Transportation Authority of Marin

Sea Level Rise Adaptation Planning for Marin County's Transportation System Project

Existing Plan Review Memo

Reference: Final Draft

V1 | October 18, 2023

Job number 295823-00

Arup US, Inc.
560 Mission Street, Suite 700
San Francisco, CA 94105
USA
arup.com

ARUP

Document Verification

Project title	Sea Level Rise Adaptation Planning for Marin County's Transportation System Project
Document title	Existing Plan Review Memo
Job number	295823-00
Document ref	Final Draft
File reference	

Revision	**Date:**	**Filename**			
	18 Aug 2023	**Description** Draft of Plan Review Memo.			
			Prepared by	**Checked by**	**Approved by**
		Name	Meg Ackerson	Jack Hogan	Brooke Dubose
		Signature			
	18 Oct 2023	**Filename**			
		Description Revised draft of Plan Review Memo. Referred to as Final Draft.			
			Prepared by	**Checked by**	**Approved by**
		Name	Meg Ackerson	Jack Hogan	Jack Hogan
		Signature			
		Filename			
		Description			
			Prepared by	**Checked by**	**Approved by**
		Name			
		Signature			

Issue Document Verification with Document ✓

Contents

Appendices

Abbreviations

Abbreviation	Definition
ABAG	Association of Bay Area Governments
ABC Waters	Active, Beautiful, Clean Waters
AGOL	ArcGIS Online
ARC	Adaptation and Resilience Collaboration
ART	Adapting to Rising Tides
BARC	Bay Area Regional Collaborative
BayWAVE	Bay Waterfront Adaptation and Vulnerability Evaluation
BCDC	Bay Conservation and Development Commission
BOD	Basis of Design
CA	California
CalOES	California Office of Emergency Services
Caltrans	California Department of Transportation
CCJPA	Capital Corridor Joint Powers Authority
CMA	Congestion Management Agency
C-SMART	Collaboration: Sea level Marin Adaptation Response Team
D4	District 4 (Caltrans)
DFE	Design Flood Elevation (DFE)
ESA	Environmental Science Associates
FEMA	Federal Emergency Management Agency
FL	Florida
FME	Feature Manipulation Engine
GGBHTD	Golden Gate Bridge, Highway and Transportation District
GIS	Geographic Information System
HOV	High-occupancy vehicle
I-580	Interstate 580
LA	Louisiana
LHMP	Local Hazard Mitigation Plan
MA	Massachusetts
MCM	Marin County Multi-Jurisdictional
MTC	Metropolitan Transportation Commission
NY / NYC	New York / New York City
OBAG	One Bay Area Grant (MTC)
OLU	Operational Landscape Unit
PEL	Planning and Environmental Linkages
PM	Postmile
RFI	Request For Information
P+SET	Permaculture + Social Equity Team (Resilient by Design Bay Area Challenge)
SF	San Francisco
SFEI	San Francisco Estuary Institute
SLR	Sea level rise
SPUR	San Francisco Bay Area Planning and Urban Research Association
SR-37	State Route 37
TAM	Transportation Authority of Marin

Abbreviation	Definition
TIP	Transportation Improvement Program
TX	Texas
UK	United Kingdom
US-101	US Highway 101
USA	United States of America
VA	Virginia
VE	High-risk coastal flood zone with at least 1-in-4 chance of flooding over 30 years (FEMA)

1. Executive Summary

As the County Transportation Agency (CTA) for Marin County, TAM works closely with local jurisdictions as well as other partners in the region and state to plan, coordinate and deliver a wide range of transportation projects and programs, including sea level rise planning for the countywide transportation system. This project, the "Sea Level Rise Adaptation Planning for Marin County's Transportation System Project", will deliver an implementation plan to address sea level rise and flooding for transportation assets in the county. In the first phase of the project, a review of existing plans and GIS datasets was completed to establish a baseline dataset and understanding of relevant previous and ongoing work in the county to guide this project, inform later phases of work, and help avoid duplicating prior efforts.

1.1 Purpose

The goals of the Existing Plan Review were threefold:

1. Establish a baseline level of awareness and understanding of the breadth and depth of existing work related to sea level rise adaptation regionally and in Marin County.
   Much work has been done to understand and plan for the impact of sea level rise in the Bay Area and in Marin County. In this project and related efforts, it is critical to avoid, to the extent possible, duplication of previous work. Reviewing prior work also allows TAM and its project team to develop an up-to-date familiarity with studies completed by local and regional partners to benefit collaboration.

