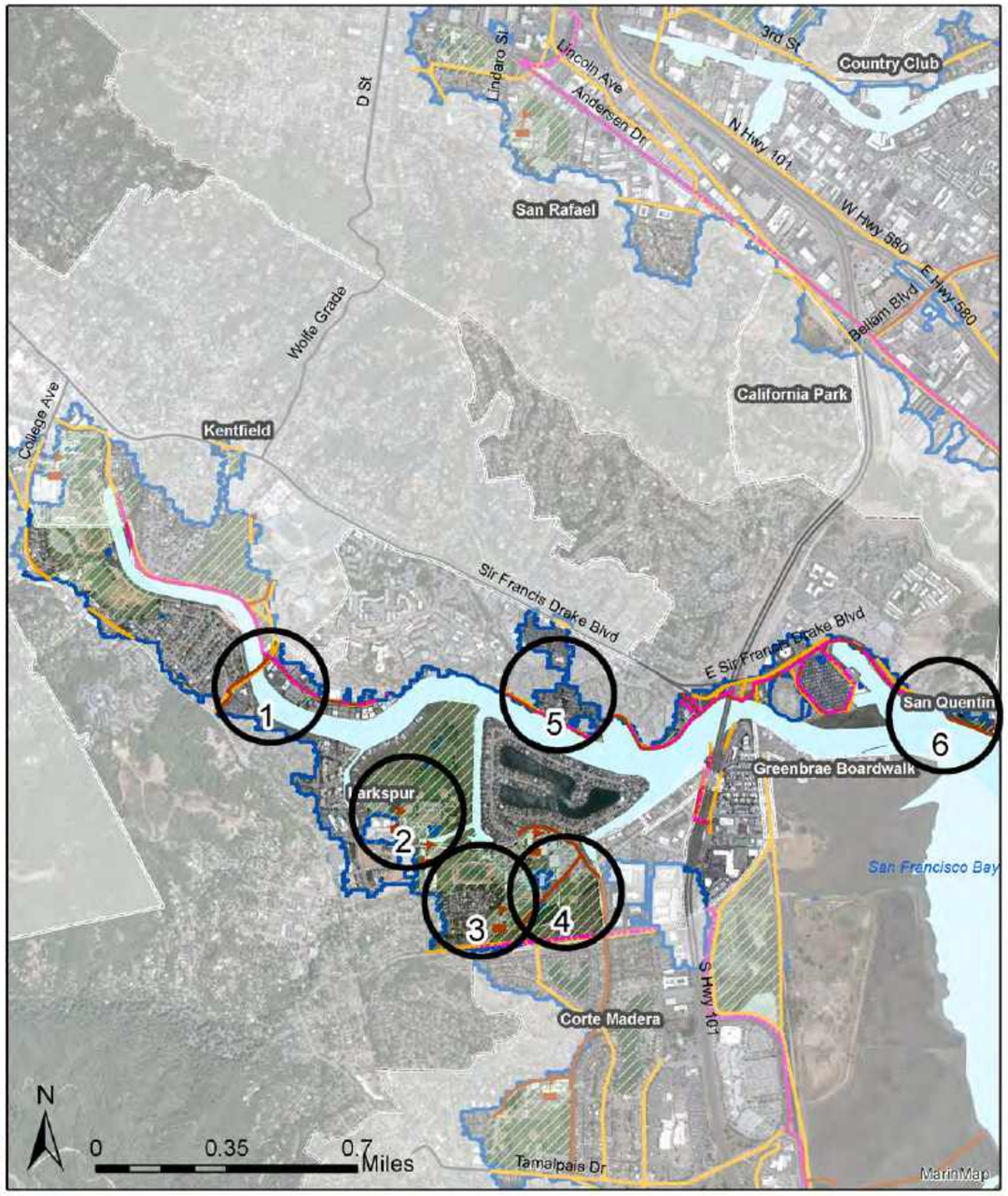


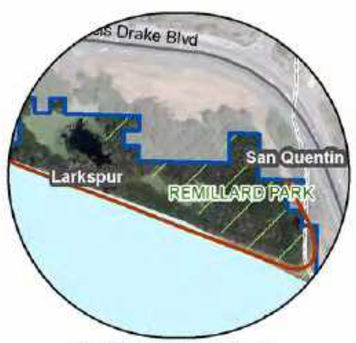
1: Bon Air Rd.

2: Piper Park & Schools

3: San Andreas High School

4: Redwood High School

5: Bon Air Landing Park



6: Remilllard Park

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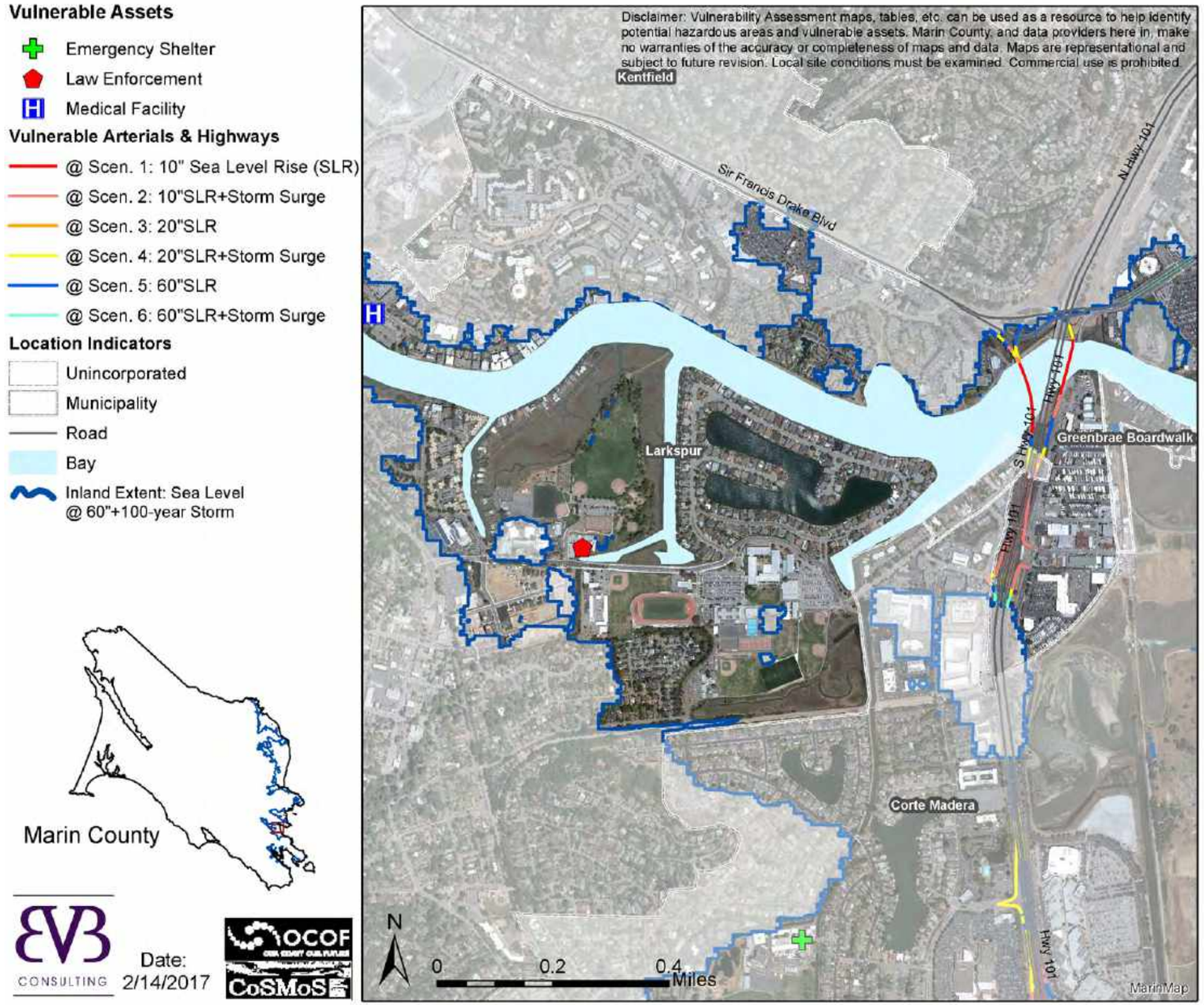
Map 95. Larkspur Vulnerable Emergency Service Assets



SAN RAFAEL

Community Profile: San Rafael

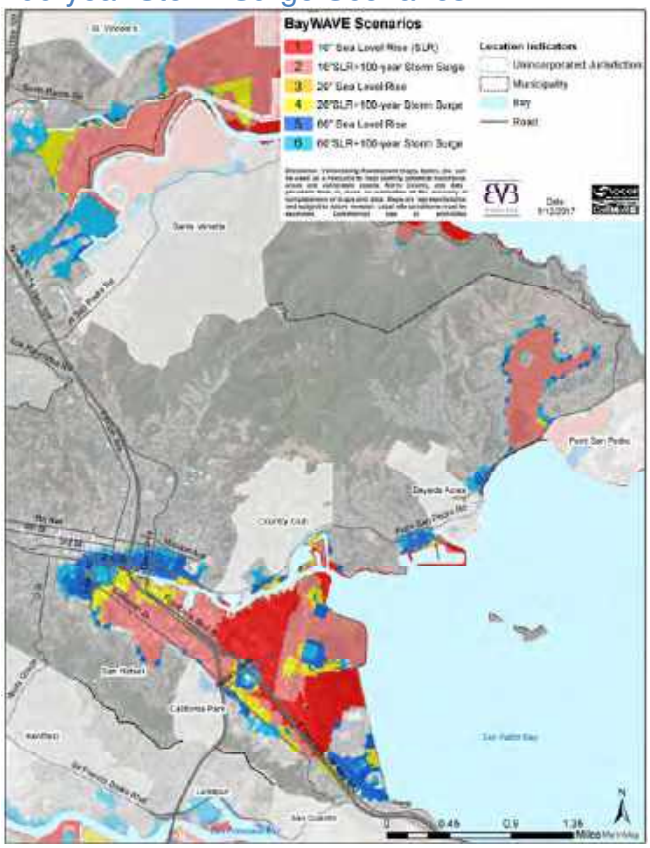
San Rafael is the Marin County seat and largest city. The city features an active boating sector, the largest downtown in the county, a university, and the county's largest employers. San Rafael is home to the largest population in general, and of low-income and limited English proficiency households. These households can be found throughout the city; however a large community exists in the low lying Canal District, the most densely populated area in the county. Compared to the other communities in the study area and the County, San Rafael could experience the most significant impacts, including:

- Flooding in the Canal area and Kerner Business District could compromise extensive multi-family housing, commercial, industrial, and recreational uses.
- US Highway 101 on and off-ramps could anticipate 100-year storm surge flooding in near-term and tidal flooding in the medium-term.
- The San Rafael Transit Center could be vulnerable in the long-term. This could compromise local and regional bus lines, and the new SMART train.
- A significant portion of downtown could face storm surges in the near- and medium-terms and sea level rise in the long-term.
- GGBHTD facilities on Andersen Drive could be vulnerable in the medium-term.
- Several schools including Bahia Vista and Glenwood Elementary, Davidson Middle, and San Rafael High schools could be vulnerable across the BayWAVE scenarios.
- Five historic landfills along the shoreline and one closed brownfield site further inland could be subject to inundation.
- Miles of electrical transmission and natural gas pipelines are in the near-term.
- Marinas and other boating facilities could be vulnerable to sea level rise in the medium- to long-term.
- Peacock Gap homes and golf course could be vulnerable to storms in the near-term and sea level rise in the long-term.
- Marin Lagoon and streets in the Las Gallinas area could begin to see peripheral tidal flooding and storm surge flooding in the near-term, and neighborhood scale flooding by the long-term.
- Fire Station 54 is vulnerable in scenario 1 and two others could have access issues.

IMPACTS AT-A-GLANCE: SCENARIO 6

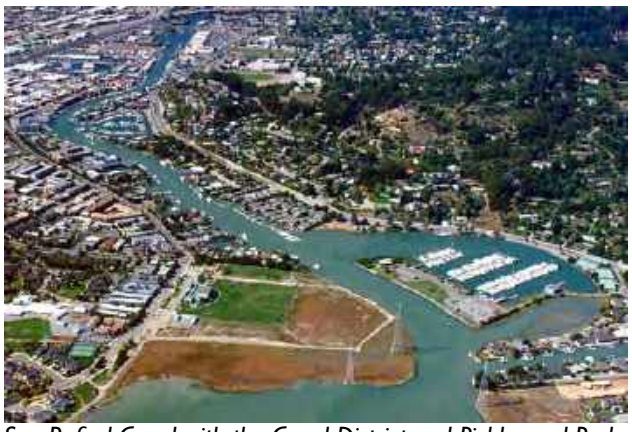
2,121 acres	58,000 people
4,700+ living units	475 commercial parcels
7.5 road miles	
Storm and tidal impacts already occur	
$2.6 billion in assessed property value; $1.7 billion in single-family home market value[200]	City of San Rafael San Rafael Sanitation District Property Owners HOAs Caltrans

Map 96. San Rafael Sea Level Rise and 100-year Storm Surge Scenarios



[200] 2016 dollars

SAN RAFAEL



San Rafael Canal with the Canal District and Pickleweed Park to the left and several homes and private marinas on the right banks of the canal. Credit: WikiMedia Commons.

Table 102. San Rafael Exposed Acres

Scenarios		Acres	
		#	%
Near-term	1	449	3
	2	1,360	10
Medium-term	3	869	6
	4	1,590	11
Long-term	5	1,856	13
	6	2,121	15

Source: MarinMap, CoSMoS

Vulnerable Assets

San Rafael's vulnerable assets include the entire Canal neighborhood and Kerner Business District, and shoreline development and boating facilities off Point San Pedro Road. In time, the impacts move into downtown San Rafael, Peacock Gap, and Marin Lagoon. Note that recent construction at the Loch Lomond Marina and surrounding properties recently completed projects to elevate the shoreline that are not accounted for in the CoSMoS models 2010 baseline imagery. Thus, flooding and onset predictions here may not be as severe as estimated in this assessment. In addition to sea level rise, subsidence is already a significant issue south of Interstate 580 and US Highway 101, and in Marin Lagoon, where development is built largely on fill atop bay mud. With sea level rise, subsidence rates could increase.

Land

Most of the vulnerable land in San Rafael was built on filled land that used to be tidal marsh or mud. Sea level rise would likely return this area to tidal habitat again without measures to protect existing land uses. With a 100-year storm surge, downtown are further inland areas within the basin of the valley as far back as Gerstle Park.

Acres

In the near-term, 449 acres, or three percent of San Rafael, could be exposed to tidal flooding at MHHW. A 100-year storm surge on top of ten inches of sea level rise, scenario 2, could flood three times as many acres. Outside of the Canal Neighborhood, much of the flooded acreage is marshland. In medium scenario 3, nearly 900 acres could flood tidally at MHHW. In scenario 4, 200 more homes could be impacted by storms surges than in scenario 2, the previous storm surge scenario. By the long-term, 1,856 acres, or roughly 15 percent of San Rafael's area could be exposed to sea level rise, and 2,121 acres could be exposed during an additional 100-year storm surge.

Parcels

San Rafael's acreage is divided in several thousand parcels, any independently owned and developed. Several publically owned parcels could also flood, especially in the near-term. Examining parcels and their and uses can provide a look into the human activities that could be flooded out by bay waters.

In the near-term, as seen in Table 105, two percent of parcels could be vulnerable to tidal flooding. With a 100-year storm surge, an additional 136 parcels and 1,438 buildings could experience temporary flooding. These are mostly buildings lining the San Rafael canals and in the low-lying areas west of the canal. The area is characterized by a variety of apartment complexes, light industrial sites, and commercial strip areas that serve the predominantly residents from Central American countries. One single family home subdivision, near Spinnaker Point, not directly at risk until later in the century, however, year round vehicular access may prove challenging before then. Bahia Vista Elementary School, Albert J. Boro Community Center and Pickleweed Park, San Rafael Fire Station 54, and the Marin County Health Innovation campus are some of the potentially impacted public facilities.

SAN RAFAEL

Table 103. San Rafael Vulnerable Residential and Commercial Parcels

Land Use	Scenarios					
	Near-term		Medium-term		Long-term	
	1		3		5	
	#	%	#	%	#	%
Residential	492	3	883	6	1,798	12
Commercial	132	11	234	19	475	40
Industrial	48	17	104	37	170	61

Source: MarinMap, CoSMoS.

Table 104. San Rafael Vulnerable Parcels by Land Uses

Land Use	Scenarios					
	1		3		5	
	Near-term		Medium-term		Long-term	
	#	Ac.	#	Ac.	#	Ac.
Commercial Improved	**116**	**98**	**213**	**267**	**419**	**527**
Commercial Unimproved	**16**	**89**	**21**	**108**	**54**	**149**
Common Area	**2**	**2**	**3**	**5**	**20**	**26**
Industrial Improved	**45**	**21**	**97**	**50**	**153**	**83**
Industrial Unimproved	**3**	**0.6**	**7**	**1**	**17**	**5**
Residential	**492**	**46**	**883**	**88**	**1,798**	**196**
Mobile Home					**154**	**1**
Multi-Family Improved	**78**	**34**	**104**	**44**	**136**	**54**
Multi-Family Unimproved	2	0.2	3	0.6	4	1
Single Family Attached	382	5	634	10	1,084	38
Single Family Improved	20	4	127	31	390	76
Single Family Unimproved	8	3	12	3	27	26
Tax Exempt	22	53	57	193	159	530
Exemption Improved	13	6	18	10	22	12
Exemption Unimproved					1	0.5

Source: MarinMap, CoSMoS

And as shown in Table 103, within the vulnerable parcels, three percent of all residential, 11 percent of all commercial, and 17 percent of industrial parcels could face tidal MHHW flooding in the near-term. In medium-term scenario 3, double these figures could anticipate tidal flooding with 883, residential parcels, 234 commercial parcels, and 104 industrial parcels. A significant 20 percent of commercial parcels and almost 40 percent of industrial parcels in San Rafael could be vulnerable to tidal flooding.

In the long-term conditions would worsen, with 40 percent of commercial and 60 percent of industrial parcels could experience tidal flooding. With a 100-uear storm surge 75 percent of San Rafael's industrial parcels could flood, and 15 percent of them would only experience storm surge flooding, the remaining could suffer the fates of both tidal and storm flooding combined. Many of these parcels are in the Canal area and Kerner Business District, this area is already highly dependent on storm water pump station to remove stormwater entering the area from the uplands. This force combined with sea level rise would require the pumps to work even harder and become overworked, or worse fail.

While not as large of a portion, 15 percent of residential parcels in San Rafael is nearly 2,000 parcels, many more than other communities in the study area. Moreover, these residential parcels are in the more affordable areas in the city and contain large numbers of low-income renter households. In fact, 34 acres amongst 78 parcels provide multi-family and could be vulnerable to tidal flooding I the near-term. By the end of the century, this figure climbs to 54 acres and 136 parcels. This is especially alarming because many of these parcels contain multiple buildings with multiple living units, thus impacting several hundred, if not thousands of households

A large number of acres are dedicated to tax exempt land. This land is typically public land, though some parcels belong to non-profit organizations. Parcels that are not dedicated to civic uses are generally parks or open space. Significant portions of open space and marshes make up the San Rafael shoreline that account for the 500 acre figure.

These losses in developable land area are significant to San Rafael, its residents, business owners, and the County as a whole. Continued use of this land would require extensive protection and reinvention.

Buildings

A majority of privately held parcels contain buildings used for housing, work, entertainment, worship, and commerce. Many public parcels can also contain buildings, especially schools, community centers, and emergency services. Without shelter, many, if not most, of the existing activities on the land would not be feasible. Damages to and destruction of buildings especially several hundred to thousands of buildings at once, would be devastating to the local, regional, and state economy for years afterwards.

In the near-term, as seen in Table 105, two percent of buildings, 410 buildings, in San Rafael could be vulnerable to higher high tides. And With a 100-year storm surge, an additional 1,438 buildings could experience temporary flooding. These are mostly buildings lining the San Rafael canals and in the low-lying areas west of the canal. The area is characterized by a variety of apartment complexes, light industrial sites, and commercial strip areas that serve the predominantly Latino residents. One section, near Spinnaker Point, is a single family home subdivision that is not directly at risk until later in the century, however, year round vehicular access may prove challenging before then. Bahia Vista Elementary School, Albert J. Boro Community Center and Pickleweed Park, San Rafael Fire Station 54, and the Marin County Health Innovation campus are some of the potentially impacted public facilities.

The Kerner business district is vulnerable in the near and medium-terms. Though some portions of the district are protected until after the medium –term because of shoreline armoring, after three feet of sea level rise this area could be saturated at high tides. Note that storm surges could cause temporary impacts as early as scenario 2.

Development is also compromised in the near-term on Irwin, 2nd, and 3rd Streets. This area, known as Montecito, includes gas stations, grocery stores, small offices, and several daily needs businesses. San Rafael High School is located here and could anticipate long-term impacts. In the medium-term, more than 1,000 buildings could be vulnerable to tidal flooding and nearly twice that could be vulnerable under a 100-year storm surge. By the long-term, nearly 2,500 buildings, or 13 percent of all buildings in San Rafael, could face some level of tidal flooding. Under storm surge conditions, 18 percent of buildings in San Rafael, or more than 3,000 buildings could experience storm damage, only 1,200 of which would only suffer storm surge flooding. Between the medium- and long-terms, ocean waters move further into the valley, crossing the freeway interchanges, flooding out the on and off ramps, reaching the Andersen and Francisco West industrial and commercial areas, downtown, and eventually the Gerstle Park neighborhood.

Table 105. San Rafael Vulnerable Buildings by Scenario

Scenarios		Buildings	
		#	%
Near-term	1	410	2
	2	1,846	10
Medium-term	3	1,088	6
	4	2,097	11
Long-term	5	2,495	13
	6	3,247	18

Source: MarinMap, CoSMoS

The Canal Neighborhood population is about 70 percent Central and South American origin and Spanish or native languages are typically spoken at home. Compared to other communities in the study area, Canal residents are younger, families are larger, incomes are lower, and residents are primarily renters. [201] ***Almost one-half of residents are housing cost burdened, paying more than 30 percent or more of their income for housing.*** [202] ***Canal Neighborhood residents own fewer cars and ride transit.*** [203] ***These residents are disproportionately vulnerable to sea level rise and some of the first people impacted by sea level rise at their front doors.***

[201] Census 2010
[202] Human Impact Partners. 2013. Healthy Marin Partnership. Community Health Needs Assessment Sub-county Health Indicators.
[203] Census 2010

Table 106. San Rafael Vulnerable Buildings Tidal Flooding* Estimates at MHHW

Flood Depth (feet)		Scenario		
		Near-term	Medium-term	Long-term
		1	3	5
0.1-1	#	94	143	108
1.1-2	#	143	212	228
2.1-3	#	187	251	346
3.1-4	#	26	206	548
4.1-5	#	3	102	401
5.1-6	#	1	9	360
6.1-7	#		1	215
7.1- 8	#			190
8.1-9	#			26

**Flood depth data is not available for all exposed areas and assets.*
Source: MarinMap, CoSMoS

Table 107. San Rafael Vulnerable Buildings' FEMA Hazus Storm Damage Cost* Estimates in Long-term Scenario 6

Buildings in Scenario 6	3,247
Yellow Tag: Minor Damage $5,000 minimum	$16,235,000
Orange Tag: Moderate Damage $17,001 minimum	$55,202,247
Red Tag: Destroyed Assessed structural value	$1,496,065,489

Source: MarinMap, CoSMoS
** 2016 dollars*

The analysis presented in Table 106 breaks down the vulnerable buildings by how much saltwater could enter the property at MHHW. Storm surges would have one to three feet of additional water and would impact significantly more buildings. In the near and medium-terms most vulnerable buildings in San Rafael experience 6 feet or shallower waters, with the majority experiencing three feet or lower. In the long-term, more than 600 buildings could flood with up to three feet, more than 1,000 buildings could flood with between three and six feet, and more than 400 buildings could be flooded with up to nine feet of saltwater at mean higher high water. Buildings that flood to these extreme on a regular basis are not useable. Even if the building itself is flood proofed, the surrounding land, roads, and utilities would likely be compromised as well, rendering the buildings uninhabitable.

Table 107 shows FEMA Hazus post-disaster estimates for damage to buildings and their contents. If all the buildings vulnerable in scenario 6, the worst case storms urge scenario analyzed in this assessment, experience minor damage a minimum of 16 million in damages could occur. If all for these buildings were to be destroyed, the worst possible outcome, up to $1.5 billion in assessed structural value vulnerable in scenario 6. Reality would likely reflect a mix of damage levels amounting to monetary values between the high and low figures calculated here.

Buildings in San Rafael are older, and many, especially downtown are unreinforced and could be weakened by flooding. These buildings are primarily mixed-use or commercial. Newer commercial buildings are typically concrete slab tilt-ups or smaller cinder block and stucco buildings. According to a BCDC profile for San Rafael for the Stronger Housing Safer Communities on seismic and flooding safety, most single-family homes in the low-lying areas of San Rafael are one- and two story homes, built in the Victorian era, the earlier part of the 20th century, post-WWII, and newer modern homes. There are also 2-4 unit dwellings, and medium- and large-sized apartment complexes typically of wood construction.[204]

According to San Rafael asset managers, several critical businesses could be vulnerable to sea level rise. These include: 30 grocery stores from 7-11 to Whole Foods Market, 10 pharmacies, 16 medical clinics, 48 doctor offices, and 29 building supply stores. These businesses either contain critical goods like medications and access to medical and buildings supplies after a major storm or flooding event or house some of the most vulnerable populations in the region.

The maps on the following pages illustrate vulnerable buildings by scenario. The areas in the call out circles enable the reader the see areas that are difficult to see on the large scale map. The circles do not indicate that these areas are more vulnerable than other areas along the shoreline.

[204] BCDC. March 2015 Stronger Housing Safer Communities. Strategies for Seismic and Flood Risk. Summary Report. San Rafael Profile: http://resilience.abag.ca.gov/wp-content/documents/housing/San%20Rafael%20Community%20Profile_final_v2.pdf

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Map 97. Southern San Rafael Vulnerable Buildings

Vulnerable Assets

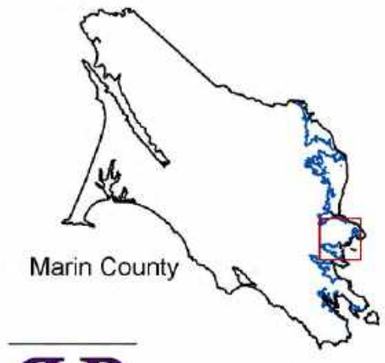
- School
- Medical Facility
- Emergency Shelter
- Fire Station

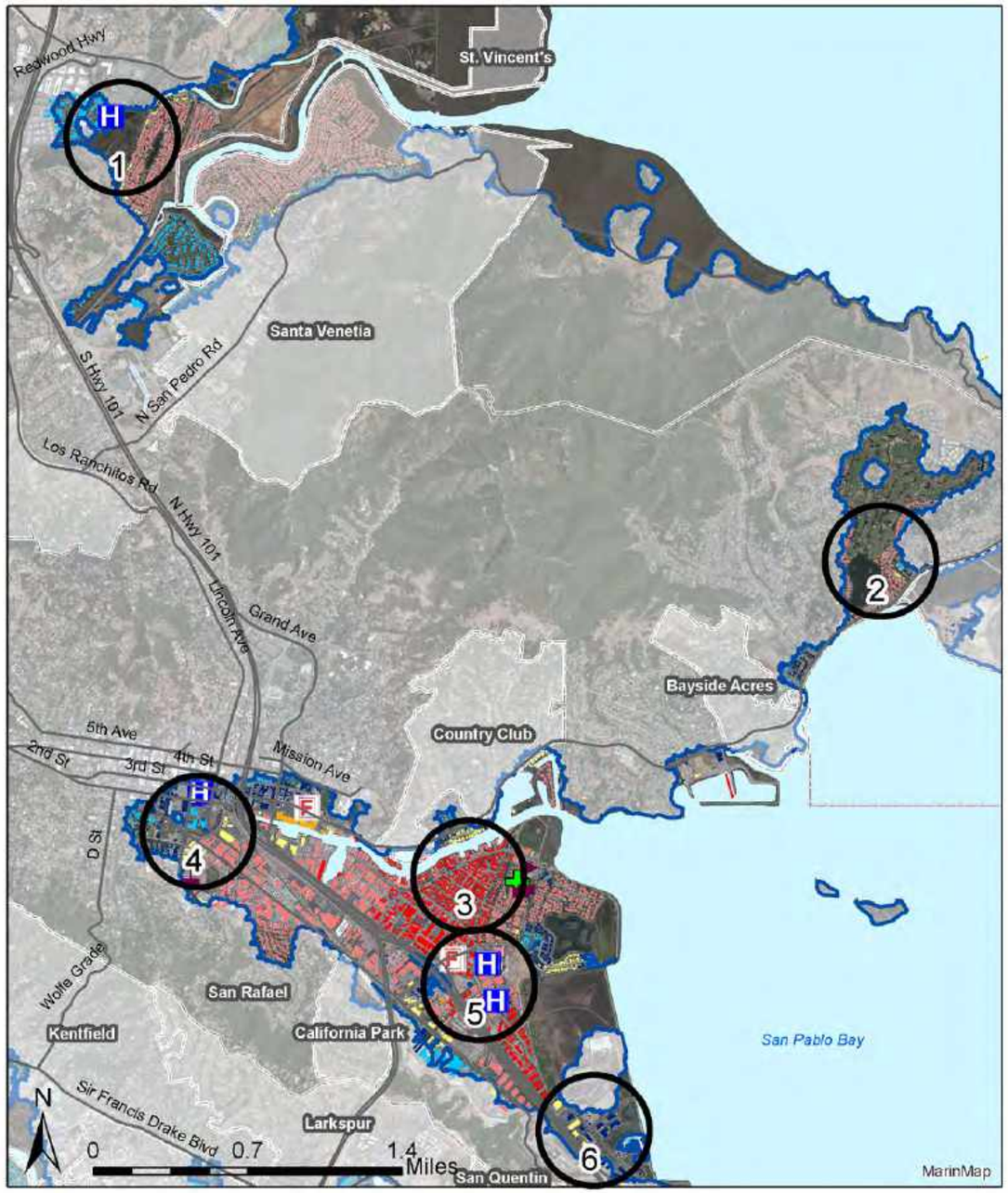
Vulnerable Buildings

- Scen. 1: 10" Sea Level Rise (SLR)
- Scen. 2: 10" SLR+Storm Surge
- Scen. 3: 20" Sea Level Rise
- Scen. 4: 20"SLR+Storm Surge
- Scen 5: 60" Sea Level Rise
- Scen. 6: 60"SLR+Storm Surge

Location Indicators

- Unincorporated
- Municipality
- Road
- Bay
- Inland Extent: Sea Level @ 60"+100-year Storm





1: Las Gallinas

2: Peacock Gap

3: Canal Neighborhood

4: Downtown

5: Interstate 580

6: End of Kerner Blvd.

Date: 4/13/2017

Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data providers here in, make no warranties of the accuracy or completeness of maps and data. Maps are representational and subject to future revision. Local site conditions must be examined. Commercial use is prohibited.

A closer examination of places where young children or disabled or older people spend much of their time reveals that nearly 50 vulnerable sites are in the vulnerable area of San Rafael. Thirty-five buildings support childcare facilities. Five buildings house residential care facilities, including:

- Aegis of San Rafael,
- Golden Home Extended Care,
- Miracle Hands Homecare,
- Saint Michael's Extended Care, and
- Schon Hyme Rest Home.

Seven convalescent facilities also house uniquely vulnerable residents. These are:

- All Saints Extended Care, Inc.,
- Country Villa San Rafael,
- Harmony House,
- Kindred Transitional Care and Rehabilitation,
- Pine Ridge Care Center,
- San Rafael Care Center, Inc., and
- San Rafael Healthcare & Wellness Center.

While these facilities may be able to withstand low levels of infrequent flooding, higher levels of water and/or more frequent flooding could be burdensome on these facilities and require relocation. Moreover, these facilities are especially vulnerable to power outages or disruptions to emergency services.

Transportation

Transportation is a major concern for San Rafael and for the entire region. San Rafael serves as a regional transit center, and nearly all routes stop here, including the newly unveiled SMART line. In the near-term, other major roads impacted are Bellam Blvd, Francisco Blvd., East, Kerner Blvd, Grand Ave. and Irwin Street.

Much like with buildings, many of the roads to be flooded first are in, or are major access ways to, the Canal District and north of Interstate 580. Residents in this area tend to live with scarce financial resources and can be especially burdened by disruptions in the transportation system or damages to their vehicles, In addition, those with health or mobility constraints, who do not own a home or car, or are not proficient in the English language, may also be disproportionally burdened by sea level rise and storms. If these residents are displaced, the upheaval and loss would be significant to the community and the regional economy that depends on their contributions.

Further, this area hosts the majority of light industrial and a major portion commercial uses that depend on the transportation network to reach clients, receive and deliver materials, and receive customers. Moreover, already constrained street parking could be flooded with tidal waters. And repeated exposure to saltwater would damage personal and commercial vehicles. Finally, emergency access for fire, ambulance, and police could be limited at a time residents are most vulnerable. In fact, Fire Station 54 could be directly flooded, damaging equipment and vehicles in the station.

In the medium-term, tidewaters extend under the freeways further into the street grid of downtown and the industrial and commercial Andersen Drive area. While US Highway 101 is generally elevated, on and off ramps at grade could be flooded out along most of its course through the city. Unlike 101; however, Interstate 580 could anticipate surface flooding between the medium- and long-terms. In the long-term, streets and homes in the Gerstle Park neighborhood west of downtown and US Highway 101 could flood when Mahon Creek overflows its banks. While previously impacted by storm surges. Pt. San Pedro Rd. could expect impacts at tidal MHHW by the long-term as well. Roads bayside of Pt. San Pedro Road, such as Mooring Road, could be vulnerable in the near-term.

Preliminary conversations with Caltrans indicate that Caltrans is well aware of the existing and arising concerns in San Rafael.[205] According to Caltrans and the CoSMoS model, flooding occurs at low spots of US Highway 101 where it connects with Interstate 580 to the south of San Rafael Harbor. These low spots typically benefit from levees and pumps others operate to protect the larger area from flooding.

Table 108 lists transportation routes that could be vulnerable by scenario and annotates the agency responsible for a road. San Rafael has jurisdiction over the majority of the exposed portion of Pt. San Pedro Road, and the County has jurisdiction bordering the small unincorporated Country Club portions.

[205] Sea Level Rise Vulnerability Assessment Interview. Caltrans. April 30, 2015. J. Peterson. D. Fahey. Marin County Development Agency. BVB Consulting LLC.

Table 108. San Rafael Vulnerable Transportation Assets

Near-term		Medium-term		Long-term	
Scenario 1	**Scenario 2**	**Scenario 3**	**Scenario 4**	**Scenario 5**	**Scenario 6**
8 miles	**22 miles**	**15 miles**	**27 miles**	**35 miles**	**41 miles**
Hwy 101 [C]	Roads in scenario 1	Roads in scenario 1	Roads in scenarios 1-3	Roads in scenarios 1-4	Roads in scenarios 1-5
Hwy 580 [C]	Pt. San Pedro Rd [L, C]	Francisco Blvd W [L]	2nd St [L]	4th St [L]	C St [L]
Bellam Blvd [L]	Acadia Ln [L]		3rd St [L]	A St [L]	Bayview St [L]
Francisco Blvd E [L]	Bahia Ln [L]		Lindaro St [L]	B St [L]	Bridgewater Dr [L]
Kerner Blvd [L]	Baxters Ct [P]		Aqua Vista Dr [L]	Hetherton St [L]	Commercial Pl [L]
Grand Ave [L]	Bedford Cv [L]		Baypoint Dr [L]	Albert Park Ln [L]	Loma Linda Rd [L]
Irwin St [L]	Billou St [L]		Baypoint Village Dr [L]	Avocet Ct [P]	Main Dr [L]
Canal St [L]	Bret Ave [L]		Biscayne Dr [L]	Brooks St [L]	Mariners Cir [L]
Alto St [L]	Bryce Canyon Rd [L]		Dodie St [L]	Chapel Cove Dr [L]	Mark Dr [L]
Amalfi Pl [L]	Carlsbad Ct [L]		Egret View [L]	Cijos St [L]	McInnis Pkwy [L]
Bahia Pl [L]	Catalina Blvd [L]		Loch Lomond Dr [L]	Dowitcher Wy [P]	Milano Pl [L]
Bahia Wy [L]	Crater Lake Wy [L]		Novato St [L]	Embarcadero Wy [L]	Mitchell Blvd [L]
Bahia Cir [L]	De Luca Pl [L]		Pelican Wy [L]	Glacier Pt [L]	Newport Wy [L]
Bay Harbor Wy [P]	Dolores St [L]		Royal Ct [L]	Grange Ave [L]	Octavia St [L]
Belvedere St [L]	Du Bois St [L]		Simms St [L]	Jacoby St [L]	Paul Dr [L]
Capri Ct [L]	Duffy Pl [L]		Yacht Club Dr [P]	Knight Dr [L]	Pelican Wy [L]
Castro Ave [L]	Duxbury Cv [L]			Leith Ln [L]	Riviera Manor [L]
Charlotte Dr [L]	Falmouth Cv [L]			Lido Ln [L]	Rockport Cv [L]
Elaine Wy [L]	Gary Pl [L]			Lochinvar Rd [L]	San Pedro Cv [P]
Fairfax St [L]	Glacier Way [L]			Lootens Pl [L]	Sandpiper Ct [L]
Front St [L]	Gloucester Cv [L]			Mariposa Rd [L]	Shores Ct [L]
Golden Gate Dr [L]	Hingham Cv [L]			Mary St [L]	Smith Ranch Rd [L]
Irene St [L,P]	Hoag St [L]			Mission Ave [L]	Taylor St [L]
Larkspur St [L]	Hyannis Cv [L]			Morphew St [L]	Waterside Cir [L]
Lido Ln [L]	Isla Vista Ln [L]			Park St [L]	Willow St [L]
Lisbon St [L]	Isle Royale Ct [L]			Peacock Ln [L]	Woodland Pl [L]
Louise St [L]	Jordan St [L]			Piombo Pl [L]	
Madera St [P]	Lagoon Pl [L]			Portsmouth Cv [L]	
Marian Ct [L]	Lagoon Rd [L]			Ritter St [L]	
Market St [L]	Lincoln Ave [L]			Riviera Pl [L]	
Medway Rd [L]	Loma Vista Pl [L]			Silk Oak Cir [L]	
Mill St [L]	Lovell Ave [L]			Summit Ave [L]	
Mooring Rd [L]	Marina Way [L]			Surfwood Cir [L]	
Novato St [L]	McNear Dr [L]			Tern Ct [P]	
Portofino Rd [L]	Mesa Verde Wy [L]			Turnstone Dr [P]	
Sea Wy [L]	Nantucket Cv [L]			Union St [L]	
Shoreline Path	Narragansett Cv [L]			Warner Ct [L]	
Smith Ranch Airport [L]	Newport Wy [L]				
Sonoma St [L]	Olympic Wy [L]				
Sorrento Wy [L]	Peacock Dr [L]				
Summit Ave [L]	Playa Del Rey [L]				
Tiburon St [L]	Plymouth Cv [L]				
Verdi St [L]	Porto Bello Dr [L]				
Vivian St [L]	Rice Dr [L]				
Yosemite Rd [L]	Riviera Dr [L]				
	Rockport Cv [L]				
	Salem Cv [L]				
	San Marcos Pl [L]				
	Shenandoah Pl [L]				
	Shoreline Pkwy [L]				
	Spinnaker Point Dr [L]				
	Tahoe Pl [L]				
	Teton Ct [L]				
	Vista Del Mar [L]				
	Windward Wy [L]				
	Woodland Ave [L]				
	Yellowstone Ct [L]				
	Zion Ct [L]				

M = Marin County; C = State of California; L = Local Municipality; P = Private. Source: MarinMap, CoSMoS

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Loch Lomond Marina Club House. Credit: BVB Consulting LLC

Compromises in the road network impact transit services. Nearly every transit service provider travels through the exposed areas in San Rafael. Not only could service be interrupted, the Golden Gate Transit and Marin Airporter facilities could be compromised as early as scenario 2. Moreover, the San Rafael Transit Center could be vulnerable to tidal flooding in the long-term. Golden Gate Transit routes 17, 22, 23, 27, 28, 29, 35, 36, 40, 42, 44, 49, 70, 71, 80, 99, 101, 117, SR7, 126, and DH could be vulnerable if they roads they travel are flooded. The following bus stops could also be flooded:

- San Rafael Transit Center
- Canal St. and Medway Rd.,
- Canal St. and Novato St.,
- Canal St. and Sonoma St.,
- Second St. and Grand Ave.,
- Third St. and Grand Ave.,
- 445 Francisco Blvd. E,
- 1525 Francisco Blvd. E,
- Irene St. and Francisco Blvd.,
- 3140 Kerner Blvd.,
- Kerner Blvd. and Bahia Way,
- Kerner Blvd. and Canal St.,
- Kerner Blvd. and Fairfax St.,
- Kerner Blvd. and Larkspur St.,
- Medway Rd. and Francisco Blvd., E
- Medway Rd. and Mill St.,
- Andersen Dr. and Jacoby St.,
- 1261, 1011, and 1022Andersen Dr.,
- Andersen Dr. and Simms St.,
- Andersen Dr. and PG&E,
- Andersen Dr. and Francisco Blvd. W,
- Andersen Dr. and Dubois St.,
- Andersen Dr. and Irwin St., and
- Bellam Blvd. and Lisbon St.,
- Bellam Blvd. and Francisco Blvd. E,
- Bellam Blvd. and I-580 EB On-Ramp
- Francisco Blvd. E and Pelican Way,
- Kerner Blvd. and Shoreline Pkwy.,
- Lindaro St. and Andersen Dr.,
- Lindaro St. and Second St.

Marin Transit routes that could be vulnerable to hazardous road conditions are 23, 29, 35, 36, 228, 233, and 257, with stops at:

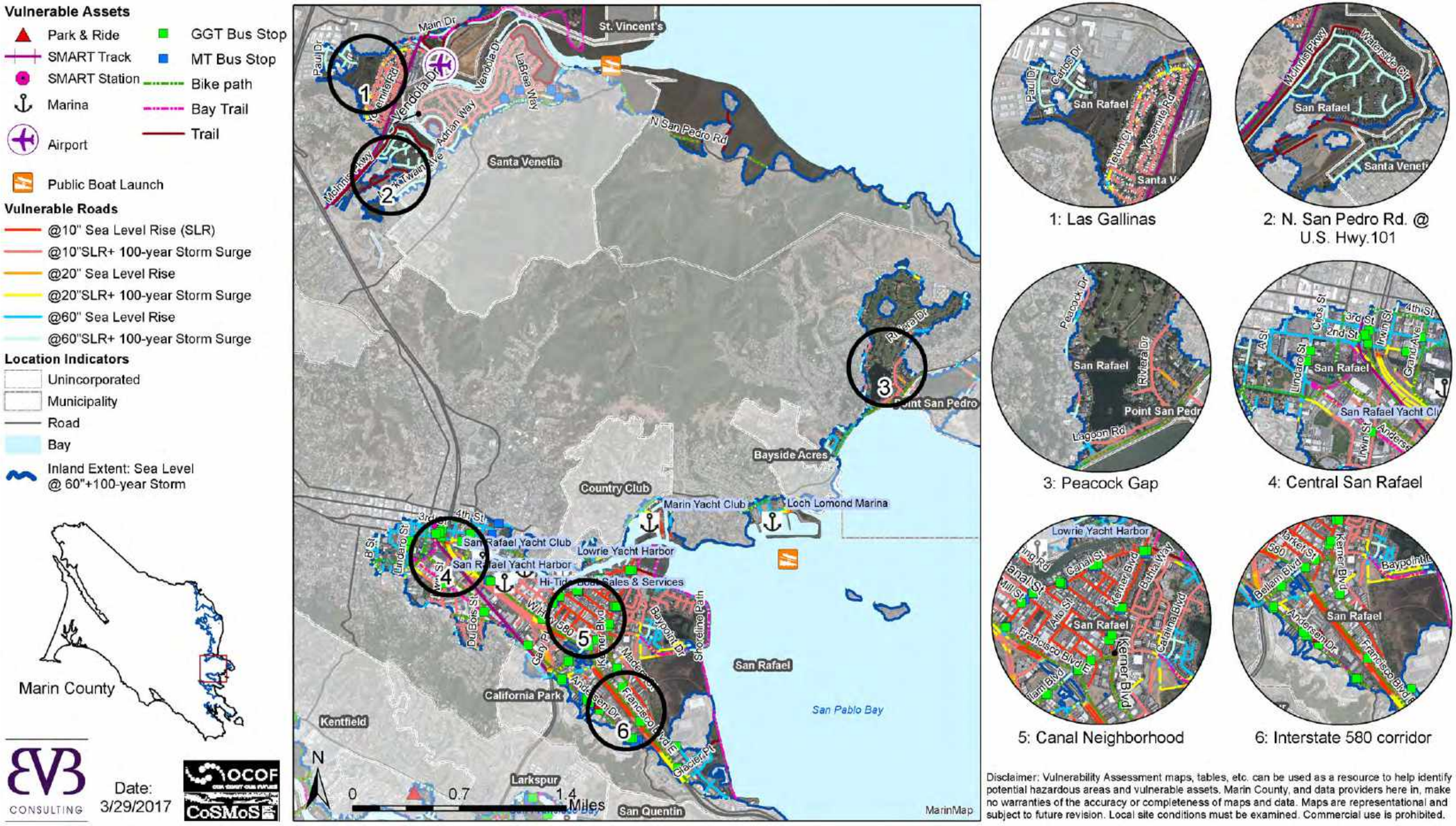
- Third St. and Grand Ave.
- San Rafael Transit Center,
- Second St. and Grand Ave.,
- 887 Andersen Dr.,
- 1011 Andersen Dr.,
- Andersen Dr. and Jacoby St.,
- Andersen Dr. and Simms St.,
- Andersen Dr. P and R Lot,
- Andersen Dr. at Office 1261,
- Andersen Dr. GGBHTD facility
- Andersen Dr. and PG&E Office,
- Medway Rd. and E Francisco Blvd.,
- Medway Rd. and Mill St.,
- E Francisco Blvd. and Bay St.,
- Canal St. and Medway Rd.,
- Canal St. and Novato St.,
- Canal St. and Sonoma St.,
- Kerner Blvd. and Canal St.,
- Kerner Blvd. and Fairfax St.,
- Kerner Blvd and Bahia Way,
- Kerner Blvd. and Larkspur St.,
- Bellam Blvd. and E. Francisco Blvd., and
- Union St. and Fourth St.

Water transportation is a major contributor the San Rafael's sense of place, commercial activity, and recreation. One of Marin's two ports is located here along with several private marinas that could experience damage from storms and their facilities flooded out if barriers walls are not adequately elevated or pier and dock pilings are not tall enough for the highest high tides. Finally, several miles of trails could be vulnerable to sea level rise including the Bay Trail and Shoreline Path.

The maps on the following pages illustrate vulnerable transportation features. The areas in the call out circles enable the reader the see areas that are difficult to see on the large scale map. The circles do not indicate that these areas are more vulnerable than others along the shoreline.

SAN RAFAEL

Map 98. San Rafael Vulnerable Transportation Assets



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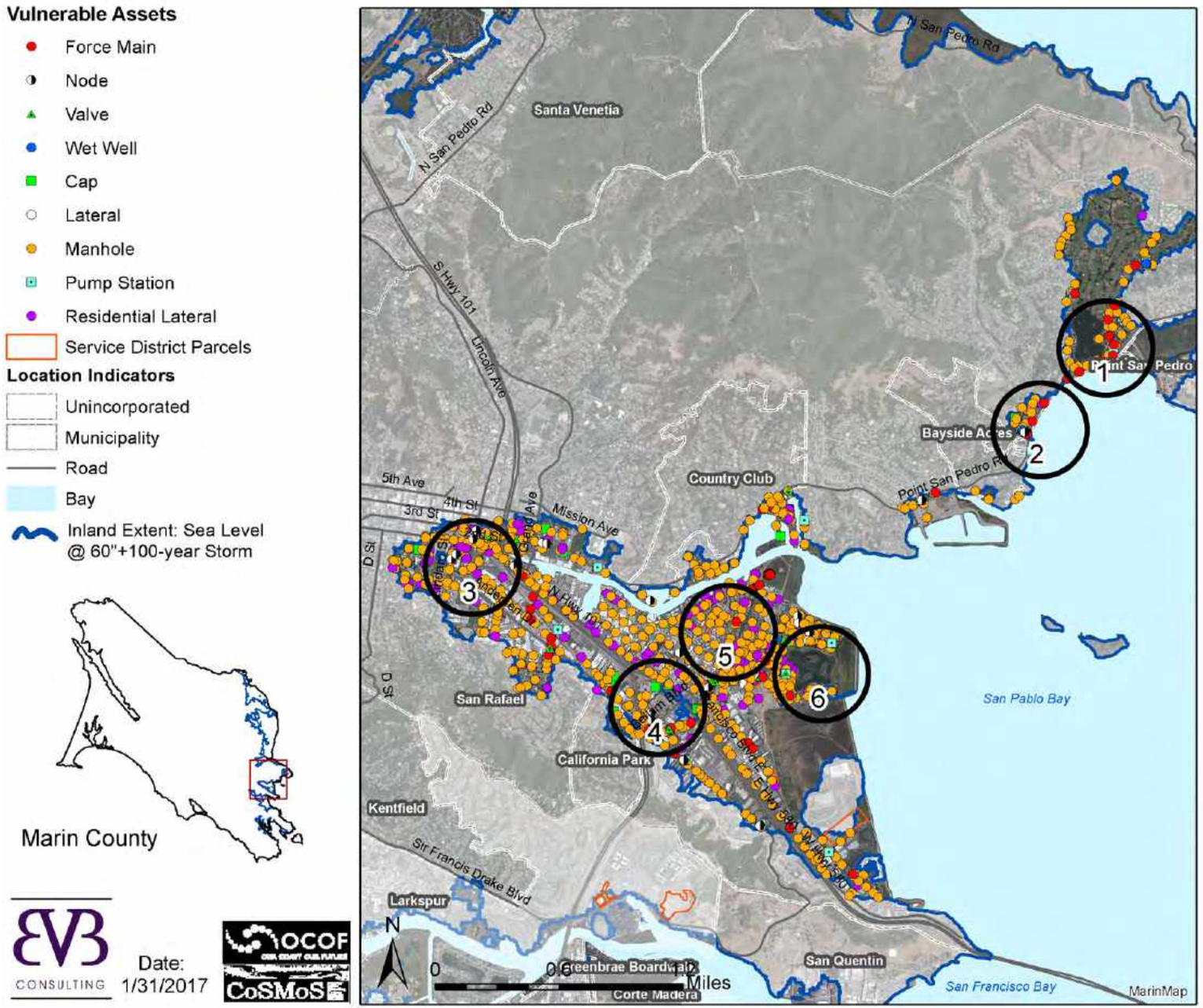
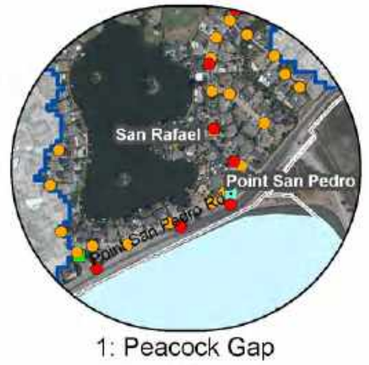
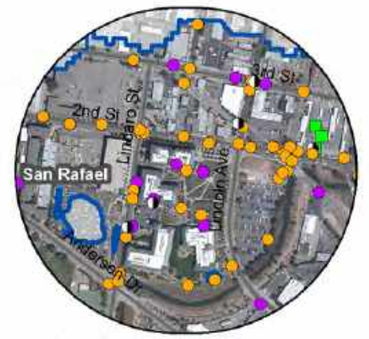
Map 99. San Rafael Vulnerable Wastewater Management Assets





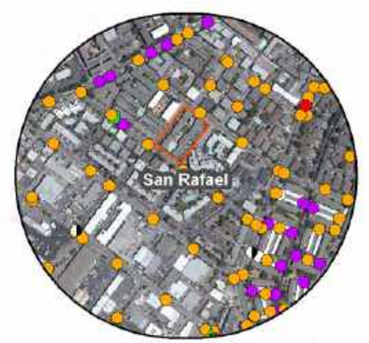
1: Peacock Gap

2: Pt. San Pedro Blvd.



3: Central San Rafael

4: Woodland Ave.



5: Canal Neighborhood

6: Spinnaker Point

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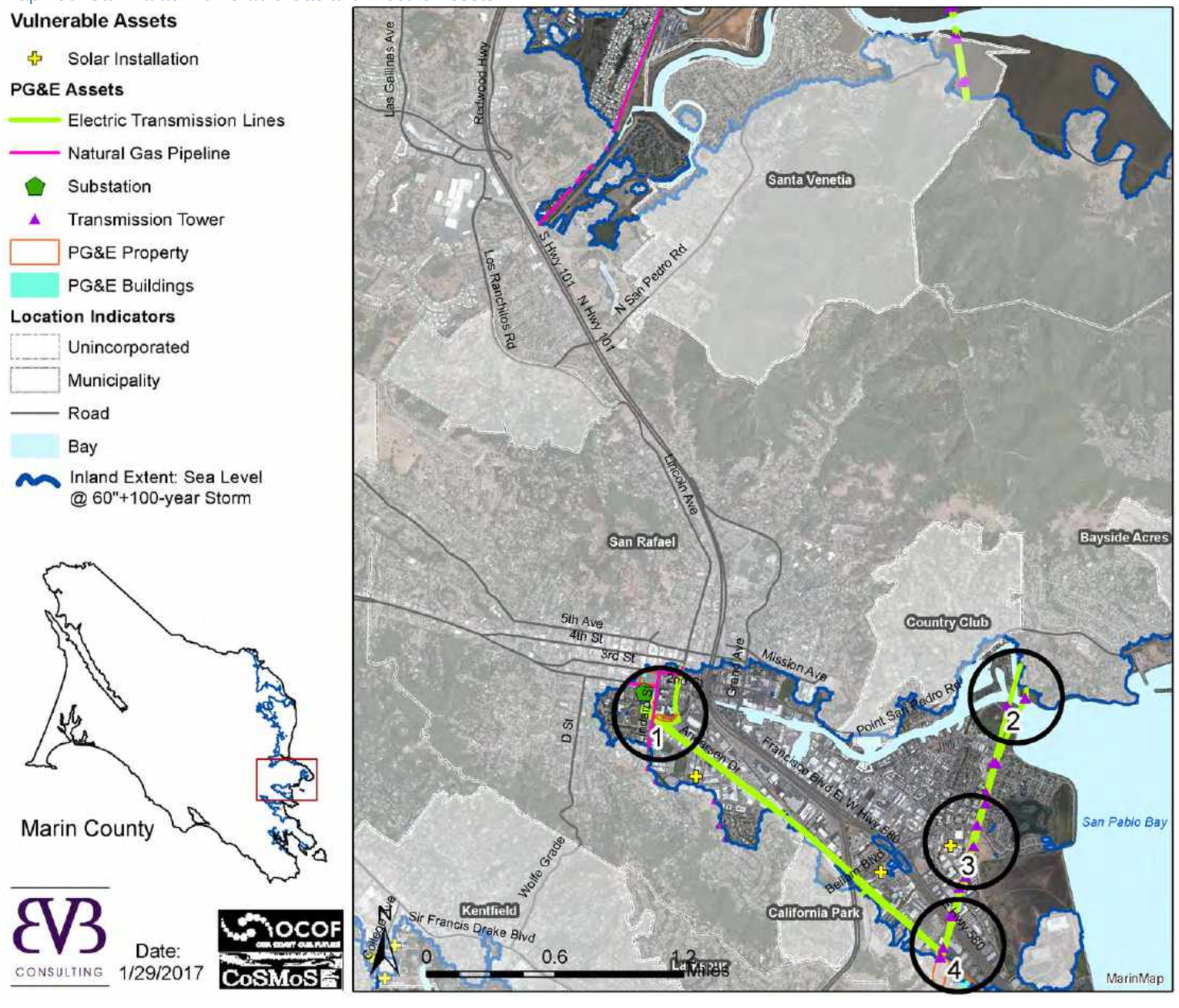
Map 100. San Rafael Vulnerable Gas and Electric Assets



1: Central San Rafael

2: San Rafael Canal

3: Canal Area

4: PG&E Yard & Offices on Andersen Dr.

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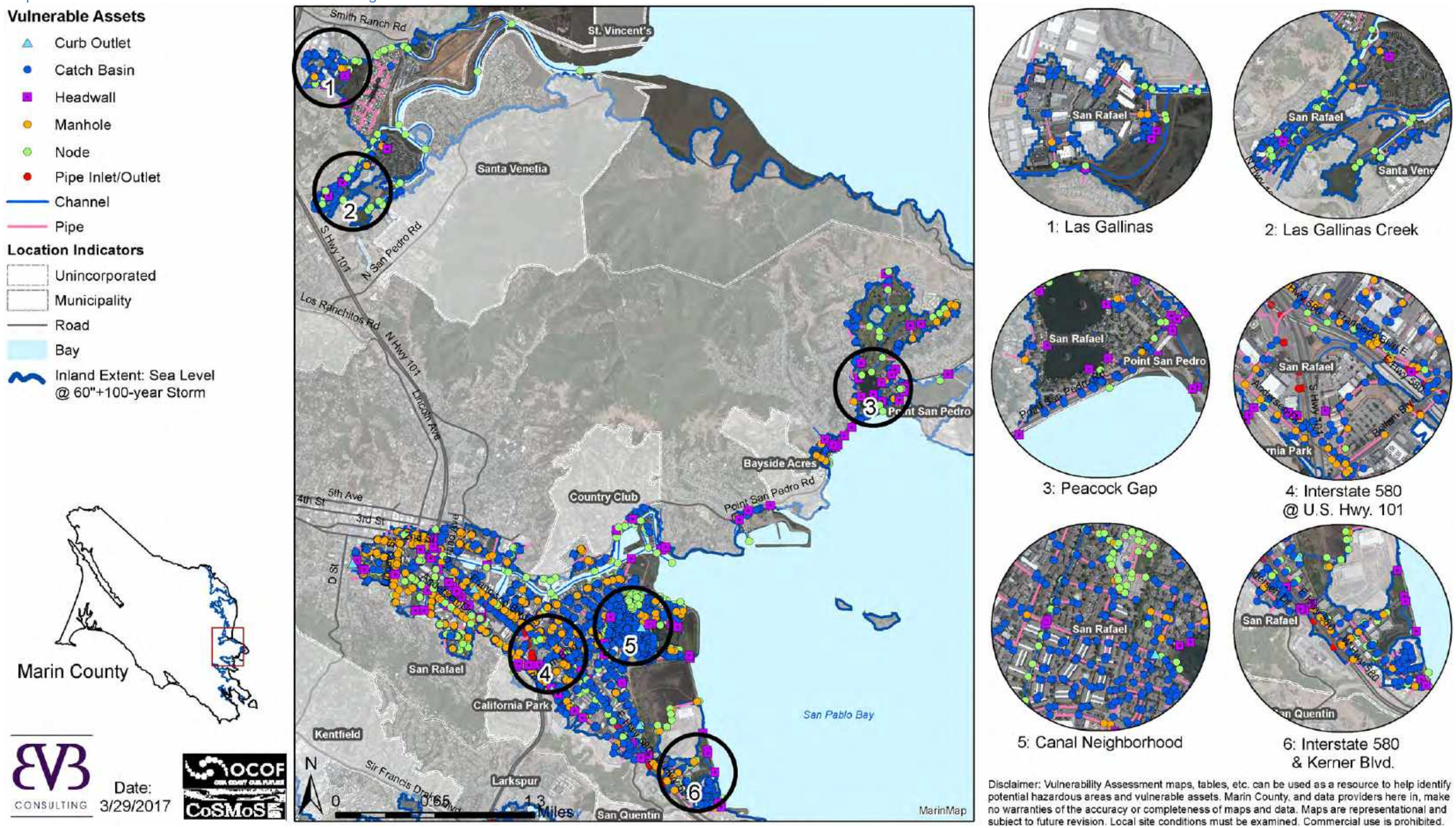
Map 101. San Rafael Vulnerable Stormwater Management Assets



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Utilities
PG&E has significant assets in San Rafael that could be exposed and vulnerable to sea level rise and storm surge impacts. Underground gas pipes could face buoyancy pressures as the water table beneath them rises and pushes them to the surface. The pressure can place bending forces on the pipes, especially where they are held down by roads. Moreover, if a road sheltering a natural gas pipe is damaged enough to rupture the pipes the consequences could be severe. The transmission lines are above ground and could be vulnerable to falling trees and high winds. In addition, posts could become damaged over time, from floating debris, and subsidence. Lastly, the PG&E offices and yard on Andersen Drive could anticipate storm surge impacts in the long-term.

The San Rafael public works building and corporate yard may not experience direct impacts until the long-term with a storm surge, and primarily in the parking lots. However, access to and from the site could be compromised in the long-term due to sea level rise alone. With respect to other utilities, San Rafael is vulnerable to similar issues as other shoreline communities in the study area such as:

- Underground pipes face compounding pressure forces from water and the road,
- Road erosion and collapse with underlain pipes,
- Saltwater inflow and infiltration causing inefficiencies in wastewater treatment,
- Continuously subsiding soils or fill,
- Escalating activity, capacity demands, energy consumption, and wear and tear on San Rafael's stormwater pump stations 50-61, and others in the wastewater collection system,
- Aging individual site connections for water, sewer, and electrical, and
- Flood waters interrupting access for employees to reach work sites.

The maps on the previous pages illustrate vulnerable utility features. The areas in the call out circles enable the reader the see areas that are difficult to see on the large scale map. The circles do not indicate that these areas are more vulnerable than others along the shoreline.

Natural Resources
The shoreline stemming away from the San Rafael Canal hosts significant riparian and tidal marsh habitats. The diked baylands further south, serve as a storm buffer between urban and tidal areas and contribute to improved water quality trapping and/or removing pollutants from runoff and wastewater. They also act as storage basins for rain runoff and saltwater during high tides.

The dike lands, wetlands, and marshes provide habitat areas for threatened and endangered species; and can serve as possible mitigation areas. Their partial or complete flooding in the winter rainy season provides needed shallow wetland habitat for many species and flocks of migratory ducks and shorebirds.[206]

Based on the National Inventory of Habitats, several endangered species are known to inhabit these tidal areas including the California Black Rail, Ridgway's Rail, the California Brown Pelican, and the tidewater goby. Other than Brick Yard Beach, San Rafael incorporated has a few beaches that are used for recreation and are not necessarily of habitat value. The Marin Rod and Gun Club beach is also narrow.

Recreation
The San Rafael shoreline and canal are highly active recreation areas. Boating, fishing, biking, and walking the pathways are the most common activities. The marinas are used for boating and could face challenges in the onset of sea level rise. Biking and walking on the streets and trails could be limited to low tides and inaccessible depending on the path's proximity to the existing shoreline.

In the near-term, McNear's Beach, Gallinas Creek, Pickleweed, and Starkweather Shoreline parks could anticipate impacts at the shoreline edges, and in the medium-term, see significant tidal flooding. In the long-term, Albert, Peacock Gap, and Schoen parks could also see tidal flooding. A few hotels, including the Extended Stay America, North Bay Inn, and Motel 6 could also be vulnerable to tidal flooding.

Emergency Services
The San Rafael Fire Department could be directly impacted at the Castro Street Station 54 in the near-term and face access issues at Station 52 and 55 in the medium- and long-terms. In addition, Bahia Vista Elementary and the Albert J. Boro Community

[206] San Rafael Community Development Department. Amended and reprinted 2013. San Rafael, CA General Plan 2020: Our Natural Resources.

Center serve as emergency shelters that could each face up to two feet of flooding by scenario 3. Finally, access on flooded roads would be severely compromised during MHHW and storms.

The maps on the following pages illustrate vulnerable natural resource, recreation, emergency and historic features. The areas in the call out circles enable the reader the see areas that are difficult to see on the large scale map. The circles do not indicate that these areas are more vulnerable than others along the shoreline.

SAN RAFAEL

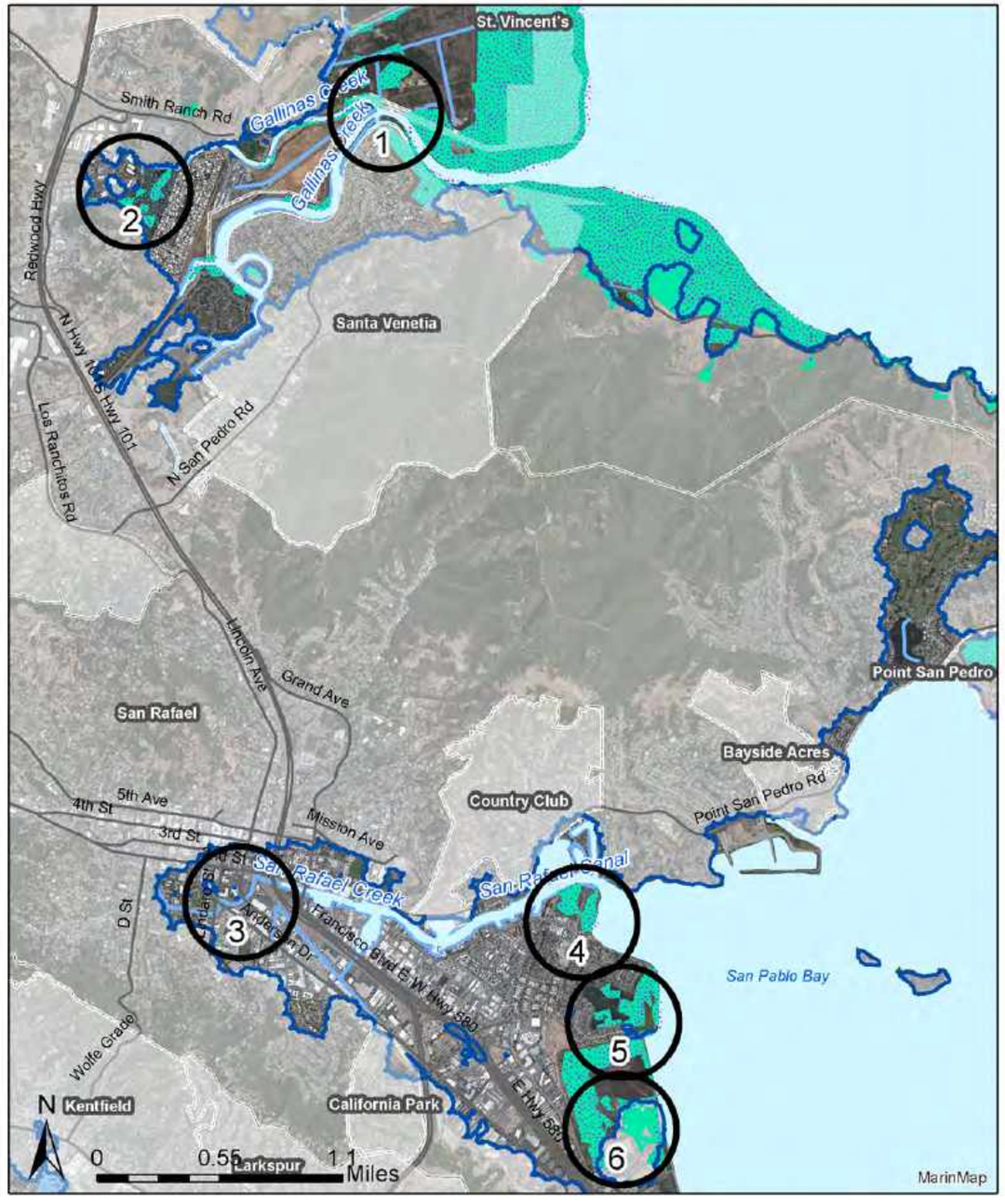
Map 102. San Rafael Vulnerable Natural Resource Assets

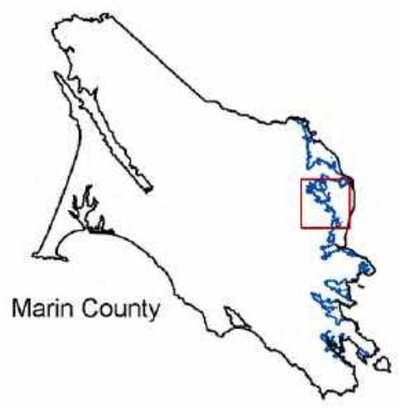
Vulnerable Assets

- Streams
- Marsh
- Estuary
- Wetland

Location Indicators

- Unincorporated
- Municipality
- Road
- Bay
- Inland Extent: Sea Level @ 60"+100-year Storm





1: Santa Venetia Marsh

2: Las Gallinas

3: San Rafael Creek

4: San Rafael Canal

5: MMWD & Bayview Marshes

6: Shoreline Park

CONSULTING

CA Dept. of Fish & Wildlife

Date: 3/29/2017

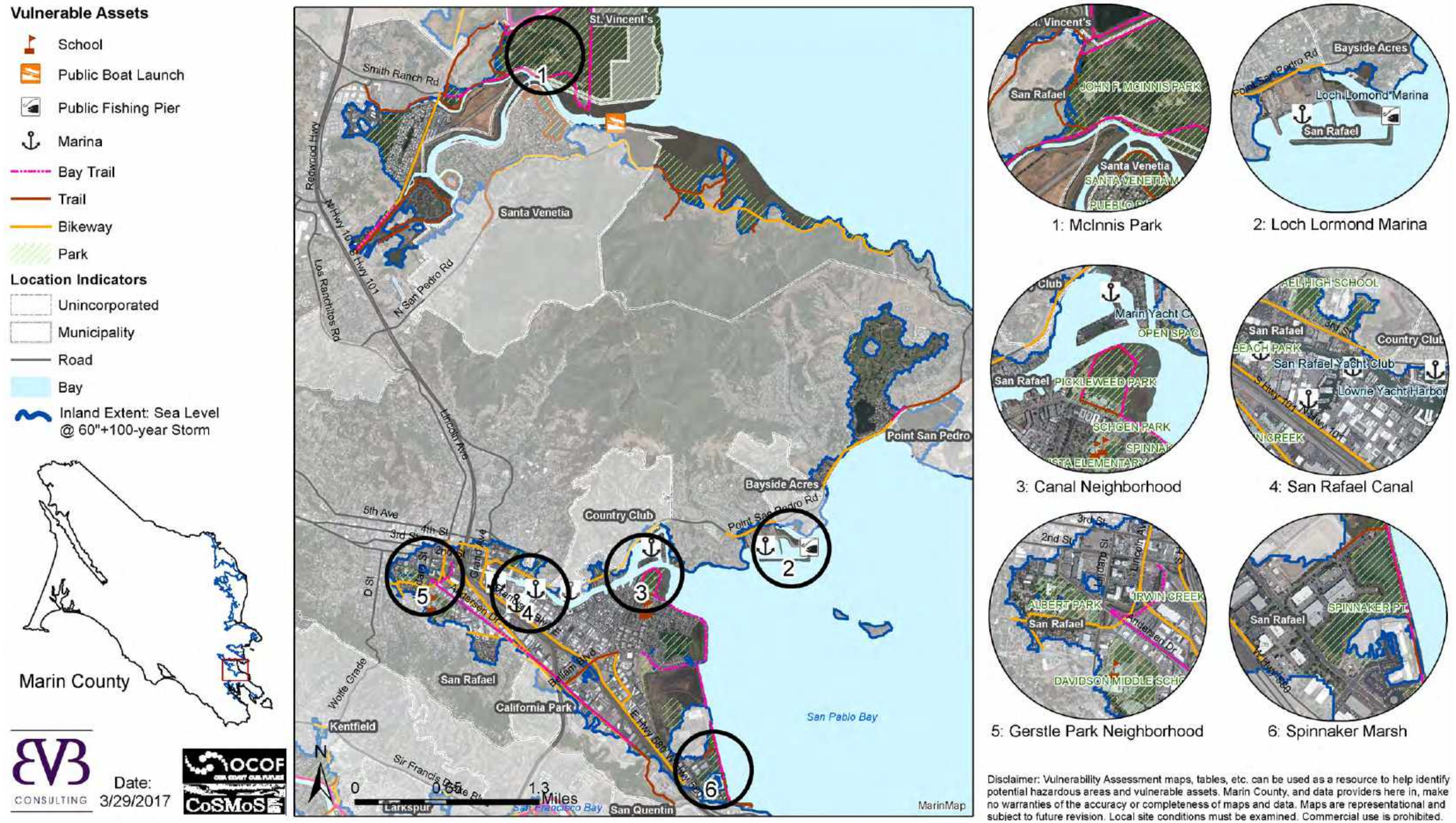
OCOF

CoSMoS

Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data providers here in, make no warranties of the accuracy or completeness of maps and data. Maps are representational and subject to future revision. Local site conditions must be examined. Commercial use is prohibited.

SAN RAFAEL

Map 103. San Rafael Vulnerable Recreation Assets



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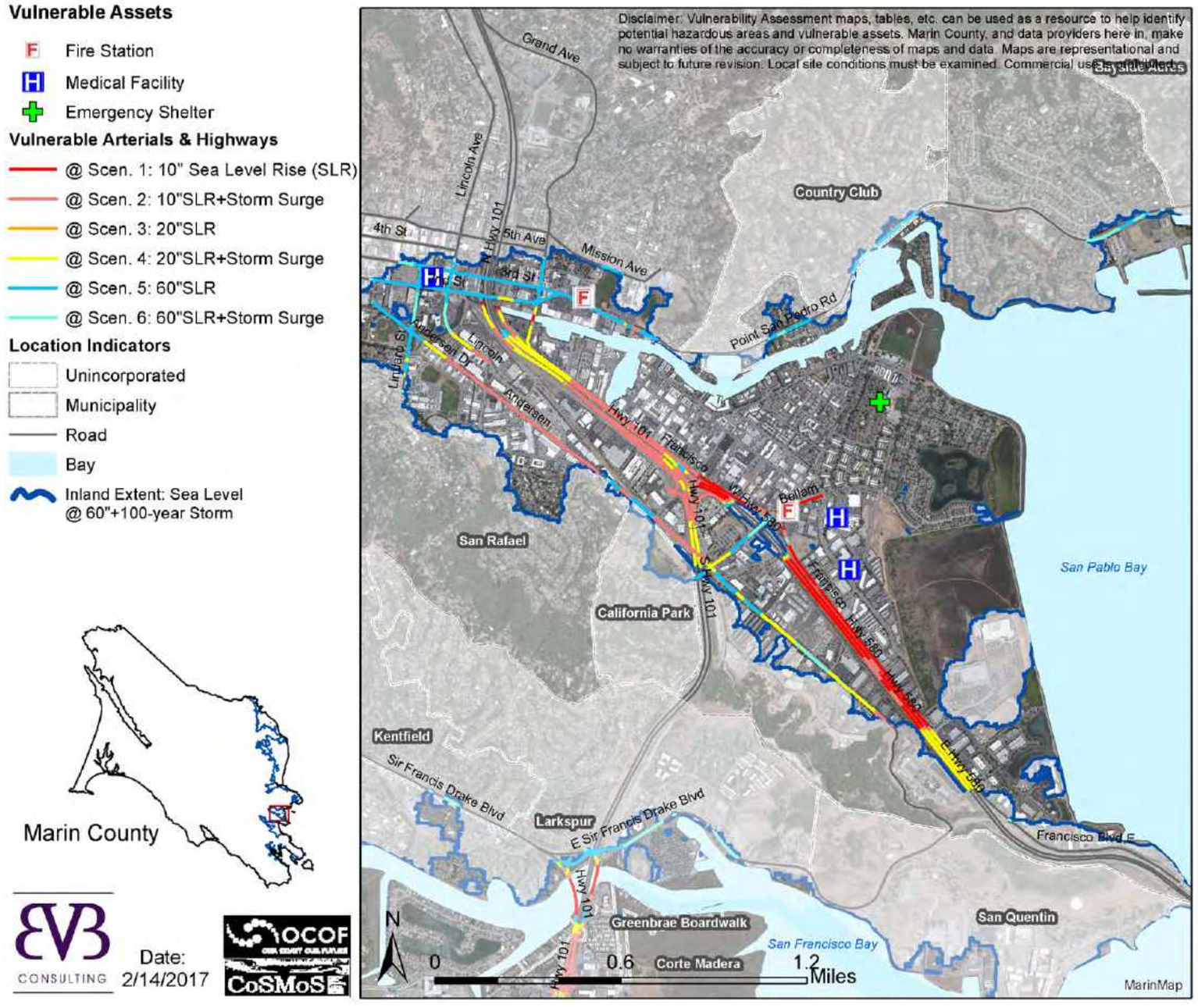
SAN RAFAEL

Map 104. San Rafael Vulnerable Emergency Service Assets



Cultural Resources

Much like other communities in Marin, San Rafael was once home to Miwok Indians prior to European settlement. San Rafael the home of Mission San Rafael Arcángel (1817), the last mission Spanish missionaries constructed in California. In 1879 the San Francisco and North Pacific Railroad reached San Rafael. The national rail network linked with San Rafael in 1888 leading to increased settlement and economic growth.[207]

San Rafael's vulnerable historic resources could be vulnerable to both tidal flooding and 100 year storm flooding from San Rafael Creek, generally in close proximity to highway 101. Resources include the Litchfield Sign (local landmark), the French Quarter, 2 potentially historic areas (Ritter Street and Gerstle Park (partial)), and 4 potentially historic structures. Archaeological resources could be present in the exposed area.

Table 109 ranks select vulnerable assets discussed above by onset and maximum flood depth at MHHW. A few public resources that are not likely to suffer tidal flooding under these scenarios, but could suffer during scenario 6, with 100-year storm surge and five feet of sea level rise. These are:

- Glenwood Elem. School,
- Department of Public Works, and
- US Post Office-Bellam Blvd.

Nevertheless, these properties could anticipate difficulties in accessing the site because the roads leading to these sites would be flooded.

San Rafael's French Quarter Historic District includes Victorian Homes now used for local businesses. Credit: Marin County CDA

[207] Wikipedia, San Rafael, California. Last updated December 15, 2016. en.wikipedia.org/wiki/San_Rafael,_California

Table 109. Example San Rafael Vulnerable Assets by Sea Level Rise Onset & Flooding at MHHW

Asset	Scenarios		
	Near-term	Medium-term	Long-term
	1	3	5
Canal area Bay Trail & open space	10'3"	11'1"	25'4"
John F. McInnis Park	7'6"	8'6"	10'6"
Starkweather Shoreline Park	5'4"	6'	16'3"
Pickleweed Park	5'	5'8"	8'9"
Hwy 580 East bound	0-4'	0-4'10"	4"-7'8"
Kerner Blvd	0-4'	0-4'7"	8"-7'5"
Francisco Blvd E	0-3'10"	0-4'7"	1'-7'5"
Bellam Blvd.	0-3'5"	0-4'	0-7'3"
Canal St.	0-3'4"	1'2"-4'2"	2'-7'11"
Bahia Way	2'-3'3"	2'4"-3'11"	5'2"-6'10"
Hwy 580 West bound	1"-2'10"	1"-3'7"	1"-6'5"
Bay Trail	0-2'3"	0-3'	0-10'3"
Castro Street Fire Station 54	1'6"	2'7"	6'7"
San Rafael Yacht Harbor	1'2"	4'	10'4"
San Rafael Municipal Harbor	1'	2'	6'
Lowrie Yacht Harbor	9"	3'7"	8'5"
Bahia Vista Elem. School/ Trinity Preschool	8"	2'3"	4'8"
Hi-Tide Boat sales & services	6"	3'4"	8'5"
Marin Yacht Club	1"	1'6"	3'9"
Marin County Health Innovation Campus	1"	1'3"	3'
Beach Park		8'11"	11'10"
Peacock Gap		6'3"	9'

Asset	Scenarios		
	Near-term	Medium-term	Long-term
	1	3	5
Neighborhood Park			
Grand Avenue		0-6’	7”-9’
Andersen Dr.		0-5’	3”-8”
Francisco Blvd W		0-4’9”	1’8”-9’5”
Peacock Drive		0-4’	9”-6’8”
SMART Rail		1’8”-3’9”	1’2”-6’8”
Loch Lomond Marina		3’7”	9’7”
Peacock Gap Lagoon and Golf Course homes		1”-3’6”	2”-8’9”
San Rafael Airport		3’5”	8’10”
Canal neighborhood		1”-3’	2”-7’8”
Marin Lagoon		5“-2’5”	1’-6’
Hwy 101 North bound		0-2’5”	6”-5’3”
Davidson Middle School		2’3”	5’9”
Pt. San Pedro Road		0-2’2”	4”-5’10”
San Rafael Yacht Club		2’2”	5’7”
Hwy 101 South bound. off ramp		0-2’	1’4”-5’
GGBHTD Headquarters & Bus Depot		1’8”-2’	4’2”-5’
Downtown		1”-1’3”	3”-3’3”
PG&E Office & Yard		1’2”	3’
Pickleweed Park facilities		1’2”	3’
Montecito Plaza		1’	2’3”
Transit Center		11”	2’5”
Marin Community Clinic		10”	3’8”
San Rafael High School		10”	2’
3rd Street		5”	10”-3’10”
SMART rail			1”-10’3”

Asset	Scenarios		
	Near-term	Medium-term	Long-term
	1	3	5
Lincoln Avenue			10”-7’4”
Schoen Park			4’2”
4th Street			1’-3’5”
2nd Street			1’-3’4”
Ritter Clinic			2’10”
Hetherton St.			1’4”-2’4”
Marin County Emergency Services			2’2”
Peacock Lane			1’4”-1’11”
San Rafael Canal	Water resource		
Marin Lagoon	Water resource		

Source: MarinMap, CoSMoS

SAN RAFAEL

Map 105. San Rafael Vulnerable Cultural Resource Assets

Vulnerable Historic Buildings

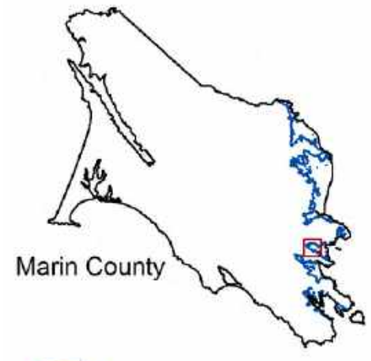
- Scen. 1: 10" Sea Level Rise (SLR)
- Scen. 2: 10" SLR+Storm Surge
- Scen. 3: 20" Sea Level Rise
- Scen. 4: 20" SLR+Storm Surge
- Scen. 5: 60" Sea Level Rise
- Scen. 6: 60" SLR+Storm Surge

Location Indicators

- Municipality
- Major Road
- Inland Extent: Sea Level @ 60"+100-year Storm

Source: Marin Map, CoSMoS, Historic Properties List (San Rafael), San Rafael Historical/architectural Survey. Credit: Marin County CDA

Archaeological resources may be present



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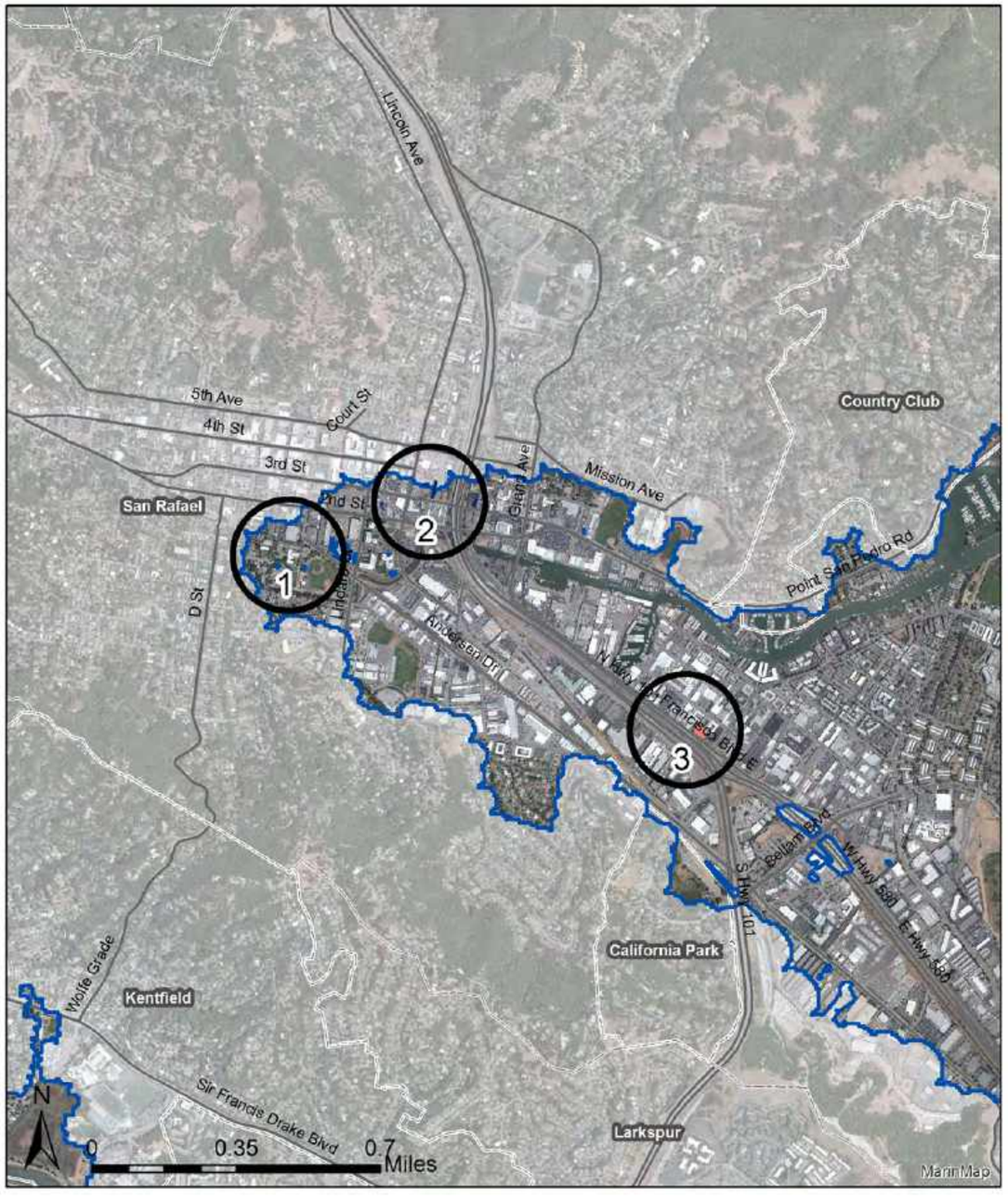


1: West San Rafael

3: Ritter Street and French Quarter

3: Litchfield Sign

Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data providers here in, make no warranties of the accuracy or completeness of maps and data. Maps are representational and subject to future revision. Local site conditions must be examined. Commercial use is prohibited.

NOVATO

Community Profile: Novato

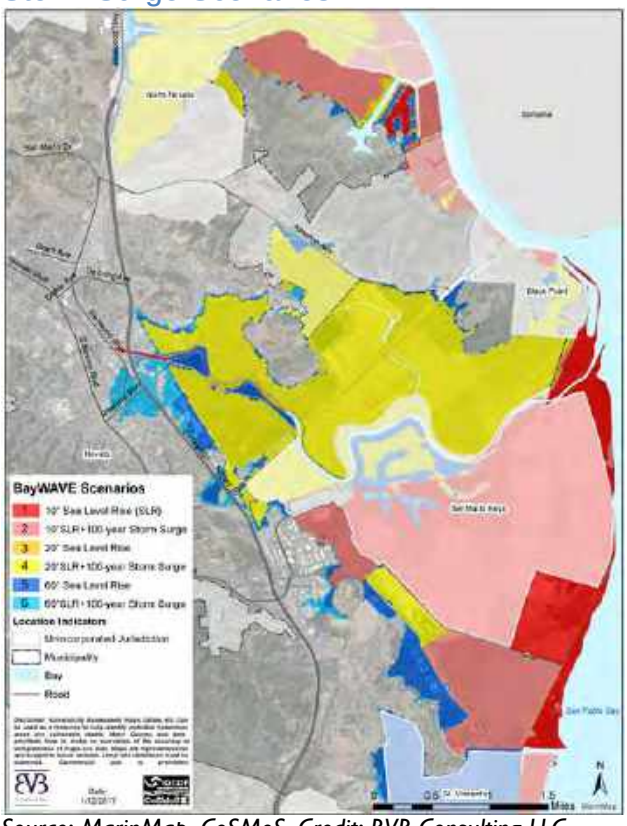
Novato is the second largest city in the county. The community is primarily residential with some large retail areas along the highway corridor. Development is largely inland with a few buildings fronted by tidal marshes and the bay. Much of the community is fronted by unincorporated areas, managed stormwater, agricultural, utility, and marsh lands. These lands could buffer Novato from the bay for several decades, thus, the majority of assets may not experience saltwater flooding until the end of the century. The following are key issues related to Novato sea level rise and a 100-year storm surge:

- The Hamilton neighborhood could anticipate the FEMA certified levee overtopped in the long-term. This would flood hundreds of homes and several professional workspaces.
- The Vintage Oaks Shopping Center could anticipate storm surge impacts in the medium-term and tidal impacts in the long-term. The loading bay would be the first section of the property to flood.
- Development east of US Highway 101 at the Bel Marin Keys and Rowland Boulevards.
- Buildings and marshes in Bahia, along Davidson Drive, and on Olive Ridge are vulnerable to sea level rise.
- State Route 37 to Sonoma and Napa is vulnerable in the near-term in several locations along its route. This road also serves as a bike path and provides access to several publically accessible natural resource assets.
- Tidal and storm surge flooding could impair travel on US Highway 101 in the long-term.
- Sonoma Marin Area Regional Transit rail tracks could be vulnerable in the near-term. Train cars could also be damaged by saltwater exposure.
- The Novato Sanitary District wastewater treatment could expect long-term impacts to several critical buildings.
- The Novato Fire Station 62 is vulnerable in the medium-term, and flooded, in part, in the long-term. In addition, the Fire Protection District and the Novato Professional Fire Fighter's Association office off Rowland Boulevard could be vulnerable in scenario 6.
- Most vulnerable parks are in Hamilton and exposed in the long-term.
- Marsh lands are vulnerable in Hamilton, Deer Island and the surrounding diked baylands, and Bahia.

IMPACTS AT-A-GLANCE: Scenario 6

4,249 acres	51,000+ people
1,100+ living units	78 commercial parcels
17 road miles	
Issues during stormwater and high tide coincidence	City of Novato Novato Fire Department Novato Sanitary District Caltrans Property Owners SMART Marin County DPW North Marin Water District
$1 billion in assessed property value; more than $650 million in single-family housing market value[208]	

Map 106. Novato Sea Level and 100-year Storm Surge Scenarios



Source: MarinMap, CoSMoS. Credit: BVB Consulting LLC.

[208] 2016 dollars

NOVATO

Vulnerable Assets

The most vulnerable assets are the wastewater treatment plant, State Route 37, and Northern Marin Water District. In the long-term, Hamilton could also be vulnerable to the levee overtopping. Due to Novato's inland development, very little of the community is directly impacted. Nevertheless, those dependent on the US Highway 101 corridor will be impacted. In addition, those who use the Novato Sanitary District treatment plant could experience wastewater disruptions.

Land

By land area, Novato is the largest municipality in the County, and relative to its size, a small area, mostly marshes, could be vulnerable to sea level rise. Nevertheless, a considerable number of acres, parcels could flood, compromising their existing land uses and human activities. In addition because of Novato's size and the existence of several smaller communities, complex levee systems, and extensive marsh land, much of the impacted developed land is dispersed into pockets of flooding.

Acres

In near-term scenario 1, 426 acres, or four percent of Novato's land area, could be exposed to sea level rise. An additional 100-year storm surge could flood a total of 1,336 acres, or 14 percent of Novato's land area. This acreage could flood tidally by the medium-term, and more than twice this amount could face storm0-surge flooding. Moving into the long-term scenario 5, all of this land plus 450 more acres could now face tidal influences. This acreage amounts to more than 40 percent of Novato's land area. Even more, 44 percent of the city, or 4,250 acres, could be exposed with an additional 100-year storm surge. By this time, flooding could extend beyond US Highway 101. By this time, marshes could be damaged beyond repair, shoreline armoring could be overtopped, and properties would unusable, some temporarily, others into perpetuity, without adaptive measures.

Parcels

Much of the exposed acreage is vulnerable marsh land that is typically used for public services, such as flood control, or waste water management. Thus, large amounts of acreage are held a few parcels by a few, mostly public, property owners. This holds true through the medium-term, though with a 100-year storm surge, 55 parcels, still less and one percent of the community's parcels could experience temporary flood conditions. In the long-term, however; bay waters could reach levels high enough to overtop protective armoring. At five feet of sea level rise 800 parcels could flood at MHHW. An additional 3 feet of storm surge waters could flood these 800 properties and an additional 450 properties could experience storm-surge flooding.

Table 110. Novato Vulnerable Acreage

Scenarios		Acres	
		#	%
Near-term	1	426	4
	2	1,336	14
Medium-term	3	1,327	14
	4	3,535	36
Long-term	5	3,998	41
	6	4,249	44

Source: MarinMap, CoSMoS

Historic flood Jan. 4, 1998, Novato. Credit: Unknown

NOVATO

Table 111. Novato Vulnerable Parcels

Scenarios		Parcels	
		#	%
Near-term	1	3	0
	2	7	0
Medium-term	3	6	0
	4	55	0
Long-term	5	800	4
	6	1,256	7

Source: MarinMap, CoSMoS

Table 112. Novato Vulnerable Parcels by Land Use

Land Use	Scenarios					
	1		3		5	
	Near-term		Medium-term		Long-term	
	#	Ac.	#	Ac.	#	Ac.
Commercial Improved					**10**	**37**
Commercial Unimproved					**6**	**82**
Industrial Improved					**8**	**11**
Industrial Unimproved					**3**	**4**
Residential					**691**	**59**
Single Family Attached					**259**	**8**
Single Family Improved					**430**	**51**
Single Family Unimproved					2	0.2
Common Area	1	33	1	33	4	67
Tax Exempt	2	82	6	480	62	1,473
Exemption Improved					2	3
Exemption Vacant					4	85

Source: MarinMap, CoSMoS

Table 113. Novato Vulnerable Residential and Commercial Parcels

Land Use	Scenarios					
	Near-term		Medium-term		Long-term	
	1		3		5	
	#	%	#	%	#	%
Residential					691	4
Commercial					16	3
Industrial					11	5

Source: MarinMap, CoSMoS.