2. Create a shortlist of potentially viable sea level rise adaptation strategies that are compatible with the Marin context and pre-identify (i.e., before GIS analysis) known vulnerability "hotspots" from prior works; accomplish this through broad review of:
   - Existing or planned projects in Marin
   - Vulnerable sites / areas in Marin (as identified from previous studies)
   - Adaptation strategies from national/international precedents

   The focus on projects, vulnerable areas, and precedent strategies prepares the team for later tasks of this project, in which concept-level adaptation measures will be identified for potential implementation in the county.

3. Develop a GIS geodatabase from prior efforts to be used in this project and held by TAM for future planning efforts.
   As a companion deliverable of this Existing Plan Review, a geospatial inventory of assets and projects has been provided to TAM in the form of a geodatabase. This baseline GIS dataset builds the foundation for the first technical task of this project, in which vulnerable assets and locations will be identified from the dataset.

1.2 Approach

The approach to this work followed these steps.

- **Request for Information (RFI):** Relevant data, plans, and studies were identified by name. The list was shared with TAM and was used in collecting documents from local and regional partners.
- **Existing Plan Inventory Review**: The collected data, plans, and studies were then reviewed for the following information:
  - Near and long-term solutions developed from previous work
  - Critical assets and communities identified by previous work

- **Precedents Review:** A high-level review of national and global precedents was undertaken to obtain examples of strategies potentially relevant to the Marin context.
- **Baseline GIS Dataset:** Geospatial information was collected through TAM and public sources online; this data was cleaned and added to a project database.
- **Existing Plan Review Memo:** The preceding work was summarized in this memo.

1.3 Outcomes

The five outcomes of this plan review set the foundation for upcoming work in this project.

1. **Existing Plan Review Memo**: Synthesis of plans, projects, and studies conducted in Marin or relevant to the county. This document summarized previously completed work to build project understanding.
2. **Shortlist of Adaptation Strategies**: Categorized as near- or long-term, this list of strategies is a starting toolkit for measures to consider in Marin.
3. **Pre-identified Critical Assets and Communities**: Cataloging vulnerable communities and transportation assets previously identified informs TAM where ongoing or completed work has been directed.
4. **National and International Precedents**: Examples of other regions globally, and the strategies they have implemented helps inform the project team about what could be possible in Marin.
5. **GIS Geodatabase and Inventory**: Geospatial data is critical to seeing where projects and studies have occurred, where vulnerable communities are located, and where SLR will reach in the future.

2. Plans and Studies

The documents reviewed were developed by local and regional bodies and include plans, studies, and projects with a bias towards transportation. These documents were examined for information about SLR vulnerability and adaptation in Marin County. The list has been summarized by scale: Regional, County, and Community/Project.

Given that local knowledge cannot be fully absorbed from a plan review, this exercise aimed to capture the landscape of SLR adaptation projects and planning at the regional, county and sub-county levels. More detail will be woven into this study through the engagement process with the Technical Advisory Committee and the Focus Groups.

2.1 Regional, County, and Community/Project Review

Table 1: Plans, studies, and project reports reviewed at the regional level, covering the San Francisco Bay Area.

Regional
• Adapting to Rising Tides (ART) Bay Area (BCDC, 2020) • BARC Raising the Bar on Regional Resilience (BARC, 2018) • BARC Shared Workplan for Regional Climate Adaptation (BARC, 2022) • Bay Adapt Joint Platform Regional Strategy for a Rising Bay Implementation Brief (BCDC, 2021) • CalOES California Adaptation Planning Guide (CalOES, 2020) • Caltrans District 4 Climate Change Vulnerability Assessment (Caltrans, 2019) • Capital Corridor Joint Powers Authority SLR Vulnerability Assessment (CCJPA, 2014) • Plan Bay Area 2050 (MTC/ABAG, 2021) • San Francisco Bay Shoreline Adaptation Atlas (SFEI/SPUR, 2019)

Takeaways relevant to Marin from the review of regional documents include:

1. There is significant agreement on where SLR impacts will occur, but there is low agreement on when impacts will occur and specifically what tipping points may exist. There are several projection timelines used with specific SLR levels which differ by climate scenario. For implementing SLR adaptation projects in Marin, it would be important to have consistency in the defined projection scenarios for practitioners to use for specific applications (e.g., transportation infrastructure planning).
2. Significant effort has gone into evaluating transportation assets in the Bay Area and their exposure to SLR. Examples include the vulnerability assessments by Caltrans and by Capital Corridor Joint Powers Authority. In Marin, this previous work provides a solid foundation upon which to build the present study. Identifying tipping points is one area of potential improvement.
3. Much of the Bay Area's critical transportation assets are located along the bay and ocean coast, particularly in Marin. This means that transportation assets, and the network more broadly, is highly vulnerable to SLR based on elevation and a lack of regional shoreline flood defense infrastructure, as identified and discussed in these regional documents.
4. Adaptation cost estimates are significant. For Marin, the total cost of protecting against two feet (2') of SLR is estimated to be $1.75B according to Plan Bay Area 2050. Regional documents acknowledge that

there is a major gap in funding between what is needed and what is potentially available from existing sources.

5. A focus on the transportation system can be an effective strategy at moving the needle on SLR adaptation. More funding has become available to address coastal resilience and transportation needs, including the state level Caltrans SB1 grants and the PROTECT program at the federal level.

Table 2: Plans, studies, and project reports reviewed at the county and community levels.

County
• Marin County Multi-Jurisdictional Local Hazard Mitigation Plan (MCM LHMP) • Marin Ocean Coast Sea Level Rise Adaptation Report (C-SMART, 2018) • Marin Ocean Coast SLR Vulnerability Assessment (C-SMART, 2016) • Marin Shoreline Sea Level Rise Vulnerability Assessment (BayWAVE, 2017) • Safety Element Update to the Countywide Plan Draft (Marin County, 2023)
Community/Project
• ART Richardson Local Assessment (BCDC, 2020) • ART San Rafael Local Assessment (BCDC, 2020) • Corte Madera Climate Adaptation Assessment (Town of Corte Madera, 2021) • Corte Madera Creek Flood Risk Management Project – Phase 1 Components (2020) • Lower Corte Madera Creek Improvement Study (2020) • Marin City Pond Flood Reduction Project – Drainage Study (2018) • Miller Avenue Streetscape Project (2017) • Mill Valley Flood Management and Drainage Master Plan (2021) • Resilient by Design Bay Area Challenge The People's Plan by Permaculture + Social Equity Team (P+SET, 2018) • Santa Venetia Floodwall Basis of Design and Project Alternatives (2023) • Sausalito General Plan (City of Sausalito, 2021) • Shallow Groundwater Response to Sea Level Rise (2022) • State Route 37 Corridor Planning and Environmental Linkages Study (SR 37 PEL Study) Draft (Caltrans, 2022) • Stinson Adaptation and Resilience Collaboration (Stinson ARC, 2022) • Stinson Beach Nature-based Adaptation Study (Coastal Conservancy/ County of Marin/ESA, 2021) • TAM Annual Report 2022 (TAM, 2022) • Tomales Bay Bulkhead Vulnerability Assessment Marin County, California (County CDA, 2022) • Tomales Bay Living Shorelines Feasibility Project (ESA, 2022)

Takeaways relevant to Marin from review of local reports, biased towards transportation, include:

1. Much effort has been spent to study and identify the exposed assets and communities in the county, and there is considerable consensus on vulnerable areas in the county, such as US101/580 interchange, State Route 37, Highway 1, and the Manzanita Park & Ride.
2. Strong interest exists for adaptation solutions that complement or enhance the natural environment, such as the Living Shorelines study in Tomales Bay, dune restoration study in Stinson Beach, and permaculture concepts in Resilient by Design project The Peoples Plan. These proposals align with the high value placed on nature and open space areas by Marin residents and political leaders. A robust discussion of tradeoffs is still needed to better understand the limitations of nature-based solutions and the effectiveness of these strategies compared to others.
3. Larger-scale flood and SLR adaptation work crosses jurisdictional boundaries which complicates implementation and calls for the county to play a key role in helping guide or facilitate action. Understanding the work completed or planned to date, and the near- and long-term needs, will support decision-making at the county level to implement appropriate adaptation solutions.
4. Still needed is a shortlist of potential project types and locations, a further understanding of processes and program cycles that agencies are obligated to follow, and crucial potential implementation roadblocks. These are all focus areas for TAM sea level rise planning.

2.2 Critical Vulnerable Assets

Appendix A.2 provides an overview of critical vulnerable assets and communities in Marin County. Assets and communities are categorized by City, Town, and Unincorporated Marin County. Below is a summary of high-level considerations for each jurisdiction in Marin County with respect to sea level rise.

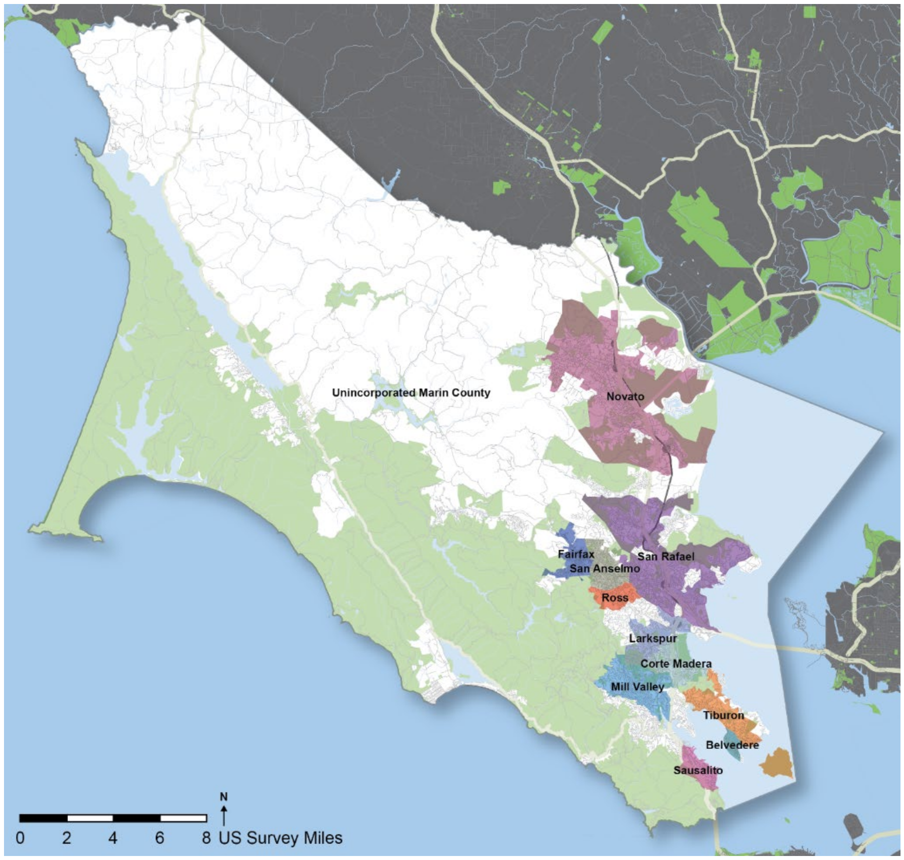

Figure 1: Incorporated Cities, Towns, and Unincorporated Marin County

Belvedere

The City of Belvedere is located in southeastern Marin County on San Francisco Bay (and offshoot Richardson Bay) and includes Belvedere Island, Belvedere Lagoon, and Corinthian Island. Access to Belvedere is dependent on low-lying roads exposed to inundation under future SLR conditions.

Corte Madera

The Town of Corte Madera is located on San Francisco Bay in central Marin County, along the US-101 Corridor on the San Francisco Bay. Approximately 10,000 people live in this low-lying coastal town. Historically, much of this area was marshland, which leaves most lower elevation residential and commercial areas in the Town vulnerable to coastal flooding. Key roadways have been identified in regional documents as vulnerable to flooding, like Lucky Drive and the US-101 corridor through downtown.

Fairfax

The Town of Fairfax sits over 100ft above sea level in inland Marin. Residents rely on the road network to access other communities in Marin and the greater Bay Area. Though none of the infrastructure in the town is exposed to coastal hazards, the essential roadways that connect Fairfax to the region may be impacted by sea level rise. Additionally, Fairfax Creek, San Anselmo Creek, and their tributaries run through the town, which may expose the town to riverine flooding.