In the long-term, impacts go from largely impacting publically owned parcels to impacting commercial, industrial, and residential parcels as well. In the long-term, tidal flooding could impact three percent of commercial, five percent of industrial, and four percent of residential parcels. While only four percent of residential, nearly 700 properties could face tidal flooding on a regular basis. With the 100-year storm urge nearly ten percent of commercial, and more than 20 percent of industrial parcels could face temporary storm surge flooding. Of the vulnerable residential parcels, about 60 developed single family acres could flood tidally.

Buildings

Most developed parcels feature one or more built structures. Most structures, unless already in a flood prone area, are not built to withstand regular or major flooding. The buildings in the exposed area of Novato are relatively newer construction compared to the other communities in the study area. In addition, a relatively small percent of Novato's building stock is vulnerable, topping off at five percent.

In scenarios 1-3, less than 20 buildings could expect tidal impacts. These buildings may be mechanical buildings or small out buildings that exist in or near the marsh lands. In the medium-term with a 100-year storms surge, scenario 4, several buildings at the storage facility in north east Novato could flood. In long-term scenario 5, nearly 700 hundred buildings could flood at MHHW. In scenario 6, with the additional 100-year storm surge, more than 3,000 buildings could flood. This figure amounts to nearly twenty percent of Novato's buildings stock.

NOVATO

Major neighborhoods include Hamilton, Bahia, Olive Ride, Davidson Street, and Los Robles.

Table 115 divides most of the vulnerable buildings by how much water could fill the premises, whether it is one, two, or ten feet of flooding. In the long-term, roughly 100 buildings are flooded with three feet or shallower of water, 30 buildings between three and six feet, and more than 500 buildings could be vulnerable to more than six feet of tide waters. While flooding with several feet of water with the average high tide would be devastating, still, even shallow depths can make a property or home unbearable to live on and difficult to service.

Table 116 shows FEMA Hazus post-disaster estimates of more than $600 million[209] in assessed structural value vulnerable in scenario 6 if all vulnerable buildings were destroyed. If all of the buildings and their contents were damaged at the yellow tag level, $4 million in damages would be estimated.[210] Reality would likely reflect a mix of the three damage levels, and a monetary figure between the low and high end figures provided here.

The maps on the following pages illustrate vulnerable buildings by scenario. The areas in the call out circles enable the reader the see areas that are difficult to see on the large scale map. The circles do not indicate that these areas are more vulnerable than others along the shoreline.

Hamilton levee and pathway. Credit: Marin County CDA

Table 114. Novato Vulnerable Buildings

Scenarios		Buildings	
		#	%
Near-term	1	6	0
	2	17	0
Medium-term	3	17	0
	4	56	0
Long-term	5	672	4
	6	3,247	18

Source: MarinMap, CoSMoS

Table 115. Novato Tidal MHHW Flood Depth Estimates for Vulnerable Buildings

Flood Depth (feet)	Scenarios		
	Near-term	Medium-term	Long-term
	1	3	5
0.1-1			54
1.1-2			38
2.1-3			11
3.1-4			13
4.1-5			11
5.1-6			16
6.1-7			23
7.1- 8			25
8.1-9			137
9.1- 10			120
10.1+			207

Source: MarinMap, CoSMoS

Table 116. Novato Vulnerable Buildings FEMA Hazus Damage Cost* Estimates

Buildings in Scenario 6	871
Yellow Tag: Minor Damage **$5,000 minimum**	$4,355,000
Orange Tag: Moderate Damage **$17,001 minimum**	$14,807,871
Red Tag-Destroyed **Assessed structural value**	$629,369,009

Source: MarinMap, CoSMoS, FEMA Hazus Model
** 2016 dollars*

[209] 2016 dollars
[210] 2016 dollars

NOVATO

Map 107. Novato Vulnerable Buildings

Vulnerable Assets

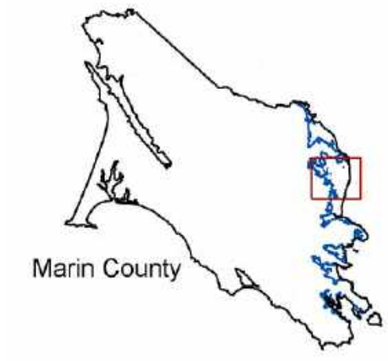
F Fire Station

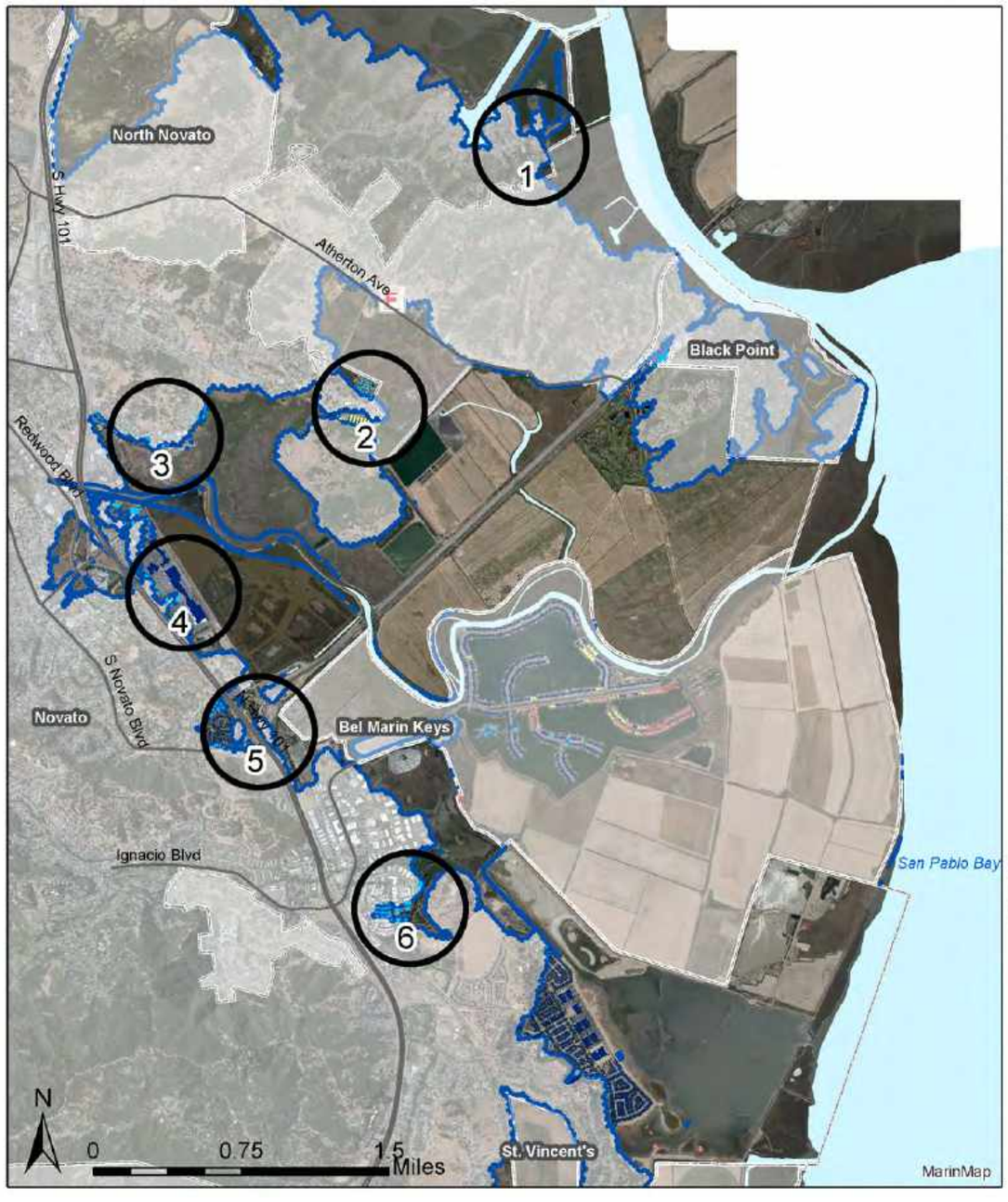
Vulnerable Buildings

- Scen. 1: 10" Sea Level Rise (SLR)
- Scen. 2: 10" SLR+Storm Surge
- Scen. 3: 20" Sea Level Rise
- Scen. 4: 20"SLR+Storm Surge
- Scen 5: 60" Sea Level Rise
- Scen. 6: 60"SLR+Storm Surge

Location Indicators

- Unincorporated
- Municipality
- Road
- Bay
- Inland Extent: Sea Level @ 60"+100-year Storm

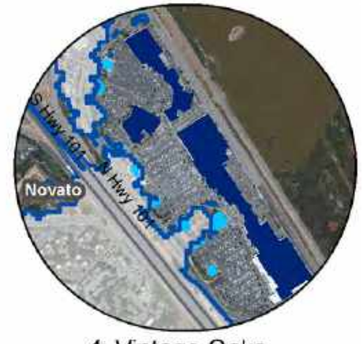




1: Bahia Neighborhood

2: Olive Ridge

3: Davidson St. Buildings



4: Vintage Oaks Shopping Center

5: Neighborhood at U.S. Hwy. 101 @ S. Novato Blvd.

6: Pamoran Rd.

Date: 3/30/2017

Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data providers here in, make no warranties of the accuracy or completeness of maps and data. Maps are representational and subject to future revision. Local site conditions must be examined. Commercial use is prohibited.

Transportation

In the near-term, major roadways could be vulnerable to sea level rise including State Routes 101 and 37, Redwood Boulevard, and Rowland Way. A handful of other roads are impacted in the near- and medium-term storm surge scenarios. By scenario 5, a significant number of roads in the low lying areas of the city, including roads on the other side of the Hamilton Levee, could be vulnerable. Examples include: Rowland Boulevard, Bel Marin Keys Boulevard, and Hamilton Parkway. Table 117 lists transportation routes that could be vulnerable by scenario and annotates if the road is managed locally, or by the state or county.

According to Caltrans District 4 managers segments of State Routes 101 and 37 that already experience seasonal flooding that could escalate in frequency and scale due to sea level rise include:

- US Highway 101 at Rowland Boulevard, Novato: This stretch floods, is adjacent to Scottsdale Pond, and a series of ponds, levees, and pumps operated by others protect it.
- US Highway 101 at the 101/37 Interchange, Novato: This vulnerable 3,100-foot stretch is protected by levees and pumps operated by others.
- State Route 37 between Atherton Avenue and US Highway 101: This stretch of State Route 37 is protected by non-engineered levees that have a history of overtopping with combined high tides and Novato Creek flows.

Transit is also impacted in Novato at the intersection of US Highway 101 and Rowland Boulevard. Vulnerable Golden Gate Transit routes are 56, 70, 71, and 80, with stops at:

- Rowland Blvd. Park and Ride, and
- Hwy 101 and Rowland Blvd.

Marin Transit route 251 has vulnerable stops at:

- Rowland Blvd. and Hwy 101 Sb Off-Ramp
- Rowland Blvd. and Redwood Blvd.,
- Rowland Blvd. At Vintage Oaks Entrance,
- Vintage Way at Sleep Train, and
- Vintage Way at Fresh Choice.

Impacts to transit can have disproportionate impacts to households without vehicles and low income household that depend on transit. Persons who work at or use the stores and services provided in this part of Novato may have to look elsewhere if measures are not taken to adapt to bay flooding. Flooding on the freeway itself could also impede travel to other bus stops that are not vulnerable under these scenarios. Regional travel on cross-county busses would also be impeded for many Novato residents.

The maps on the following pages illustrate vulnerable transportation features. The areas in the call out circles enable the reader the see areas that are difficult to see on the large scale map. The circles do not indicate that these areas are more vulnerable than others along the shoreline.

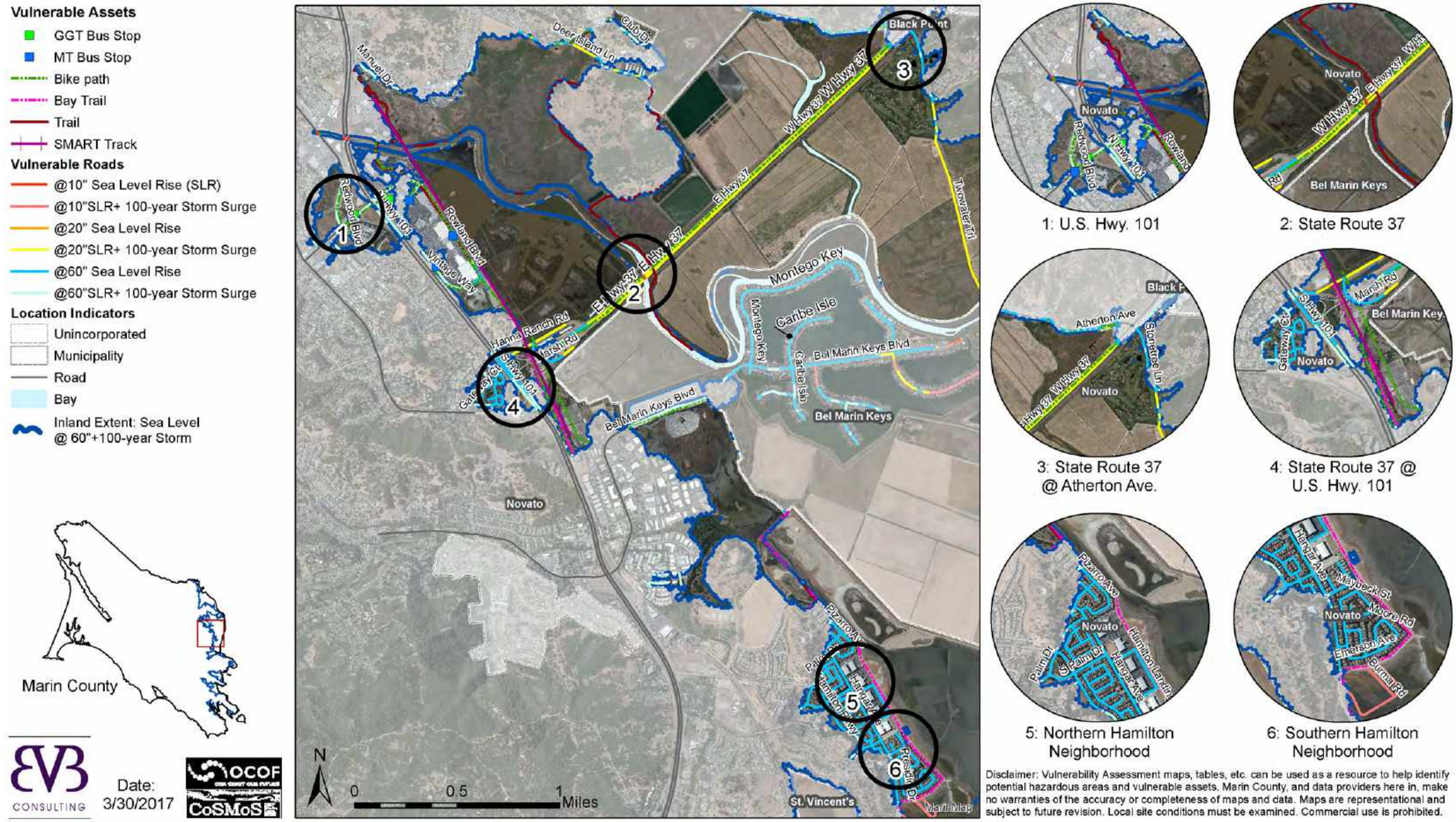
Rowland Way behind Vintage Oaks Shopping Center. Credit: BVB Consulting LL

Table 117. Novato Vulnerable Transportation Routes

Near-term		Medium-term		Long-term	
Scenario 1	**Scenario 2**	**Scenario 3**	**Scenario 4**	**Scenario 5**	**Scenario 6**
0.1 miles	**0.5** miles	**0.5** miles	6 miles	**15** miles	**17** miles
Hwy 101 [C] Hwy 37 [C] Redwood Blvd [L] Rowland Wy [L]	Roads in scenario 1 Burma Rd [L] Perimeter Rd [L] Terminal Rd [L]	Roads in scenario 1	Roads in scenarios 1 and 2 Hamilton Dr [L] Ryan Ave [L] Deer Island Ln [L] Hanna Ranch Rd [L] Marsh Rd [L] Olive Ave [L] Two water Trl	Roads in scenarios 1-4 Rowland Blvd [L] Bel Marin Keys Blvd [L] Hamilton Pkwy [L] Alconbury Wy [L] Alhambra Ct [L] Amelia Dr [L] Arnold Dr [L] Audubon Wy [L] Avocet Ct [L] Caliente Real [L] Club Dr [L] Emerson Ave [L] Ferdinand Way [L] Gann Way [L] Gateway Ct [L] Greenham Ct [L] Hamilton Landing [L] Hangar Ave [L] Hayford Ct [L] Holliday Dr [L] Hospital Dr [L] Inyo Cir [L] Laconheath Ave [L] Lassen Ln [L] Lavenham Rd [L] Los Padres Cir [L] Manuel Dr [L] Maybeck St [L] Mildenhall St [L] Modoc Pl [L] Moore Rd [L] Palm Dr [L] Pizarro Ave [L] Plumas Cir [L] Presidio Dr [L] Renaissance Rd [L] Richardson Rd [L] Richardson Wy [L] Ripley Ln [L] S Palm Dr [L] San Pablo Ave [L] San Pablo Ct [L] Stern Dr [L] Stonetree Ln [L] Tahoe Cir [L] Trinity Dr [L] Vintage Wy [L] Wood Bridge Wy [L]	Roads in scenarios 1-5 Balboa Ct [L] Binford Rd [L] Donna St [L] El Arroyo Pl [L] El Granada Cir [L] Emerson Ave [L] Fairhaven Wy [L] Frosty Ln [L] La Crescenta Cir [L] Lea Dr [L] Leafwood Dr [L] Loleta Ln [L] Louis Dr [L] Palm Dr [L] Pamaron Wy [L] Rush Landing Rd [L] San Pablo Wy [L] Terminal Rd [L] Topaz Dr [L] Toyon Wy [L] Vera Cruz Ave [L]

M = Marin County; C = State of California; L = Local Municipality; P = Private. Source: MarinMap, CoSMoS

Map 108. Novato Vulnerable Transportation Assets



Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data providers here in, make no warranties of the accuracy or completeness of maps and data. Maps are representational and subject to future revision. Local site conditions must be examined. Commercial use is prohibited.

Map 109. Novato Vulnerable Gas & Electric Asset

Vulnerable Assets

- Solar Array

PG&E Assets

- Electric Transmission Line
- Natural Gas Pipeline
- Substation
- Transmission Tower
- PG&E Property
- PG&E Buildings

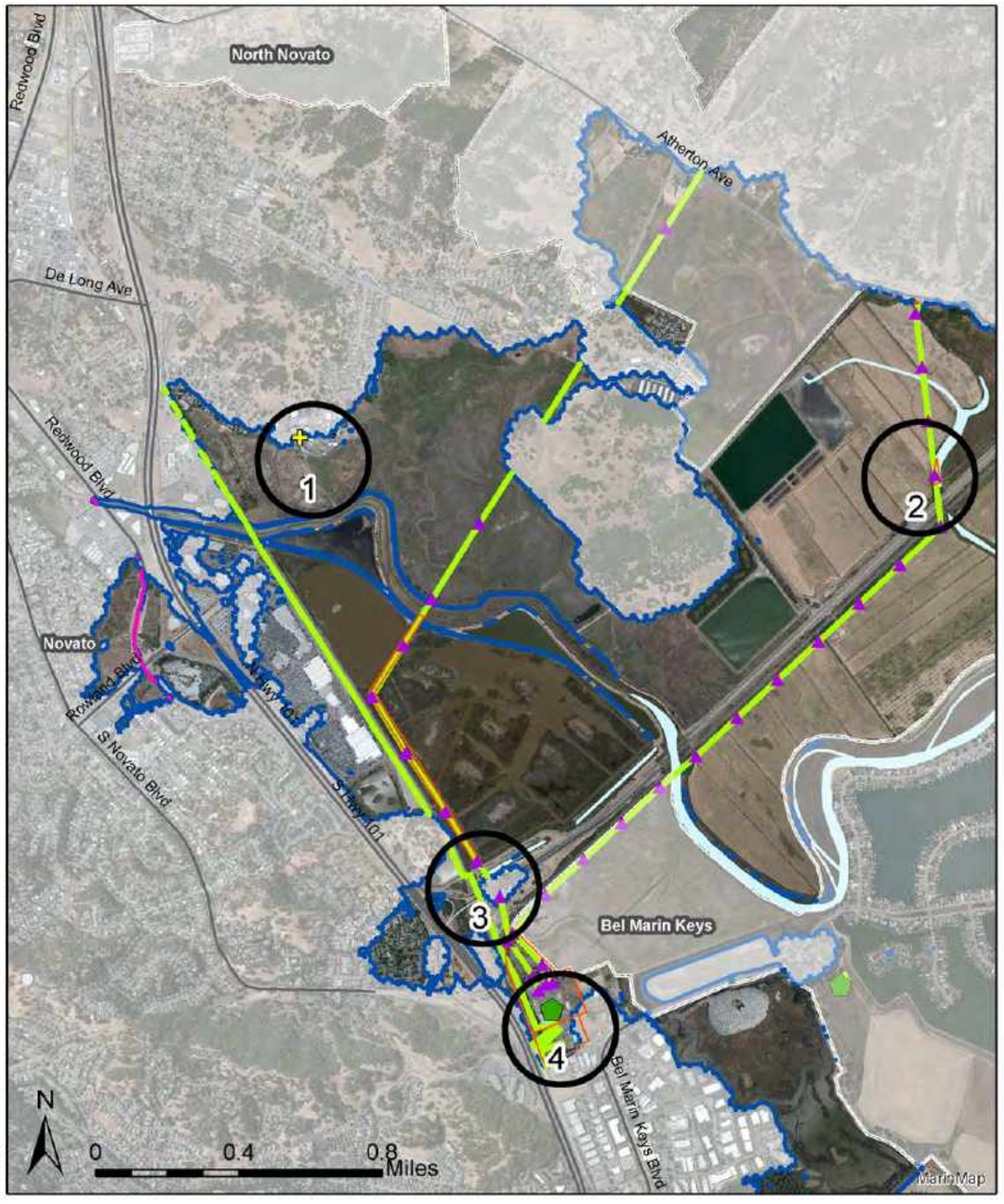
Location Indicators

- Unincorporated
- Municipality
- Road
- Bay
- Inland Extent: Sea Level @ 60"+100-year Storm

CONSULTING

Date: 4/1/2017

CoSMoS



1: Novato Wastewater Treatment Plant

2: State Route 37

3: State Route 37 @ U.S. Hwy. 101

4: PG&E Substation

Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data providers here in, make no warranties of the accuracy or completeness of maps and data. Maps are representational and subject to future revision. Local site conditions must be examined. Commercial use is prohibited.

NOVATO

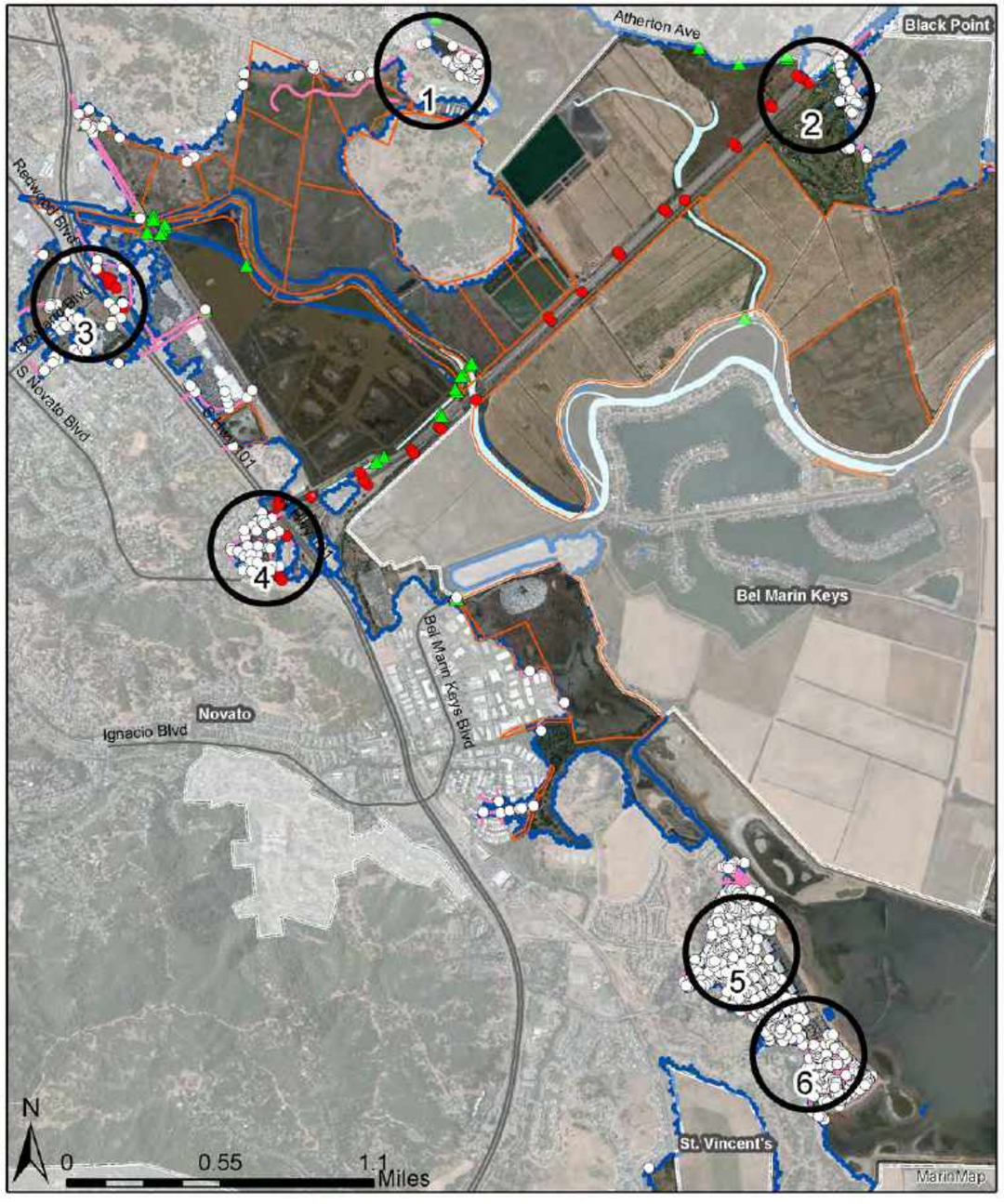
Map 110. Novato Vulnerable Stormwater Assets

Vulnerable Assets

- Unspecified Node
- Culvert
- Pipe Inlet/Outlet
- Pipe
- Flood Control Parcels

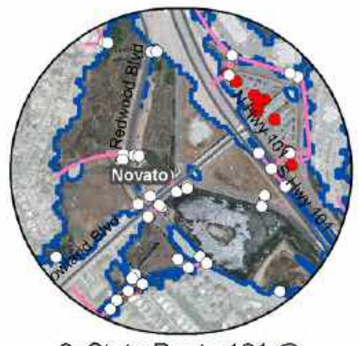
Location Indicators

- Unincorporated
- Municipality
- Road
- Bay
- Inland Extent: Sea Level @ 60"+100-year Storm



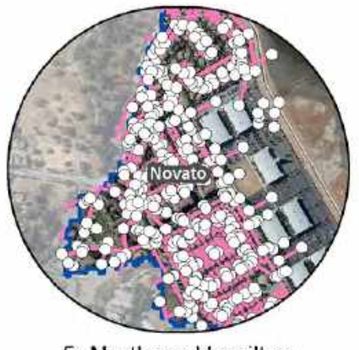
1: State Route 101 @ Rowland Blvd.

2: State Route 37 @ Atherton Ave.



3: State Route 101 @ Rowland Blvd.

4: Lynwood Hill area



5: Northern Hamilton

6: Southern Hamilton

EVB CONSULTING

Date: 2/15/2017

OCOF CoSMoS

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Utilities
The primary utility issues in Novato are related to the Novato Sanitary District Wastewater Treatment Plant, North Marin Water District (NMWD) office and yard, and the PG&E transmission towers spanning across the Novato marshlands.

The Novato Sanitary District Treatment plant is vulnerable just before 3 feet of sea level rise. By scenario 5, the lower half of the plant is covered by tidal waters. Storm conditions may impact the plant sooner. The water will not likely be high enough to impact the process; however, electrical components may be lower and saltwater corrosion of the tanks and buildings could take a toll over time. Moreover, the highest high tides could reach even further into the facility. To read more about the NSD wastewater treatment plant see the Utilities Profile.

The North Marin Water District is vulnerable to sea level rise, storm surges, and rain events significant enough to back up Rush Creek. Other impacts could include corrosion and contamination of fire water reserves. For other issues related to NMWD see the Utilities Profile.

PG&E transmission towers in Novato's marshlands in Marin County's stormwater diked baylands and Bahia are already showing the effects of subsidence, with leaning towers and taut lines. As sea level rise continues, subsidence will worsen. In addition, the minimum height needed between the towers and the land surface could be flooded, bringing the electrical currents closer to the water.

Finally, Novato is vulnerable to similar issues as other low lying area in the study area such as:

- Underground pipes face compounding pressure forces from water and the road,
- Road erosion and collapse with underlain pipes,
- Saltwater inflow and infiltration causing inefficiencies in wastewater treatment,
- Continuously subsiding soils or fill, and
- Escalating activity, capacity demands, energy consumption, and wear and tear on pump stations in stormwater and wastewater systems,
- Aging individual site connections for water, sewer, and electrical, and
- Flood waters interrupting access for employees to reach work sites.

The maps on the previous pages illustrate vulnerable utility features. The areas in the call out circles enable the reader the see areas that are difficult to see on the large scale map. The circles do not indicate that these areas are more vulnerable than others along the shoreline.

Working Lands
Most of the vulnerable working lands in Novato are leased out to ranchers for grazing. As this area floods more consistently, less grazing will be possible, and animal waste may enter into the bay when tidewaters retreat.

Natural Resources
Several hundred acres of tidal and stormwater marsh lands could expect higher salinity concentrations and water levels. These occurrences could push marshlands inland where feasible. Scottsdale Marsh, the Bahia shoreline, and Deer Island are habitats that could be impacted.

The longfin smelt, Ridgway's Rail, tidewater goby, Steelhead trout, and salt marsh harvest mouse are the listed species recorded in this area according to the Natural Diversity Database. The smelt is list as threated on the California species list and a candidate for the federal list. The Ridgway's Rail, tidewater goby, and harvest mouse are federally listed.

Recreation
Some marsh pathways in the flood control lands could expect impacts in the near-term during average high tides. Most parks impacted in Novato are in the Hamilton area and include:

Scenario 5:
- Bahia Mini Parks
- Future Hamilton Rec Area
- Hamilton Airport Park
- Hamilton Amphitheater Park
- Slade Park
- Hamilton Community Center
- South Hamilton Park

Scenario 6:
- Scottsdale Marsh

In addition, Deer Island Park could become an island at average high tides, as opposed to seasonal high tides and stormwater coincidences.

The Bay Trail could expect a high number of low lying segments underwater at MHHW. In addition, segments on the Hamilton levee could be vulnerable in the long-term to flooding and erosion.

The maps on the following pages illustrate vulnerable natural resource, recreation, emergency and historic features. The areas in the call out circles enable the reader the see areas that are difficult to see on the large scale map. The circles do not indicate that these areas are more vulnerable than others along the shoreline.

NOVATO

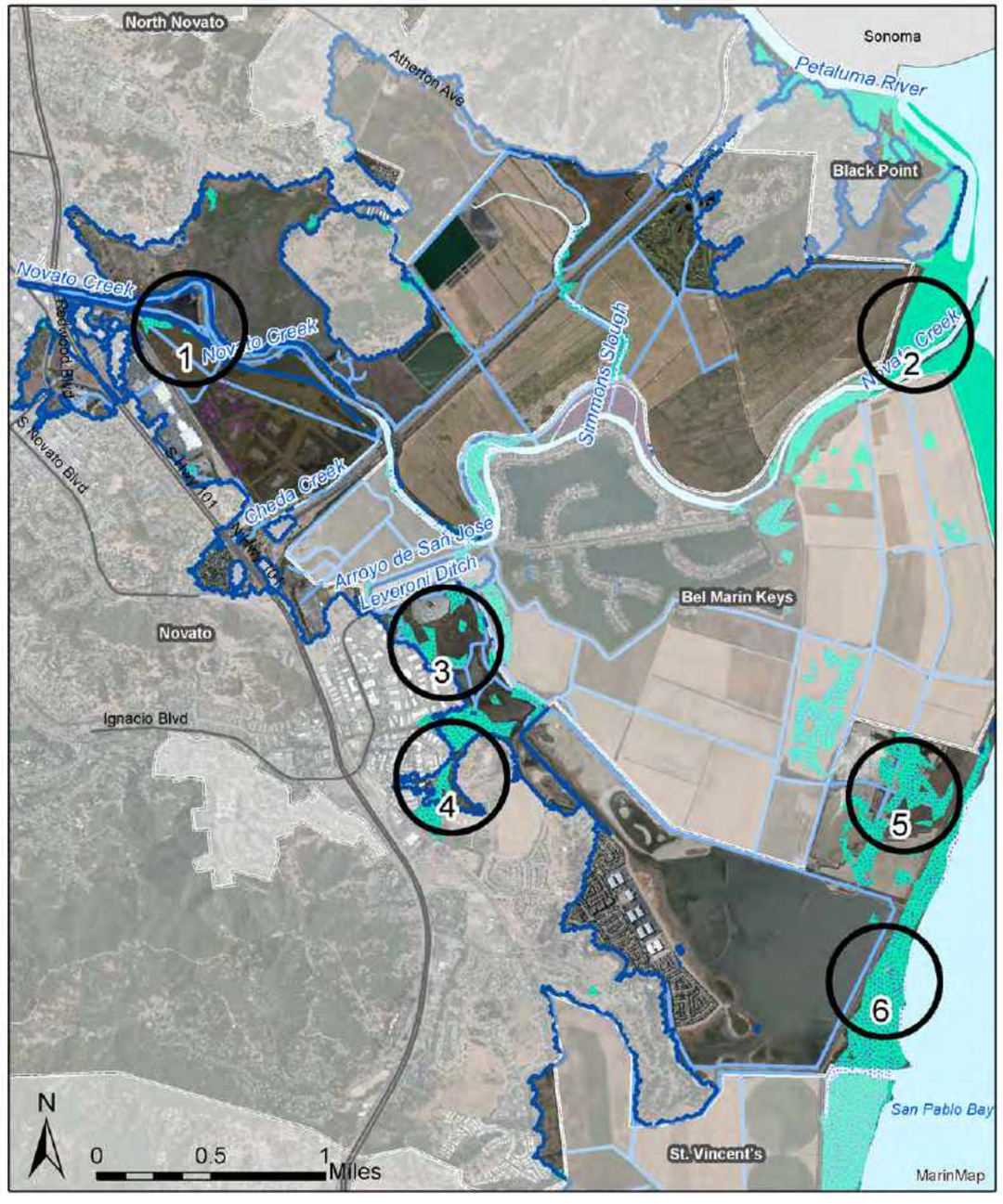
Map 111. Novato Vulnerable Natural Resource Assets

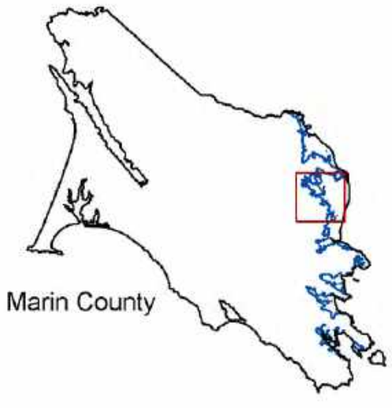
Vulnerable Assets

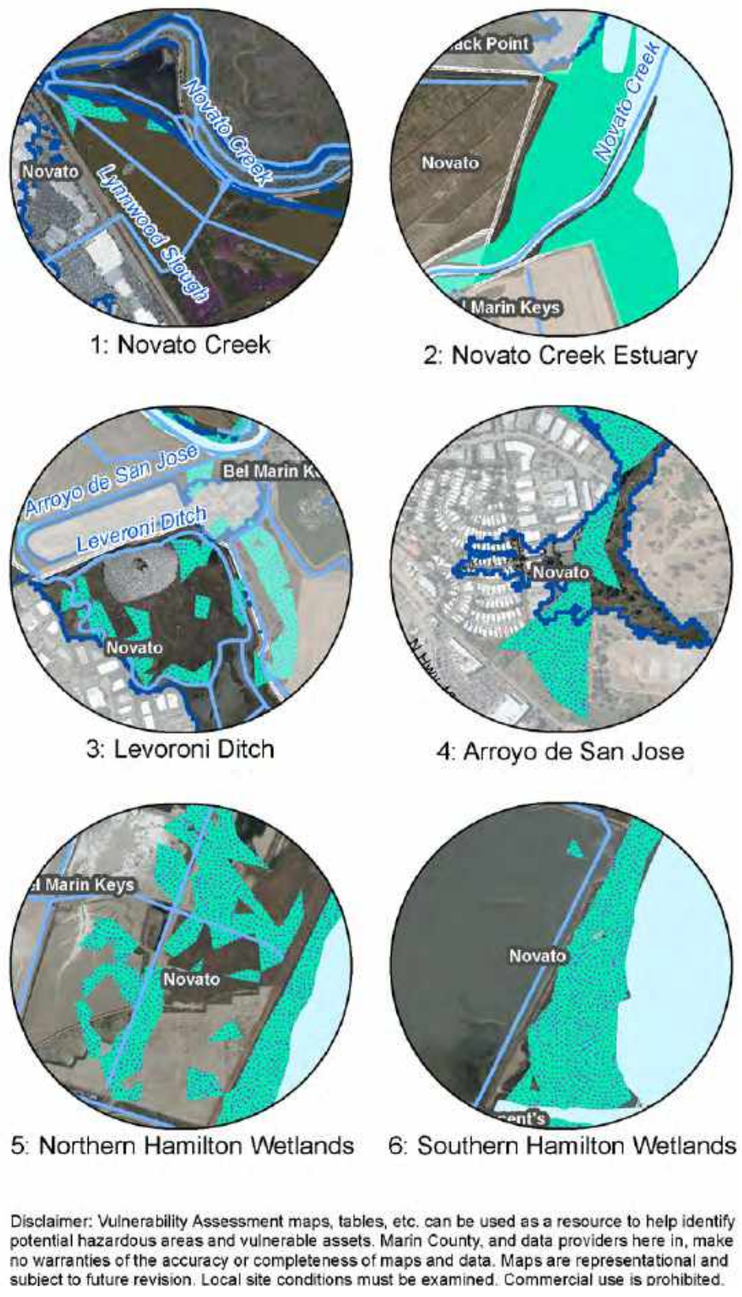
- Streams
- Marsh
- Estuary
- Wetland

Location Indicators

- Unincorporated
- Municipality
- Road
- Bay
- Inland Extent: Sea Level @ 60"+100-year Storm







Date: 1/22/2017

Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data providers here in, make no warranties of the accuracy or completeness of maps and data. Maps are representational and subject to future revision. Local site conditions must be examined. Commercial use is prohibited.

NOVATO

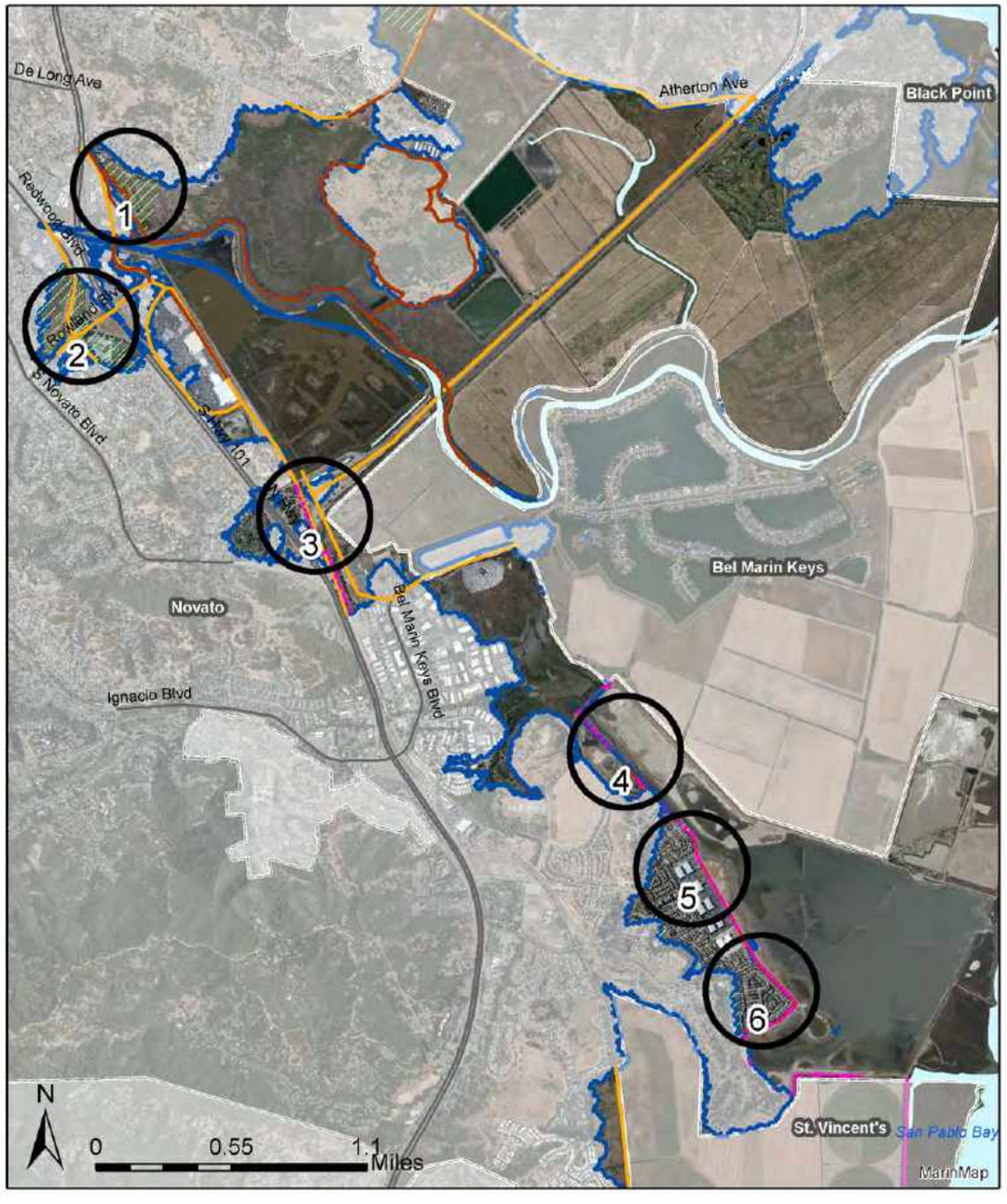
Map 112. Novato Vulnerable Recreation Assets

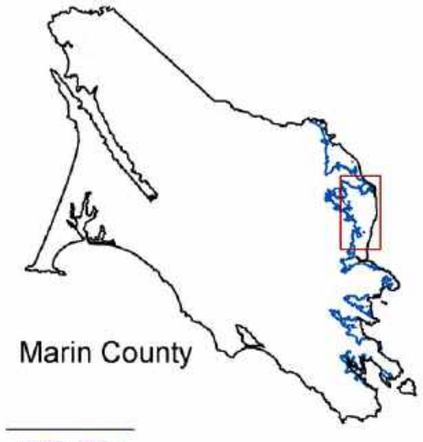
Vulnerable Assets

- Bay Trail
- Trail
- Bikeway
- Park

Location Indicators

- Unincorporated
- Municipality
- Road
- Bay
- Inland Extent: Sea Level @ 60"+100-year Storm





EVB CONSULTING

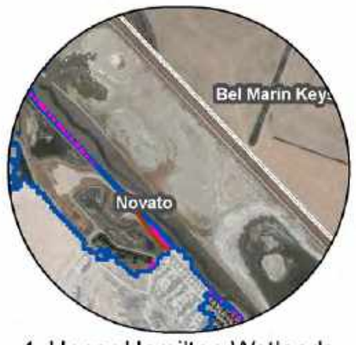
Date: 1/25/2017

OCOF CoSMoS

1: Slade Park

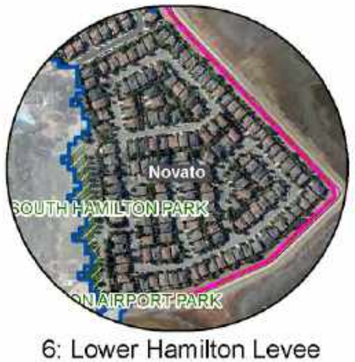
2: Scottsdale Marsh

3: State Route 37



4: Upper Hamilton Wetlands

5: Middle Hamilton Levee



6: Lower Hamilton Levee

Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data providers here in, make no warranties of the accuracy or completeness of maps and data. Maps are representational and subject to future revision. Local site conditions must be examined. Commercial use is prohibited.

SMART Rail Bridge, Novato. Credit: Marin County DPW

Hamilton Field's Headquarters now serves as the Novato Arts center. Credit: Marin County CDA

Emergency Services

In addition to concerns for emergency vehicle access on flooded roads, the Novato Fire Station 62 could expect a high tide average of 5 inches of water in the medium-term and up to a foot of water in the long-term. In addition, the Novato Professional Firefighters Association Office is vulnerable in scenario 6.

Cultural Resources

In the 1930's, the 1,779 acre Hamilton Army Air Field was constructed as headquarters for the 1st Wing of the Air Force, one of only three such bases in the nation.[211] The site was transferred to the US Navy, Army and Coast Guard in 1974, and is now part of Novato. Currently buildings house a variety of residential and commercial uses.

[211] Maniery, M.L., and C.L. Baker. 1998. National Register of Historic Places Registration Form – Hamilton army Air Field Discontinuous Historic District.

Map 113. Novato Vulnerable Cultural Resource Assets

Source: CoSMoS, MarinMap, National Register of Historic Places Registration Form – Hamilton Army Air Field Discontiguous Historic District

The National Register of Historic Places Registration Form identifies 3 areas of the historic district.[212] Of the three areas, Area C could be subject to average high tide flood depths of 2'5'' to 10'4'' by the long-term scenarios. All ten of its contributing resources could flood, including:

- Double hangars,
- Air Corps shops and hangar #9,
- Flagpole- 75 foot tall with plaque,
- Headquarters building,
- Officers' Barracks, and
- Electrical transformer vault.

Archaeological sites could be present in the exposure zones.