Larkspur

The City of Larkspur, located in central Marin, encompasses Corte Madera Creek and touches San Francisco Bay, exposing it to coastal and riverine flood hazards. The Larkspur Ferry Terminal connects the area to San Francisco via ferry while US-101, which runs through the city, provides vital connection to other communities in Marin and the Bay Area. Roadways in Larkspur also provide vital connectivity to Marin General Hospital.

Mill Valley

The City of Mill Valley touches Richardson Bay, part of San Francisco Bay, and extends upland towards Mount Tamalpais. The coastal areas of the city include Bothin Marsh, contain transit centers, commercial districts, and residences, among other assets and services. Onramps to US-101 corridor and key ingress/egress routes are vulnerable to flooding and SLR due to elevation, existing drainage capacity, and proximity to creeks and Richardson Bay.

Novato

The northernmost city in Marin, Novato sits on San Pablo Bay, part of San Francisco Bay. The city includes wetland areas and Novato Creek, which runs through the main commercial district. SR-37 and US-101 meet in the city. This interchange has been identified as a critical transportation asset vulnerable to sea level rise from previous studies, discussed in Appendix A.2.

Ross

The town of Ross is a small, inland community of roughly 2,000 residents. It is located along the Corte Madera Creek, upstream of Larkspur. It is connected to nearby communities via Sir Francis Drake Boulevard, a major corridor that connects to US-101. Though none of the infrastructure in Ross is directly exposed to coastal hazards, the tidal influence from the San Francisco Bay is expected to extend upstream in Corte Madera Creek as a result of future sea level rise which could worsen the existing riverine flood issues along this creek during future extreme rainfall and high tide events. The essential roadways that connect Ross to the region may also be impacted by sea level rise.

San Anselmo

The Town of San Anselmo sits about 50ft above sea level in inland Marin. Residents rely on the road network to access other communities in Marin and the greater Bay Area. Though none of the infrastructure in the town is exposed to coastal hazards, the essential roadways that connect San Anselmo to the region may also be impacted by sea level rise. San Anselmo Creek and its tributaries run through the town, which expose the town to riverine flooding. The tidal influence from the San Francisco Bay is expected to extend upstream in Corte Madera Creek as a result of future sea level rise which could worsen the existing riverine flood issues in San Anselmo during future extreme rainfall and high tide events.

San Rafael

The City of San Rafael is situated on San Rafael Bay, part of the San Francisco Bay. Approximately 60,000 people reside in the city, which contains wetlands and rivers (Gallinas Creek, South Fork Gallinas Creek, and San Rafael Creek) that border or cross important infrastructure. US-101 and I-580 converge in San Rafael, and this interchange has been identified as a critical asset in previous studies (discussed in Appendix A.2) due to it being a low-lying asset susceptible to flooding and a key connection point for regional traffic.

Sausalito

The City of Sausalito is located along the coastline of San Francisco Bay into Richardson Bay in southern Marin. The Sausalito Ferry Terminal and the main downtown ingress/egress route to downtown, Bridgeway, are key infrastructure assets that connect the city to the region and are vulnerable to SLR. US-101 forms the western border of Sausalito, bypassing the downtown area, but onramps and offramps to the highway may be vulnerable to flooding due to elevation, existing drainage infrastructure, creek crossings, and proximity to Richardson Bay.

Tiburon

The Town of Tiburon comprises a peninsula that extends from main Marin into the San Francisco Bay. Tiburon Boulevard (CA-131), which connects the town (and adjacent Belvedere) to the mainland, is a key transportation asset exposed to coastal hazards like sea level rise.

Unincorporated Communities

Unincorporated communities in the County of Marin include Greenbrae, Kentfield, Marin City, Bolinas, Dillon Beach, Forest Knolls, Inverness, Lagunitas, Marshall, Nicasio, Olema, Point Reyes, San Geronimo, Stinson Beach, and Tomales.[1] Many of these communities are connected via vulnerable roadways, like SR-37, Shoreline Highway (SR-1), Lucky Drive, Sir Francis Drake Boulevard (Inverness), US-101, and Donahue Street (Marin City) as key examples. See the following figure for network link volumes in the county for a typical weekday, noting significant number of trips that pass through the eastern half of Marin.