[212] Ibid.

Table 118 ranks select vulnerable assets in Novato by onset and flood depth at MHHW. A 100-year storm surge would add an additional 1 to 3 feet of water to these properties. Note also, above average high tides could impact more properties than accounted for in this analysis.

Several assets could be impacted during the storm-surge scenario only, unlike the other that would subject to tidal and storm flooding. These are:

- Novato Corporate Yard,
- Las Robles Mobile Home Park,
- Novato Fire Association office, and
- NMWD administrative office and yard (with stormwater combination).

Table 118. Example Novato Vulnerable Assets by Sea Level Rise Onset and Flooding at MHHW

Asset	Scenario		
	Near-term	Medium-term	Long-term
	1	3	5
Scottsdale Marsh	Flooded at existing high tides		
Hamilton		3'8"-11'6"	9'-29'3
NSD Wastewater treatment plant		2"-1'7"	5"-4'6"
Bay Trail		0-8"	0-12'7"
Vintage Oaks shopping center		3"-8"	7"-1"8"
Fire Station 62		5"	1'
S. Hamilton Park			11'6"
Deer Island			10'10"
Hamilton Pkwy.			4'8"-10'9"
Hamilton Amphitheater Park			10'6"
SMART Rail			0-9'8"
Rush Creek			8'10"
Hwy 37 West bound off ramp			2"-8'4"
Slade Park			8'
Hamilton Community Center			8'
Hwy 37 East bound			0-7'
Bahia Mini Parks			6'9"
Rowland Blvd.			0-2'7'
Hwy 101 North bound			0-2'
Hwy 101 South bound			0-1'9"
NMWD air valves			No data
NMWD fire water reserves			No data
Automated valve connecting NMWD & MMWD			No data
PG&E electrical transmission towers	In existing marsh areas		

Source: MarinMap, CoSMoS, Asset Manager Interviews

UNINCORPORATED

Community Profile: Unincorporated Marin

Within the study area, unincorporated communities are sprinkled up the shoreline. Most vulnerable areas are residential, with a few commercial areas impacted in Marin City, Strawberry, Almonte, and Waldo Point Harbor, and in Black Point in the north. Marin County unincorporated communities are regulated by the County of Marin. In the near-term, 3,450 acres could be exposed to sea level rise. By the long-term, 8,644 acres could be exposed to sea level rise and 9,196 acres could be exposed with an additional 100-year storm surge. Key issues in Marin County's unincorporated communities include:

- Development in the tidal zone in Waldo Point Harbor, Paradise Cay, Greenbrae, and Strawberry could be vulnerable in the near-term.
- Communities along tidal estuaries and creeks such as Kentfield, Santa Venetia, and Tamalpais Valley are first vulnerable to storms in the near- and medium-terms, and vulnerable to sea level rise in the long-term.
- In the low lying exposed areas in nearly every community, except Kentfield, subsidence is an ongoing issue that sea level rise could only exacerbate. This impacts buildings, roads, and utility infrastructure.
- Bel Marin Keys, if left to tidal influences, could be flooded out by the end of the century.
- Several key roads, including, Shoreline Highway from the Manzanita Park and Ride to Tam Junction, US Highway 101 in Marin City, Waldo Point Harbor, and Greenbrae, State Route 37 in North Novato, Tiburon Boulevard at the Cove Shopping Center, Redwood Highway and Sir Francis Drake Boulevard in Greenbrae and Larkspur, and Bel Marin Keys Boulevard already weather seasonal storm flooding. These roads could anticipate more frequent tidal impacts and more severe storm impacts sooner than later.
- Some North Marin Water District infrastructure in North Novato and Bel Marin Keys may be vulnerable in the long-term.
- Marin County Health Innovation Campus in San Rafael is vulnerable in the near-term to storm surge and the medium-term to sea level rise.
- The Marin City shopping center would experience more severe flooding seasonally through the near-term, and flooding from ocean storm surge and sea level rise in the medium and long-terms.

IMPACTS AT-A-GLANCE: SCENARIO 6

9,200 acres exposed	51,000+ people
3,800+ living units	77 commercial parcels
30+ miles flooded	Property Owners Caltrans SMART Marin County DPW North Marin Water District Marin Couth Fire and Sherriff Sanitary Districts PG&E
Existing seasonal flooding and subsidence	
$945 million in assessed property value; more than $650 million in single-family housing market value[211]	

Greenbrae Boardwalk. Credit: BVB Consulting LLC

Santa Venetia. Nov. 25, 2015. Credit: Light Hawk Aerial

[211] 2016 dollars

Vulnerable Assets

The most vulnerable assets in Marin County's unincorporated communities in the near-term are Shoreline Highway through Almonte, Waldo Point Harbor houseboats and facilities, Greenbrae homes and facilities, and Paradise Cay homes and marina. The elevated homes on Greenbrae Boardwalk and floating homes in Waldo Point Harbor may be more adaptable in the near term than homes with solid foundations. In the medium-term, portions of Bel Marin Keys could face impacts, as would Santa Venetia homes, Tamalpais Valley homes, and the Greenwood Cove, Strawberry Circle, Strawberry Village Shopping Center, homes along Seminary Drive in Strawberry, and Kentfield creek side homes. In the long-term, Black Point and North Novato could anticipate damaging impacts.

Many of the unincorporated communities are in, near, or depend on low lying flood prone areas and require stormwater engineering to stave off the impacts of seasonal flooding. Sea level rise could exacerbate this seasonal storm flooding, and in some cases, could flood out an entire community. Note that recent construction at the Waldo Point Harbor entrance and parking area would reduce the amount and timing of on land flooding estimated by the CoSMoS model. In addition, numbers may be low for this community because not all houseboats are digitized. In addition, the model treats tide gates in Bel Marin Keys as open, where as in practice, community managers could close the gates to prevent lagoon flooding, likely through the near- to medium-terms.

The following sections detail the land, building, transportation, utility, working land, natural resource, recreation, emergency, and cultural assets that that are sensitive to saltwater flooding and subsidence, with little to no ability to adapt to higher high tide conditions and therefore, vulnerable to sea level rise and a 100-year storm surge.

Table 119. Unincorporated Marin Communities' Acreage Exposed by BayWAVE Scenario

Location	Scenarios					
	Near-term		Medium-term		Long-term	
	1	2	3	4	5	6
Bel Marin Keys	1,759	1,794	1,802	2,155	2,332	2,350
Waldo Point Harbor	598	610	604	611	611	613
St. Vincent's	256	346	339	353	1,240	1,413
Strawberry	255	282	270	301	328	375
North Novato	118	575	226	2,457	2,827	2,930
San Quentin	116	115	115	115	122	135
Tiburon	102	108	103	108	107	113
Almonte	99	137	115	146	146	157
Paradise Cay	67	69	69	74	91	111
Santa Venetia	29	211	56	221	232	269
Pt. San Pedro	14	62	58	65	78	83
Greenbrae	13	21	14	22	24	24
Kentfield	10	28	12	33	53	118
Bayside Acres	9	9	10	10	12	24
Country Club	4	4	4	4	9	10
Black Point	1	58	62	346	388	408
Tamalpais		28	1	29	28	30
Marin City				3	7	36
California Park					9	10
Total	**3,450**	**4,457**	**3,860**	**7,053**	**8,644**	**9,196**

Source: MarinMap, CoSMoS

Land

Land is a scare resource in Marin County. Sea level rise would only reduce the available dry land even further, displacing tens of thousands of people.

Acres

Near-term: Scenarios 1 & 2

As shown in Table 119, in near-term scenario 1, 3,450 acres could be flooded at the average high higher tide (MHHW) across 19 unincorporated communities. Of the near twenty areas that could be vulnerable, the top three with the largest area exposed to tidal flooding are:

1. Bel Marin Keys, 1,750 acres,
2. Waldo Point Harbor area, 598 acres, and
3. St. Vincent's, 256 acres.

Strawberry is a close fourth with 255 acres. Black Point, Tamalpais Valley, Marin City, and California Park are not exposed under scenario 1.

Add an additional storm surge, scenario 2, and 1,000 more acres could be vulnerable to storm surge impacts within the unincorporated area. The top three under storm surge conditions are similar, though North Novato replaces St. Vincent's with 575 acres flooded. Strawberry and Santa Venetia could expect several hundred acres flooded with surge waters. Note that much of the flooded area is marsh and open lands, especially north of the Tiburon peninsula.

While not high in acreage numbers, communities such as Almonte, Greenbrae, Waldo Point Harbor, and Paradise Cay, that are relatively small, could experience tidal and storm flooding on a large portion of their developed area.

Medium-term: Scenarios 3 & 4

In the medium-term, trends and values for tidal flooding are similar to the near storm surge scenario 2. With a 100-year storm surge; however, significantly more acreage could temporarily flood. North Novato and Bel Marin Keys could expect more than 2,000 flooded acres during a storm surge if the bay rises by 20 inches. Overall, roughly 7,000 acres could flood under scenario 4 conditions. Most protective shoreline levees in unincorporated Marin, if not already overtopped in the near-term, would be overtopped at this water level.

Long-term: Scenarios 5 & 6

In long-term scenario 5, more than 8,500 acres could be subject to tidal flooding and storm surge flooding, and an additional 600 acres could expect storm surge flooding. In long-term scenario 5, the most acres are flooded in:

1. North Novato, 9,800 acres,
2. Bel Marin Keys, 2,300 acres, and
3. St. Vincent's, 1,400 acres.

Adding the additional storm surge only exacerbates flooding potential in these three communities and several others. Waldo Point Harbor could anticipate roughly 600 acres exposed across all of the scenarios, which is the entire community. Black Point, Strawberry, and Santa Venetia could anticipate 200 to 400 acres exposed in the low lying areas of their community.

Parcels

Near-term: Scenarios 1 & 2

As shown in Table 120, in near-term scenario 1, eighty-two parcels could be flooded at MHHW. Many of these parcels are marshy or in the water with houseboats. Of the communities that could be vulnerable, the top three with the highest number of parcels exposed to tidal flooding are:

1. Waldo Point Harbor, 59 parcels,
2. Greenbrae, 54 parcels, and
3. Bel Marin Keys, 45 parcels.

Elevated and floating homes on these parcels may prove to be adaptable to rising tides.

Dipsea Café along Coyote Creek. King Tide, Nov. 25, 2015. Credit: Marin County CDA

Table 120. Unincorporated Marin Vulnerable Parcels in the Near-term

Location	Near-term			
	Scenario 1		Scenario 2	
	#	%	#	%
Waldo Point	59	12	68	14
Greenbrae	54	62	68	78
Bel Marin Keys	45	6	121	16
Paradise Cay	28	8	34	9
Strawberry	26	2	29	2
Almonte	22	32	46	68
Bayside Acres	19	9	19	9
Tiburon	13	4	22	7
St. Vincent's	7	10	12	18
Santa Venetia	4		604	36
Kentfield	2	0	4	0
Black Point	1	0	9	1
Country Club	1	0	2	0
San Quentin	1	1	1	1
Tamalpais			97	4
Total	**282**	**2**	**1,088**	**8**

Source: MarinMap, CoSMoS

Table 121. Unincorporated Marin Vulnerable Parcels in the Medium-term

Location	Medium-term			
	Scenario 3		Scenario 4	
	#	%	#	%
Bel Marin Keys	97	13	172	23
Waldo Point	64	13	73	14
Greenbrae	57	66	70	80
Paradise Cay	38	10	54	15
Almonte	32	47	52	76
Strawberry	25	2	76	5
Bayside Acres	19	9	20	9
Tiburon	16	5	22	7
Black Point	15	2%	46	5
St. Vincent's	12	18	13	19
Santa Venetia	4	0	652	39
Kentfield	3	0	9	0
Tamalpais	3	0	98	4
Country Club	2	0	2	0
San Quentin	1	1	1	1
North Novato			24	3
Total	**388**	**3**	**1,384**	**10**

Source: MarinMap, CoSMoS

Paradise Cay and Strawberry are a close fourth with more than 25 flooded parcels. Tamalpais Valley, Marin City, and California Park are not exposed under scenario 1.

Add an additional storm surge, scenario 2, and just less than 1,000 more acres could be vulnerable to storm surge impacts. The top three under storm surge conditions are:

1. Santa Venetia, 604 parcels,
2. Bel Marin Keys, 121 parcels, and
3. Tamalpais Valley, 97 parcels.

While not high in number of parcels, the small communities of Greenbrae, Almonte, Waldo Point Harbor, and Paradise Cay, could experience tidal and storm flooding on a large portion of their developed area. By the end of this term, 60 percent of Greenbrae parcels could suffer regular tidal flooding, and another twenty percent would flood during a storm-surge. Floating homes in Waldo Point Harbor and elevated homes on piers along Greenbrae Boardwalk may adapt well to higher water levels due to storm surge.

Medium-term: Scenarios 3 & 4

Overall, roughly 400 acres could experience tidal flooding in medium-term scenario 3, mostly in water based communities. For example, if protective levees and tide gates fail, Bel Marin Keys could experience flooding on the highest number of parcels, followed by Waldo Point and Greenbrae.

By number, under storm surge conditions, Santa Venetia levee failures could lead to more than 650 being flooded. These parcels amount to nearly 40 percent of the community's parcels. Santa Venetia is followed by Bel Marin Keys and Strawberry. By proportion, Almonte is the second most compromised with 64 percent of existing g parcels flooded. In unincorporated Marin, in medium-term scenario 4, 20 inches of sea level rise with a 100-year storm surge, these levee breaches could facilitate flooding about 1,400 parcels.

Long-term: Scenarios 5 & 6

As shown Table 122, in long-term scenario 5, 82 parcels could be flooded at the average higher high

tide (MHHW). Houseboat and unauthorized water oriented communities are almost entirely compromise, with flood water reaching further inland into the narrow valleys of the south, and open low lands of the north. Of the communities that could be vulnerable, the top three with the highest number of parcels exposed to tidal flooding are:

1. Bel Marin Keys, 711 parcels,
2. Santa Venetia, 653 parcels, and
3. Strawberry, 155 parcels.

Paradise Cay, Tamalpais Valley, Waldo Point, and Greenbrae follow. Bel Marin Keys also tops the list of most compromised, with 94 percent of parcels vulnerable to tidal flooding at MHHW. Both Greenbrae and Almonte parcels are around 80 percent compromised, with Santa Venetia, the next most compromised at 40 percent of parcels flooded.

Add a 100-year storm surge, scenario 6, and about 1,000 more parcels could be vulnerable to storm surge impacts. The top three vulnerable communities under storm surge conditions are:

1. Santa Venetia, 821 parcels,
2. Bel Marin Keys, 750 parcels, and
3. Strawberry, 287 parcels.

Kentfield follows with more than 250 flooded parcels as Corte Madera Creek overflows its banks. The top three compromised communities by percent of community are:

1. Almonte, 100 percent,
2. Bel Marin Keys, 99 percent, and
3. Greenbrae, 82 percent of parcels flooded.

Almonte is an essential regional asset and through way to West Marin, Mill Valley, and the Marin Headlands. Bel Marin Keys and Greenbrae are highly sought after residential locations that sustain significant storm exposure.

Table 122. Unincorporated Marin Vulnerable Parcels in the Long-term

Location	Long-term			
	Scenario 5		Scenario 6	
	#	%	#	%
Bel Marin Keys	711	94	750	99
Santa Venetia	653	39	821	49
Strawberry	155	9	287	17
Paradise Cay	103	28	193	52
Tamalpais	94	4	109	4
Waldo Point	75	15	78	15
Greenbrae	70	80	71	82
Black Point	66	8	172	20
Almonte	53	78	69	100
Kentfield	52	2	236	9
California Park	41	15	54	20
North Novato	30	4	53	7
Bayside Acres	23	11	36	17
St. Vincent's	22	32	32	47
Tiburon	18	5	81	24
Country Club	6	1	21	5
San Quentin	1	1	9	11
Marin City			20	4
Point San Pedro			5	50
China Camp			5	45
Total	**2,173**	**15**	**3,102**	**22**

Source: MarinMap, CoSMoS

Greenbrae Boardwalk. Credit: BVB Consulting LLC

Buildings

Many parcels contain buildings, especially in Southern Marin. Buildings typically provide the most function and direct benefit to human activities, are costly to repair or replace, and contain valuable personal or business property. The most vulnerable buildings in Unincorporated Marin are those that already exist beyond mean sea level in Waldo Point, Greenbrae, and Black Point. The floating homes in Waldo Point Harbor and elevated homes on piers along Greenbrae Boardwalk may be more adaptable than homes with solid foundations. While not counted as buildings, unauthorized residential boats moored in Richardson's' Bay are also vulnerable to dramatic changes in tide and storm surges. The next most vulnerable are development on fill, typically found in Bel Marin Keys, Paradise Cay, Tamalpais, and Santa Venetia.

Near-term: Scenarios 1 & 2

In the near-term, about 200 buildings could be exposed to tidal flooding, primarily in Greenbrae and Waldo Point, where homes are elevated on piers or float over the tide lands, which could also allow them to adapt to flooding. According to CoSMoS and MarinMap, nearly 60 percent of Greenbrae buildings, mostly homes, could be compromised. In addition, several buildings close to the water in Almonte, Paradise Cay, Bel Marin Keys, and Strawberry could also experience tidal flooding.

Under 100-year storm surge conditions, these communities would experience worsening conditions. More than 1,000 additional buildings would now experience storm-surge flooding, if they have not already. These buildings are concentrated in Santa Venetia, with more than 900 flooded buildings, where storm surges would overtop protective levees along Las Gallinas Creek. Santa Venetia is also susceptible to subsidence that is likely to worsen as sea levels rise and infiltrate the soggy soils beneath the development.

By portion of buildings compromised by tidal and storm surge flooding, the top three communities are:

1. Greenbrae, 90 percent,
2. Santa Venetia, 40 percent, and
3. Waldo Point, 25 percent of parcels flooded.

In the near-term, storm surge flooding could have significant impacts in these communities, especially Greenbrae. The communities have weathered these dramatic conditions in the past; however, these events are likely to increase in severity and frequency.

Table 123. Unincorporated Marin Vulnerable Buildings in the Near-term

Location	Near-term			
	Scenario 1		Scenario 2	
	#	%	#	%
Greenbrae	72	59	112	91
Waldo Point	61	16	89	23
Bel Marin Keys	20	3	118	17
Almonte	7	1	63	7
Strawberry	7	0	58	3
Paradise Cay	4	1	48	16
Uninc. Tiburon	1	0	18	6
Santa Venetia			911	41
Tamalpais			100	3
Black Point			15	1
Country Club			5	1
Bayside Acres			3	1
Point San Pedro			2	2
China Camp			1	9
Total	**172**	**0**	**1,552**	**2**

Source: MarinMap, CoSMoS

Medium-term: Scenarios 3 & 4

In the medium-term, more than 400 buildings could experience tidal flooding at MHHW. These buildings are concentrated in Bel Marin Keys, Greenbrae, and Waldo Point Harbor, with around 90 buildings each. Fifty buildings in Paradise Cay could also experience tidal flooding. The top three exposed communities in the medium-term are Greenbrae, at 66 percent, Waldo Point, at 23 percent, and Paradise Cay at 17 percent of buildings compromised by tidal flooding. Under storm-surge conditions, the communities with the highest number of flooded building are:

1. Santa Venetia, 945 buildings,
2. Bel Marin Keys, 176 buildings, and
3. Strawberry, 117 buildings.

By portion of flooded buildings within the community, the top three exposed communities are:

1. Greenbrae, 93 percent,
2. Santa Venetia, 42 percent

3. Paradise Cay, 25 percent.

The elevated homes along Greenbrae Boardwalk have superstructures that sit on piers over the tide lands. They may be more adaptable to than homes on solid foundations.

Table 124. Unincorporated Marin Vulnerable Buildings in the Medium-term

Location	Medium-term			
	Scenario 3		Scenario 4	
	#	%	#	%
Greenbrae	81	66	115	93
Waldo Point	87	23	90	23
Bel Marin Keys	92	13	176	25
Almonte	30	3	84	9
Strawberry	33	2	117	7
Paradise Cay	52	17	80	26
Uninc. Tiburon	13	4	18	6
Santa Venetia	2	0	945	42
Tamalpais Valley	2	0	103	4
Black Point	18	2	30	3
Country Club	6	1	6	1
Bayside Acres	2	1	5	2
Point San Pedro	2	2	4	5
China Camp	1	9	1	9
Kentfield			11	0
Study Area	**424**	**1**	**1,969**	**3**

Source: MarinMap, CoSMoS

Long-term: Scenarios 5 & 6

In the long-term, nearly 3,000 buildings could be exposed to tidal flooding on the shores of Unincorporated Marin, amounting to 4 percent of the parcels in Unincorporated Marin. The top three tidally flooded communities by number of buildings are:

1. Santa Venetia, 982 buildings,
2. Bel Marin Key, 683 buildings, and
3. Strawberry, 185 buildings.

By proportion, the top three vulnerable water oriented communities are:

1. Greenbrae, 97 percent,
2. Bel Marin Key, 96 percent, and
3. Paradise Cay, 51 percent of buildings.

With the additional 110-year storm surge, 1,000 more buildings, for about 5 percent of buildings in the unincorporated portion of the study area, could be damaged by flooding.

Table 125. Unincorporated Marin Vulnerable Buildings in the Long-term

Location	Long-term			
	Scenario 5		Scenario 6	
	#	%	#	%
Greenbrae	119	97	120	98
Waldo Point	90	23	386	100
Bel Marin Keys	683	96	707	99
Almonte	86	9	106	11
Strawberry	185	11	264	15
Paradise Cay	157	51	219	71
Tiburon	17	6	23	7
Santa Venetia	982	44	1,142	51
Tamalpais Valley	98	3	103	4
Black Point	65	6	89	8
Country Club	18	4	21	4
Bayside Acres	5	2	6	3
Point San Pedro	21	24	25	2
China Camp	1	9	1	9
Kentfield	79	3	247	8
St. Vincent's	10	11	16	18
San Quentin	10	3	32	9
California Park	10	5	13	6
Marin City	1	0	38	9
Study Area	**2,856**	**4**	**3,826**	**5**

Source: MarinMap, CoSMoS

The top three storm surge flooded communities by number of buildings are:

1. Santa Venetia, 1,142 buildings,
2. Bel Marin Key, 683 buildings, and
3. Waldo Point, 306 buildings.

By proportion, the top three vulnerable communities with the greatest portion of vulnerable buildings are:

1. Waldo Point, 100 percent
2. Bel Marin Key, 99 percent, and
3. Greenbrae, 98 percent of buildings.

By scenario 6, 60 inches of sea level rise and a 100-year storm surge, entire communities could be left in recovery, or at worst retreat.

The following sections provide area specific details related to buildings in each incorporated community starting in Southern Marin and traveling north. Southern Marin, with the exception of Santa Venetia, is more vulnerable in the near- and medium-term.

Marin City

The Marin City shopping center could face storm impacts in the long-term and some minor flooding could impact the current Ross building. Buildings beyond the shopping center, including apartments and Martin Luther King Academy, could also experience impacts during a 100-year storm.

Waldo Point Harbor

Every building and houseboat in Waldo Point Harbor could anticipate impacts from sea level rise and a 100-year storm surge. The houseboats and marina facilities could flood over seven feet in the medium-term and nearly eleven feet at MHHW. The businesses at the US Highway 101 on ramp could anticipate over two feet of flooding.

Floating homes made of wood are the primary housing type and building type in the community. The few land based commercial buildings are wooden structures. Development is divided into two areas, Waldo Point Harbor and Richardson Bay Marina. In total, about 450 houseboats and 800 to 900 people live here. Many of the houseboats are held to pylons with u-locks that could float off the top of the pier if the tide is high enough. Others are tied with ropes that have their limits or could hold the home under water as the tides rise. Roughly twenty buildings, known as arcs, are the most vulnerable because they are attached to the ground and do not fluctuate with the tides. In addition, many front entrances to the homes are on the lower level with finger docks that go down or up to the water, depending on the tide. If the tide is too high, the finger docks may become unsafely slanted, or even flooded at one end or the other. These ramps are already relatively steep at king tides according to the Richardson Bay Floating Homes Association. Finally, the parking and access areas could be flooded and are already prone to continuous subsidence.

At the marina, ten percent of the slips can be used for residential purposes. Additionally, live aboards, or unauthorized boats anchored in the waters of Richardson Bay one or more persons may live on, are highly vulnerable to storms and higher tides. According to the Richardson Bay Floating Homes Association, about 240 unauthorized boats are in the Bay as residences, though some may be junk boats without residents. The marina office is highly vulnerable on Gate 6 Road, which is vulnerable to subsidence. The businesses off the entrance to US Highway 101 northbound could be vulnerable to over two feet of tidewaters. By the long-term scenario, if the docking systems, land base, and homes are not able to adjust, the entire building stock could be lost.

Almonte, Tamalpais Valley

Housing at risk is in the low-lying area off Coyote Creek where it meets Bothin Marsh. These homes are protected by earthen berms or levees and pump stations for stormwater that stave off current high tides. However, with a combination of stormwater, storm surge, and high tide the area can flood. Sea level rise could exacerbate this in the near-term. Storm surges in the medium-term could impact 100 properties. By the medium-term, a couple of properties could anticipate tidal MHHW flooding. In the long-term, nearly 100 properties could anticipate tidal impacts at MHHW. These properties are a relatively small portion of the housing stock in the community.

Strawberry

Vulnerable properties in Strawberry are concentrated in low lying pockets along the steep shoreline. In the near-term, these include the commercial properties along Seminary Marsh, residential properties along Greenwood Cove.

Richardson Bay Marina, East Pier 6 looking to the west pier. Waldo Point Harbor. April 2016. Credit: BVB Consulting LLC

View of pathway and tidal zone of Coyote Creek. Tamalpais Valley. Feb. 2016. Credit: Marin County DPW

Vulnerable homes bordering Greenwood Cove. Feb. 18, 2016. Credit: Marin County DPW.

Paradise Cay Aerial View. Credit: Unknown

The Westminster Presbyterian Church, preschool, and emergency shelter is located here and could be impacted near the end of the century. Strawberry Circle could anticipate storm impacts in the near-term and tidal flooding in the long-term. A few homes along Seminary Drive could be vulnerable to sea level rise in the long-term. The Strawberry Village Shopping Center could be vulnerable by scenario 6, along with homes along Harbor Point.

All of the commercial properties in Strawberry could anticipate impacts including retail, restaurants, a gas station, and others along Seminary Marsh and the Strawberry Village Shopping Center. The vulnerable residential parcels make up a small portion of all the residential parcels in the community. Properties on the bluff edge may also to subject to increases in erosion and could face bluff collapse.

Unincorporated Tiburon and Paradise Cay

While properties are impacted in unincorporated Tiburon, most are not directly impacted. A few homes could be impacted nearing Paradise Cay. Beaches, docks, and bluff stability could be of concern however for several properties.

Paradise Cay is quite the contrary. This community rests mostly on the shore and into San Pablo Bay. Paradise Cay, much like Waldo Point Harbor, could be completely lost to sea level rise with more than 70 percent of the parcels compromised by MHHW tidal flooding in the long-term. Storm surges could do significant damage before sea level rise takes full affect, especially considering the storm impacts on erosion and subsidence. These parcels and buildings are all south east of Paradise Drive. The buildings across the road are safe under the BayWAVE scenarios.

Greenbrae

Greenbrae low lands could be vulnerable. The Greenbrae Boardwalk is in the tidal zone east of US Highway 101 and along Corte Madera Creek west of 101. The eastern portion is slightly more vulnerable than the western portion, with every building exposed in the near-term. In the near-term on the northern side, nearly every home is exposed to a 100-year storm surge. Pylons that extend deep into the bay mud typically support these homes and elevate them above the marsh, which can make them more adaptable. This portion of the community may be lost in the long-term. The land flanking US Highway 101 is also vulnerable. Marin RV Park is located here along with a few businesses and a gas station.

Kentfield

Kentfield is located north east of Larkspur up Corte Madera Creek. The majority of the buildings including, Kent Middle School, Bacich Elementary School and College of Marin, could be vulnerable in scenario 6. A few buildings along McAllister's Slough could be vulnerable to a 100-year storm surge by scenario 4. Many of the homes here and lining Beren's Slough could be vulnerable to sea level rise alone in the long-term. Nevertheless, this community is vulnerable to stormwater flooding, and when combined with the BayWAVE scenarios, the combined flooding could be damaging sooner.

California Park

Ten parcels in California Park could be vulnerable to sea level rise by scenario 5, and 13 with the additional 100-year storm surge. Very little of this hillside community is impacted directly.

Bayside Acres and County Club

Bayside Acres and Country Club are two small communities along Pt. San Pedro Road, each bordered by San Rafael on three sides and bay water on the remaining side. These communities are primarily residential. In addition to residential, Country Club features Lowrie Yacht Harbor, a commercial enterprise. In the near-term, Country Club properties along the bay could experience sea level rise impacts. Ten or so more properties could be vulnerable to long-term sea levels between Pt. San Pedro Road and the Marin Yacht Club. Bayside Acres could anticipate a few buildings closest to the water vulnerable in the medium- and long-terms.

Point San Pedro

Point San Pedro features McNear's Beach Park. In the long-term, scenario 6, a 100-year storm surge could reach the clubhouse, pool, and fronting lawn. The larger bay front lawn that leads to the McNear's Beach Pier will be slowly compromised by the tide between the medium and long-terms. By scenario 5, this area would shrink by about half. To learn more about this facility see the recreation section of this profile or the Recreation Profile.

Santa Venetia

The vulnerable area of Santa Venetia is primarily residential. A few small commercial parcels are impacted along Pt. San Pedro Road, as is Gallinas Landing. Every building and property east of N. San Pedro Road is vulnerable to storm surge waters by scenario 2, and sea level rise alone between the medium-term and the long-term. This may be possible around three feet of sea level rise when the levees protecting the existing housing could be overtopped by tidal waters. By scenario 6, more than 900 homes could be impacted. The homes and business just west of North San Pedro Road could be vulnerable in scenario 6.

Santa Venetia during a major flood. Credit: Marin County DPW

St. Vincent's

St. Vincent's is home to St. Vincent's private school, Silveira Ranch grazing lands, and sanitary district lands that are also leased for grazing. These open lands are often wet during storms and high tides seasonally. The school and farm buildings are not vulnerable to salt water under the BayWAVE scenarios. To learn more about this area, see the utilities and agricultural sections of this Profile.

Bel Marin Keys

Bel Marin Keys is a managed community that interfaces with tidewater held at bay by a large levee system on the affronting state public lands, and local protections including tide gates that manage the flow water into and out of the manmade lagoons. The model treats the lagoons as a continuous tidal system and does not account for lagoon engineering and management. Because of this, the model may overestimate flooding depths and extents in the near- and medium-terms. In the long term, especially with a storm surge, it is possible the tide gates and levees buffering the community from tidal influx could be overwhelmed.

Low lying properties in Black Point. Credit: Marin County CDA

Black Point and Green Point

Black Point's vulnerable parcels are concentrated along the inland marshes near State Route 37 and in the small commercial area on Atherton Drive. The low-lying homes in the marshes off Hunter's Club Road could be vulnerable to sea level rise in the medium-term. While several hillside parcels could be vulnerable to erosion, much of the buildings are perched on the bluffs out of the potential tidal flow. Some of the shoreline buildings have docks and piers that could be damaged in storms and may need to be adjusted to not flood during average high tides in the near-term.

Green Point does not have many vulnerable parcels. Those that are situated around the marshes could be vulnerable in the long-term to sea level rise and a 100-year storm surge. Only a few could be impacted by sea level rise alone in the same time period.

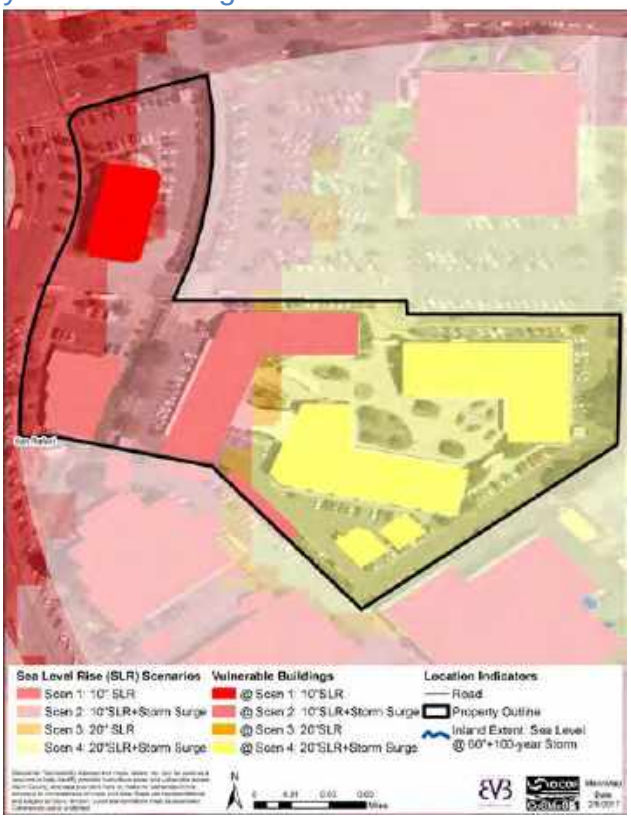
North Novato

Several undeveloped shoreline parcels could be vulnerable to sea level rise in the near-term. In the long-term, water can reach to the Marin County Airport at Gnoss Field, and beyond US Highway 101impacting a few business at the airport and along Binford Road.

County Owned Facilities

While technically in San Rafael, the Marin County Exhibition Hall and parking lot area vulnerable to a 100-year storm surge. In addition, McInnis Park could anticipate tidal and storm surge waters engulf the creek side athletic fields and park entrance. The Marin County Health Innovation Campus is also in San Rafael in the highly vulnerable Canal District.

Map 1. Health Innovation Campus is Vulnerable to Sea Level Rise and a 100-year Storm Surge

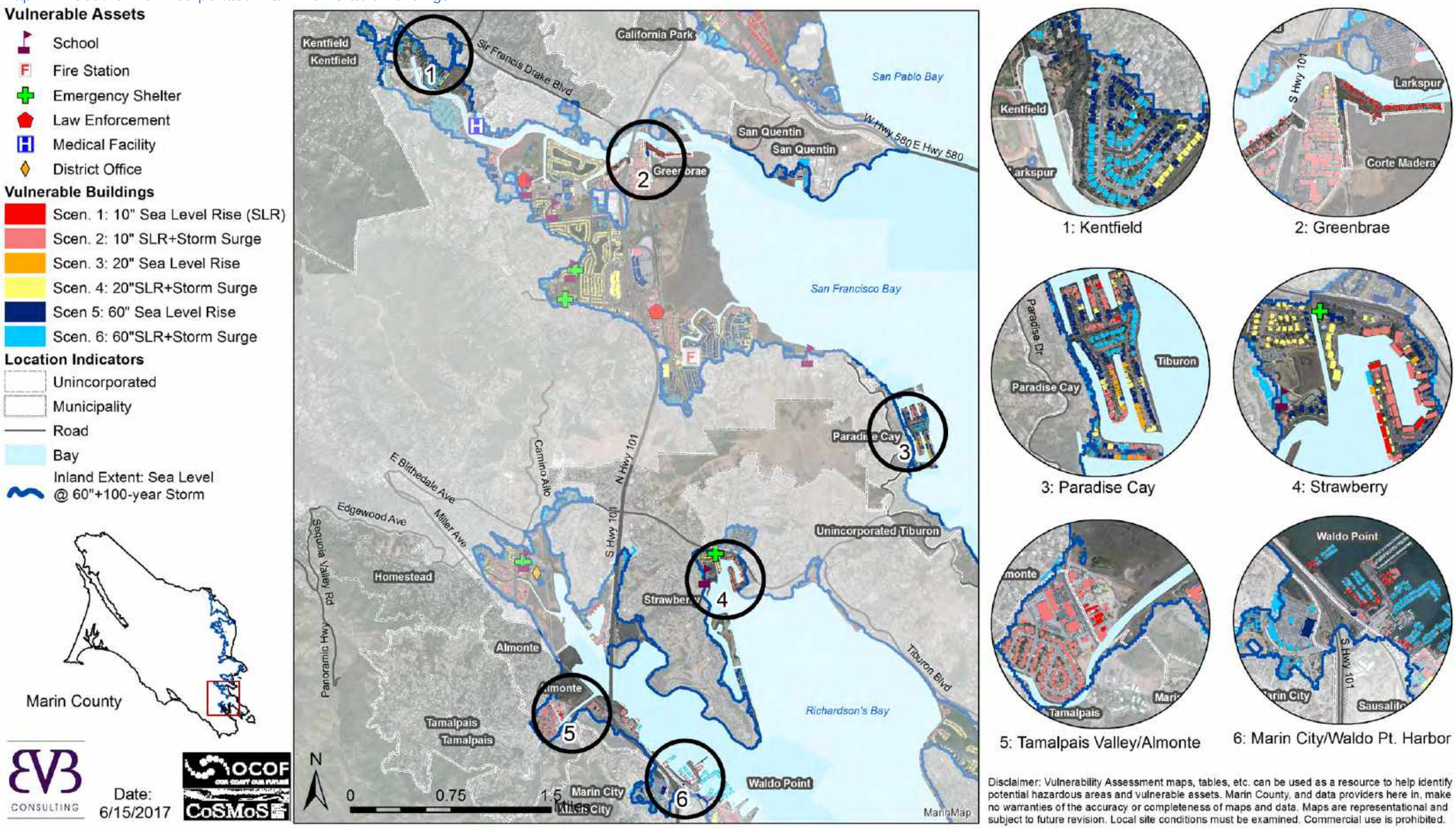


In the near-term, access to the site could be an issue, and the buildings facing Kerner Boulevard. could impacts with a storm surge in the near-term and sea level rise in the long-term. The rear two buildings could be vulnerable to a storm surge in scenario 4 and sea level rise in scenario 5.

In addition, the county owns or holds several easements for utility equipment, such as stormwater pump stations that could also anticipate tidal flooding. Finally, several other county parks could be vulnerable, though they do not have vulnerable to buildings and are discussed in the recreation section of this profile.

The maps on the following pages illustrate vulnerable buildings. The areas in the call out circles enable the reader the see areas that are difficult to see on the large scale map. The circles do not indicate that these areas are more vulnerable than others along the shoreline.

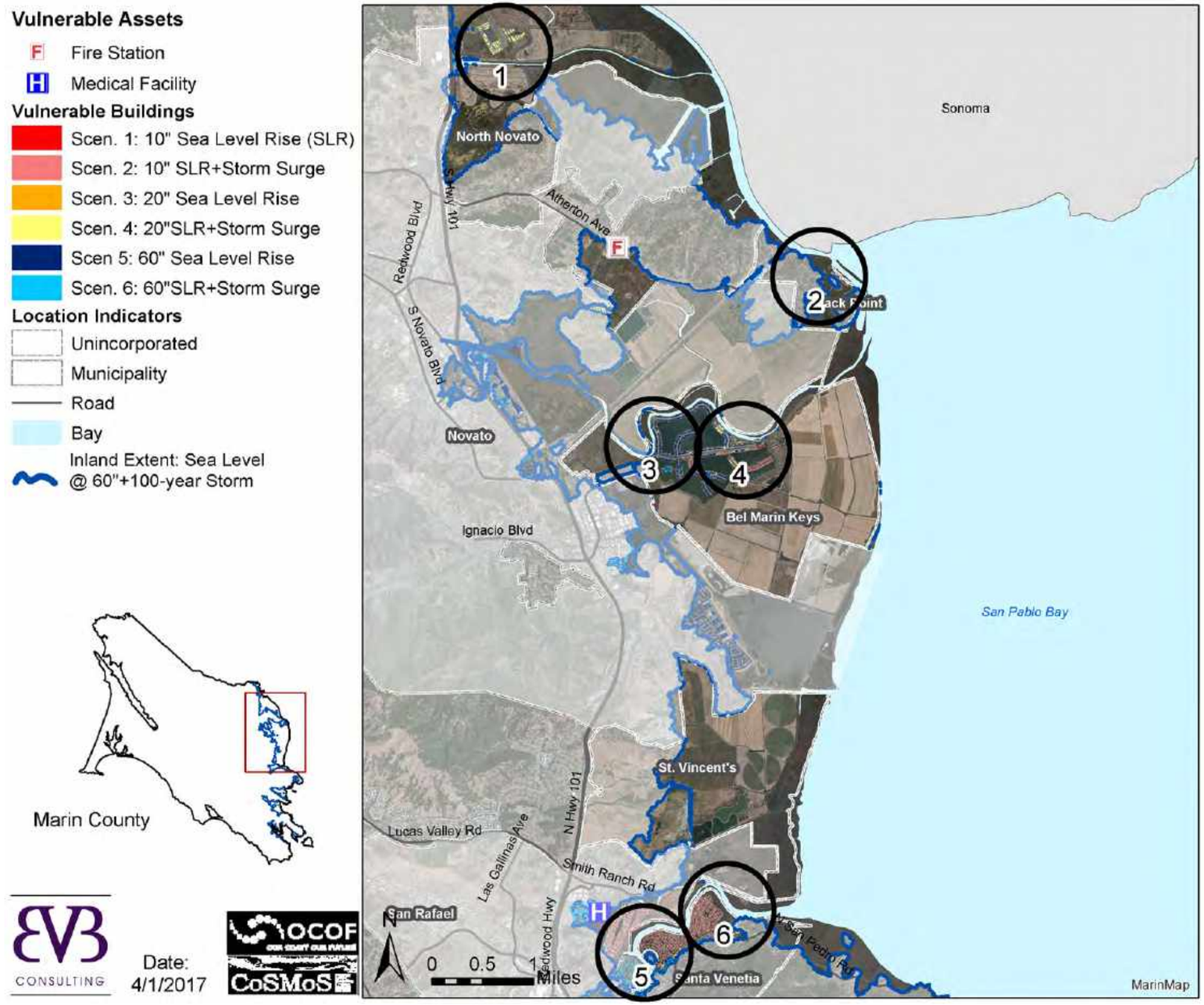
Map 114. Southern Unincorporated Marin Vulnerable Buildings



Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data providers here in, make no warranties of the accuracy or completeness of maps and data. Maps are representational and subject to future revision. Local site conditions must be examined. Commercial use is prohibited.

UNINCORPORATED

Map 115. Northern Unincorporated Marin Vulnerable Buildings



1: Gnoss Field Airport

2: Black Point

3: Western Bel Marin Keys

4: Eastern Bel Marin Keys

5: Western Santa Ventia

6: Eastern Santa Venetia

Date: 4/1/2017

Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data providers here in, make no warranties of the accuracy or completeness of maps and data. Maps are representational and subject to future revision. Local site conditions must be examined. Commercial use is prohibited.

Collectively, all of the communities could anticipate 3,000 parcels with nearly 4,000 buildings vulnerable to sea level rise. This is about one quarter of the parcels and one third of the buildings impacted in the study area. In the long-term, fifteen percent of the parcels and five percent of the buildings in unincorporated Marin could be compromised. Table 125 summarizes the number of buildings impacted in each community across the BayWAVE scenarios.

While a very small portion of the vulnerable properties are commercial, a majority of the commercial properties in the study area in the County of Marin could be vulnerable to sea level rise and nearly all could be vulnerable under scenario 6 parameters. Within the study area, the Santa Venetia and Kentfield may hold the last available commercial parcels in the study area.

Taking a closer look at the buildings across the unincorporated Marin communities, the majority of buildings could experience up to three feet of tidal flooding across scenarios 1, 2, and 3 with roughly 100, 250, and 1,200 buildings respectively. In scenario 1, almost 20 buildings could anticipate more than three feet to six feet of flooding. In scenario 3, nearly 75 buildings could anticipate tidal impacts between three feet to six feet of flooding, and nearly 100 could anticipate depths more than six feet up to 10 feet. By scenario 5, nearly 1,300 buildings could anticipate tidal impacts between three feel to six feet of flooding, nearly 250 could anticipate depths more than six feet up to 10 feet, and 80 could experience depths beyond 10 feet. These figures are available in Table 126. Appendix B provides this table for each unincorporated community.

Table 127 estimates damage costs using FEMA tagging designations for buildings and their contents. If every vulnerable building is destroyed under scenario 6 conditions $945 million in assessed structural value could be lost. At minor levels of damage, up to $65 million in damages could occur across the unincorporated area in the study area.[212]

Amongst the communities, Strawberry could expect the greatest loss in assessed structural value, followed by Bel Marin Keys and Santa Venetia. At yellow tag levels of damage, minor damage, because of the number of buildings impacted, Santa Venetia could expect the most substantial losses of $5 to 19 million.[213] Bel Marin Keys follows with $3.5 million to $12 million in damages. Waldo Point Harbor is third, with nearly $2 million to $6.5 million in potential damages at the minor level.[214]

Table 126. Unincorporated Marin Vulnerable Buildings by Flood Depth at MHHW

Flood Depth (feet)	Scenarios		
	Near-term	Medium-term	Long-term
	1	3	5
0.1-1	34	111	266
1.1-2	23	102	492
2.1-3	56	44	422
3.1-4	13	50	615
4.1-5	3	9	576
5.1-6	4	14	175
6.1-7	1	36	58
7.1- 8	1	48	37
8.1-9	1	16	118
9.1- 10		1	41
10.1+			81

Source: MarinMap, CoSMoS

Manzanita Area during king tide. Nov. 25, 2015. 10:40 a.m.

[212] 2016 dollars

[213] 2016 dollars
[214] 2016 dollars

Table 127. Unincorporated Vulnerable Buildings FEMA HAZUS Storm Damage Cost* Estimates in Long-term Scenario 6

Location	Yellow Tag: Minor Damage $5,000/building minimum	Orange Tag: Moderate Damage $17,001/building minimum	Red Tag: Destroyed Assessed structural value
Almonte	$530,000	$1,802,106	$37,738,121
Bayside Acres	$30,000	$102,006	$5,340,362
Bel Marin Keys	$3,535,000	$12,019,707	$188,722,172
Black Point	$445,000	$1,513,089	$15,807,484
California Park	$65,000	$221,013	$1,508,352
Country Club	$105,000	$357,021	$6,311,404
Greenbrae	$600,000	$2,040,120	$8,836,871
Kentfield	$1,235,000	$4,199,247	$99,778,853
Marin City	$190,000	$646,038	$24,685,548
North Novato	$1,340,000	$4,556,268	$7,911,796
Paradise Cay	$1,095,000	$3,723,219	$123,268,429
Point San Pedro	$125,000	$425,025	$33,137
San Quentin	$160,000	$544,032	$689,013
Santa Venetia	$5,710,000	$19,415,142	$124,787,181
St. Vincent's	$80,000	$272,016	$4,477,392
Strawberry	$1,320,000	$4,488,264	$214,941,911
Tamalpais	$515,000	$1,751,103	$22,654,207
Tiburon	$115,000	$391,023	$36,868,808
Waldo Point	$1,930,000	$6,562,386	$21,056,654
Total	**$19,125,000**	**$65,028,825**	**$945,417,695**

Source: MarinMap, CoSMoS

** 2016 dollars*

Transportation

Transportation impacts could be the main issue in several communities, where shut downs and detours, if possible, would impact many more people than properties. In addition to over land flooding that could damage the road surface, roads could be vulnerable to erosion and subsidence. Several locations already experience seasonal flooding, such as Manzanita, that prompt several-hour traffic delays. These events could increase in frequency and intensity, potentially to unmanageable and unbearable chronic flooding. The most vulnerable high capacity roads in the unincorporated communities are:

- Shoreline Highway from the Manzanita Park and Ride to Tam Junction in Almonte and Tamalpais Valley,
- US Highway 101 in Strawberry, Greenbrae, and US-101 and State Route 37 in Black Point and North Novato,
- Tiburon Boulevard at the Cove Shopping Center bordering Strawberry,
- Redwood Highway in Greenbrae,
- Bel Marin Keys Boulevard,
- Atherton Avenue in Black Point, and
- N. San Pedro Road in Santa Venetia.

Table 128 shows the cumulative lengths of all the roads and trails vulnerable in each community. The table also annotates who is responsible for the roadway. In several cases, responsibility for a road may be divided amongst several governments that will need to work together when making improvements and adjustments for higher floodwaters. Examples include Point San Pedro Road, Paradise Drive, and Sir Francis Drake Boulevard. In addition, several streets are privately maintained and could necessitate action by homeowner's associations or individual property owners. The property owners would likely need to work in cooperation with the public street improvement the private street connects to. The annotations are as follows:

M = Marin County
C = State of California
L = Local Municipality
P = Private

Overall, up to three miles, mostly under the purview of Caltrans, could be vulnerable in the near-term. In scenario 2, the 100-year storm surge could impact twelve more local roads, especially in Santa Venetia, Strawberry, Tamalpais Valley, and Almonte. By scenario 3, all of the roads in the previous scenario could expect tidal impacts though at a lesser extent of 7.4 miles. Scenario 4 adds a few more roads to the list and floods more of the already vulnerable roads to reach 24 miles of road impacted by 20 inches of sea level rise and a seasonal 100-year storm surge. By scenario 5, 5 feet of sea level rise, nearly 18 miles could expect tidal flooding, including those in scenarios 1-4, additional streets in Strawberry, and the first roads that could be impacted in Marin City. By scenario 6, an additional 12.5 miles could be compromised by nuisance, or temporary, flooding.

Marin City

Marin City could experience impacts to overland flooding from sea level rise on Highway 101, Donohue Street, and Drake Avenue at the off ramp from 101 south extending into the community. When these roads flood from stormwater and high tides seasonally, it can create extensive traffic backups along 101, and eliminates all vehicular access to and from Marin City. In addition, US Highway 101 already suffers from subsidence. This is evident by two large bumps from the sanitary sewerage pipes crossing underneath. According to Sanitary District engineers, the highway is sinking around the pipes. Disruptions in this system could also greatly impact essential transit service.

Stormwater Pond in Marin City. US Highway 101 is behind. Credit: Marin County DPW

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Table 128. Unincorporated Marin Roads Vulnerable to Sea Level Rise and a 100-year Storm Surge

	Near-term		Medium-term		Long-term	
	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
	3 miles	15 miles	7 miles	24 miles	18 miles	30 miles
Almonte		Hwy 101 [C] Bolinas St [M] Pohono St [M] Shoreline Hwy [C]		Roads in scenario 2	Roads in scenarios 2 & 4 Almonte Blvd [M]	Roads in scenarios 2, 4 & 5 Helen Ave [M]
Bayside Acres				Beach Dr [M]	Beach Dr [M]	Beach Dr [M]
Bel Marin Keys	Bel Marin Keys Blvd [M]	Roads in scenario 1 Bahama Reef [M] Del Oro Lagoon [M]	Roads in scenario 1	Roads in scenarios 1-3	Roads in scenarios 1-4 Bermuda Harbour [M] Calypso Shores [M] Caribe Isle [M] Cavalla Cay [M] Dolphin Isle [M] Montego Key [M]	Roads in scenarios 1-5
Black Point				Atherton Ave [M] Bachelors Rd [P] Bayview St [P] Beattie Ave [P] Bucks Landing Rd [C] Cavallero Ct [P] Channel Dr [P] Days Island Rd [P] Holly Ave [P] Norton Ave [P] Olive Ave [M] School Rd [M]	Roads in scenario 4 Glen Rd [P] Harbor Dr [P] Hunters Club Rd [P] Tamarin Ln [P]	Roads in scenarios 4 & 5
California Park					Auburn St [M] Woodland Ave [M]	Roads in scenario 5
China Camp		N San Pedro Rd [M]		Roads in scenario 2	Roads in scenarios 2 & 4	Roads in scenarios 2, 4, & 5
Country Club		Harbor View Ct [M]		Roads in scenario 2	Roads in scenarios 2 & 4	Roads in scenarios 2, 4, & 5 Pt. San Pedro Rd [M] Summit Ave [M]
Greenbrae	Greenbrae Boardwalk [P]	Hwy 101 [C] Lucky Dr [M]		Roads in scenario 2	Roads in scenarios 2 & 4	Roads in scenarios 2, 4, & 5

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	Near-term		Medium-term		Long-term	
	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
Kentfield				Berens Dr [M] Lilac Ave [M] McAllister Ave [M]	Roads in scenario 4 Lancaster Ave [M] Sherwood Ct [M] Stadium Wy [P]	Roads in scenarios 4 & 5 Acacia Ave [M] Bon Air Rd [M] College Ave [M] Hillside Ave [M] Kent Ave [M] Laurel Grove Ave [M] Sir Francis Drake Blvd [M]
Country Club						Pt. San Pedro Rd [M, L]
Marin City					Hwy 101 [C] Donahue St [M] Drake Ave [M]	Rods in scenario 5 Terners Dr [M]
North Novato	Hwy 37 [C]	Roads in scenario 1	Roads in scenarios 1 &2	Roads in scenarios 1-3 Airport Rd [M] Binford Rd [M]	Roads in scenarios 1-4 Hwy 101 [C]	Roads in scenarios 1-5
Paradise Cay		St. Lucia Place [M]		Roads in scenario 2 Jamaica St [M] Paradise Cay Marina [P] St Thomas Wy [M]	Roads in scenarios 2 & 4 Martinique Ave [M]	Roads in scenarios 2, 4, & 5 Saba Ln [M] Trinidad Dr [M]
Pt. San Pedro		McNear Brickyard Rd [P] McNears Rd [P]		Roads in scenario 2 Pt. San Pedro Rd [M]		
San Quentin	Hwy 580 [C]	Roads in scenario 1	Roads in scenarios 1 & 2	Roads in scenarios 1-3	Roads in scenarios 1-4 Levee Rd [P]	Roads in scenarios 1-5 Waterfront Rd [P]

	Near-term		Medium-term		Long-term	
	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
Santa Venetia		N San Pedro Rd [M] Adrian Wy [M] Ash Wy [M] Birch Wy [M] Descanso Wy [M] Estancia Wy [M] Galerita Wy [M] Geneva Wy [M] Hacienda Wy [M] Hawthorn Wy [M] La Pasada [M] La Playa Wy [M] LaBrea Wy [M] Mabry Wy [M] Meadow Dr [M] Palmera Wy [M] Rafael Wy [M] Rosal Wy [M] Vendola Dr [M]		Roads in scenario 2 Rincon Wy [M]	Roads in scenarios 2 & 4	Roads in scenarios 2, 4, & 5 Edward Ave [M] Lowell Ave [M] Mark Twain Ave [M] Steven Wy [M] Whittier Ave [M]
Strawberry	Hwy 101 [C]	Roads in scenario 1 Barbaree Way [M] Channel Lndg [P] Greenwood Bay Dr [P] Greenwood Cove Dr [M] Redwood Hwy Frontage Rd [M] Salt Lndg [M] Seminary Dr [M]	Roads in scenarios 1 & 2	Roads in scenarios 1 &2 De Silva Island Dr [P] E Strawberry Dr [M] Strawberry Cir [M]	Roads in scenarios 2 & 4 Belvedere Dr [M] Captains Lndg [M] Harbor Cove Way [M] Ricardo Rd [M] Seadrift Lndg [M] Tiburon Blvd (CA 131) [C] Villa Laguna [P]	Roads in scenarios 1-5 Heron Dr [M] Strawberry Lndg [P] Strawberry Village [P] Weatherly Dr [M]
Tamalpais		Shoreline Hwy [C] Tennessee Valley Rd [M] Almonte Blvd [M] Cardinal Ct [M] Cardinal Rd [M] Flamingo Rd [M]		Roads in scenario 2	Roads in scenario 2	Roads in scenarios 2 & 5 Gibson Ave [M]
Waldo Point	Gate 6 Dock [P] Gate 6 Rd [M]	Gate 6 1/2 Rd [P] Liberty Dock [P]	Roads in scenarios 1 & 2	Roads in scenarios 1-3 Shoreline Hwy [C] Bolinas St [M]	Roads in scenarios 1-4	Roads in scenarios 1-5 Main Dock [P]

Source: MarinMap, CoSMoS

Shoreline Highway, Tam Junction, Almonte. King tide, Nov. 24, 2015. Credit: Marin County CDA

Waldo Point Harbor

Waldo Point Harbor is one of the first communities to experience local road impacts. Gate 6 Road, maintained by Marin County, and Gate 6 Dock, maintained privately, are vulnerable in near-term scenario 1. In addition, parking areas for residents and marina users could also be compromised here. Waldo Point Harbor recently completed a project elevating the parking area four feet to account for subsidence and erosion. Gate 6½ Road could expect storm surge flooding by scenario 2, and tidal flooding by scenario 3, preventing residents from reach their house boats. In addition, the entrance to Waldo Point Harbor at US Highway 101 and Bridgeway, could flood tidally in the long-term, and be compromised by sea level rise and a 100-year storm surge seasonally in the medium-term. Finally, the marina and harbor facilities, including Liberty Dock and Main Dock, could be vulnerable to storm surge damage and high tides that reach beyond the pylons of the facility in the near-term.

Almonte & Tamalpais Valley

Nuisance flooding already burdens Almonte and Tamalpais Valley multiple times a year. Two major interchanges, commonly known as Tam Junction and Manzanita, are the gateway to Muir Woods, the Marin Headlands, and Mill Valley, where US Highway 101, Shoreline Highway, and Miller Avenue come together. Shoreline Highway at the US Highway 101 off ramp already suffers seasonal flooding and could expect tidal flooding of up to two feet in the medium-term. The Manzanita interchange is undergoing engineering studies to better manage the storm and tidewaters that prevent traffic flow for commuters, transit riders, visitors, and locals. Tam Junction could expect tidal flooding in the long-term. Nearer Coyote Creek, Shoreline Highway could expect flooding in the medium-term. Neighborhood roads vulnerable border Coyote Creek, and could expect tidal flooding impacts if the creek tops its banks. Of note, school aged children not be able to get to school via Miller Avenue, which floods now seasonally, and could expect tidal impacts in the medium-term.

Transit also travels through area. In fact, the Manzanita park and ride lot serves as a transit hub for commuters that park their cars under the freeway overpass. Golden Gate Transit, Marin Transit, the Marin Airporter, Sonoma Airport Shuttle, private company employee buses, such as Genentech, and others pick-up commuters from the Manzanita site. The lot already experiences flooding during seasonal high tides and storm event combinations. By long-term scenario 5, the lot could be vulnerable to high levels of flooding multiple times a month several months of the year. Transit also travels through Tam Junction. The shuttle and parking area for taking visitors to West Marin is based in the vulnerable area as well.

Hundreds of bicyclists take on Shoreline Highway and use the Mill Valley/Sausalito Pathway, and each could be tidally flooded by the medium-term. Additionally, the walking path along Coyote Creek that is part of the Bay Trail on top of the levees protecting lower Tamalpais Valley is vulnerable.

Strawberry

In the near-term, US Highway 101 off ramps here could expect tidal impacts. This area already floods seasonally. With respect to local roads, Strawberry may avoid tidal impacts until the long-term, and could expect storm surge flooding along Seminary Drive, the Frontage Road, and smaller streets in

Greenwood Cove in the near-term, and De Silva Island Dr., Strawberry Drive, and Strawberry Circle. By the long-term, Seminary Drive could expect more than 3½ feet of water at MHHW, and Redwood Highway Frontage Road could expect nearly five feet of tidal flooding at MHHW. In addition, private docks and piers could expect storm damage and flooding in the near-term.

Transit routes are also vulnerable along these roads. The MT and GGT stops that could be flooded out at high tide and/or with a 100-year storm surge are:

- Redwood Highway Frontage Rd. & Belvedere,
- Strawberry Frontage Rd. & US 101 North on-Ramp,
- 598 Redwood Highway Frontage Rd.,
- Redwood Frontage Rd. at Seminary Dr., and
- Seminary Dr. Bus Pad South Bound.

Unincorporated Tiburon & Paradise Cay
The roads in lower Paradise Cay are vulnerable to seasonal flooding and continuous subsidence. These influences are anticipated to get worse in the near-term. However, the roads are with the housing tracks and the buildings protect the roads from flooding until the long-term, except St. Lucia Place, which could expect medium-term tidal impacts at the end of the cul-de-sac. Residents in these communities could also be burdened by breakdowns in the Tiburon and Corte Madera road networks because they must travel through them to reach their community.

Kentfield
Much like with buildings, roads are primarily impacted in scenario 6. Roads in the Berens and McAllister Slough areas may be subject to flooding by scenario 2, and could likely suffer tidal impacts in the medium- to long-terms. This could also impact transit services and the stop at College Avenue and Kent Avenue.

Greenbrae
Greenbrae is vulnerable in the near-term, as is the US Highway 101 off Ramp to Sir Frances Drake Blvd. If the boardwalk is vulnerable people may not be able to safely access or leave their homes. The boardwalk is the only accessible by foot. The parking area could also experience tidal flooding in the medium-term. The remaining neighborhood could expect storm surge impacts, including Lucky Drive west of the freeway. Shoreline trails here and a bus stop at the freeway off ramp are also vulnerable. Bus stops include:

- Sir Francis Drake Blvd. & McAllister Ave.,
- 2052 Redwood Highway, and
- South Eliseo Dr., & Via Holon.

Finally, privately owned and maintained docks and piers could be damaged in storms and high tides.

California Park
California Park properties dependent on access from Woodland Avenue could be prevented at MHHW in the long-term. Traveling beyond Woodland Avenue in to San Rafael could be compromised sooner.

Bayside Acres & County Club
Lowrie Yacht Harbor in Country Club is vulnerable to storms and extreme high tides. Point San Pedro Road is vulnerable along its route in these communities and San Rafael in the long-term that could impact residents and travelers from passing through the area.

Waldo Point Harbor King Tide. Nov. 24, 2015. Credit: Marin County CDA

Santa Venetia
Several local roads could be vulnerable to storm surges in the near-term, and could experience tidal flooding by the long-term. Pt. San Pedro Road could

expect long-term flooding near the primary residential area and medium-term impacts with up to nine inches of tidal flooding in China Camp State Park. Santa Venetia, in general, is vulnerable to subsidence that will likely worsen as MHHW moves inland. Finally, privately owned and maintained docks and piers could be damaged in storms and high tides.

Transit through the exposed area travels and stops on Adrian Way. Adrian Way could be flooded by more than five feet of tidal waters near the stop locations and much of its path. In addition, SMART rail tracks from mile post 15.9 to 16.9 could be vulnerable to the BayWAVE scenarios. The SMART track would likely only be vulnerable under scenario 6, sea level rise combined with a 100-year storm surge.

St. Vincent's
The Bay Trail and a local trail could be vulnerable in this area, as is a portion of the SMART track at miles posts 21.4 to 23.0.

Bel Marin Keys
Bel Marin Keys Blvd., leading to Bel Marin Keys is not impacted until scenario 6. Long-term tidal flooding could compromise access at the entrance. Within the community, Bel Marin Keys Blvd. could expect tidal flooding at the far end, its intersection with Del Oro Lagoon, and at the end of Bahama Reef. Every street, according to the CoSMoS model, could expect tidal and 100-year storm surge impacts across the BayWAVE scenarios, with the majority flooded at MHHW by the long-term. Privately and HOA owned and maintained docks and piers could be damaged in storms and high tides, though many of these facilities are within the internal lagoons that could temper the effects of sea level rise. In addition, one public dock in the community could be vulnerable in the near-term.

Black Point and Green Point
Black Point and Green Point could expect long-term sea level rise impacts to State Route 37 leading all the way up to Atherton Avenue from U.S. Highway 101, with depths reaching more than eight feet. Storm surge impacts could occur by the medium-term. This road is already vulnerable to stormwater, high tide storm surge combinations seasonally and is being studied by Caltrans for improvements. Atherton Avenue could expect impacts off and on along its course, with primarily long-term storm surge exposure. At School Road and Olive Road, storm surges could reach Atherton Avenue in the medium-term and tidal MHHW exposure in the long-term. Atherton Avenue is vulnerable to sea level rise in the medium-term by Hunter's Club Road. Hunter's Club Road could expect impacts in the near-term with a storm surge. Under scenario 6, storm surge exposure could be felt near the golf course. Day Island, Norton Avenue, and Channel Road could all experience long-term sea level rise impacts. In addition to roads, the Black Point Boat Launch could expect a 75 percent reduction is capacity in the long-term with predicted average high tides according to asset managers. Privately owned and maintained docks and piers could be damaged in storms and high tides.

North Novato
Primary transportation issues in North Novato are at the Marin County Airport at Gnoss Field, and US Highway 101 flooding just north of the airport and Binford Road. These assets could expect long-term average high tide impacts. Gnoss Field could expect more than ten feet of tidal floodwater by scenario 5.

In addition, SMART track mile posts 32.9 to 33.4, could be vulnerable through this stretch of the county.

The maps on the following pages illustrate vulnerable transportation features. The areas in the call out circles enable the reader the see areas that are difficult to see on the large scale map. The circles do not indicate that these areas are more vulnerable than others along the shoreline.

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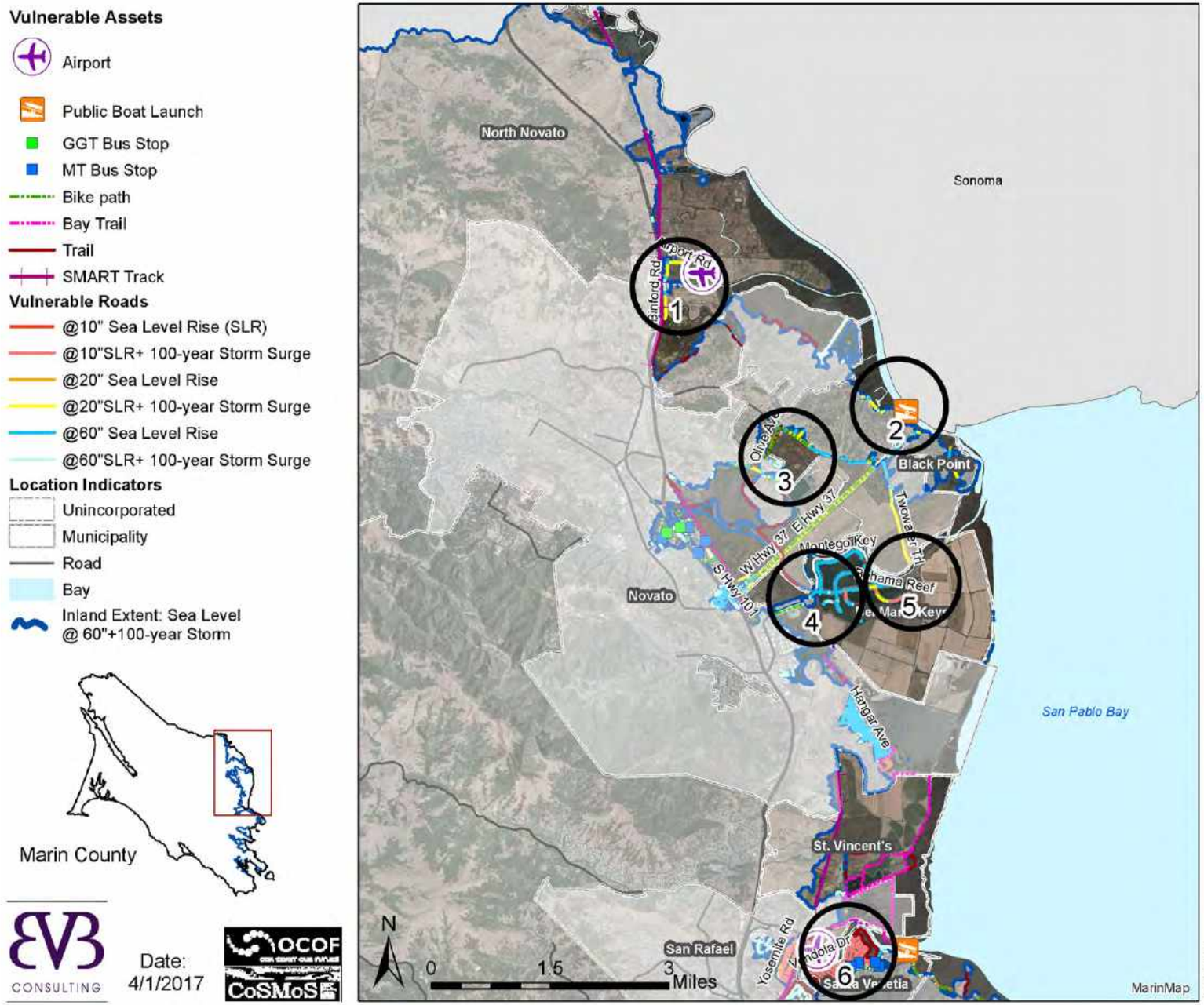
Map 116. Northern Unincorporated Marin Vulnerable Transportation Assets



Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data providers here in, make no warranties of the accuracy or completeness of maps and data. Maps are representational and subject to future revision. Local site conditions must be examined. Commercial use is prohibited.

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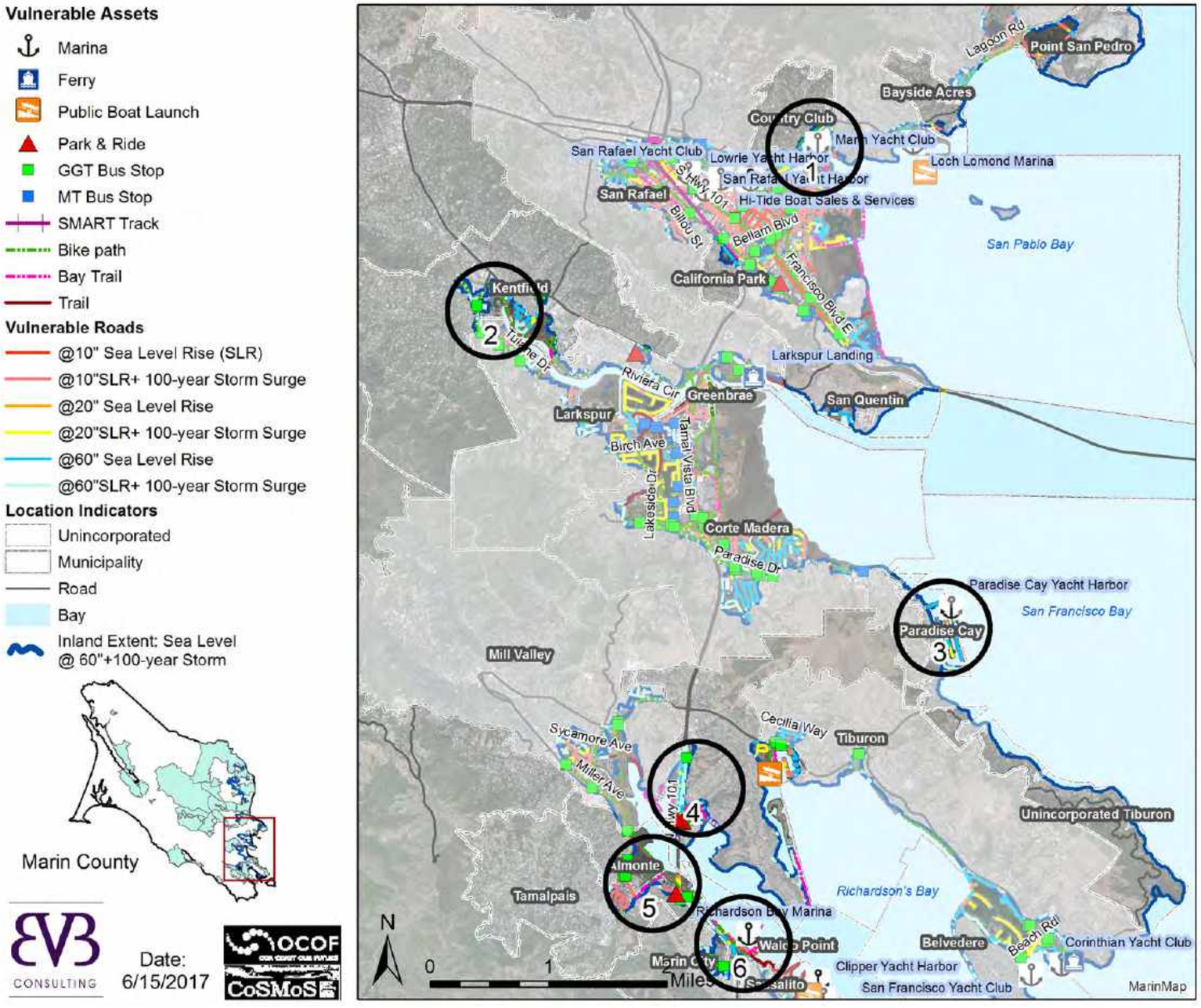
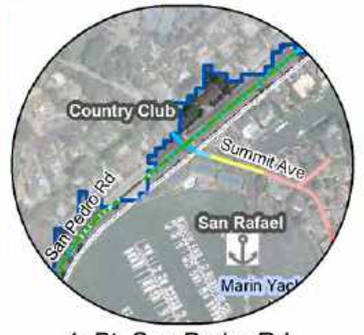
Map 117. Southern Unincorporated Marin Vulnerable Transportation Assets





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Utilities

Every unincorporated community is dependent on regional and local utilities. To get a full picture of utility concerns for the whole county read the Utilities Profile. Every community in the study area could expect the following utility vulnerabilities:

- Underground pipes facing compounding pressure forces from water and the road,
- Road erosion and collapse with underlain pipes,
- Saltwater inflow and infiltration can cause inefficiencies in wastewater treatment,
- Continuously subsiding soils or fill, and
- Pump stations in storm water and wastewater systems could expect escalating activity and capacity demands, more energy consumption, and wear and tear.

Most of Marin's unincorporated communities depend on service providers with headquarters and facilities in incorporated areas. For example, the six sanitary districts serving in Almonte, Tamalpais Valley, and Strawberry send their effluent to the SASM wastewater treatment plant in Mill Valley, Santa Venetia that pipes its effluent to Las Gallinas wastewater treatment plan on the edges of San Rafael, and Bel Marin Keys sends its effluent to Novato for treatment.

Water issues may be a concern in the North Marin Water District where assets in Bel Marin Keys could be compromised. By the medium-term, the Bel Marin Keys distribution system could expect impacts from saltwater intrusion. In addition, a cathodic protection anode bed that protects this communities water pipelines from corrosion may also be vulnerable.

In addition, most of the sanitary district and water district lands in St. Vincent's and Bel Marin Keys used in their processes could be vulnerable to sea level rise flooding. This could impact infiltration rates for the sanitary district process.

Waldo Point Harbor is unique because each home is outfitted with utilities that travel through flexible hoses that are attached below the dock with enough slack to adjust for today's high and low tides. If the tides are too high, these hoses may no longer reach and could become disconnected. Moreover, these systems depend on pumps for water and wastewater. If the electrical components of the pumps become flooded, the utilities would also turn off. Greenbrae Boardwalk, like Waldo Point Harbor, has utilities along the dock, or boardwalk; however, the water and sewer pipelines are freestanding. The gas, electric and water lines are elevated and the sewer is buried with three elevated pumps.

The maps on the following pages illustrate vulnerable utility features. The areas in the call out circles enable the reader the see areas that are difficult to see on the large scale map. The circles do not indicate that these areas are more vulnerable than others along the shoreline.

Greenbrae Boardwalk utility lines line the pathway. Credit: BVB Consulting LLC

Stormwater pump station. Santa Venetia. Credit: BVB Consulting LLC

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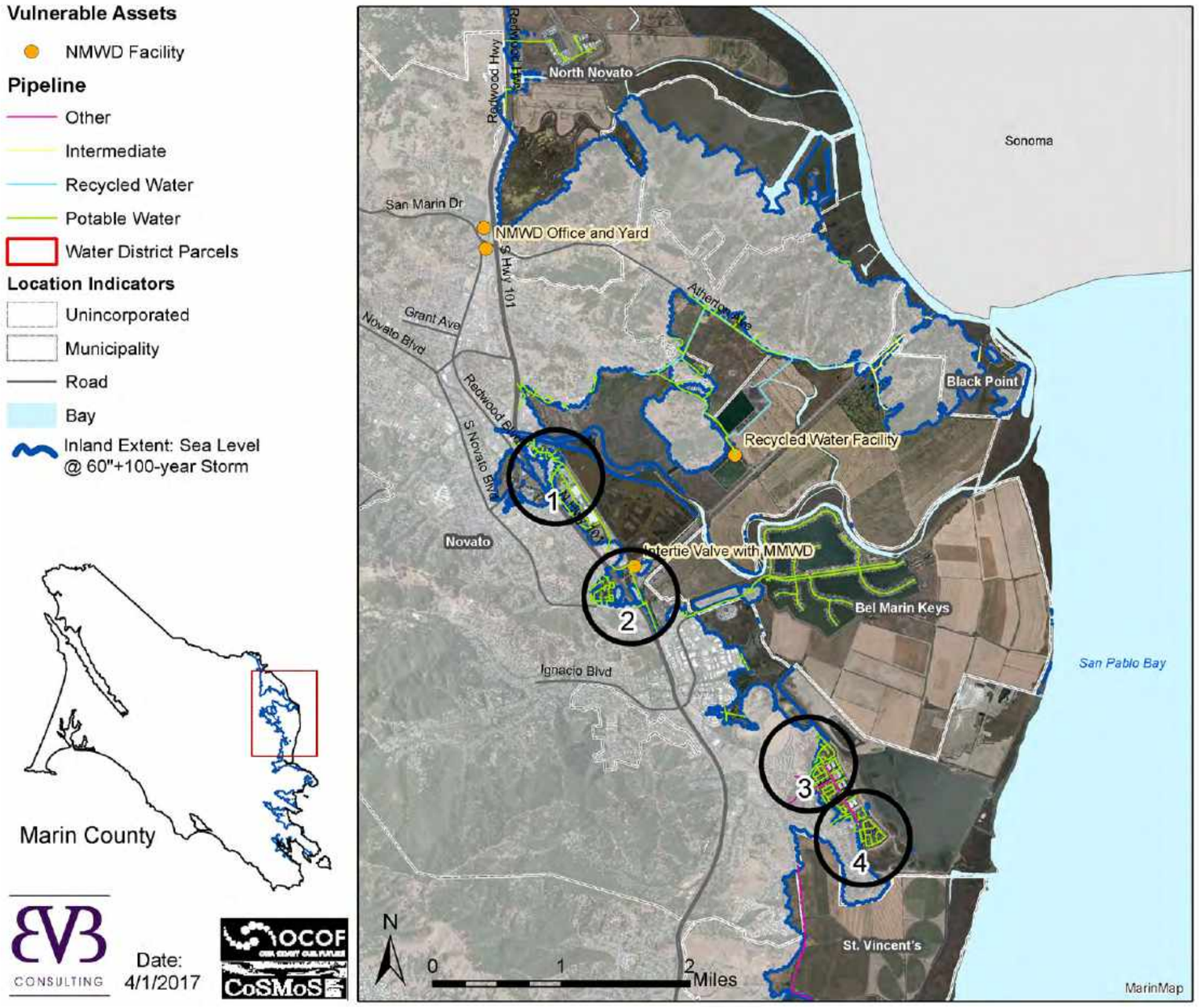
Map 118. Northern Unincorporated Marin Vulnerable Potable Water Assets



1: U.S. Hwy. 101 @ Rowalnd Blvd.

2: U.S. Hwy. 101 @ State Route 37

3: Upper Hamilton

4: Lower Hamilton

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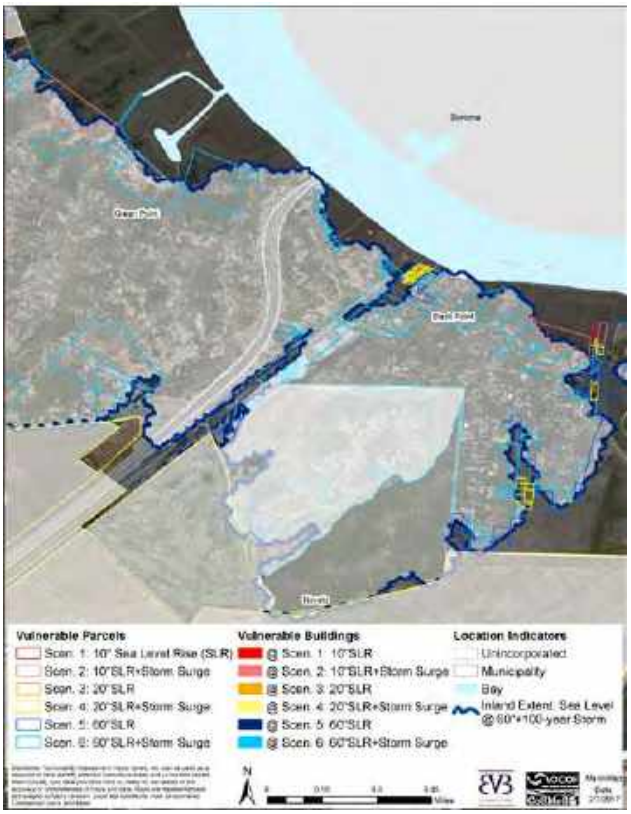
Unincorporated Tiburon does host a small treatment plant for Sanitary District Number 5 that could experience long-term flooding during a 100-year storm surge, though asset managers did not assess the site as being sensitive to temporary flooding.

Communities in the study area using Onsite Wastewater Treatment Systems are Unincorporated Tiburon and Black Point. However, many of the built areas of these properties are at higher elevations than the exposed area, and could be free from impacts from sea level rise. In the worst case, sea level rise could alter soil permeability and chemistry in the disposal field. If water levels are high and sustaining enough, effluent from the disposal field could contaminate the estuary. Even new shallow or above ground systems, with high water level kill switches, could be impacted by flood waters and affected by power outages. Erosion could also reduce land area available for percolation. Finally, if groundwater rises under septic tanks with enough pressure, the tanks could pop out of the ground.

Utility lines at East Road 6 Houseboats at Waldo Point Harbor. Credit: BVB Consulting LLC

These systems are privately managed by the landowner and regulated by Marin County and the Regional Water Quality Control Board. The Marin Countywide Plan (CWP), the Marin County Development Code, and the State Water Control Board's Onsite Wastewater Treatment Systems Policy regulate septic systems.

Map 119. Black Point & Green Point Properties with Potentially Vulnerable OWTSs



Map 120. Unincorporated Tiburon Properties with Potentially Vulnerable OWTSs

Santa Venetia floods during 1983 storm that caused major damage in the Bay Area. Credit: Marin Watersheds

Stormwater management is large function of the County of Marin Department of Public Works and a significant amount of land is dedicated to stormwater management for containment and infiltration. In addition, critical infrastructure relays stormwater from pipes, accessible by manholes, tide gates, or pump stations. Some of this infrastructure could weather sea level because it is newer and/or has more advanced technology than older options. Nevertheless, these assets, such as pump stations, could sink in the face of liquefying underlain soils, be overtopped entirely, compromised during an extended power outage, and corrode and wear from increased use and saltwater exposure if not adequately elevated. In total, roughly 15 pump stations, more than 81,000 feet of pipes, and several channels, and a few ponds that could expect new or worsening tidal water flooding.

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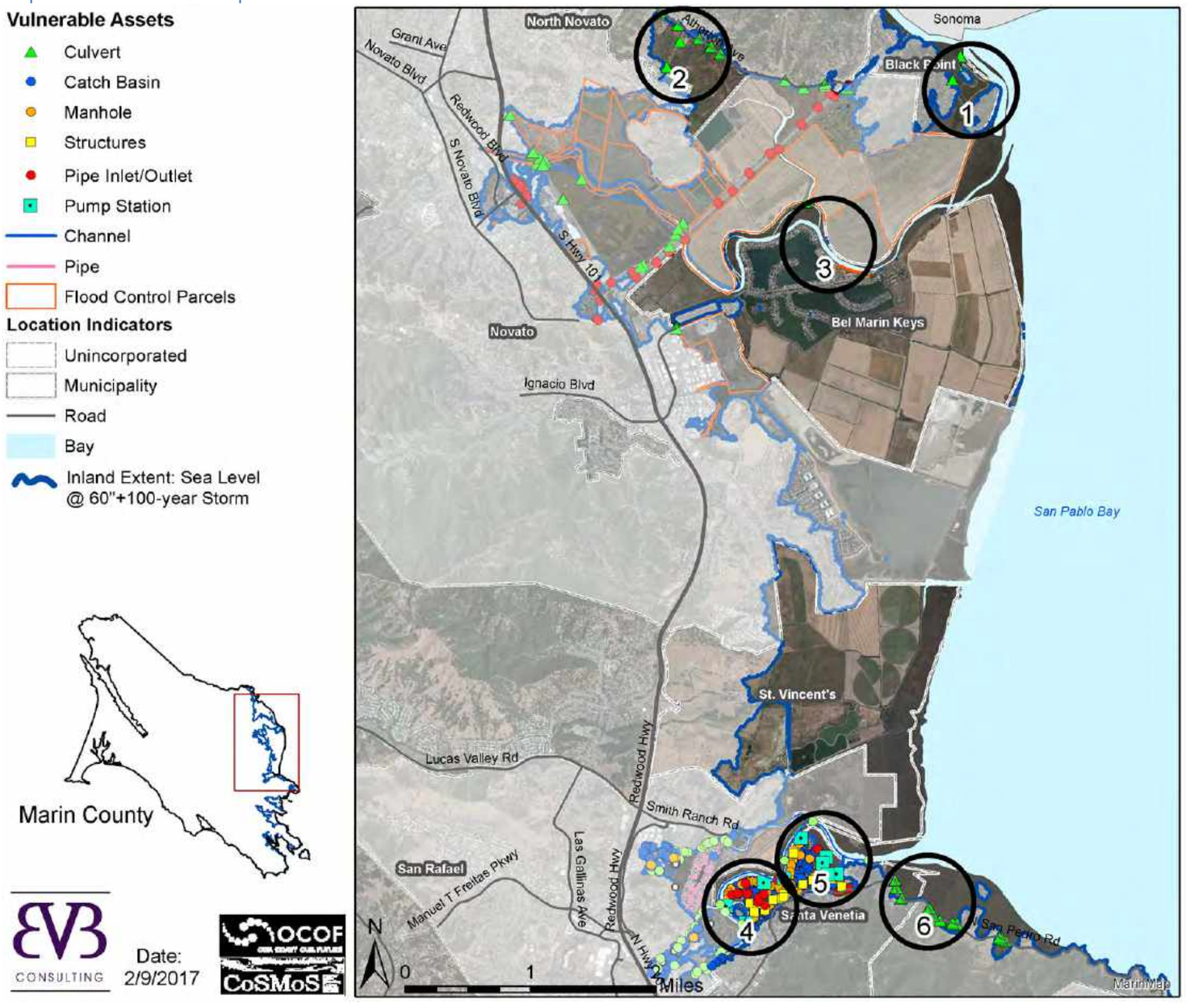
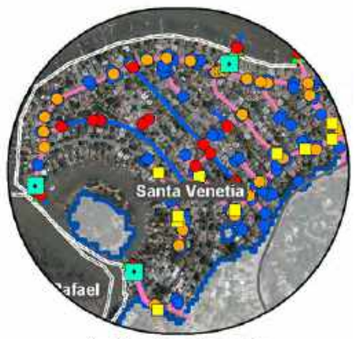
Map 121. Northern Unincorporated Marin Vulnerable Stormwater Assets



1: Black Point

2: Atherton Ave. @ Olive Ave.

3: Bel Marin Keys



4: Santa Venetia

5: Santa Venetia

6: N. San Pedro Rd.

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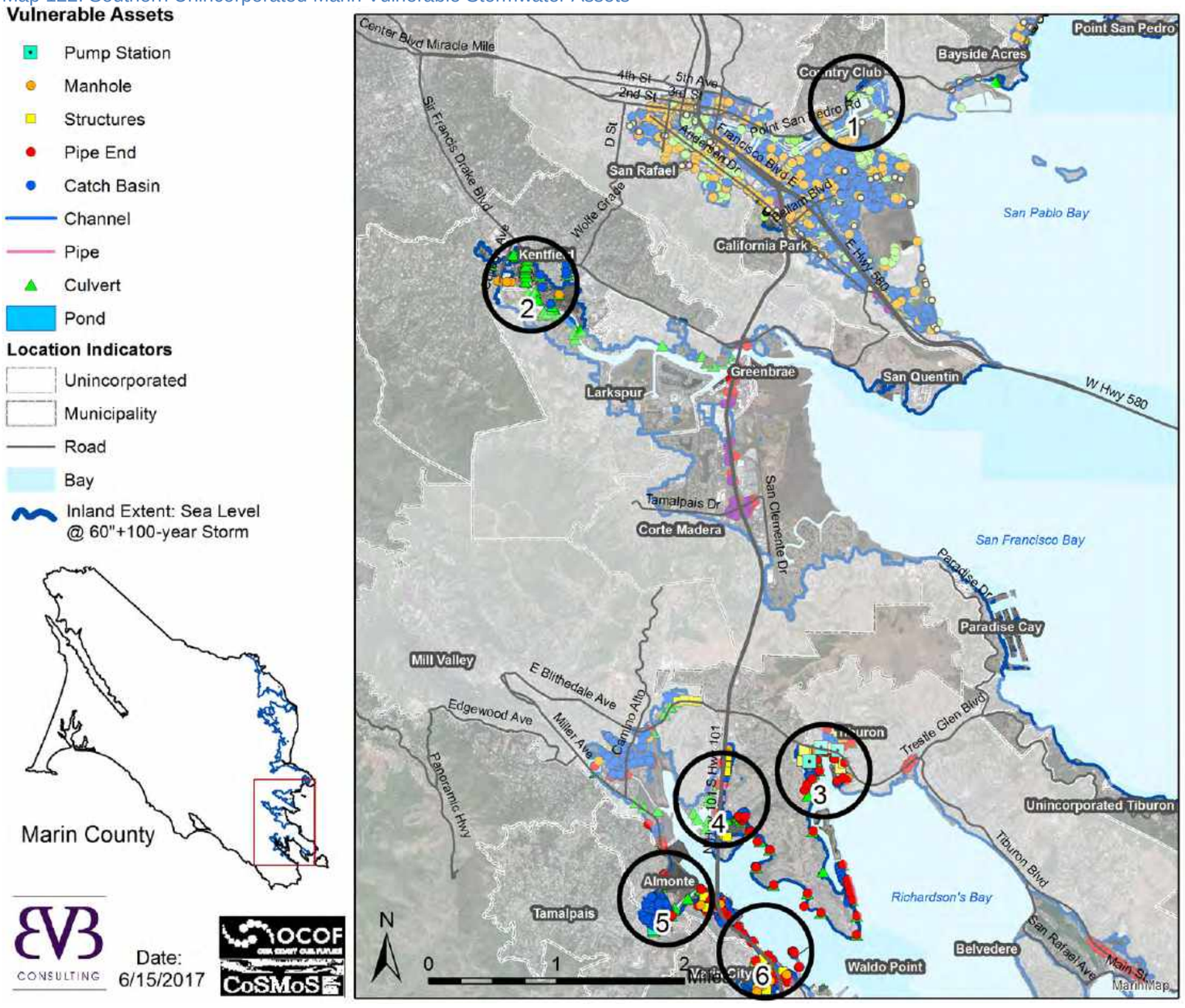
Map 122. Southern Unincorporated Marin Vulnerable Stormwater Assets

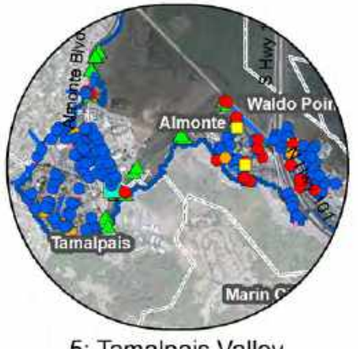


1: Pt. San Pedro Rd.

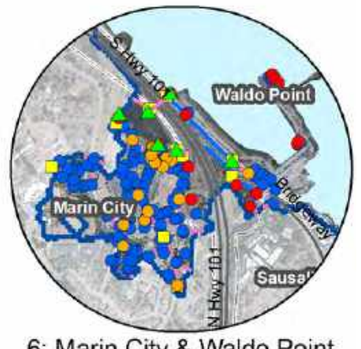
2: Corte Madera Creek

3: Saltworks Canal

4: Strawberry @ Da Silva Island



5: Tamalpais Valley & Almonte



6: Marin City & Waldo Point

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Electric transmission tower on Nyhan Creek levee in Tam Valley. Credit: Marin County DPW

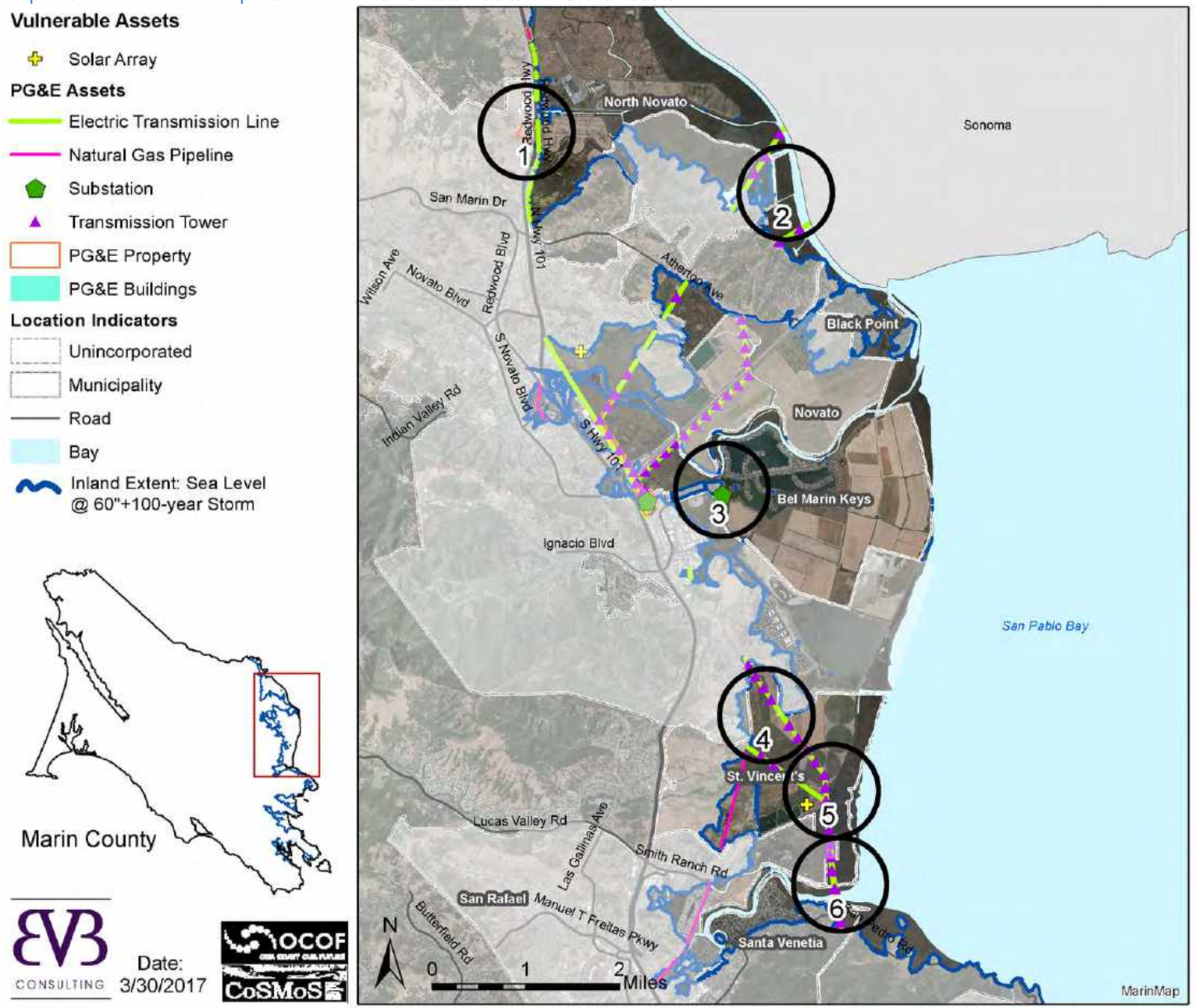
PG&E repair from storm damage in Tamalpais Valley. Credit Marin County DPW

With respect to PG&E natural gas and electrical assets, several can be found in the unincorporated areas. With the exception of Black Point, the communities in the study receive natural gas the PG&E. Both natural gas and electrical transmission lines could be vulnerable in St. Vincent's. Bel Marin Keys has a vulnerable electrical substation, which if flooded, could impact Bel Marin Key residents. Finally, nearly forty transmission towers along Highway 37 and a more northerly trajectory could expect higher water levels and increased levels of subsidence.