[1] Marin Communities - County of Marin (marincounty.org)

3. National and Global Adaptation Precedents

This high-level review of national and global SLR adaptation precedents aimed to identify areas outside of the county that have implemented strategies relevant to the Project. The goal was to identify additional adaptation solutions that might be compatible with the Marin context despite not being included in existing plans or studies present in the region. Their strategies have been grouped by theme in this section.

The areas evaluated included coastal cities in the USA with bays and estuaries, like New York City, New Orleans, and Boston, and international cities that have implemented unique solutions to address SLR, including Singapore, Hamburg, Rotterdam, and the United Kingdom. The locations and the plans reviewed can be found in the following table, along with a description of governance structures that support implementation of the plans.

Table 3: National and global precedents reviewed for this project.

City / Region	Plans Reviewed	Governance Structures
Singapore, Singapore	ABC Waters	The Public Utility Board developed references for developers and professionals on how to implement resilience solutions.[2]
Hamburg, Germany	Hamburg HafenCity Master Plan	A private company that is a subsidiary wholly owned by the city oversees development.
North Atlantic (USA) -Boston, MA -New York City, NY -Norfolk, VA	Climate Ready Boston (2016) Boston Coastal Flood Resilience Design Guidelines NYC Climate Resilience Design Guidelines North Atlantic Coast Comprehensive Study Report Norfolk Coastal Storm Risk Management	- Climate Ready Boston was an initiative led by the City of Boston Planning Department. They developed Coastal Flood Resilience Design Guidelines and recommended that the City of Boston implement initiatives. - New York City Council passed Local Law 41 requiring public projects to follow the established guidelines.[3] - Collaboration between the City of Norfolk and the USACE identified vulnerable assets and the City of Norfolk undertook planning and implementation of strategies.
South Atlantic / Gulf of Mexico (USA) -Miami Beach, FL -New Orleans, LA	Resilient 305 – Greater Miami & The Beaches (2010) New Orleans Masterplan (2018)	- Greater Miami & the Beaches is a partnership of Miami-Dade County, the City of Miami, and the City of Miami Beach. Resilient 305 prioritizes intergovernmental and community collaboration to achieve shared goals.

[2] https://www.pub.gov.sg/abcwaters/designguidelines

[3] https://climate.cityofnewyork.us/initiatives/climate-resiliency-design-guidelines/

		- New Orleans's Masterplan is a planning and policy document for the use of elected officials who will adopt it and fund its implementation.
Rotterdam, Netherlands	Rotterdam Masterplan (2019)	Planning document by the city to align development with vision.
United Kingdom	Managing the Coast in a Changing Climate	An independent climate change committee published the document to provide guidance to communities facing sea level rise challenges.

Figure 2: Map showing areas explored for national and international case studies with strong SLR adaptation strategies.

These regions have implemented overlapping strategies, which have been collected into the following themes.

3.1 Short-Term Safety Procedures

Cities can implement near-term safety solutions while long-term projects are identified and developed. As one example, in Hamburg, evacuation routes are posted and prioritized in coastal areas as road elevation (a long-term solution) is planned. Communication modes, incident management, and response measures would need to be evaluated and developed (perhaps coordinated with local emergency responders), but they can be implemented in shorter timelines than SLR adaptation projects.

The United Kingdom (UK National Flood and Coastal Erosion Program, 2018) has partnered with Google to alert people of flooding. Flood warnings now appear on Google Search and through Google Maps with live alerts becoming visible seconds after they have been issued. The warnings include vital information on steps people can take to keep themselves and their property safe when flooding is expected.

Safety measures may be a compelling immediate measure for Marin to prioritize road elevation projects and prevent traffic delays, miscommunication, and potential loss of life during flood events.

3.2 Coastal Zoning Ordinances

Zoning can be a powerful tool to manage and guide SLR adaptation. Coastal Zoning Ordinances, such as limiting the areas of development or requiring flood protection measures, have been implemented in various places globally.