The utilities represented on the maps show the available geographic digitized data. Absence of a utility feature on the maps may be because the data is not available in a digitized format; not because the features are not considered vulnerable.

The maps on the previous and following pages illustrate vulnerable utility features. The areas in the call out circles enable the reader the see areas that are difficult to see on the large scale map. The circles do not indicate that these areas are more vulnerable than others along the shoreline.

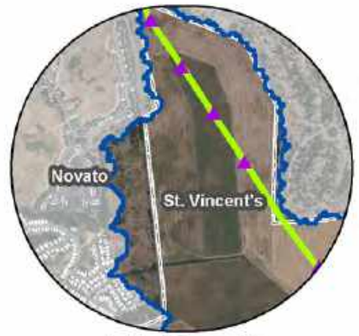
Map 123. Northern Unincorporated Marin Vulnerable Gas and Electric Assets



1: North Novato

2: Bahia

3: Bel Marin Keys



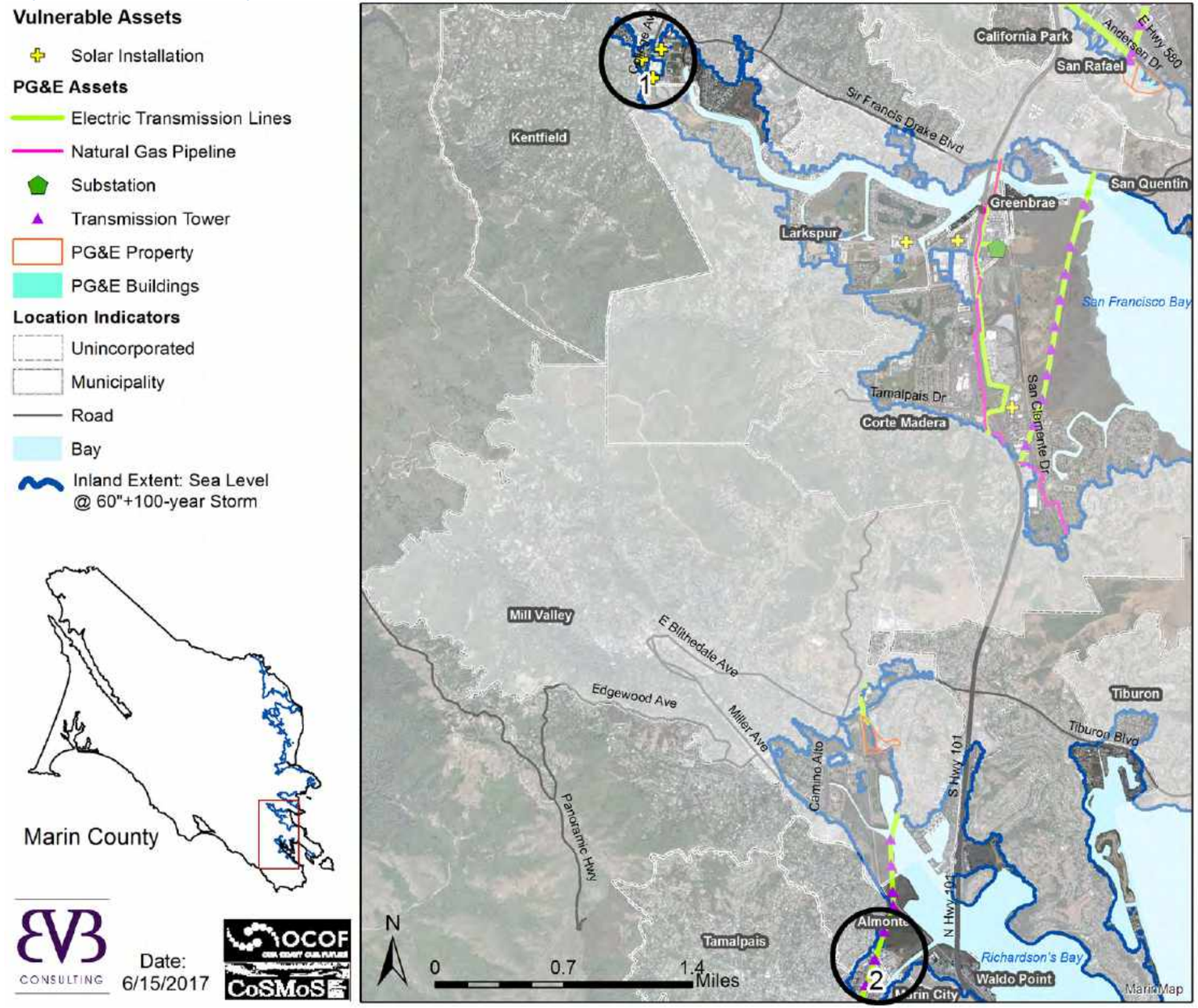
4: St. Vincent's

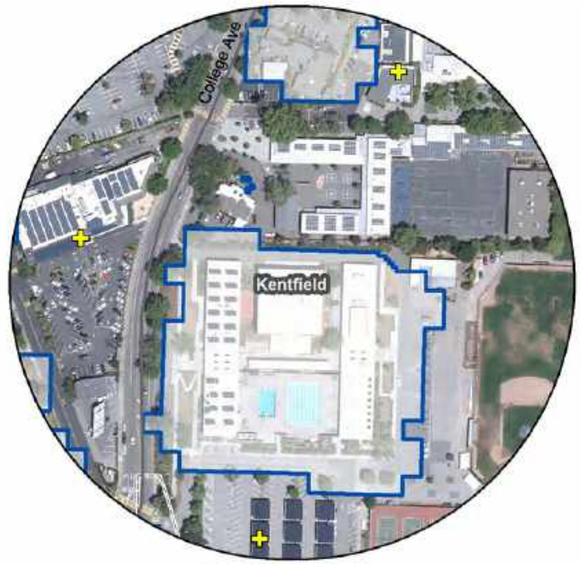
5: St. Vincent's

6: Las Gallinas Creek

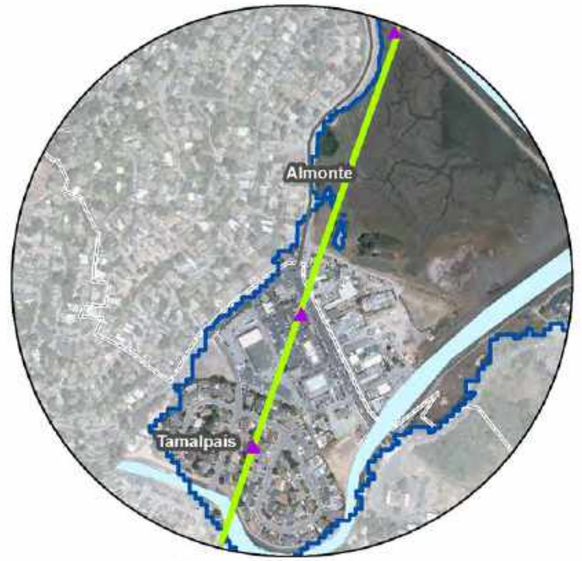
Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data providers here in, make no warranties of the accuracy or completeness of maps and data. Maps are representational and subject to future revision. Local site conditions must be examined. Commercial use is prohibited.

Map 124. Southern Unincorporated Marin Vulnerable Gas and Electric Assets





1: College Ave.



2: Tamalpais/Almonte

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Working Lands

The few operations vulnerable to sea level rise on the Marin shoreline are ranches, dairies, and small produce farms. The parcels are concentrated in St. Vincent's, surrounding Bel Marin Keys, and in North Novato. In addition to losing valuable grazing land to salt water, loss of vehicular access to and from sites and processing facilities during storms, and eventually, on a regular basis could be a significant factor.

As shown in Table 129, the main area impacted is public land that is leased to ranchers for grazing. Under scenario 5, with 60 inches of sea level rise, just more than 4,100 acres across 27 parcels could be vulnerable. With storm conditions, an additional 200 acres across twelve parcels could be vulnerable.

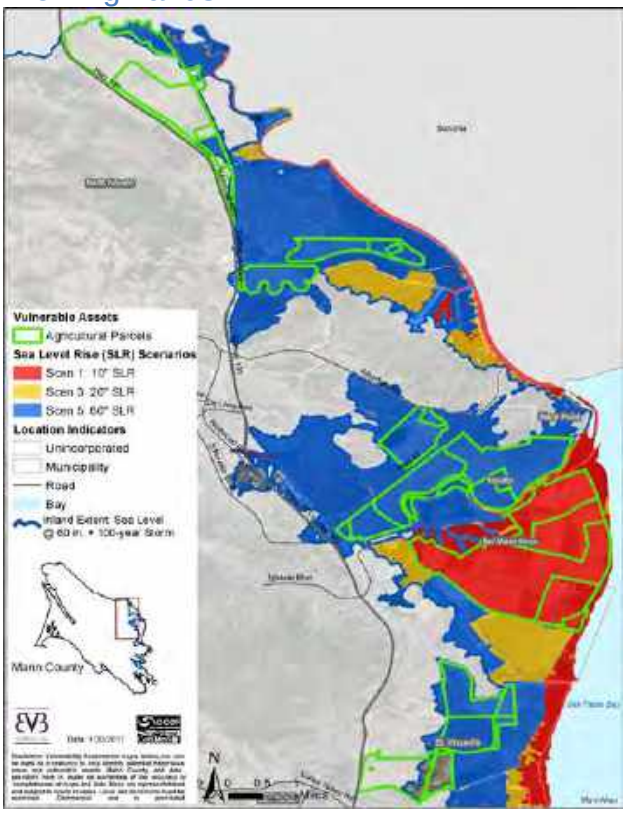
Table 129. Vulnerable Agricultural Parcels and Acreage by Community

	Scenario			
	Near- to Medium-terms		Long-term	
	1 & 3		5	
	#	Acres	#	Acres
Bel Marin Keys	1	28	4	178
North Novato			7	510
St. Vincent's			5	460
Public Land	8	1,924	11	3,000
Total	**9**	**1,952**	**27**	**4,148**

Source: MarinMap, CoSMoS

Pacheco Pond. Bel Marin Keys. Credit: Marin County DPW

Map 125. Unincorporated Marin Vulnerable Working Lands



Vulnerable land based operations account for $17,745,567 in assessed land and improvement value[215] that could expect losses as lands newly under water become waters of the State. Moreover, agriculture is a highly regulated industry at nearly all levels of government. For example, at the federal level is the Clean Water Act (Sections 401 and 404)[216] and total maximum daily sediment loads that farmers must comply with to reduce erosion and sediment loads to creeks. In several cases, to comply and improve water quality, farmers have fenced off creeks from livestock wading, installed new stream crossings and restored riparian areas that could be compromised under these sea level rise scenarios. Habitat changes prompted by sea level rise could require new conservation management plans and improvements in the coming decades to ensure water quality standards are upheld.

[215] 2016 dollars

[216] US Environmental Protection Agency. Water: Clean Water Act. *Water Quality and 401 Certification.* http://water.epa.gov/lawsregs/guidance/cwa/waterquality_index.cfm

Santa Venetia Marsh. Credit: BVB Consulting LLC

Marshes along Richardson Bay. Credit: C. Solin

Natural Resources

Paradise Beach and McNears Beach in unincorporated Marin are rocky and narrow and are highly vulnerable to sea level rise.

Marshes and mudflats are far more extensive and offer rich wildlife habitat. Bothin Marsh and Coyote Creek front Almonte and Tamalpais Valley, the Strawberry tidal area and the Seminary Marsh in Strawberry, Corte Madera Ecological Reserve extending to Greenbrae, China Camp State Park marsh, Santa Venetia Boardwalk Marsh, and extensive marshes up the shores of Saint Vincent's, Bel Marin Keys, Black Point, Green Point, and North Novato. These marshes and mud flats provide feeding and breeding grounds for the endangered Ridgway's Rail, salt marsh harvest mouse, and the tidewater goby. Federally listed endangered plants found in the vulnerable areas are white-rayed pentachaeta, Tiburon paint brush, and Tiburon jewel flower.

Marshes, if flooded more frequently can become flooded out and convert to mudflat habitat. If the marshes are supplied with adequate sediment from upstream or have room to retreat landward they may be able to maintain the higher elevation marsh habitats. This is possible in the northern portion of the study area, where large swaths of open land exist. In the southern portion of the study area, this is less feasible due to development barriers. Marshes here could expect significant habitat shifts as sea level rise.

Several wildlife reserves are along the shoreline and in the open waters on islands, such as Aramburu Island, used by birds, Marin Islands, Castro Rocks, used by seals and sea lions, and San Pablo Wildlife Reserve. Additionally, several patches eel grass, totaling roughly 20 acres, likely an underestimation based on comparing aerial photography, ecological studies, and state data sources, were observed around the Tiburon Peninsula.

Recreation

Recreational opportunities in unincorporated Marin are bountiful. The main recreation assets that could be compromised are beaches, on-street bike pathways and sidewalks, dedicated bike and walkways, and boating facilities in the vulnerable area. The Charles McGlashan pathway is vulnerable where it meets Shoreline Highway in Tamalpais Valley, pathways around Black Point, Bel Marin Keys, Greenbrae and Strawberry could expect

impacts in the medium-term. Many of these pathways are lengths of the Bay Trail. The portion of the Mill Valley/Sausalito Pathway fronting Almonte and Tamalpais Valley is vulnerable in the near-term. The County of Marin also operates a boat launch in Black Point that could expect reductions in capacity of up to 75 percent in the long-term, when flooding could reach seven feet at MHHW.

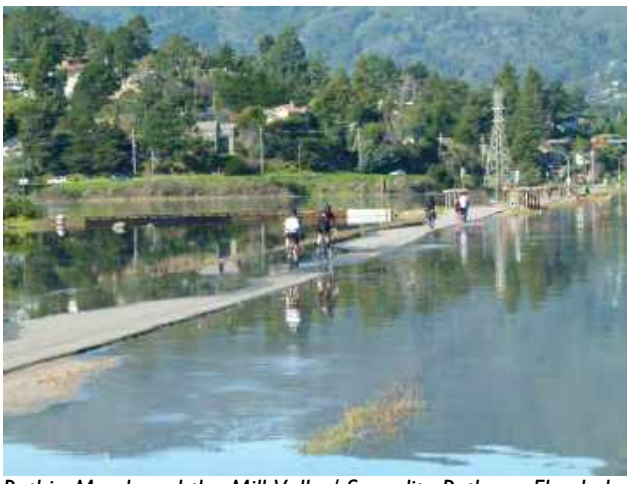
In addition, the low lying portions of several county parks could be inundated at average high tides. At Paradise and McNears Beach Parks, the beach component could disappear in the medium- to long-terms. The highly utilized fishing piers here are also vulnerable to weakening and overtopping in the long-term, especially during storms. At McNears Beach Park, the club house and pool are also vulnerable in the long-term scenario 6.

McInnis Park could also anticipate some impacts along the creek channel into the soccer fields and eventually reaching the entrance. The McInnis Trail could also be compromised at high tides. The marshlands bordering the park could expect habitat transitions. Other parks, such as Ring Mountain, Deer Island are mostly uplands and would only experience flooding on the lower fringes. This is also the case for China Camp State Park and Angel Island State Park; however, in both parks the main attractions and gathering places are on the shore.

District-run parks and pathways in Strawberry could be vulnerable in the near-term, as could Cavila Cay Park in Bel Marin Keys. Additional parks in Strawberry and the remaining parks in Bel Marin Keys could be vulnerable by long-term scenario 5, as are parks in North Novato and Santa Venetia.

Boating activities in Richardson Bay Marina, Waldo Pint Harbor, Lowrie Yacht Club, Bel Marin Keys boat launches and public dock, private docks and piers could be vulnerable to storm surges and may need to adjust to accommodate rising high tides. In addition, visitor serving hotels and restaurants in Almonte and Tamalpais Valley could also be vulnerable to sea level rise in the near-term.

The maps on the following pages illustrate vulnerable natural resource, recreation, emergency and historic features. The areas in the call out circles enable the reader the see areas that are difficult to see on the large scale map. The circles do not indicate that these areas are more vulnerable than others along the shoreline.



Bothin Marsh and the Mill Valley/ Sausalito Pathway Flooded at king tide. Credit: J. Poskazner

Black Point Boat Launch at State Route 37 and the Petaluma River. Credit: BVB Consulting LLC

Table 130. Unincorporated Marin Vulnerable Parks and Facilities

	Near-term		Medium-term		Long-term	
	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
Almonte	Charles F. McGlashan Pathway[M]	See scenario 1				
Bel Main Keys	Cavalia Cay Park Bahama Reef Boat Launch Dolphin Isle Boat Launch	See scenario 1			See scenario 1 Public Dock Bel Marin Keys Yacht Club Caribe Isle Park Montego Park Calypso Bay Public Dock Bahama Reef Boat Launch Del Oro Park	See scenarios 1 & 5
Black Point	Black Point Boat Launch [M]	See scenario 1				
North Novato					Rush Creek [M] Deer Island [M]	See scenario 4
Santa Venetia	Santa Margarita Island [M] Santa Venetia Marsh [M]	See scenario 1			Pueblo Park [M] Adrian Rosal Park [M] Castro Park[M]	See scenarios 1 & 5
Strawberry	Brickyard Cove Community Park Community Park Boat Launch Strawberry Point Tidal Area [M] Strawberry Point Park Aramburu Island [M]	See scenario 1				
San Rafael	John F. McInnis Park [M] Buck's Landing	See scenario 1				
Tiburon	Paradise Beach Park [M]	See scenario 1				

Source: MarinMap, CoSMoS

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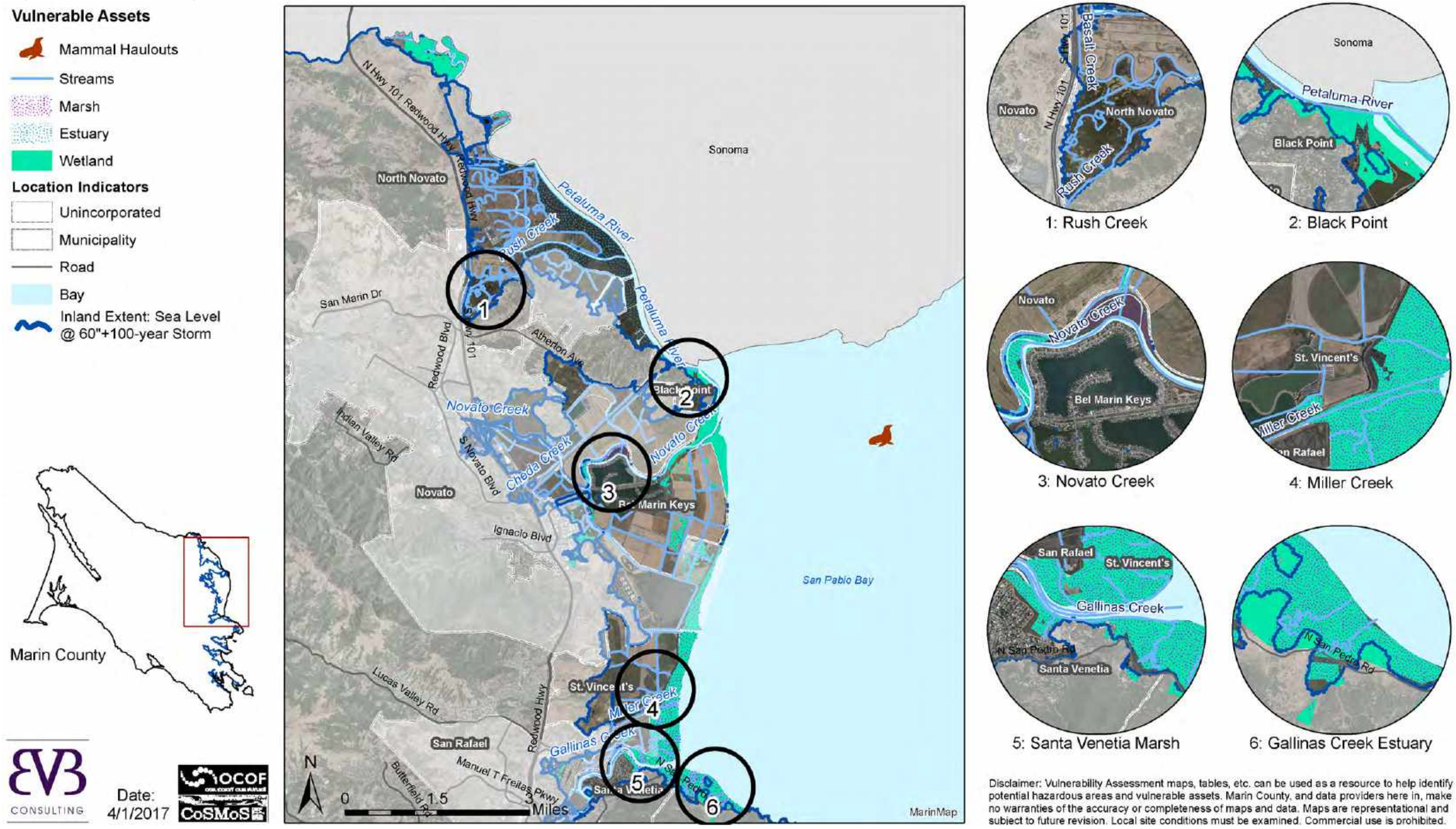
Map 126.Northern Unincorporated Marin Vulnerable Natural Resource Assets



Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data providers here in, make no warranties of the accuracy or completeness of maps and data. Maps are representational and subject to future revision. Local site conditions must be examined. Commercial use is prohibited.

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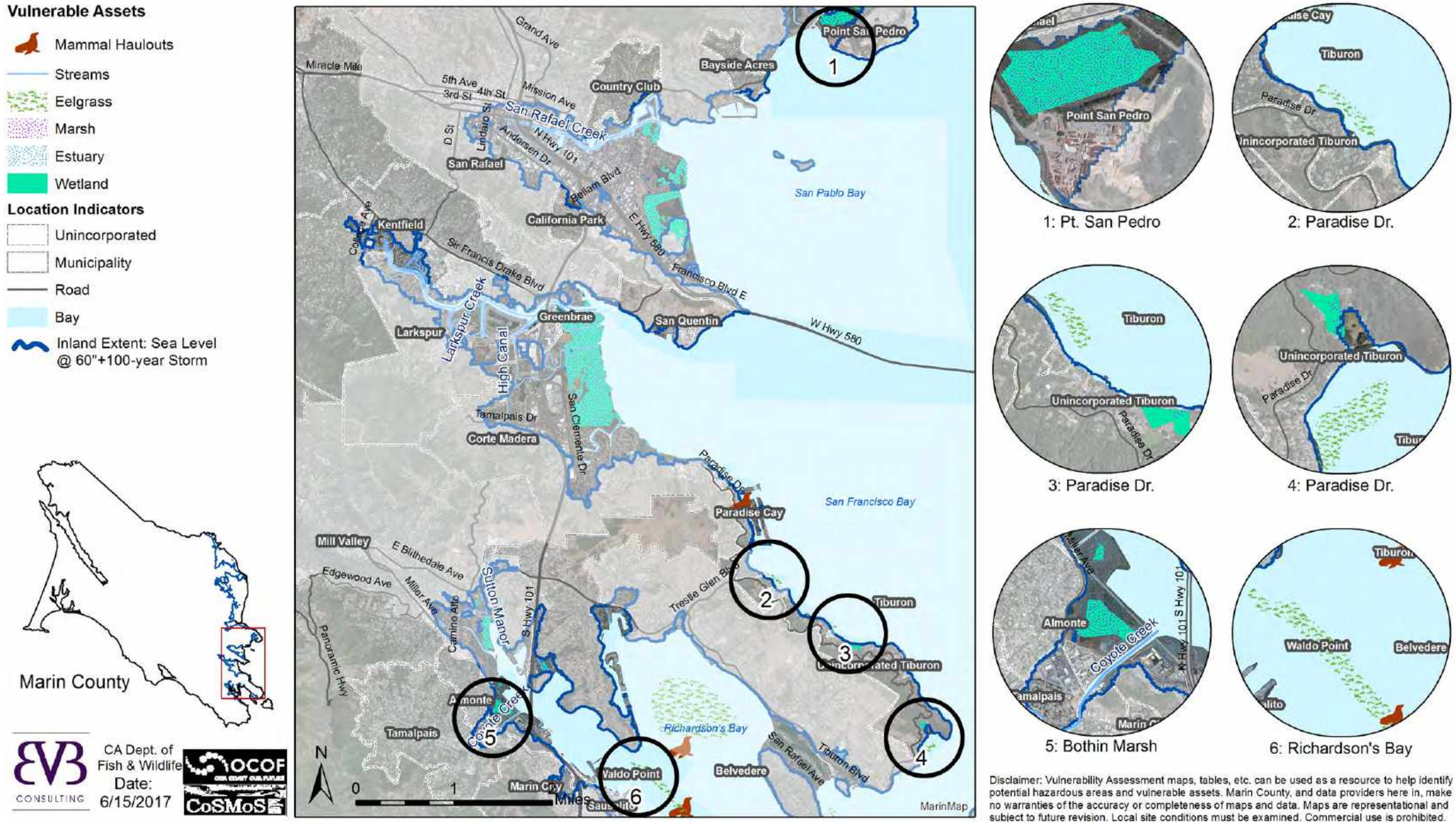
Map 127. Southern Unincorporated Marin Vulnerable Natural Resource Assets



1: Pt. San Pedro

2: Paradise Dr.

3: Paradise Dr.

4: Paradise Dr.

5: Bothin Marsh

6: Richardson's Bay

Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data providers here in, make no warranties of the accuracy or completeness of maps and data. Maps are representational and subject to future revision. Local site conditions must be examined. Commercial use is prohibited.

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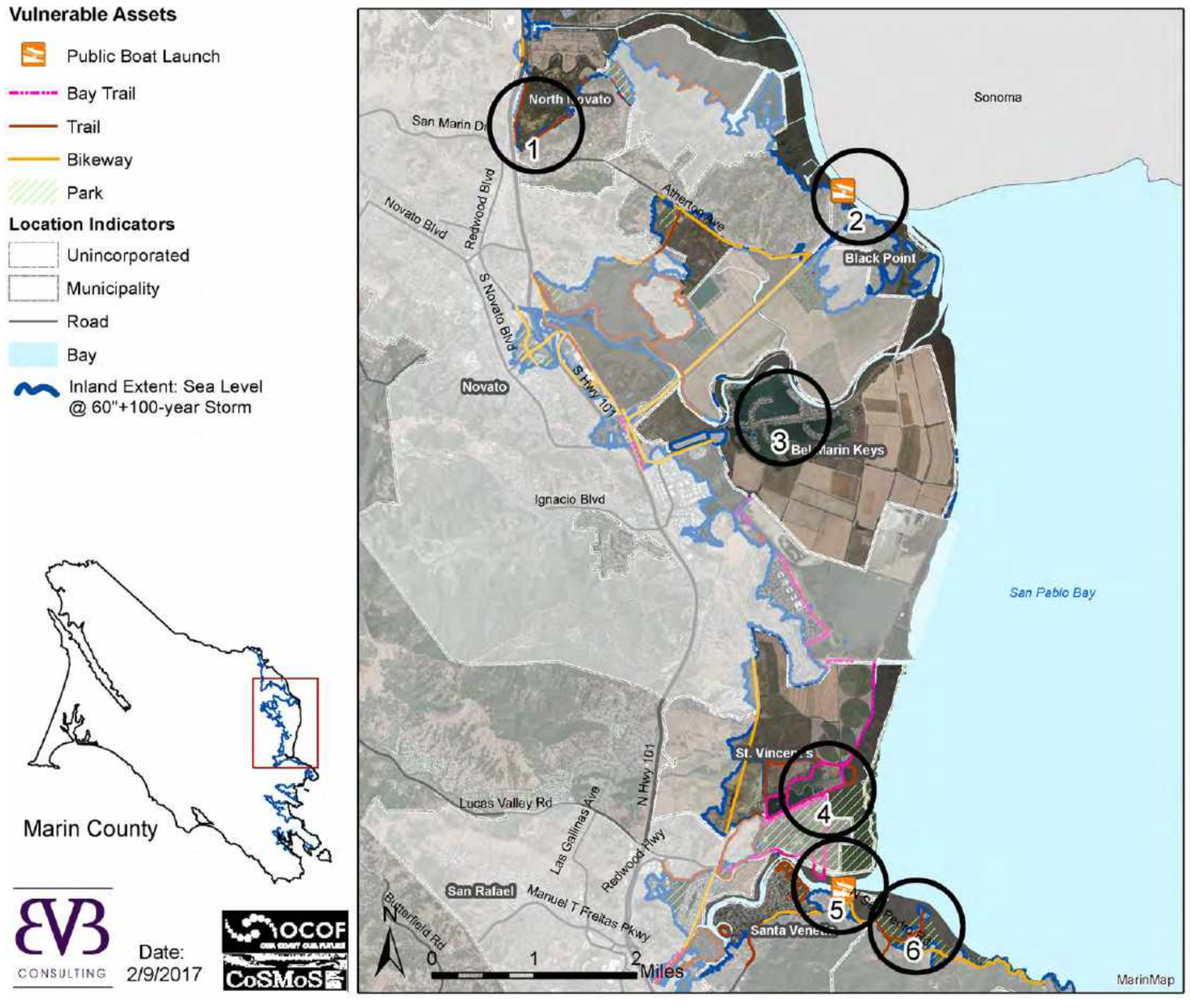
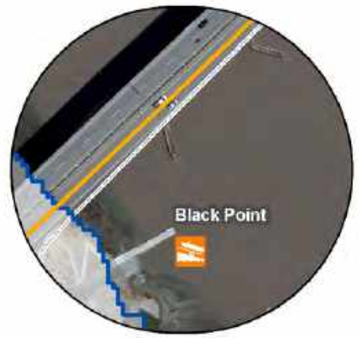
Map 128. Northern Unincorporated Marin Vulnerable Recreation Assets



1: Rush Creek



2: Petaluma River Boat Launch & Fishing Access

3: Bel Marin Keys

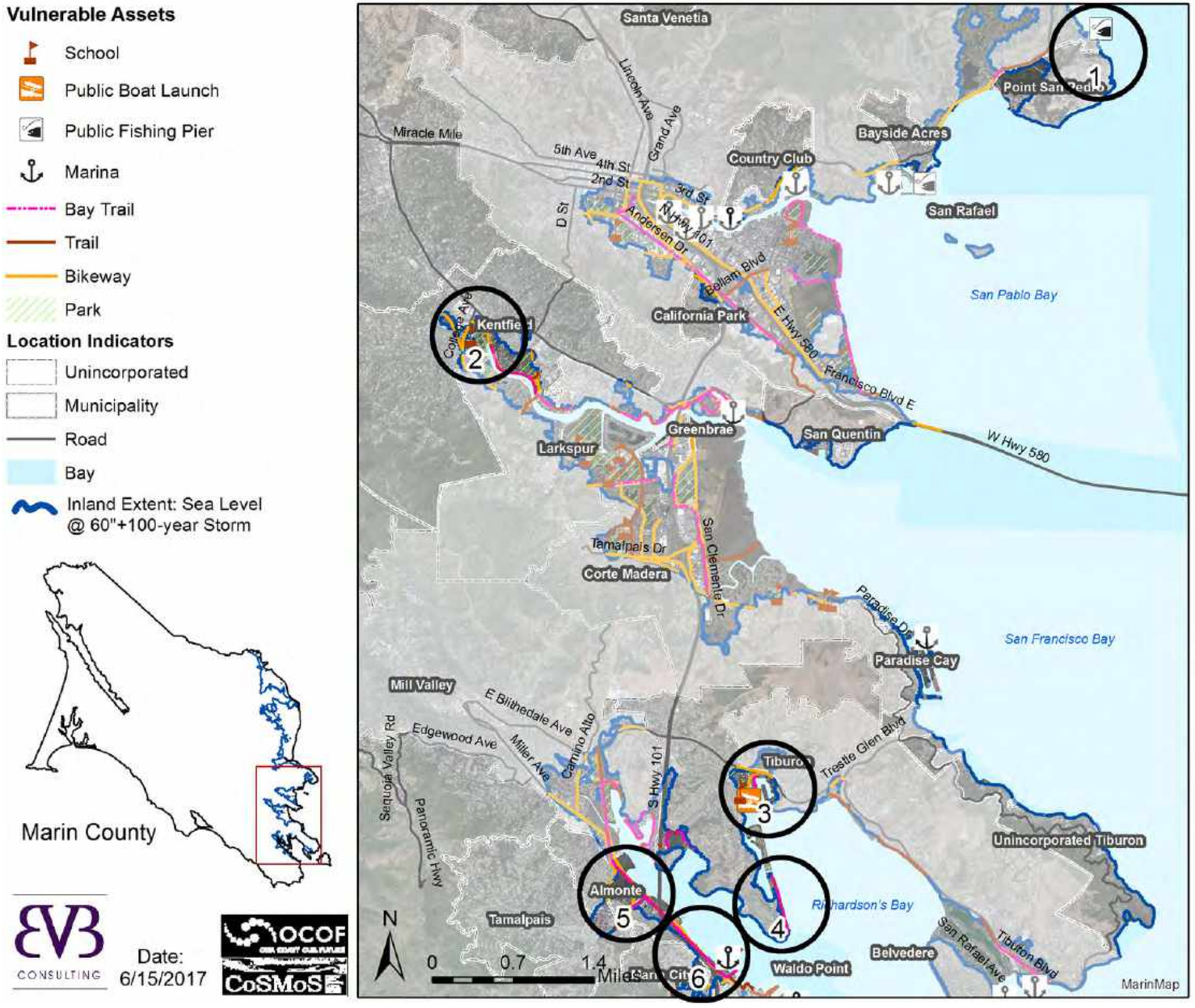
4: St. Vincent's

5: Buck's Landing

6: China Camp State Park

Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data providers here in, make no warranties of the accuracy or completeness of maps and data. Maps are representational and subject to future revision. Local site conditions must be examined. Commercial use is prohibited.

Map 129. Southern Unincorporated Marin Vulnerable Recreation Assets



1: McNears Beach Park

2: Kentfield

3: Strawberry

4: Strawberry Point

5: Tamalpais Valley

6: Waldo Point Harbor

Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data providers here in, make no warranties of the accuracy or completeness of maps and data. Maps are representational and subject to future revision. Local site conditions must be examined. Commercial use is prohibited.

Emergency Services
All but two of the unincorporated communities do not have vulnerable emergency service assets. First, the fire service water tanks and reserves in the greater Novato area could be a concern for the northern shoreline communities. These features are mapped in the Utilities Profile. Finally, Marin County Sheriff maintains a rescue boat at Richardson Bay, or Kappas Marina. This marina is vulnerable in the near-term to damage. This feature is mapped in the Emergency Services Profile.

The main cause for concern with respect to emergency services is interrupted or blocked vehicular access. This could lengthen response times and require alternative routes be used or developed. Much like with utilities, the communities rely on emergency service assets headquartered in other communities. Unincorporated Tiburon and Paradise Cay could be burdened by impacts to the Tiburon Fire Department and the Corte Madera Fire Department, and the Central Marin Police Department. Santa Venetia, California Park, Bayside Acres, and Country Club could be impacted by interruptions in San Rafael emergency services and access. And finally, Bel Marin Keys, Black Point, Green Point, and North Novato could be vulnerable to interruptions to the Novato Fire Department and access for all other emergency services. To read more and reference maps about access issues, see the Transportation and Emergency Service Profiles.

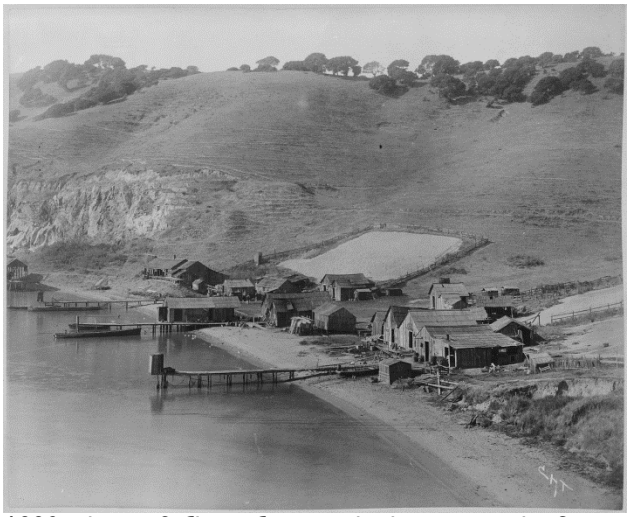
Cultural Resources
Key resources in unincorporated Marin are federal or state lands. Historic sites may contribute to local sense of place and can help define community character and identity. Specific locations of archaeological sites are confidential.

Fort Baker
National Register of Historic Places
Vulnerable Resources: Seawall, Marine Hoist and Dock, Refueling Dock and Marine Railway
Scenarios: All
Flood Depths: 0-7'10''+100-year storm surge
Primary Building Materials: Concrete, Wood, Steel

At the southeastern foot of Marin County, Fort Baker was acquired by the Federal Government in 1866 and served as an Army Post until the mid-1990s. Now part of the Golden Gate National Recreation Area; its historic structures have remained intact including the numerous military buildings. Three structures in the low lying area looking out to Horseshoe Bay could be vulnerable to flood depths of more than 4 feet in the near-term and nearly 8 feet plus storm surges in the long-term:

1. Seawall
2. Marine Hoist
3. Refueling Dock and Marine Railway
4. Replacement Value = $2,142,003[217,218]

Horseshoe Cove and Fort Baker (circa 1950s) Credit: Golden Gate National Recreation Area Park and Archives Record center



1889 photo of China Camp with drying grounds. Source: Wikipedia.

[217] National Park Service. 2015. Adapting to Climate Change in National Parks
[218] 2015 dollars

Angel Island
California State Landmark
National Register of Historic Places (Immigration Station)
Vulnerable Resources: Ferry terminal (access, non-historic)
Scenarios: All
Flood Depths: 0- 6'9''+100-year storm surge

Historically, Angel Island is known for its immigration station, sometimes referred to as the "Ellis Island of the West." From 1910-1940, hundreds of thousands of immigrants, typically from China and Japan, were detained on the island, sometimes for months as part of immigration control. The island is a popular destination for visitors with a variety of recreational activities and historic buildings.

The Angel Island ferry terminal is vulnerable in the near-term, with flood depths increasing in medium- and long-term scenarios. If the ferry terminal floods it could cause a reduction or loss in tourism activity and revenue needed to sustain the historic buildings on higher grounds. Aside from the ferry terminal, Angel Island's historic structures are not directly vulnerable to sea level rise.

China Camp State Park
National Register of Historic Places
Vulnerable Resources: Shrimp Shed and 305' Pier
Scenarios: All
Flood Depths: 0-10'0''+100-year storm surge
Primary Building Materials: Wood
Historic American Landscape Survey: *Underway*

China Camp was once home to Miwok Native Americans and a historic shell mound marks their presence here. This site is also one of the only remaining historic Chinese-American shrimp villages in the Bay Area. In the late 1800s, China Camp housed around 500 residents, many from Canton, who made a living in shrimp harvesting. The shrimp was typically dried on the banks and shipped back to China for medicinal purposes. Both racially motivated legislation and environmental changes led to the decline of shrimping practices. Several of the historic structures are intact and protected by a seventy-five acre 1979 National Register of Historic Places designation. Lastly, a Historic American Landscape Survey is underway.[219]

Vulnerable structures at China Camp include the wood-framed shrimp shed and 305 foot pier along its waterfront. Flood depths could reach up to ten feet, potentially drowning the pier and structurally damaging to both resources. The Shrimp Shed serves a visitor center with educational panels and artifacts and is open to the public. These historic artifacts could also be damaged, if tide water enters the building. Erosion could further exacerbate impacts to the site, damaging the cultural landscape and the beach itself. Furthermore, North San Pedro Road through China Camp already floods at king tides. This would worsen with higher sea levels.

Table 131 ranks example vulnerable assets by onset and flood depth. Note that a 100-year storm surge could add one to three feet of saltwater. Moreover, the highest high tides could impact a larger area and result in greater depths as well. Several assets that could anticipate 100-year storm surge flooding only in long-term scenario 6 are

- Shopping center, housing, and Martin Luther King Jr. Academy, Marin City,
- Anthony G. Marin College, and Bacich Elementary and Adaline E. Kent Middle Schools,
- Strawberry Point Elem. School and Strawberry Village Shopping Center, Strawberry,
- Paradise Cove Treatment Plant, Unincorporated Tiburon,
- Marin County Expo Center and Amphitheater, Santa Venetia, and
- An additional five archeological sites.

December 12, 2016 king tide floods China Camp historic pier. Credit: R. Rothbart

[219] Patillo, C. *China Camp HALS*. Last updated July 1, 2012. http://halsca.blogspot.com/2012/07/china-camp-hals.html

Table 131. Example Unincorporated Marin Vulnerable Assets by Sea Level Rise Onset & Flooding at MHHW

Location	Asset	Scenarios		
		1	3	5
		Near-term	Medium-term	Long-term
Confidential locations	Archaeological Sites	3 sites no data	5 sites no data	14 sites 1’11’’ to 10’8’’
Pt. San Pedro	China Camp State Park	7’6”	8’1”	18’4”
San Rafael	John F. McInnis Park	7’6”	8’6”	10’6”
Pt. San Pedro	China Camp Historic District* 2 historic structures	0-7’3’’	0-7’8’’	0-10’0’’
Santa Venetia	Santa Venetia Marsh	7’	7’10”	9’11”
San Pablo Bay	San Pablo Bay Wildlife Area	6’9”	7’2”	19’
Santa Venetia	Santa Margarita Island	5’8”	6’8”	8’8”
Bel Marin Keys	Del Oro Park	5’2”	5’8”	8’9”
Bel Marin Keys	Cavalia Cay Park	5’1”	5’8”	8’9”
Bel Marin Keys	Dolphin Isle Boat Launch	5’1”	5’8”	8’9”
Lucky Drive	Homes on water west of 101	0-5’	0-5’8”’	3’-8’6”
Greenbrae Bdwk	Homes east of 101	0-4’9”	0-5’5”	5’-8’5”
Bel Marin Keys	Bahama Reef Boat Launch	4’6”	5’2”	8’1”
Waldo Point	Richardson Bay Marina	4’5”	7’4”	18’7”
Fort Baker	National Recreation Area 3 Classified Structures*	0-4’5’’	0’-5’2’’	0-7’10’’
Pt. San Pedro	Mc Nears Beach Park	4’4”	5’9”	8’
Bel Marin Keys	Bel Marin Keys Blvd	0-3’10”	0-4’6”	0-8’6”
Angel Island	Angel Island Ferry Terminal	0-3’’	0-11’’	0-6’9’’
Black Point	Black Point Boat Launch	2’8”	3’10”	7’
Bel Marin Keys	Homes west of Bel Marin Keys Blvd.	0-2’7”	0-3’	3”-4’9”
Paradise Cay	Homes	0-2’4”	0-2’8”	5’3”
Greenbrae Bdwk	Greenbrae Boardwalk raised walkway	5”-1’7’	1’-2’4”	3’3”-5’
Almonte	Seaplane Adventures	9”	2’	5’
Tamalpais	Tam Junction businesses	0-8”	7”-2’	1’5”-5’3”
Paradise Cay	Paradise Cay Yacht Harbor	2”	1’6”	3’10”
Waldo Point	Businesses		0”-7’7”	1’5”-10’10”
Almonte	Charles F. McGlashan Pathway		7’6”	10’8”
Tamalpais	Shoreline Highway		5”-7’5”	2”-12’5”
Strawberry	Brickyard Cove		6’11”	9’11”
Strawberry	Greenwood Cove homes		2”-6’6”	6”-8’
Strawberry	Strawberry Recreation District		5’11”	8’11”
Strawberry	Strawberry Recreation District		5’4”	10’
Strawberry	Strawberry Point Tidal Area		5’1”	8’1”
Strawberry	Strawberry Point Park		4’10”	9’2”
Strawberry	Strawberry Recreation District		4’4”	8’1”

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Location	Asset	Scenarios		
		1	3	5
		Near-term	Medium-term	Long-term
Almonte	Shoreline Highway		0-3'10"	1'6"-7'
Santa Venetia	Santa Venetia homes		1"-3'6"	2"-6'7"
Greenbrae	Marin RV Park		1'4"-2'5"	3'5"-6'
Bel Marin Keys	Montego Park		2'	5'4"
Almonte	Shoreline Hwy at U.S. Highway 101 (Manzanita)		1'3"-2'	4'3"-5'
Almonte	Shoreline development		0-2'	1'8"-5'
Tamalpais Valley	Birdland neighborhood		0-1'10"	2"-5'9"
Strawberry	Strawberry Circle		7"-1'10"	1'5"-4'9"
Waldo Point	Gate 6 Road		0-1'9"	1'10"-4'9"
China Camp SP	N. San Pedro Road		0-1'8"	1'7"-3'8"
Strawberry	Homes along Seminary Dr.		3"-1'3"	8"-3'6"
Almonte	Caltrans corporate yard		1'	4'
Bayside Acres	Beach Drive		1"-1'	2'4"-3'10"
Santa Venetia	N. San Pedro Road		0-9"	1'8"-3'5"
San Quentin	Buildings		3"-7"	8"-1'5"
Bel Marin Keys	Bel Marin Keys CSD office		6"	1'3"
Strawberry	Westminster Presbyterian Church & preschool		6"	1'2"
San Rafael	Marin County Health Innovation Campus		4"	3'4"
St. Vincent's	SMART Rail			0-10'9"
Novato	Deer Island			10'10"
North Novato	Marin County Airport @ Gnoss Field			10'4"
Bel Marin Keys	Caribe Isle Park			7'4"
Bel Marin Keys	Calypso Bay Public Dock			7'4"
Bel Marin Keys	Bel Marin Keys Public Dock			7'4"
Bel Marin Keys	Bel Marin Keys Yacht Club			7'4"
North Novato	SMART Rail			0-7'
Santa Venetia	Castro Park			6'11"
Santa Venetia	Neighborhood streets			6"-6'8"
Santa Venetia	Candy's Park			6'3"
Black Point	Atherton Avenue			0-6'
Santa Venetia	Adrian Rosal Park			5'10"
Santa Venetia	Pueblo Park			4'11"
Strawberry	Redwood Highway Frontage Road			1'2"-4'10"
Strawberry	Strawberry Circle homes			1'4"-4'8"
Country Club	Pt. San Pedro Road			5"-4'
Marin City	S. Hwy 101 Off Ramp			5"-4'
Strawberry	Commercial along Seminary Marsh			5"-4'
Kentfield	Apartments & offices off Sir Francis Drake Blvd.			3'10"
Strawberry	Baseball diamonds			3'10"
Strawberry	Seminary Drive			7"-3'7"

Location	Asset	Scenarios		
		1	3	5
		Near-term	Medium-term	Long-term
Corte Madera	Ring Mountain			3'6"
Strawberry	Tiburon Blvd.			5"-3'4"
Bel Marin Keys	Homes east of Bel Marin Keys Blvd.			3"-3'3"
North Novato	Hwy 101 South bound off ramp			1'9"-2'7"
Almonte	Tam Junction			1'6"-2'5"
Almonte	Almonte Blvd.			1'10"-2'5"
Kentfield	Homes along McAllister Slough			6"-2'5"
North Novato	Redwood Highway			1'9"-2'4"
North Novato	Hwy 101 North bound			4"-2'4"
Marin City	Hwy 101 North bound			0-2'
Strawberry	De Silva Island Drive			10"-1"10"
Kentfield	Stadium Way			1'5"-1'9"
Paradise Cay	Paradise Cay Marina			1'-1'10"
Strawberry	Hwy 101 North bound			1'7"-1'8"
Kentfield	Homes along Beren's Slough			10"-1'8"
Strawberry	Hwy 101 South bound off ramp			2"-1'
Bel Marin Keys	NMWD Cathodic Protection Well			No data
Unincorporated Tiburon	Paradise Beach Park	Beach floods at existing high tide		
Bel Marin Keys	NMWD Water distribution system	Underground asset		
Marin City	Sewage Pipes under Hwy 101	Subsidence, underground asset		
Strawberry	Salt Works Canal	Water Resource		
Strawberry	Aramburu Wildlife Preserve	No data		

Source: MarinMap, CoSMoS

CONCLUSION

Conclusion

The Bay Waterfront Adaptation and Vulnerability Evaluation (BayWAVE) sea level rise vulnerability assessment examined the exposure, sensitivity, and adaptive capacity of built and natural assets in Marin County. Many of Marin's essential and beloved shoreline assets are vulnerable to sea level rise and a 100-year storm surge. Key takeaways from this assessment are:

- Everything is connected— impacts to one asset or one community could have regional impacts. Even people who live high and dry could vulnerable to disruptions along Marin's shoreline, especially travel to and from work, school, and health services. Thus, asset managers, property owners, elected and appointed officials, government and consultant professionals will all need to work together to strategize for and implement the best possible outcomes.
- Without safeguards, kinks in the utility and transportation networks could impact hundreds of thousands of residents, employees, and visitors as early as the near-term. Disruptions or damages to these networks could be crippling to modern daily life. Few alternative route options are politically or physically viable.
- Areas seasonally impacted now or during king tides could flood almost daily in the near-term.
- Shifts to higher high tides impact public and private ownership under the public trust doctrine requiring hundreds of households to pay fees to the State they do not currently pay.
- Areas on fill and bay mud will face increasing rates of subsidence.
- The majority of low-lying areas, even those protected by levees, could experience tidal impacts after three feet of sea level rise.
- Some of the most vulnerable places are occupied by those with the least amount of resources and abilities.
- San Rafael and small shoreline unincorporated communities in Southern Marin could be the first to experience significant tidal flooding in the near-term.

Mill Valley from Mount Tamalpais. Credit: Ed Callert

15-year Expectations

Storm surge flooding could impact 2,500 parcels and 3,800 buildings. These figures amount to six percent of parcels and buildings in the study area. Storm surge flooding, especially combined with stormwater flooding, could impact North Novato at Gnoss Field, Sea level rise flooding could reduce useable living space, and adversely affect tourism, transportation, recreation and natural resources within 15 years. The first threats are to buildings, roads, and original utility systems along the shoreline. Tidal closures and/or damage to roads, and breakdowns utility networks could have regional ripple effects beyond the flooded areas for extended period of time.

In this near-term timeframe, tidal flooding at 10 inches of sea level rise (MHHW) could reach 5,000 acres with 1,300 parcels and 700 buildings, potentially impacting tens of thousands residents, employees, and visitors. These figures amount to two percent of parcels and one percent of buildings in the study area. Monthly tidal flooding could adversely impact San Rafael east of US Highway 101, bayfront Belvedere and Tiburon, Greenbrae, Waldo Point, and Paradise Cay within this time period.

CONCLUSION

With an additional 100-year storm surge added to sea level rise, the previously impacted acres, parcels, and buildings could face tidal and storm surge flooding. And an additional 3,000 acres, with Black Point on the Petaluma River, lower Santa Venetia, Belvedere around the lagoon, bayfront Corte Madera, bayfront Mill Valley, Marinship in Sausalito, Tamalpais, and Almonte.

Eight miles of road could expect tidal flooding. Many of the flooded intersections already experience storm and king tide flooding. These are:

- The Manzanita area, US Highway 101 at Shoreline Highway,
- Miller Avenue in Mill Valley,
- The Marinship area in Sausalito,
- US Highway 101 in Corte Madera and Larkspur, and
- State Route 37 in Novato.

This is expected to worsen in severity and could be experience daily by near-term scenario 1. Tidal flooding could soon start to regularly reach the Canal area of San Rafael all the way to Interstate 580. Several roads that are now dry may begin to experience seasonal, king tide, and storm surge flooding. These would be roads in Santa Venetia, Tamalpais, Belvedere, Mill Valley, Marin Lagoon of San Rafael, and bayfront Corte Madera and Larkspur.

Water travel infrastructure could be compromised at ferry facilities in Larkspur, Tiburon, and Sausalito preventing commuters from traveling to work. Even if the facilities are able to handle near-term high tides, providing safe parking and access to ferry users could prove challenging. Smaller marinas and boat launches along the bay in Sausalito, Mill Valley, Strawberry, Tiburon, Belvedere, Bel Marin Keys, and Black Point could be flooded out and unusable several months out of the year during high tides. Storm surges can be powerful enough to damage and sink boats. This is especially a corncen for residential boats.

Southern Marin Fire Protection and Sausalito Police Deparmtent boats are included in the boats harbored in marinas vulnerable to sea level rise. The Castro Fire Station in San Rafael is vulnerable to tidal flooding in the near-term and the California Highway Partrol could expect storm surge flooding in this time period. Most concerning, however; is the potential inability of emergency vehicles to access people and places in danger due to the roads flooded in the near-term.

In addition, the marshlands that buffer the shoreline communites from high tides and storm surges could begin to experience tranistions in habitat, especially those in Southern Marin where they are typically bordered by urban development. Consequently, the waters here would get deeper and flood out the existing habitat. This might shift marsh habitat from high marsh to low marsh, low marsh to mud flat, and mud flats to open water. Without adequate light in deeper waters, eelgrass beds would shrink. Collectively, these habitat shifts could have significant impacts on vulnerable species, such as the salt marsh harvest moue, Ridgway's Rail, or the long-fin smelt.

IMPACTS AT-A-GLANCE: SCENARIO 2

5,000 acres flooded @ MHHW	**200,000+ residents plus commuting employees**
8,000 acres flooded @ MHHW +100-year storm surge	**2,000 agricultural acres** (mostly ranch)
4,500 homes, businesses, & institutions	**Property Owners County of Marin Municipalities Caltrans Sanitary Districts Water Districts Fire Districts Sausalito Police Department CHP SMART GGBD MTA PG&E AT&T DFW CA Wildlife Conservation Board**
80 miles of wet road, 3 ferry landings, 5 marinas, 4 boat launches	
Beaches Tidal Marshes Eelgrass beds Wetlands	

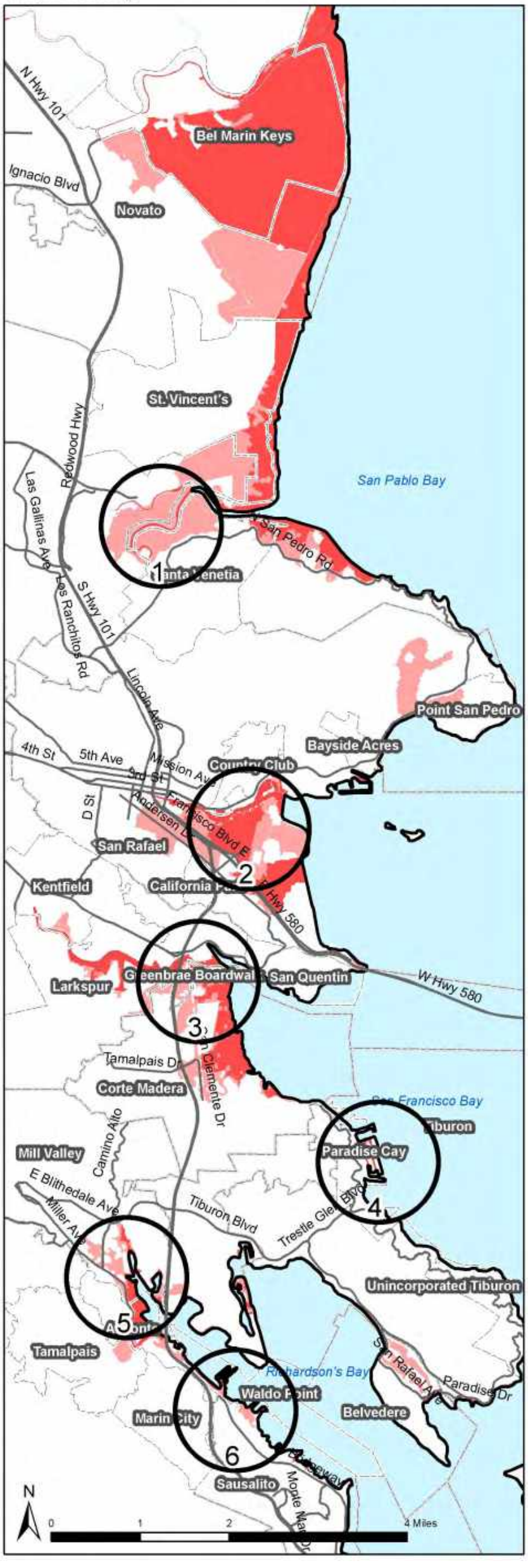
Map 131. Fifteen-year Expectation: Near-term Vulnerable Assets

NEAR TERM

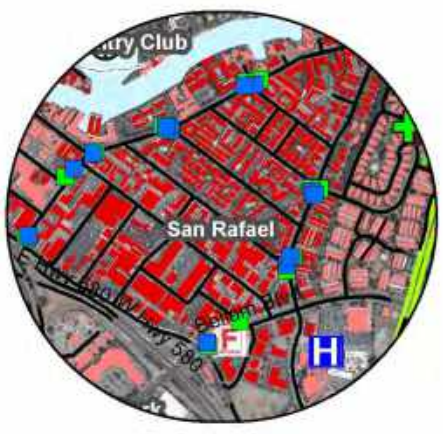
Scenario 1:
10 in. Sea Level Rise

Scenario 2:
10 in. Sea Level Rise
+ 100-year storm surge

In 15 years, high tides could threaten Marin's shoreline buildings, roads, and original utility systems. Damage and breakdowns in road and utility networks would impact the entire County, especially Southern Marin. Tidal flooding (red) could reach 5,000 acres, 1,300 parcels, 700 buildings, and 8 miles of road in San Rafael east of State Route 101, bayfront Belvedere and Tiburon, Greenbrae Boardwalk, Waldo Point, and Paradise Cay. A 100-year storm surge (pink) would flood these areas with storm surge flooding, and flood an additional 3,000 acres, 2,500 parcels, 3,800 buildings, and 20 miles of road in North Novato, Black Point on the Petaluma River, lower Santa Venetia, Belvedere Lagoon, bayfront Corte Madera and Mill Valley, Marinship in Sausalito, Marin Lagoon in San Rafael, Tamalpais, and Almonte. Flooded ferry facilities would prevent commuters and visitors from traveling across the Bay. Boating facilities in Sausalito, Mill Valley, Strawberry, Tiburon, Belvedere, San Rafael, Bel Marin Keys, and Black Point may be inaccessible. This is especially a concern for marinas with residential boats and Southern Marin Fire and Sausalito Police boats. The Castro St. Fire Station in San Rafael is vulnerable to tidal flooding, though all emergency professionals would be denied vehicular access to people in vulnerable areas Southern Marin marshlands would shift high marsh to low marsh to mud flat, and eelgrass beds could shrink under deeper darker waters. These habitat shifts would have significant repercussions for plant, insect, fish, and animal species.



1: Santa Venetia



2: Canal Area

3: Greenbrae Boardwalk/ Larkspur

4: Paradise Cay

5: Mill Valley

6: Waldo Point Harbor

Vulnerable Assets

Vulnerable Buildings
- Scen. 1: 10" Sea Level Rise (SLR)
- Scen. 2: 10" SLR+Storm Surge
- Park
- Vulnerable Road
- Marin Transit Stop
- Golden Gate Transit Stop
- Park & Ride
- SMART Track
- Airport
- Marina
- School
- Medical Facility
- Emergency Shelter
- Fire Station
- District Office
- Gas Pipe
- Electrical Tranmission Tower
- PG&E Property
- Transmission Lines

Sea Level Rise Scenarios
- Scen 1: 10" SLR
- Scen 2: 10"SLR+Storm Surge

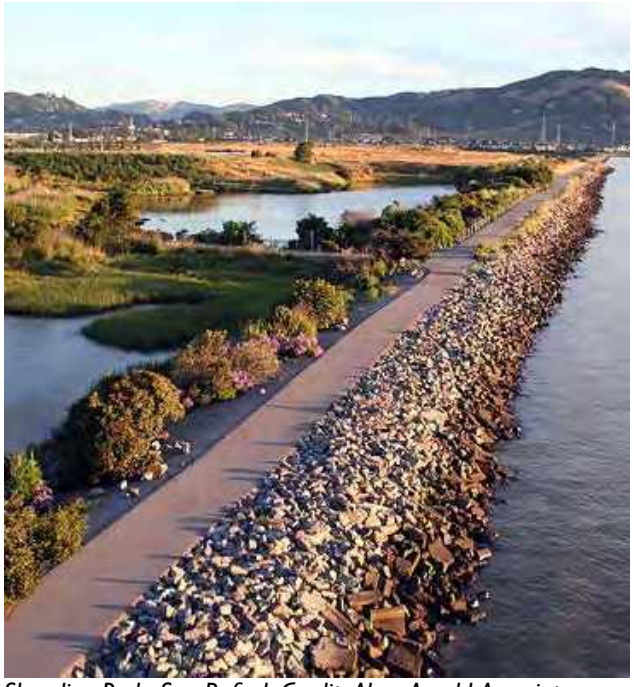
Location Indicators
- Unincorporated
- Municipality
- Road
- Bay

Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data providers here in, make no warranties of the accuracy or completeness of maps and data. Maps are representational and subject to future revision. Local site conditions must be examined. Commercial use is prohibited.

Date: 3/29/2017

IMPACTS AT-A-GLANCE: SCENARIO 4

6,700 acres flooded @ MHHW	**200,000+ residents plus commuting employees**
13,500 acres flooded @ MHHW +100-year storm surge	**2,000 agricultural acres** (mostly ranch)
5,600 homes, businesses, & institutions	**Property Owners County of Marin Municipalities Caltrans Sanitary Districts Water Districts Fire Districts Sausalito Police Department CHP SMART GGBD MTA PG&E AT&T DFW CA Wildlife Conservation Board**
62 miles of wet road, 3 ferry landings, 5 marinas, 4 boat launches	
Beaches Tidal Marshes Creeks Eelgrass beds Ponds Wetlands	



Shoreline Park, San Rafael. Credit: Abey Arnold Associates

Mid Century Expectations

In this medium-term timeframe, tidal flooding at 20 inches of sea level rise (MHHW) could reach nearly 7,000 acres, 3,000 parcels, and 2,000 buildings, and impact even more residents, employees, and visitors than in the near-term. These figures amount to two percent of parcels and three percent of buildings in the study area. Monthly tidal flooding could adversely impact the same locations flooded in the near-term, though more severely.

With an additional 100-year storm surge, the previously impacted acres, parcels, and buildings could face tidal and storm surge flooding, and an additional 7,000 acres, with 2,200 parcels and 3,600 buildings could anticipate storm surge flooding. These figures amount to eight percent of parcels and seven percent of buildings in the study area. This is a significant jump in impacted area, likely because many inadequate levees and other shoreline armoring structures could be overtopped at this water level. Storm surge flooding could impact the same locations as in near-term storm surge scenario 2, and extends further inland beyond the marshes of Mill Valley, Strawberry, San Rafael, St. Vincent's, and North Novato.

Eighteen miles of roadway, ten more miles than in the next fifteen years, could expect tidal flooding. Many of the impacted roads are the same as those impacted in the near-term, though much greater lengths could anticipate tidal flooding at MHHW and depths of flooding would increase on segments exposed to flooding in the near-term. Storm surge flooding could reach a total of 62 miles of roadway. Water travel could experience similar outcomes as in the near-term, though the highest high tides and storms surges would cause even more damage than weathered twenty years earlier.

With respect to utilities, pipelines under vulnerable roads, and lateral pipes to vulnerable properties, would become squeezed between rising groundwater and the confining roadway. This could cause pipes to bend and break, and could even damage roadways. In the medium-term, impacts to the North Marin Water District assets would impact water service in Bel Marin Keys and unincorporated Novato. Vulnerable electrical substations, transmission towers and lines, and underground natural gas pipelines along the shoreline would be compromised by flooding and subsidence, and would subsequently affect transportation, sewer,

stormwater, food storage, and communications assets, and general public safety.

This twenty inch increase in sea level would continue to shrink trapped habitats in Southern Marin. Storm surges would only exacerbate erosion as well.

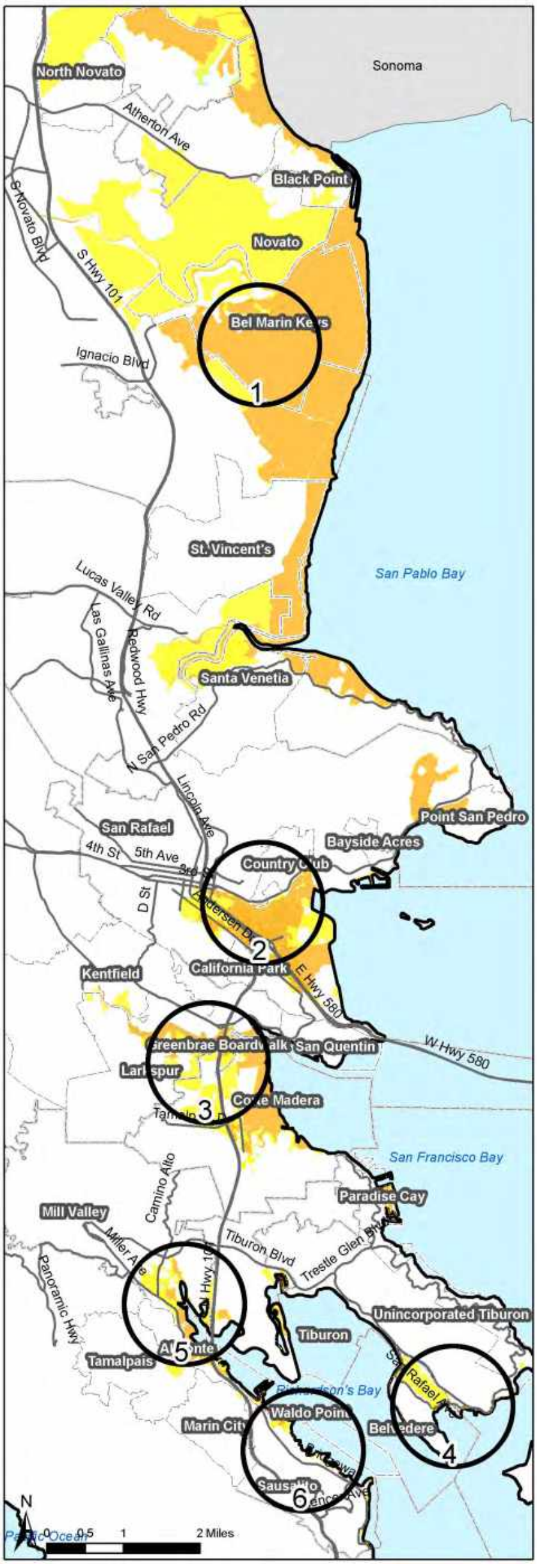
Map 132. Mid-century Expectation: Medium-term Vulnerable Assets

MEDIUM TERM

Scenario 3:
20 in. Sea Level Rise

Scenario 4:
20 in. Sea Level Rise
+ 100-year storm surge

Tidal flooding could reach 7,000 acres, 3,000 parcels, 2,000 buildings, and 18 miles of roadway in the same locations impacted in the near-term, though more severely. With a 100-year storm surge, the area vulnerable to tidal flooding would also experience storm surge flooding. An additional 7,000 acres, 2,200 parcels (8%), 3,600 buildings (7%), and 40 miles of roadway could anticipate storm surge flooding. Most levees south of Novato are not designed to withstand this level of flooding and would be overtopped. Storm surge flooding would extend further inland beyond the marshy areas of Mill Valley, Strawberry, San Rafael, St. Vincent's, and North Novato. Water travel could experience similar outcomes as in the near-term, though the highest high tides and storms surges would cause even more damage than weathered twenty years earlier. Pipelines beneath flooded roads could become squeezed between rising groundwater and the roadway, cause pipes to bend and break, and even damage roadways, this is true for sanitary, stormwater, and potable water pipes. PG&E substations, electrical transmission towers and lines, and natural gas pipelines could be bent or broken by flooding, subsidence, and erosion, with far reaching impacts on utilities, buildings, and transportation. This ten inch increase in sea level would continue to shrink trapped beach and marsh habitats in Southern Marin. Shoreline parks and pathways would flood often.



1: Southern Bel Marin Keys

2: U.S. Hwy. 101
@ Interstate 580

3: Riviera Circle

4: Tiburon/Belvedere

5: Mill Valley

6: Marinship

Vulnerable Assets

- Scen. 3: 20" Sea Level Rise
- Buildings Vulnerable to Storm Surge
- @20"+Storm Surge
- Park
- SMART Track
- Marin Transit Stop
- Golden Gate Transit Stop
- Park & Ride
- Ferry
- Airport
- Boat Launch
- Marina
- School
- Medical Facility
- Law Enforcement
- Emergency Shelter
- Fire Station
- District Office
- Gas Pipe
- Electrical Tranmission Tower
- Substation
- Transmission Lines

Sea Level Rise (SLR) Sceanrios

- Scen 3: 20" SLR
- Scen 4: 20"SLR+Storm Surge

Location Indicators

- Unincorporated
- Municipality
- Road
- Bay

Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data providers here in, make no warranties of the accuracy or completeness of maps and data. Maps are representational and subject to future revision. Local site conditions must be examined. Commercial use is prohibited.

EVB CONSULTING Date: 4/1/2017 OCOF CoSMoS

IMPACTS AT-A-GLANCE: SCENARIO 6

16,300 acres flooded @ MHHW	200,000+ residents plus commuting employees
18,000 acres flooded @ MHHW +100-year storm surge	4,150 agricultural acres (mostly ranch)
12,100 homes, businesses, & institutions	Property Owners County of Marin Municipalities Caltrans Sanitary Districts Water Districts Fire Districts Sausalito & Central Marin Police Departments CHP SMART GGBD MTA PG&E AT&T DFW CA Wildlife Conservation Board
$15.6 billion in assessed property value[220]	
200 miles of wet road, 3 ferry landings, 5 marinas, 4 boat launches	
Beaches Tidal Marshes Creeks Eelgrass beds Ponds Wetlands	

Kappas Marina. April 2016. Credit: Richardson's Bay Floating Homes Association.

End of Century Expectations

In this long-term timeframe, tidal flooding at 60 inches of sea level rise (MHHW) could reach nearly 7,000 acres, 8,000 parcels, and 9,000 buildings, potentially impacting hundreds of thousands of residents, employees, and visitors. These figures amount to 13 percent of parcels and 12 percent of buildings in the study area. Regular tidal flooding could adversely impact the same locations impacted in the near- and medium-terms and significant portions of what would have previously only flooded during a 100-year storm surge. The areas that could now also be tidally flood at this higher high tide are:

- Tamalpais Valley,
- Mill Valley from the Richardson's Bay shoreline up to and beyond Camino Alto between Miller and East Blithedale Avenues,
- Mill Valley and Strawberry fronting US Highway 101 between Seminary Drive and Tiburon Boulevard,
- Santa Venetia north of N. San Pedro Boulevard,
- Cove Neighborhood, Tiburon,
- Belvedere Lagoon neighborhood,
- Paradise Cay,
- Mariner Cove, Marina Village, Madera Gardens, and major retail centers lining US Highway 101,
- Riviera Circle, Creekside, and Heatherwood neighborhoods, Larkspur,
- Interstate 580 and westward towards Andersen Drive in San Rafael and the community of California Park,
- Marin Lagoon and Peacock Gap neighborhoods, San Rafael,
- Bel Marin Keys northern and southern lagoon areas,
- Hamilton, Vintage Oaks, and pockets of development east of US Highway 101 at Rowland Boulevard and State Route 37 in Novato, and,
- North Novato at US Highway 101 and Binford Road.

In long-term scenario 6, storm surge flooding could occur on nearly 13,500 acres hosting 12,600 parcels with 12,000 buildings. These figures amount to nearly one-fifth of parcels and more than 15 percent of the buildings in the study area. Areas that could anticipate storm surge flooding under scenario 6 conditions are:

- Sausalito west of Bridgeway,
- Marin City neighborhood,

[220] 2016 dollars

- Mill Valley east of East Blithedale Avenue at the Alto Shopping Center,
- Las Gallinas and North San Pedro Boulevard, east of US Highway 101, San Rafael,
- Bayside Acres,
- Country Club, and
- Kentfield.

Tidal and storm surge flooding could cause significant economic losses. Minor storm impacts alone could account for $61 million[221] in property damages. The market value of vulnerable single-family homes could exceed $20 billion in 2016 dollars. The assessed value, typically less than market value, for all the vulnerable parcels in the study area is $15.6 billion.[222] By the end of the century, these figures would likely be even higher.

One-hundred miles of public and private roadways, or five percent of all road miles in the study area, could be vulnerable to tidal flooding. Roads could simply degrade more quickly, or if flood waters are deep enough, become impassable when tides rise. Lane miles could be more than double this figure. An additional 30 miles of roadway could be vulnerable at 60 inches of sea level rise and a 100-year storm surge.

In addition, several park and rides, several hundred bus stops, and bus transit and SMART rail routes could flood. The San Rafael Transit Center, where the SMART train and nearly all buses stop, is vulnerable in the long-term to sea level rise. high tides. Breakdowns in the transportation network would have major impacts on the economy and daily life functions. In addition, significant safety hazards could cause injury or loss of life.

Flooding at the SASM and Novato Sanitary Wastewater Treatment Plants is a significant vulnerability that could arise, potentially disrupting hundreds of thousands of people. By this time, much of the low-lying shoreline sanitary sewer and stormwater infrastructure could be overrun with tidal waters.

By the end of the century, sea level rise could have direct impacts to Tiburon Fire Station No. 1, Corte Madera Station No. 13, and Novato Atherton Avenue Fire Station. A few emergency shelters in Southern Marin communities could be vulnerable to tidal flooding, and several more could expect 100-year storm surge flooding and may not be available when needed most. By this time, the Central Marin Police Department could have to stave off flood water surrounding the site to reach Larkspur and Corte Madera residents in need.

Southern Marin marshes may no longer exist by the end of the century, destroying the habitat of several shoreline birds and mammals. Northern Marin marshes would become increasingly tidally influenced, with tide water reaching US Highway 101 in Bel Marin Keys and North Novato up the Petaluma River. Typically freshwater marshes west of US Highway 101, for example, Sutton Marsh, could also be subject to damaging salinity impacts. Tidal marsh lands may increase in Northern Marin if they are not prevented from migrating inland.

Finally, all of these assets contain or contribute to the well-being of the region's cultural, archeological, and historic resources that constitute each community's sense of place. This is especially a concern for Sausalito, Tiburon, and Novato.

China Camp Historic pier. December 2016 King Tide. Credit: Ron Rothbart

[221] 2016 dollars
[222] 2016 dollars

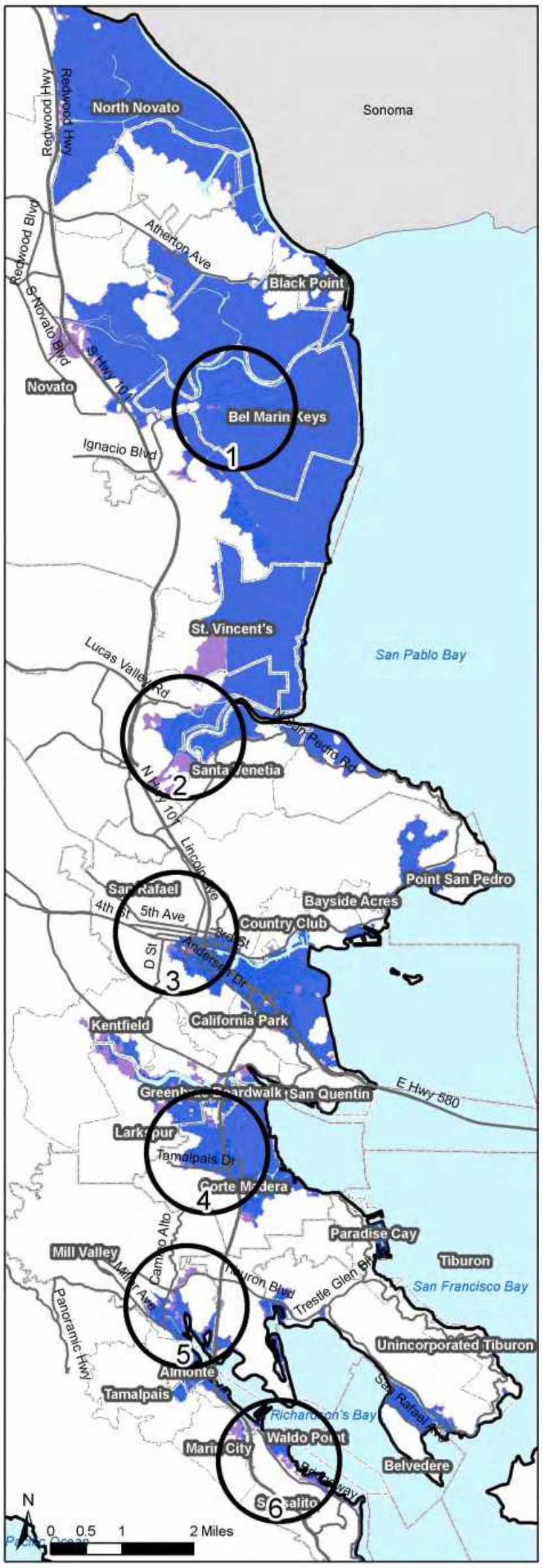
Map 133. End of Century Expectations: Long-term Vulnerable Assets

LONG TERM

Scenario 5:
60 in. Sea Level Rise

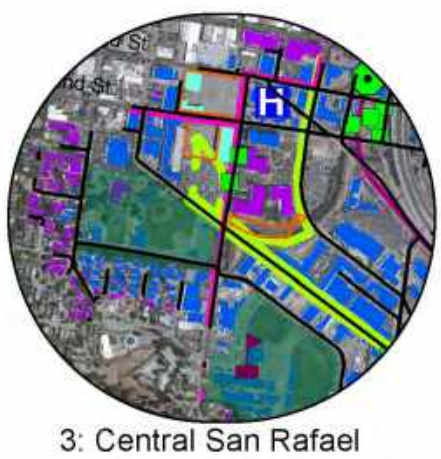
Scenario 6:
60 in. Sea Level Rise
+ 100-year storm surge

By 2100, tidal flooding could reach nearly 7,000 acres, 8,000 parcels (13%), 9,000 buildings (12%), and 100 miles of road. Higher high tides could adversely impact the locations flooded in medium-terms, and significant portions of the areas that previously suffered storm surge flooding. Tidal flooding would reach beyond the State Routes 101and 580 in low-lying areas, into Southern Marin's narrow valleys and creek sides, and over every levee in Marin County. A 100-year storm surge could flood these areas, and an additional 6,500 acres, 4,600 parcels (20% total), 3,000 buildings (15% total), and 30 miles of road, extending to Sausalito west of Bridgeway, Marin City housing, Mill Valley's Alto Shopping Center, Las Gallinas and N. San Pedro Blvd. in San Rafael, Bayside Acres, Country Club, and Kentfield. Minor building damage could amount to $61 million (2016 dollars). Vulnerable single family homes exceed $20 billion in market value (2016 dollars). Several park and rides, hundreds of bus stops, and bus routes, and SMART rail track, including the San Rafael Transit Center, could experience flooding. Disruptive flooding at the SASM and NSD wastewater treatment plants and pump stations would affect tens of thousands of people. Storm surges could flood Tiburon Fire Station No. 1, Corte Madera Fire Station No. 13, and Novato Atherton Ave. Fire Station. A few emergency shelters in Southern Marin flood at high tide, and many more could be closed during a storm. The Central Marin Police Department may have to navigate deep water to reach Larkspur and Corte Madera shoreline residents. In Southern Marin, mud flats and water would dominate existing marshes. In the north, tidal marshes could expand.

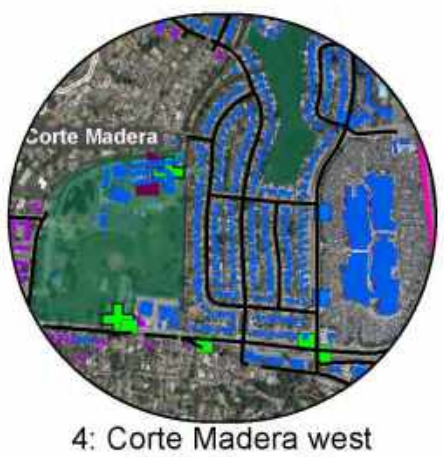


1: Bel Marin Keys

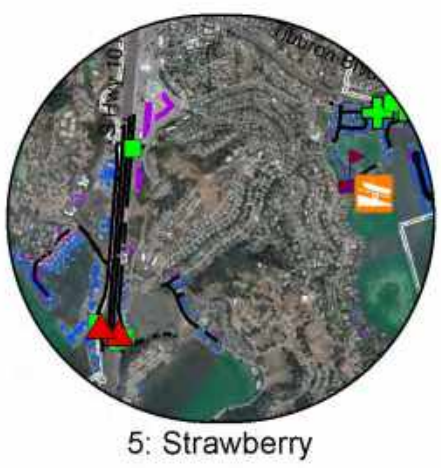
2: Marin Lagoon/Las Gallinas



3: Central San Rafael



4: Corte Madera west of U.S. Hwy. 101



5: Strawberry

6: Marin City

Vulnerable Assets

Vulnerable Buildings
- @60" Sea Level Rise
- @ 100-Year Storm Surge
- Park
- Park & Ride
- Marin Transit Stop
- Golden Gate Transit Stop
- Public Boat Launch

- SMART Station
- SMART Track
- School
- Medical Facility
- Emergency Shelter
- Gas Pipe
- Transmission Lines

Sea Level Rise (SLR) Scenarios
- Scen 5: 60" SLR
- Scen 6: 60"SLR+Storm Surge

Location Indicators
- Unincorporated
- Municipality
- Road
- Bay

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Date: 4/1/2017

Table 132. East Marin Assets Vulnerable to Sea Level Rise and a 100-year Storm Surge

	Near-term Scenarios 1 & 2	**Medium-term** Scenarios 3 & 4	**Long-term** Scenario 5	**Long-term w/ surge** Scenario 6
Sausalito	• Marinship neighborhood • GGBHTD Sausalito Ferry • Shops & restaurants east of Bridgeway • Swedes Beach • Tiffany Beach • Dunphy Park • Emergency rescue boats	• Cass Gidley Marina • Clipper Yacht Harbor • Fire Station • Gate 5 Road • Marina Plaza Harbor • Pelican Yacht Harbor • Schoonmaker Beach & Marina	• Bay Trail • Bridgeway • Turney Street Boat Ramp • Yee Tock Chee Park	• Sausalito Marin City Sanitary District treatment plant
Mill Valley	• Residential and commercial at Shelter Bay and Hamilton Dr. to 101	• Bay Trail • Bayfront Park • Mill Valley Middle School • Miller Avenue • Sycamore neighborhood • Redwood Retirement • SASM treatment plant • Shelter Bay • Shelter Bay neighborhood • Mill Valley/ Sausalito Pathway	• Camino Alto • E. Blithedale Avenue • Freeman Park • Hauke Park • Redwood Highway Frontage Road • Sycamore Avenue • Sycamore Park	• Mill Valley Recreation Center • Sutton Manor shopping center • Tamalpais High School
Belvedere	• West Shore Road homes • San Francisco Yacht Club	• Belvedere Corp Yard • Belvedere Lagoon homes • San Rafael Avenue	• Beach Road • Belvedere Community Center Mini Park • West Shore Road	• City Hall, Police Department, community center
Tiburon	• Richardson Bay Lineal Park • Downtown commercial • Blackie's Pasture • Mc Kegney Green • Corinthian Yacht Club • Ferry facilities • Cypress Garden Park • Pt. Tiburon Shoreline Park	• Cove Shopping Center • Library • Post Office • Tiburon Blvd. Shopping • Town Hall • Tiburon Fire Station	• Bay Trail • Bel Aire Park • Main Street • Pt. Tiburon Marsh • Tiburon Blvd. • Zelinsky Park	
Corte Madera	• Marina Village • Mariner Cove Neighborhood • Paradise Dr. auto dealerships and commercial • Corte Madera Creek Path • CA Highway Patrol Marin office • Triangle Marsh	• Bay Trail • Corte Madera Town Center Commercial • Cove Elementary School • Hal Brown Park • Marin Montessori • Higgins Dock • Madera Gardens Lagoons Neighborhood off Madera Dr. • Neil Cummins Elem. School (emergency shelter) • Paradise Drive • Tamalpais Drive • The Village at Corte Madera • San Clemente Park	• Hwy 101 • Redwood Highway • Ring Mountain • San Clemente Drive • Shorebird Marsh • Skunk Hollow Park • Town Park	• Aegis Senior Living • Fire Station 13 • Bike Trail • Holy Innocents Episcopal (emergency shelter) • Marin Country Day School (emergency shelter) • Marin Lutheran Church (emergency shelter) • MMWD Headquarters

	Near-term Scenarios 1 & 2	Medium-term Scenarios 3 & 4	Long-term Scenario 5	Long-term w/ surge Scenario 6
Larkspur	• Bay Trail • Remillard Park • Cal Park wetlands • Bon Air Landing Park • Larkspur Landing Beach	• Doherty Drive • Golden Gate Mobile Homes Park • Hamilton Park • Larkspur Landing Ferry facility and emergency fuel reserve tanks • Redwood High School • Riviera Circle homes • San Andreas High School • Tamiscal High School	• Heatherwood Park • Hwy 101S • Redwood Highway • Sir Francis Drake Blvd. • Riviera Circle	• Niven Park • PG&E Substation behind Cost Plus World Market • Henry Hall Middle School
San Rafael	• Bay Trail • Francisco Blvd E • Canal Street • Hwy 580 • Kerner Blvd • Marin County Health Innovation Campus • Marin Yacht Club • Canal/Shoreline open space • AT&T Headquarters and Yard • Fire Station No. 54 • Bahia Way • Pickleweed Park • Jean & John Starkweather Shoreline Park • Hi-Tide Boat sales & services • San Rafael Yacht Harbor • Tiscornia Marsh	• 3rd Street • Andersen Drive • Beach Park • Canal District • Davidson Middle School • Peacock Gap Golf Course • Downtown • Francisco Blvd W • GGBD offices and depot • Grand Avenue • Loch Lomond Marina • Lowrie Yacht Harbor • Marin Lagoon • Montecito Plaza • Hwy 101 • Peacock Drive • Peacock Gap Lagoon and golf course homes • Peacock Gap Neighborhood Park • PG&E office and yard • Pickleweed Park facilities • Pt. San Pedro Road • SMART tracks • San Rafael High School • San Rafael Transit Center • San Rafael Yacht Club	• 2nd Street • 4th Street • Albert Park • Candy's Park • Hetherton Street • Lincoln Avenue • Schoen Park • Smith Ranch Airport • SMART tracks, eastern San Rafael	• US Post Office-Bellam Blvd. • Department of Public Works • Glenwood Elementary School

	Near-term Scenarios 1 & 2	Medium-term Scenarios 3 & 4	Long-term Scenario 5	Long-term w/ surge Scenario 6
Novato	• Scottsdale Marsh • Bahia Marsh	• Bay Trail	• Deer Island Preserve • Hwy 37 East bound • Fire Station 62 • Future Hamilton recreation area • Hamilton Airport Park • Hamilton Amphitheater Park • Hamilton Community Center • Hamilton Parkway • Hwy 101 North bound • North Marin Water District intertie valve with Marin Municipal Water District • NMWD Pipes, Bel Marin Keys • Novato Sanitary District Treatment Plant • Vintage Oaks shopping center	• Fire Protection Administrative Services • Las Robles Mobile Home Park • North Marin Water District headquarters (w/ stormwater) • Novato Corp Yard • Novato Fire Association Office • Rowland Blvd. • Rush Creek • Hwy 101 South bound • Slade Park • SMART rail • South Hamilton Park • Hwy 37 West bound

	Near-term Scenarios 1 & 2	Medium-term Scenarios 3 & 4	Long-term Scenario 5	Long-term w/ surge Scenario 6
Unincorporated Marin	• Greenbrae • Waldo Point Marina, Homes, and Businesses • Bel Marin Keys Blvd. • Caltrans Corporate Yard, Almonte • Tam Junction Commercial • Paradise Cay homes and marina • Black Point Boat Launch Mc Nears Beach Park • Richardson Bay Marina, Waldo Point • Bahama Reef Boat Launch, Bel Marin Keys • Cavalia Cay Park, Bel Marin Keys • Dolphin Isle Boat Launch, Bel Marin Keys • Del Oro Park, Bel Marin Keys • Santa Margarita Island, Santa Venetia • Santa Venetia Marsh • Seaplane Adventures, Almonte • Strawberry Community Park boat launch • Paradise Beach Park • Marin County Sheriff Water rescue boat	• Charles F. McGlashan Pathway, Almonte • Shoreline Highway, Almonte • Almonte Blvd. • Almonte Sanitary District • Beach Drive, Bayside Acres • Bel Marin Keys CSD Office • Bel Marin Keys Yacht Club • Calypso Bay Public Dock, Bel Marin Keys • Caribe Isle Park, Bel Marin Keys • Homes east of Bel Marin Keys Blvd. • Homes west of Bel Marin Keys Blvd. • Montego Park • Marin RV Park, Greenbrae • Apartments on offices off Sir Francis Drake Blvd., Kentfield • Homes along Barren's Slough, Kentfield • Homes along McCallister Slough, Kentfield • Buildings, San Quentin • N. San Pedro Road • Santa Venetia homes • Brickyard Cove • Commercial along Seminary Marsh • Greenwood Cove homes • Homes along Seminary Dr. • Strawberry Circle • Strawberry Point Park • Strawberry Point Tidal Area • Birdland Neighborhood • Westminster Presbyterian Church & preschool	• Bel Marin Keys Public Dock • Atherton Avenue • Pt. San Pedro Road • Hwy 101, Greenbrae • Redwood Highway, Greenbrae • Stadium Way • Hwy 101, Marin City • Redwood Blvd., Marin City • Gnoss Field Airport • Hwy 101, North Novato • Redwood Highway, North Novato • SMART rail, North Novato • Adrian Rosal Park • Buck's Landing • Castro Park • Santa Venetia neighborhood streets • Pueblo Park • SMART tracks, St. Vincent's • De Silva Island Drive • Hwy 101, Strawberry • Redwood Highway Frontage Road • Seminary Drive • Cathodic protection well	• Adaline E Kent Middle School • Anthony G Bacich Elementary School • College of Marin • Kent Middle School • Martin Luther King Jr Academy • St. Andrews Presbyterian Church • Marin County Expo Center and Amphitheater • Strawberry Point Elem School • Strawberry Point Elementary School • Strawberry Recreation Center • Strawberry Village shopping center • Tiburon Blvd. • Paradise Cove treatment plant

Source: MarinMap, CoSMoS

CONCLUSION

Boardwalk One and Larkspur Plaza Drive affordable multi-family housing on Corte Madera Creek. Larkspur. Credit: Marin County DPW.

Table 132 lists the Marin shoreline communities' vulnerable assets by onset for each community and unincorporated Marin. These assets are vulnerable under the six scenario selected for the BayWAVE process, 10 inches, 20 inches, and 50 inches of sea level rise, and each with a 100-year storm. A significant degree of uncertainty exists as to how soon these increases in sea level could occur because future carbon emissions, a major variable in modeling, are an unknown. However, even if global citizens stabilize carbon emissions, sea level rise would likely continue. Moreover, even if the growing global population reduces carbon emissions to levels where atmospheric concentrations decline, the decline will be slow and sea levels would still likely continue to rise for decades, and hundreds of years could pass before the sea level stabilizes or drops.[223,224] If emissions continue to increase, the rate of sea level rise is also likely to increase and these assets could be vulnerable sooner than this assessment presents. Because of this uncertainty, this assessment is the first step in an iterative process that will need to be updated as additional science becomes available and adaptation efforts are implemented. The sea level rise preparation process will require consistent monitoring and evaluation to improve modeling assumptions and ensure preparation efforts are effective and efficient.

Built and natural features in Table 132 are many assets to be addressed in adaptation planning. Some communities are already adapting to sea level rise. Efforts in Waldo Point, Strawberry, Las Gallinas, the Redwood Landfill, and others are already working to decrease vulnerability to higher tides and subsidence. Implementing additional adaptation measures may require new institutional, legal, and financing arrangements, engineering measures, and other incremental actions property owners and government entities can take. These measures and sea levels on the coast must be monitored and evaluated to inform need and effectiveness of these types of strategies. This vulnerability assessment lays the informational foundation for adaptation planning and implementing the necessary measures to protect, accommodate, retreat, or preserve existing geographies.

Combined with potential losses in West Marin due to potential sea level rise, the impacts to Marin County will be significant across all asset categories. The image to the left combines estimates for land area that would be lost at MHHW across the near-term, 2030, the medium-term, 2050, and the long-term, 2100 scenarios applied to Western and Eastern Marin.

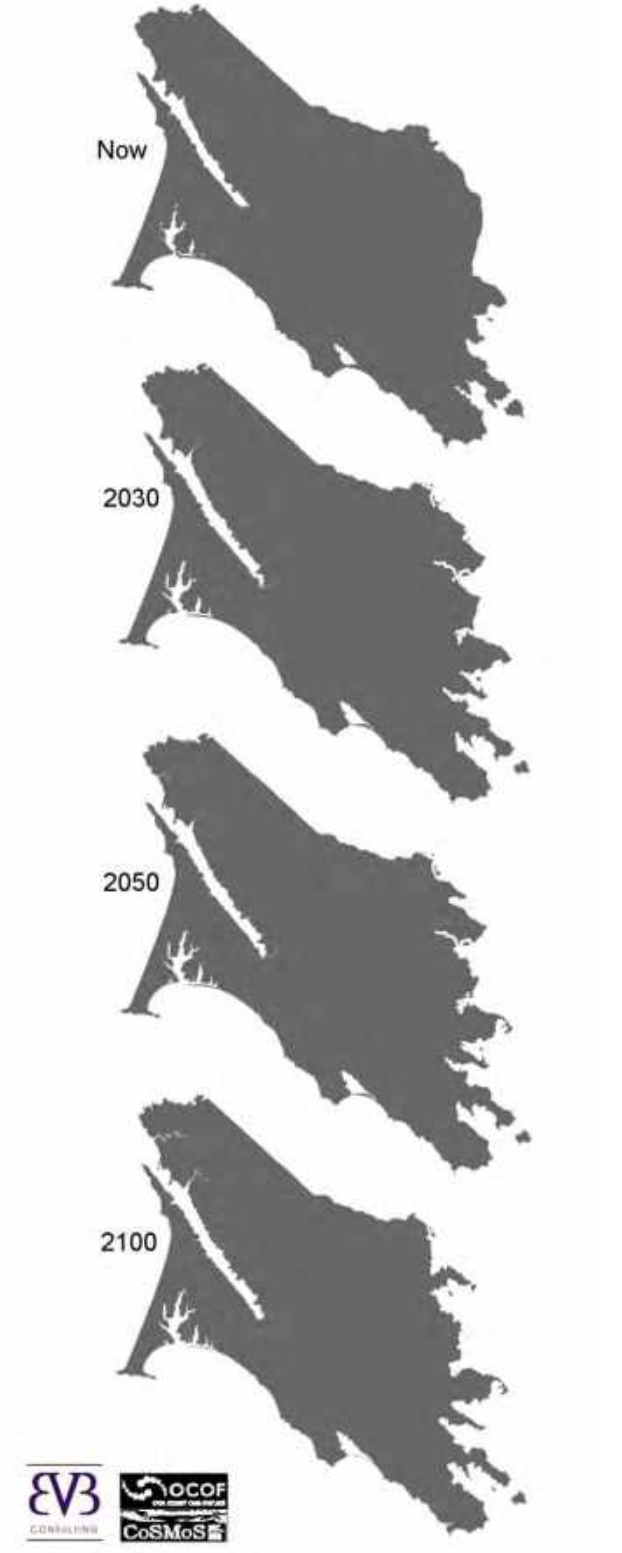
With the Vulnerability Assessment complete, Marin County, municipal, and special district governments, and other essential service providers, non-profits, and property owners have a glimpse of a potential future with higher tides. By the end of the century, sea level rise could significantly alter daily life in Marin County. The Vulnerability Assessment summarizes the worst case scenario with business as usual. Fortunately; business as usual is already changing with significant restoration, conservation, and redevelopment efforts along the Marin shoreline that show promise for the coming decades.

[223] IPCC Fourth Assessment Report: Climate Change 2007. Climate Change 2007: Working Group I: The Physical Science Basis. 10.7.2 Climate Change Commitment to Year 3000 and Beyond to Equilibrium. https://www.ipcc.ch/publications_and_data/ar4/wg1/en/ch10s10-7-2.html

[224] IPCC Fourth Assessment Report: Climate Change 2007. Climate Change 2007: Working Group I: The Physical Science Basis. 10.7.4 Commitment to Sea Level Rise. https://www.ipcc.ch/publications_and_data/ar4/wg1/en/ch10s10-7-4.html

CONCLUSION

Figure 6. Estimated Decreases in Marin County Land Area due to Sea Level Rise



Sea level rise is a moving target, and likewise, adaptation efforts will need to keep pace and be able to adjust more quickly than the seas rise. Moving forward, government official, residents, and professionals will have to weigh the options to protect, reinvent, or relocate existing assets where feasible, or at worst, what assets cannot be saved. These decisions will trigger several other challenging questions, especially in an area where developable land is not readily available, demand for housing is high, and new development can be politically challenging. Getting through these questions, entering the study and planning phases, getting approvals, securing funding, and implementing improvements can be a multi-year to multi-decade process. Because of this, it is imperative that sea level rise preparation planning and implementation is strongly supported and undertaken promptly and continuously in the coming decades to ensure the County and its residents are prepared for and safe from sea level rise. The future phases of BayWAVE will explore these options further and provide the basis for continued discussion, planning, and action.

Miller Avenue at Bothin Marsh, Mill Valley. King tide, Nov. 25, 2015. Credit Marin County DPW

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APPENDIX A

Appendix A: Vulnerability Assessment Interview Tool

BayWAVE Program

Bay Waterfront Adaptation and Vulnerability Evaluation

Asset vulnerability assessment tool and script

Managing Agency:_____ Date:_____

Asset Manager Name(s):_____ Phone: _____

Asset:_____

This assessment tool will be used to gather information on how sea level rise can impact public assets on Marin's bayside shoreline. Thank you for taking the time to respond to this series of questions. At most, it could take 1 hour to answer 30 questions. The tool asks several yes or no and short answer questions, followed by ranking degrees of sensitivity, adaptive capacity, and risk factors associated with sea level rise and storm surges. Lastly, the tool asks for preliminary ideas for adaptation. Let's begin.

The first set of questions may be useful in the planning process and will help get us thinking about sea level rise and storm surge preparation.

1. Are there efforts underway to address SLR/SS (emergency or climate change efforts) at your agency or organization?
   ◯ No ◯ Yes, _____
2. What is your level awareness of sea level rise?
   ◯ None ◯ Low, heard/read of SLR ◯ Moderate, involved in training/project ◯ High, expert
3. What is your general workplace's awareness of sea level rise?
   ◯ None ◯ Low, heard/read of SLR ◯ Moderate, involved in training/project ◯ High, expert
4. Please describe the current physical condition of the asset. Are there existing stresses, are they likely to improve/worsen?

5. Has the asset been disrupted in the past due to an unplanned stress e.g., weather-related closure, emergency repair, strike?
   ◯ No ◯ Yes. How long did disruption last? _____
   5a. Was the asset able to continue functioning? ◯ No ◯ Partially ◯ Yes

6. When was the last repair or update? _____
7. Is any major maintenance or repair planned? ◯ No ◯ Yes, when_____

8. Were/are any permits from state and regional agencies, such as the Bay Conservation and Development Commission (BCDC), required to do conduct needed work in questions 5, 6, 7 or other flood prevention measures? If yes, please describe your experience with the permit process.

For the second set of questions, please respond about how the following sea level rise and storm surge could impact the asset. Impacts the asset could be exposed to include:

- Permanent flooding
- Temporary flooding
- Rising water table
- Saltwater intrusion/corrosion
- High wind impacts
- Beach/cliff erosion
- Habitat shifts (natural resource assets only)

The following questions address sensitivity, adaptive capacity, adaptation ideas, and risk for each. For the sensitivity assessment, sensitivity is defined as the *degree an asset could be damaged or the service it provides disrupted*. Please indicate if the asset will be sensitive for each exposure according to these levels:

BayWAVE Vulnerability Assessment Tool | 1

No Sensitivity: Not impaired, damaged, or disrupted

Low Sensitivity: Minimally impaired, damaged, or disrupted. The asset may require minor repairs or suffer minimal disruption.

Medium Sensitivity: Somewhat impaired, damaged, or disrupted. The asset may require repairs and able to maintain most functions.

High Sensitivity: Greatly impaired, damaged, or disrupted with complete loss or shut-down. The asset will require significant repairs and disruption could impact public health and safety.

Maximum Sensitivity: Permanent loss or disruption.

Using the definitions of sensitivity above, how sensitive is *the asset* to:

	No	Low	Med	High	Max
9. Temporary flooding?	○	○	○	○	○
10. Permanent flooding?	○	○	○	○	○
11. Cliff/beach erosion?	○	○	○	○	○
12. Water table rising?	○	○	○	○	○
13. Saltwater intrusion/corrosion?	○	○	○	○	○
14. High winds?	○	○	○	○	○
15. Habitat shifts?	○	○	○	○	○

16. If the asset is sensitive to any of these exposures, how could exposure impact the asset. For example, % reduction in service, hours of system shutdown; what is the NATURE of the sensitivity?

Please rate the level of adaptive capacity of the asset for each exposure you rated medium, high or maximum. Adaptive capacity is defined as t*he ability of an asset to recover from the damage or disruption from the elements the asset is exposed to WITHOUT human intervention*. Please indicate the level of adaptive capacity for the asset according to these categories:

Maximum Adaptive Capacity: Asset is able to tolerate [impact], no need for intervention.

High Adaptive Capacity: Asset is able to tolerate [impact] and cope with the consequences without the no need for significant intervention or modification (e.g. alternate infrastructure routes, elevated structure). Could be easily replaced, repaired.

Medium Adaptive Capacity: Asset is somewhat able to tolerate [impact], and cope with the consequences with significant intervention or modification (repair, replacement are possible)

Low Adaptive Capacity: Asset has limited ability to tolerate [impact], and cope with the consequences (no alternative routes, no restoration possible. Would require replacement or very costly repairs.

No Adaptive Capacity: Asset is not able to tolerate [impact]. Not reparable or replaceable in current location.

Using the definitions above please indicate the asset's level of adaptive capacity for each of the moderate, high, and maximum sensitivity exposures. *[insert appropriate exposures into the blanks below]*

	No	Low	Med	High	Max
17._____	○	○	○	○	○
18._____	○	○	○	○	○
19._____	○	○	○	○	○

If you rated the asset as having High or Maximum adaptive capacity you are finished with the questionnaire. If you rated the asset as having No, Low, or Medium adaptive capacity, please continue as adaptation may be necessary to ensure the asset avoids destruction and unsafe conditions. The following questions are about potential adaptation considerations and options.

20. What, if any, adaptation or preparation actions have been incorporated into managing the asset for flooding and/or storms?

21. What ideas do you or your agency have for new adaptation or preparation actions?

Physical:

Social:

Financial:

Political:

If no action is taken, sea level rise and storms could have potentially damaging consequences for the asset and those the asset serves. Responses to these question will help prioritize preparation actions for the most sensitive, least resilient assets. While you may not know the answer to each question, please make your best judgment.

22. How important is the asset as an economic generator?
    ◯ very ◯ somewhat ◯ not $_____
23. What is the value to the community?
    ◯ high ◯ medium ◯ low ◯ none
24. Does the asset have features that are at-grade or below-grade, e.g., building openings (door, windows, vents) mechanical or electrical equipment, pumps, utilities, building heat, ventilation, power systems or finished basements?
    ◯ no ◯ yes, _____
25. What would be the cost to repair/ replace the asset?
    ◯ high ◯ medium ◯ low $_____
26. How many people could be affected?
    ◯ region ◯ community ◯ neighborhood ◯ site ◯ none
27. Are any underrepresented/vulnerable populations affected?
    ◯ no ◯ yes, (mark all that apply)
    - ◯ People with limited mobility or disability
    - ◯ Renters
    - ◯ People of color
    - ◯ Low income people
    - ◯ People over 75 years old
    - ◯ Institutionalized populations (hospitals, nursing homes, prisons)
    - ◯ Households with limited English proficiency
    - ◯ Households lacking vehicle
    - ◯ Other _____
28. Are there health impacts? ◯ no ◯ yes, _____
29. Are there safety impacts? ◯ no ◯ yes, _____
30. What is the spacial extent or scale of the impact?
    ◯ regional ◯ local ◯ site ◯ less than site

Thank you. This concludes the assessment questions for this asset. Is there anything else you would like to share?

APPENDIX A

Table 133. Interviewed Agencies and Managers

PG&E	Amy Dao, Community Energy Manager, Sustainable Communities
	Kin Robles, Community Energy Manager (post interview)
	Dave Canny, Senior Manager, North Bay Division
Bel Marin Keys Community Service District	Noemi Camargo-Martinez, Manager
	P. Carey Parent, Principal, Cle Group
	Kyle Mac Donald, Cle Group
Buck's Landing	William Miller, CA State Parks
	Bree Hardcastle, CA State Parks
CA Coastal Conservancy	Marilyn Latta, Project Manager
	Kelly Malinowski, Project Manager
	Jeff Melby, Project Manager
	Matt Gerhart, Deputy Program Manager
CA Highway Patrol	Lt. Robert Mota
Canal Center	Douglas Mundo, Exec. Dir
Central Marin Police	Todd Cusimano, Chief
Central Marin Sanitation Agency	Brian Thomas, Technical Services Manager
City of Belvedere	Mary Neilan, City Manager
	Eric Banvard, Building Official
	Scott Derdenger, Public Works Mgr
City of Larkspur	Neal Toft, Director of Planning and Building
	Daryl Phillips, CBO, Phillips Seabrook Associates, Floodplain Manager and Building Official
	Scott Shurtz, Fire Chief
City of Mill Valley	Danielle Staude, Senior Planner
	Scott Schneider, Engineering Manager
	Tom Welch, MVFD
	Bob Peterson, Director of Public Works
City of Novato	Tony Williams, Planner
	Russ Thompson, Public Works Director
	Pam Shinault,
	Bob Brown,
City of San Rafael	Paul Jensen, Community Development Director

	Doris Toy, P. E. San Rafael Sanitation District, District Manager, District Engineer
	John Bruckbauer, Emergency Management Coordinator
	Dean Allison, Director of Public Works
	Kevin McGowan, Assistant Public Works Director/City Engineer
	Cory Bytof, Sustainability & Volunteer Program Coordinator
City of Sausalito	Johnathon Goldman
County Parks	Mischon Martin, Chief of Resources and Science
	Brian Sanford, Superintendent for Parks, Southern Region
	Ari Golan, Superintendent for Parks, Northern Region
	Chris Chamberlain, Superintendent for Parks, Central Region
	Steve Petterle, Principal Landscape Architect
	James Raives, Senior Open Space Planner
County Roads	Reuel Brady
Floating Homes Association	Teddie Hathaway
	Brad Hathaway
Gnoss Field (airport)	Dan Jensen
Golden Gate Bridge, Hwy & Trans	Raymond Santiago, Senior Planner
	Wilson Lau, Supervising Civil Engineer
Golden Gate Ferry	Colin McDermott
	Tim Hanners, Maintenance Manager
Heath Ceramics	Robin Petravic, Owner and Managing Director
Kent Middle School	Skip Kniesche Principal
	Liz Schott, Super Intendent
Kentfield Planning Adv. Board	Board Members
Las Gallinas Valley Sanitary District	Irene Huang, Assoc. Engineer
	Mark Williams, General Manager
	William Miller
	Mike Cortez, District Engineer
Loch Lomond Marina	Betsy Oller, Office Manager
Marin Audubon	Barbara Salzman
Marin County DPW	Patrick Zuroske, Public Improvements

Marin Municipal Water District	Kristin Cole, Water System Planning & Special Projects
	Carl A Gowan, P.E. Principal Engineer
Marin Yatch Club	Paul Simmons, Commodore
Monticello Shopping Center	Dennis Fisco, Seagate Properties, Inc.
Neil Cummins Elementary School	Wolf Gutscher, Dir. Of Facilities
North Marin Water District	Chris DeGabriele
	Drew McIntyre, Chief Engineer
	Robert Clark, Operations/Maintenance Superintendent
Novato Fire District	Dep. Chief Adam Brolan
Novato Sanitary District	Erik Brown, P.E., Technical Services Manager
	Steve Krautheim, Field Services Manager
	Sandeep Karkal, General Manager-Chief Engineer
Ross Valley Sanitary District	Greg Norby, P.E., General Manager
	Katherine Hayden, P.E. Interim District Engineer
	Steve Miksis, Acting Chief of Operations
San Rafael Airport	Bob Herbst
San Rafael School District	Dr. Mike Watenpaugh, District Superintendent
	Dr. Daniel Zaich, Director, Strategic Initiatives
	Theresa Allyn, Executive Assistant
	Chris Thomas, Chief Business Official
	Sarah, Schoening Group Inc.
SASM	Mark Grushayev, Wastewater Treatment Plant Manager
Almonte Sanitary District	Brian Robinson, Manager
Alto Sanitary District	Roger Paskett, Manager
Richardson's Bay Sanitary District	Johnny Tucker, Manager
Homestead Valley Sanitary District	Bonner Beuhlar, Manager
Tamalpais Valley Sanitary District	Jon Elam, Manager
Sanitary District No. 5, Tiburon	Tony Rubio, Manager

Sausalito -Marin City Sanitary District	Omar Arias, Operations Supervisor
	Kevin Rahman, Associate. Engineer
Sausalito School Dist.	Alan Rothkop, Dir. of Facilities
SMART	Linda Meckel
Southern Marin Fire District	Chief Tubbs
State Fish & Wildlife	Karen Taylor, Associate Wildlife Biologist
	Tom Huffman, Bay Delta Region Director
	Larry Wyckoff, Senior Wildlife Biologist
Mill Valley Middle School/ Strawberry Point Elem School	John Binchi, Operations. Director
Strawberry Rec Center	Leanne Kreuzer, District Manager
Tamalpais Union High School Dist.	David O'Connor, Facilities Director
Town of Corte Madera	Kelley Crowe, Associate Civil Engineer, Public Works
	Phil Boyle, Senior Planner
	Adam Wolff, Director of Building and Planning
Town of Tiburon	Scott Anderson, Community Development Director
	Patrick Barnes, Director of Public Works
	Rich Pearce, Fire Chief
	Mike Cronin, Police Chief
Transportation Authority of Marin	Nick Nguyen, P.E., Principal Project Delivery Manager
	Dianne Steinhauser, P.E., Exec Director
Waste Management	Ramin A. Khany, General Manager
	Glen Roycroft, Site Engineer
Westminster Presbyterian Church	Adam Krivatsy
	Rob McClellan, Minister
	Len Ganote
	Atamp Marvais

Central California and its implications on nearshore processes. Journal of Marine Systems v. 68.

APPENDIX B

Appendix B: Public Comments

From: Peter Hogg
To: Choo, Chris
Subject: Sea Level Rise Vulnerability
Date: Wednesday, April 26, 2017 2:11:49 PM

Chris,

Many thanks for your presentation in Mill Valley last night.

The purpose of this email is to clarify the points I raised concerning the use of the words "Greenbrae Boardwalk" in the draft report.

I am a resident of Greenbrae Boardwalk, a community of 46 houses on the edge of Corte Madera Creek directly opposite the Larkspur ferry terminal and east of the railroad trestle. Based on the tables of the number of properties affected by sea level rise it appears that the draft report uses the phrase "Greenbrae Boardwalk" to refer to those portions of the unincorporated community of Greenbrae that are in the flood plain, specifically (1) the houses on Lucky Drive to the west of Highway 101, and (2) the houses on the Greenbrae Boardwalk to the east of Highway 101. These two communities are substantially different in regard to the possible impact of sea level rise.

My suggestion is that you revise the draft report by either (1) replacing the words "Greenbrae Boardwalk" with simply "Greenbrae", or preferably (2) recognize that the houses on Lucky Drive are more similar to the houses across the water on Riviera Circle than they are to the houses on the Greenbrae Boardwalk. This would of course require significant updates to those tables with entries for "Greenbrae Boardwalk"

If you wish I would be willing to identify by page number what I consider to be misleading information in the draft report concerning the unincorporated area of Greenbrae.

I noted that the 36" impact of the 100-year storm on the sea water elevation is the same number that FEMA used for the height of 'storm waves' in Sausalito, Belvedere, and Tiburon in the recently updated FIRM maps. Areas protected from storm waves, e.g. Ross Valley west of Highway 101 would not be subject to the same impact as areas east of Highway 101 (e.g. the Greenbrae Boardwalk). Does your analysis recognize this?

Other sections of the report when describing areas with flood gates, e.g. Bel Marin Keys, stated that the analysis was based on the water elevations when the flood gates were "open". This would cause a highly misleading analysis particularly because it ignores the effect for which the flood protection measures were installed. Did I misinterpret the report in this respect?

Cheers
Peter

Peter Hogg
President

Construction Information Systems, Inc.
P.O. Box 1205
Mill Valley, CA 94942

Email: system2020@msn.com

Telephone: 415-785-7926

From: Arlene.F@Yahoo.com
To: Choo, Chris
Subject: Hillview, Larkspur Comment re. SLR Vulnerability Assessment Public Draft Report
Date: Saturday, April 29, 2017 8:10:07 AM

Hello Chris,

In the Larkspur Community Profile section of The Sea Level Rise Vulnerability Assessment Public Review Draft Report, the SLR / Storm Surge map (Map 86) incorrectly shows that the Hillview neighborhood west of BonAir Bridge is shaded in blue which denotes only being affected by a 60" SLR + 100 yr. storm surge. This is incorrect as many residents are currently being flooded by king tides / storm events. Many residents also are required to carry flood insurance *now*. Please compare results against FEMA flood maps and groundtruthing in the area.

Photo: Cornell Avenue, Larkspur during a 2016-2017 winter storm

As Map 86 is revised, the statistics in the chart above it and elsewhere in the report will have to be revised to correctly show the number of residential homes affected.

Please note there are flood mitigation projects being evaluated in the area. But, until such drainage projects & possible pump station are *actually* completed (which may be years down the road, if at all if there is

insufficient funding), the report should show this area very vulnerable. Even if such projects are completed, the nearby levees still need to be raised and improved to protect our area from rising tides and seas. We need to be on the radar so we get funding for levees, etc.

Thank you.
Arlene Fox

---

http://www.marincounty.org/main/baywave/vulnerability-assessment

From: AileneF@Yahoo.com
To: Chao, Chris
Subject: Re: Additional Hillview, Larkspur Comments re. SLR Vulnerability Assessment Public Draft Report
Date: Wednesday, May 10, 2017 5:41:37 PM

All comments below refer to the Draft Larkspur Community Profile of Marin Shoreline Sea Level Rise Vulnerabilty Assessment Report.

Page 242 & 245:
Reference to Heatherwood neighborhood should be replaced with Heather Gardens.

Page 247 / Map 87
Item 2 is incorrectly called Creekside Neighborhood. It's Hillview.

Page 248 Transportation Section & elsewhere
I suggest you include flooding impacts on Bon Air Rd. which serves as a major artery to Marin General Hospital and medical offices on South Eliseo. During January 2017 storm, Bon Air Rd. near Bon Air Bridge was covered with ~1.5 feet of water.

Page 248:
Incomplete sentence in third paragraph discussing affected transit routes.

Bullet items which follow, include Bon Air Rd.

Page 251:
In Emergency Services section, CMPD also serves San Anselmo.

In Cultural Resources section, "home" should be "homes".

APPENDIX B

From: Erik Brown
To: VanBelleghem, Bridgit
Cc: Choo, Chris
Subject: RE: REMINDER: Marin Sea Level Rise Public Meeting Tomorrow!
Date: Monday, May 15, 2017 4:47:39 PM
Attachments: 02_AssetProfiles_BuWAVE_VA_17_02_20_NSD Comments.pdf

Thanks Bridgit. I have a proposed markup (attached) that I believe will answer your questions. Please let me know if you have any questions.

Thanks,
Erik

From: VanBelleghem, Bridgit [mailto:BVanBelleghem@marincounty.org]
Sent: Monday, May 15, 2017 11:54 AM
To: Erik Brown
Cc: Choo, Chris
Subject: RE: REMINDER: Marin Sea Level Rise Public Meeting Tomorrow!

Hi Erik:

I looked back and it seems I missed the pump station edit. I'll fix that.

The reclamation lands don't seem vulnerable if they are designed to be "sacrificed," unless the district would need to locate alternative lands. Would that be the case?

As for the initial comments on elevation, I recall your expert concluding that the assessment is accurate. Do you still have the emails of record?

Thank you,
Bridgit

From: Erik Brown [mailto:erikb@novatosan.com]
Sent: Tuesday, May 02, 2017 7:58 AM
To: Gurley, Margaret
Cc: Choo, Chris
Subject: RE: REMINDER: Marin Sea Level Rise Public Meeting Tomorrow!

Hi Margaret,

There are still a number of inaccuracies regarding the Novato Sanitary Districts facilities in the report. We have provided previous comments, but not all have been addressed. Will there still be an opportunity to provide comments?

Thanks,
Erik

APPENDIX B

UTILITIES

Novato Sanitary District

The Novato Sanitary District Treatment plant is vulnerable just before 3 feet of sea level rise. By scenario 5, the lower half of the plant is covered by tidal waters. Storm conditions may impact the plant sooner. Much like SASM, the first buildings to be vulnerable are the shops and garages. However, the over flow basins are impacted early on. Next to be impacted are the UV Disinfection and Final Effluent Processing buildings. By 5 feet of sea level rise, tides reach the anaerobic digestion and clarification tanks. Adding a storm surge could also flood around the ~~primary and~~ secondary clarifiers altogether. The water will not likely be high enough to impact the process, however, electrical components may be lower and saltwater corrosion of the tanks and buildings could take a toll. The lower half of the plant is bordered by a concrete retaining wall and berm that protect against flood waters. The wall and berm can be extended vertically to provide protection from sea level rise. A 4-foot vertical addition to the wall and a 1 foot addition to the berm would protect against scenario 6.

The district also has some facilities in Bel Marin Keys that are transitioning to submersible machines, and others at Gnoss Field Airport that could be vulnerable to higher tides. However, the more submersed they are, the faster wear and tear could damage the machine.

On-site Waste Water Treatment (OWTS)

The only community in the study area using OWTSs is Black Point. However, many of the built areas of these properties are at higher elevations and may be free from impacts from sea level rise. In the worst case, sea level rise could alter soil permeability and chemistry in the disposal field. If water levels are high and sustaining enough, effluent from the disposal field could contaminate the estuary waters. Even new shallow or above ground systems, with high water level kill switches, could be impacted by flood waters and affected by power outages. Erosion could also reduce land area available for percolation. Finally, if ground water rises under septic tanks it could have enough pressure to cause tanks to pop out of the ground.

These systems are privately managed by the land owner and regulated by Marin County and the Regional Water Quality Control Board. Septic systems in are regulated by the Marin Countywide Plan (CWP), the Marin County Development Code, and the State Water Control Board's Onsite Wastewater Treatment Systems Policy. More information on regulations can be found at http://www.marincounty.org/depts/cd/divisions/environmental-health-services/septic-systems.

Table 37: OWTS System Vulnerabilities

Land Area	• Erosion can reduce the land area available to percolate waste. Saltwater intrusion into the leach field could impact percolation rates and reduce useable area.
Materials/ Models	• Older single field gravity systems are more susceptible to storm flooding than modern systems equipped with "flip" switches that turn off percolation when groundwater elevates too high. • Newer systems are vulnerable to power outages.

Source: Marin County Environmental Health and Safety

Comment [EB1]: We don't have any shops or garages at the lower end of the plant. Confusing us with the City's Corp Yard?

Comment [EB2]: All pump stations at BMK are submersible type, not transitioning.

Comment [EB3]: NSD does not have any facilities at Gnoss Field. Our northernmost facility on the east side of 101 is a gravity line that ends at the end of the cul-de-sac of Rush Landing Court.

Comment [EB4]: Suggest striking this paragraph altogether. The statement regarding submersible pumps is inaccurate. The submersible pumps are located in a wetwell (basically a deep vault) that is water tight (no groundwater infiltration). These pump stations are less susceptible than the old style wet well/dry well pump stations because the electrical components are all above ground. A vulnerability could exist if brackish water infiltrates the gravity sewer lines that drain into these pump stations. However, it is unclear from this report if that is a real possibility.

DRAFT - CONFIDENTIAL

APPENDIX B

From: Hannah Doress
To: Choo, Chris
Cc: Terrie Green; Douglas Mundo
Subject: Shore Up Marin input on Vulnerability Assessment
Date: Wednesday, May 17, 2017 12:13:39 PM

Dear Chris,
Thank you for your hard work leading up the BayWave Vulnerability Assessment. As I said at the Mill Valley public meeting, we want to commend this important effort that is vital to moving all of us closer to solutions for these pressing problems. In particular we would like to commend the thoroughness of the report, especially compared to other counties choosing more of an asset estimate approach. We deeply appreciated that you interviewed Douglas Mundo and Terrie Green for the report and the care you took to analyze the social equity implications of each class of assets and vulnerabilities. We hope there will be future opportunities where you can present results of the assessment in more detail to community members and stakeholders. We appreciate and look forward to continuing our ongoing collaboration with you.

Following is input from Shore Up Marin that we hope you can incorporate into the report:

Feedback on Executive Summary (HD notes in bold)

Eight miles of road could expect tidal flooding. Many of these flooded areas already experience seasonal and king tide flooding. These are:
- Manzanita, Almonte
- Miller Avenue in Mill Valley,
- the Marinship area in Sausalito,
- US Highway 101, Corte Madera, Larkspur, and
- State Route 37 in Novato.
- **Please add "Marin City / 101 southbound lanes"**

Include More on Marin City - note the pipes and flooding impacts of SLR say that's not in the scope of the tools and study but it is critical to access additional flooding and complimentary data to consider with the vulnerability assessment in adaptation planning.

This is expected to worsen in severity and become increasingly frequent. Tidal flooding would reach the Canal area of San Rafael, spreading to I-580. Several roads in Santa Venetia, Tamalpais, Belvedere, Mill Valley, Marin Lagoon of San Rafael, and bayfront Corte Madera and Larkspur would begin to experience seasonal, king tide, and storm surge flooding more frequently. **Include Marin City / 101 South here.**

....

Most concerning, however, is the potential inability of emergency professionals and vehicles to access people in or through flooded areas. **(mention Marin City)**

....

Recommendation: we recommend the County use "real world" measurement for communication with the public e.g. 1 foot 3 inches versus or in addition to 15" because of how people process information, visualize and make meaning out of measurements.

APPENDIX B

Feedback on the Vulnerability Assessment in general:

The value of assessing vulnerability is in planning to address the real world experience of community members, to prevent emergencies and protect residents and assets. This real world experience includes other factors that are influenced / made more severe by sea level rise, for example the flooding in Marin City / on 101 which is worsened by tides which block drainage. As you articulated well in the Mill Valley presentation, the limitations of sea level rise models affect all vulnerability assessment. This is why we feel it is critical to include that caveat and include a list of complementary resources and datasets which institutionalize this knowledge and how to best incorporate it in sea level rise planning within the body of the report. This safeguards against many potential challenges which include:

- Future staff changes in which unstated assumptions may not be carried forward,
- Oversimplification of the issues by less topically familiar decision-makers, stakeholders and community members,
- Lack of alignment between hazard mitigation and sea level rise adaptation, and
- Potential under-prioritizing sea level rise adaptation in areas currently most impacted by flooding.

Given that sea level has increased 8 inches over the last century and during the most recent half a century flooding has worsened, is it not logical to point the finger at sea level rise as a key factor? Climate Central cites a 2014 study showing sea level rise as a significant driver of increased flooding, "Long-term trends show that minor coastal flooding along the East, Gulf, and West Coasts occurred only about once every one to five years in the 1950s, but was occurring about once every three months by 2012" http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0170949

Given that all shoreline areas will experience below ground impacts such as more frequent blockage of drainage pipes, salinization of ground water / bay side agriculture / fresh water marshes, etc. is it not prudent to at least include those concerns and pointers to relevant data sources / best practices as a recommendation for stakeholders to consider? Should we not recommend government staff conduct additional projections to determine the vulnerability of communities when the whole water system is factored in? Here's Climate Central on sea level rise, storms, flooding, sewers, and East Oakland:
http://www.climatecentral.org/news/sea-level-rise-oakland-sewer-17567

If the twin goals of the vulnerability assessment are to 1. protect the public by encouraging stakeholders to initiate protective projects and 2. to engage community members to understand and support adaptation, we would argue that it undermines community engagement not to include the most severe current flooding that affects the most stakeholders.

We hope you will amend these concerns into the report so communities are not planning based on a world in which sea level rise proceeds independently of other inputs such as watershed flooding, pumps, and the broader water and infrastructure systems.

I hope you will recommend that each entity using the report to move forward with analyzing or implementing solutions will also include community-based knowledge of past flooding

impacts and patterns, data that is available about streams, creeks and other bodies of water, available FEMA data, and perhaps actuarial data if it is helpful. We hope the report will also include an exhortation and resources to assist readers to stay up to date with the latest mapping tools, research, data and advances in the study of sea level rise, flooding and adaptation.

Thanks again for this opportunity to provide feedback and for your hard work.

Hannah
for Shore Up Marin

Hannah Doress

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APPENDIX B

From: Judy Schriebman
To: Choo, Chris
Subject: BayWave comments
Date: Sunday, May 28, 2017 6:37:32 PM

Hi Chris,

I just went over the part of the report on sewage agencies and have the following comments. I hope to get to the rest of the report at some time!

1. Doc page 93, was LGVSD inadvertently left off the list??? Or was there a reason?
2. Page 94, first paragraph; Hatches. I don't think we use that term anywhere. Did some other district? It would be helpful to say these "hatches" are at the treatment plants. I at first thought they were referring to manhole covers; not so.
3 Page 96, LGVSD bullet points—"Main Lagoon" should be "Marin Lagoon"

That was it!

400 pages to go.... ;)

Judy

APPENDIX B

From: Jean
To: Choo, Chris
Cc: Fred Dupuis; Charlie McDonald; Kutter, Rhonda
Subject: Comments for the draft Marin Shoreline SLR Vulnerability Assessment May 29, 2017
Date: Tuesday, May 30, 2017 11:55:35 AM
Attachments: ChrisChoo SLR, GIC comments May 29, 2017.rtf

Chris,
Please see our attached comments from the Greenbrae Improvement Club for the Draft Marin Shoreline Sea Level Rise Vulnerability Assessment.
Thank you for your work, and for taking our comments. We look forward to working together on Sea Level Rise on the Adaptibability phase.

Jean

Jean Severinghaus
Greenbrae Improvement Club, Chair Environment and Planning Committee
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APPENDIX B

Dear Chris Choo,
Thank you for meeting with leadership of the Greenbrae Improvement Club (GIC) and Supervisor Rodoni on May 3rd, 2017, taking our input on the draft Marin Shoreline Sea Level Rise Vulnerability Assessment (SLR Vulnerability Study), and clarifying a number of our questions.

Fred Dupuis, GIC President, Charlie MacDonald, Executive Board Member, and Jean Severinghaus, Chair, Environment and Planning Committee appreciate your making corrections to the conclusions regarding the Greenbrae Boardwalk.

The community would like you to
a) locate our community correctly, separating out the Lucky Drive homes and the Incorporated Redwood Highway North Larkspur areas from the Greenbrae Boardwalk, and redo all the data tables to reflect the corrections so the SLR Vulnerability Study becomes comprehendible—thank you for agreeing to do that. The Greenbrae Boardwalk is 100% EAST of 101 and has 48 total homes. (Summary Page 305)

b) correct that 100% of our HOUSES (Buildings, pages 302-303) are already elevated, and are generally able to be elevated higher, so are adaptable (not as assumed p.306 on 'pylons driven deep into the mud'). The recent FEMA Flood map update names the BFE here as 10': a few homeowners are in the grant application pool to elevate their homes in response. It would be very helpful for the County to be sure the grant program gets followed thru.

c) restate the adaptability of communities residing above living salt-marshes to SLR — (see Methods, Phase 3, Adaptive Capacity p. 6)—the salt marshes adapt to daily flooding "without human intervention", so both the Larkspur Boardwalk One and the Greenbrae Boardwalk PARCELS (Parcels, page 300) vulnerability to flooding should be corrected. The parcels are adaptible. (Please correct also Summary pages 305-306). In 2015-16 El Nino, we experienced 6" to 12" of increased tide height due to the heat in the ocean, presumably a preview to that much sea level rise, now back to predicted levels. The parcels seemed to be fine and so were the homes despite several flood events.

c1) Utilities, page 322: The GB utilities have been successfully adapted to the past century of sea level rise and salt water intrusion thanks to efforts of the GIC: the gas, electric and water lines are elevated and the sewer is buried with three elevated pumps. The parking lot is raised four feet above Redwood Highway North.

c2) GB appears three times in Table 132—please correct (Page 341)

c3) Marin Park (Page 342) is in incorporated Larkspur and has 350 residents and serves as the City of Larkspur's Low Income Housing. All of the industrial businesses and mobil homes of Redwood Highway North in Larkspur are currently vulnerable to flooding, and are mainly protected by a few residents of the Greenbrae Boardwalk inflating a dam during storm events. This should be listed. This could be corrected by

raising the GB easements to stop the flooding during tidal events while allowing continued access and staging for the GB in the rest of the times. The dam does not help the GB itself in any way but is a service to the neighborhood.

c4) (Page 312) Do the FEMA damage cost estimates in Table 127 apply to the GB or to both the Lucky Drive, Redwood Hwy North and GB altogether?

c5) Page 308, please correct maps and inserts to separate out GB from Lucky Drive.

d) Please restate the science of living salt marshes with sea level rise. The SLR Vulnerability report should state that salt marshes accrete or rise vertically and adapt to SLR without human intervention. They do so by growing vegetation falling and adding to mud sediments. Storm flood events with landslides and lots of mud in the water are particularly contributory to the continued health of the salt marshes with sea level rise. The boardwalks communities' parcels of land have adapted over the last 100 years of 8" of SLR by accreting vertically (the Greenbrae Boardwalk community has been here since 1903). Aside from being visible under the historic foundations this is documented locally on the adjacent Corte Madera Ecological Reserve (CMER) by two recent US Geological Survey and SF State University mud core, elevation, and sedimentation studies. The salt marsh, if it continues to be protected from the human-caused vulnerabilities of ferry erosion and of removal of natural sediments from Corte Madera Creek and SF Bay, should continue to adapt to SLR for quite some time.

BCDC recognizes the issue of endangering the SF Bay's marshes by over-removal of sediments from the system and is looking to address it. The salt marshes need more sediments now and as sea level rises.

To this point about sediments, how can the nine planned District 9 flood detention basins on the Corte Madera Creek be constructed so as not to remove the storm sediments from the Creek which this and other SF Bay salt marshes critically need as sea level rises?

e) We could use help with study from a hydrologist of the potential vulnerability of the salt marsh to increasing tidal prism as sea level rises: there are six meanders that nourish the marsh. They appear to be deepening and widening and several small new ones are forming. Is there a vulnerability to the buildings along these six meanders and to the survival of the salt marsh with this geomorphologic change? Should they be protected? The unprotected meanders to the north across the creek by the ferry appear to be removing the entire marsh: it is expected to disappear within 20 years.

f) The marsh belonging to the CMER east along the Creek to the Bay entrance facing the ferries is unprotected and has eroded an estimated 50 feet in the past 36 years, with 6' lost in the past 5 years alone. Once the marsh is gone it's gone. The face should be protected with some kind of revetment/living shoreline now before SLR worsens the ferry impact. (25 Year Monitoring Study of the revetment shoreline protection project, GGBHTD)

g) The GGBHTD was lead agency and installed a rock revetment shoreline protection in 1989 after nine years of discussions with environmentalists, the BCDC, USACE, CMER and Boardwalk: BCDC documented 12-24 feet of loss of marsh face. The revetment was designed to break up the ferry waves and engine surges at a design height just at the mud-vegetation edge elevation. The revetment has been highly successful per the studies, both in its action as living shoreline protection, healed over by mud and vegetation, supporting the living salt marsh, and by preventing further landward loss of the half mile or so of private properties. The MHHW tidal elevation line in a recent survey approximately follows the top of the rock revetment. Now we have 3 inches of sea level rise at the Golden Gate since the revetment's installation and its design height is being overtopped. The 25 Year Study above measured elevations on transects: it showed on several transects, where the revetment had been disturbed by the Spartina Removal Project, new erosion as much as 18 feet landward. This would appear to presage a vulnerability that will soon need to be addressed; i.e. renewed ferry erosion of the boardwalk properties and the Corte Madera Ecological Reserve salt marshes behind them as sea level rise overtops the successful protection. The face of the marsh will need to be protected, possibly by simply adding six inches of rock, or another solution, protecting the parcels and the many services the salt marsh provides the larger communities.

In sum, we very much appreciated meeting with you regarding this Vulnerability Study and look forward to working together with you on sea level rise Adaptation issues.

Best wishes,

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APPENDIX B

From: Elizabeth Clark
To: Choo, Chris
Subject: Comments on Draft BayWAVE Vulnerability Study
Date: Tuesday, May 30, 2017 12:01:47 AM
Attachments: ResiliencyPlanv.EFMfinal.pdf

Dear Ms. Choo,

I've spoken to you on a couple of occasions at meetings where you presented the Draft BayWAVE Study to the public. I haven't done an exhaustive review of the study, but, as I live in Larkspur, I read the separate section pertaining to Larkspur and parts of the larger study, and would like to comment on several things I have concerns about.

I'm concerned that the BayWAVE study may have categorized our home (and those in our boardwalk community) by the same criteria by which the vast majority of homes were assessed, which would yield, in my view, an inaccurate result. Our homes, elevated on fixed piers above a tidal salt marsh, are different from conventional homes, as they are designed to accommodate natural flooding. Corte Madera Creek stormwater and Bay tidal waters flow under our homes, none of which flood. The marsh around us and our lots flood naturally, but our homes do not.

A conventional home's floor elevation might be at 9.5' and maybe a foot or so above its surrounding lot. Floor elevations of homes on Larkspur's Boardwalk One, where I live, are typically in a range above 9.5' up to maybe 12' elevation, with surrounding lot elevations of 4-8' elevation, which is comprised of tidal salt marsh habitat and sloughs/drainage channels. My concern is that the criteria used in the BayWAVE Study, that resulted in our boardwalk homes being judged as highly/immediately vulnerable, were possibly based on low marsh elevations around our homes, rather than, or averaged with, estimated elevations of the homes themselves. Our lots ***by nature and by definition*** flood; the boardwalk homes have been here for decades, DO NOT flood, because they're raised above the surrounding marsh, and can be raised higher. We live WITH floods, not in opposition to them.

I realize higher water from sea level rise and precipitation is coming, to which we will be vulnerable. However, our homes are adaptable in a way that other buildings and homes on Corte Madera Creek are not. On a map that shows future flooding, our homes and boardwalk would be islands, rather than shown as submerged. Our homes can be raised fairly inexpensively, compared to other homes/apartment buildings on the creek, or new foundations that enable flotation. Some examples of other innovative adaptations that make homes more resilient can be found on this website - https://www.niftyhomestead.com/blog/floating-homes.

Therefore, I think it's fair to ask that an explanation be included in the final study that describes the criteria that were used to assess **our boardwalk homes**. They are THAT unique, such that I don't think they should be treated or assessed in the same way as conventional buildings. If the criteria used for our home were the same as those for other/conventional homes, which I'm guessing was based on some average of the elevation of our lots and estimated floor elevations, that would not be an accurate assessment, as it makes it look like our HOMES flood, when it's the properties that flood – by definition. One could argue that Greenbrae Boardwalk homes might be treated separately from conventional homes, as well. Perhaps houseboat communities would also warrant a special set of criteria for vulnerability assessment, as well.

I feel it's important to comment about this because your document should, if it's not going to recommend any solutions, at least not discourage thinking of new solutions, by hastily condemning a unique community that happens to be very adaptable to flooding. Our boardwalk community is a potentially resilient example of coexisting WITH future flooding, rather than an example of the most vulnerable to flooding and therefore the first to be destroyed by flooding. A high vulnerability assessment designation may convey automatically that our homes, let alone the marsh habitat we live on, are not worth protecting, buying or insuring, when in actuality, they have much more value being adaptable than most nearby homes along the creek.
I'm asking you to make a note in the BayWAVE study about our community, describing that it is a community uniquely adapted to flooding, similar to a houseboat community, except our homes are fixed, above the tides, and can be raised. The marsh will always be flooded, but our homes can be adapted to rising tides.

SPECIFIC COMMENTS BY PAGE:

P. 242 – Map 86 is not interactive nor "zoomable", so one cannot see detail. I live within an area that is completely red, a 30-acre area of red – highest vulnerability. That is because it is a marsh. Marshes are vulnerable to flooding, but they also are supposed to flood by definition, and some are resilient, but some will need to be restored and adapted with human help.

p. 242 – *"Housing along Corte Madera Creek canals, sloughs, and lagoons could be vulnerable in the near- to medium-terms, this includes,* ***Boardwalk 1****, the multi-family units across the canal on Larkspur Plaza, the southern portion of the Heatherwood neighborhood, and some housing west of S. Eliseo Drive."* COMMENT: It's inaccurate to include Boardwalk One homes in the same category with conventional homes that will flood with no adaptability. Boardwalk One homes are eminently adaptable to living with floods; conventional homes/bldgs. are not.

GENERAL COMMENTS:

1. Not at all meant as criticism, but you may want to know that there are quite a few typos in the draft assessment that hopefully won't be there in the final.
2. Piper Park Marsh is not named specifically where other marshes are NAMED in the BayWAVE Study. "Piper Park" is named, and the marsh is mentioned, but not by name. The reason I mention this is because two partners and I in the Environmental Forum of Marin Master Class, are currently trying to get the City of Larkspur to take stewardship of Piper Park Marsh, which is not currently zoned as open space or marsh conservation. This effort is needed, because several times over the years, the City has tried to fill in parts of the marsh (to create a city corporation yard), and/or the Larkspur Corte Madera School District has proposed installing night lights around the sports field adjacent to the marsh. Boardwalk One residents have objected to both and other actions that compromise the marsh. The City has not assumed stewardship, nor acknowledged that it's an important asset to the City and its residents. So, calling it by name, Piper Park Marsh, in the BayWAVE study would be a helpful step toward acknowledging it as an important, known asset. My partners and I, as part of an Environmental Forum of Marin project, created the Piper Park Marsh Resiliency Proposal, attached for your perusal, which we are currently working on with the City's DPW Director, Julian Skinner, and which we will be presenting to the City Council in June.

I commend you on this very thorough and important study, and hope to hear a response to my comments. Question: is this draft study similar to an EIR, in which comments will be incorporated, as written, into the final document, or how are public comments used to improve your final document?

Thank you for your time and dedication, and hopefully in advance for a reply.

Elizabeth A. Clark

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