In Hamburg, Germany, building development has been restricted within 66ft (20m) of the water. The shoreline area has been zoned as public open space and moves the city closer to its goal of having interconnected green spaces throughout its jurisdiction. Restricting development at the waterfront can be a compelling strategy for areas of high vulnerability while allowing the potential addition of public spaces or new transportation corridors such as bike trails.

In Singapore, minimum crest levels for certain properties may be 5 feet or more above adjacent street levels. Designs require sizing setback distances as well as ramps, stairs, and landscaping to enhance this feature of the property and benefit the public realm. Additionally, new developments are permitted to consider deployable flood barriers only when elevating the building platform is cost prohibitive or otherwise infeasible. Barriers can be static like concrete walls or deployable like gates. In applications of this strategy, new buildings see reduced flood risk while surface streets are temporarily left at existing elevations.

3.3 Living Shorelines

Living shorelines rely on natural features, like vegetated marshes and dunes, to address coastal erosion. This approach differs from traditional grey infrastructure strategies, like concrete seawalls, by working with the natural environment and depending on local ecosystem functions to prevent erosion.

In 2006, Singapore set an ambitious goal to become the City of Gardens and Water and launched its Active, Beautiful, Clean Waters (ABC Waters) program. Through ABC Waters, Singapore seeks to provide a "transition zone" between public waterways and amenities. The following figure shows a cross-section of this transition zone, which gently slopes upward away from the water and contains significant vegetation and public walkways before reaching city infrastructure and buildings. The transition zone includes a deep landscape setback that provide enough horizontal space for gradual slope up to building entry with amenities including plantings, walking paths, seating, and other amenities. Planters with integrated seating soften the transition between elevated hardscape and vegetated public areas along the shoreline.

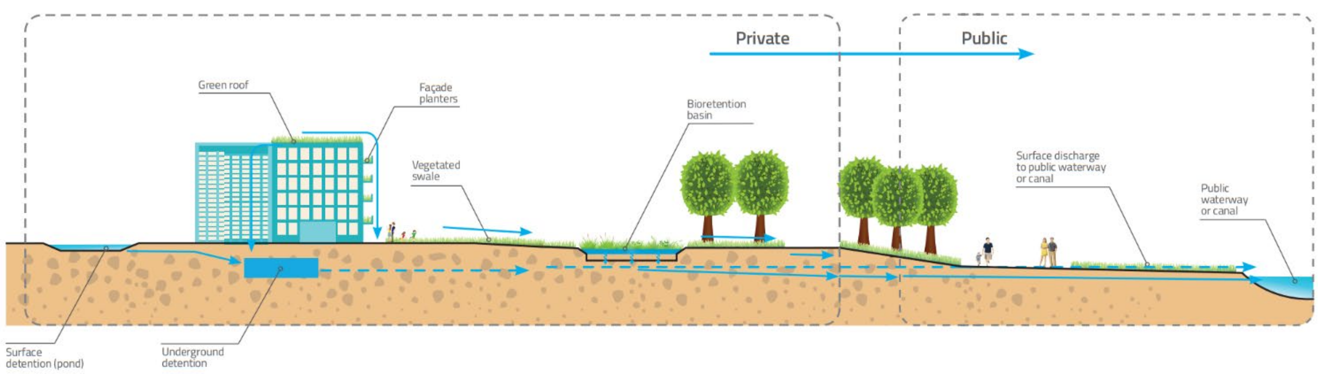

Figure 3: Strategies implemented as part of Singapore's ABC Waters program.

In Miami Beach, FL, high groundwater and saltwater intrusion affect what vegetation can be planted along the shoreline and throughout the city. Outdoor spaces are required to have flood-resistant, saltwater-tolerant species. This requirement enhances resilience to both coastal and stormwater flooding. Trees with high evapotranspiration rates also help mitigate extreme heat events.

Another living shoreline strategy is called managed realignment, which has the goal to set back the shoreline and restore coastal environments. This strategy usually involves (1) removing or deliberately breaching flood defenses to allow flooding up to higher ground or create a new defense line or (2) realigning coastal cliff frontages to allow cliff erosion. It has advantages in removing long-term financial commitments to maintain defenses and in restoring natural environments and processes. Managed realignment can create new habitat area that acts as a natural buffer to coastal waves and is much cheaper to maintain over the long-term. This was applied to the Twitchell Marsh area in the UK by creating a breach in the sea wall to connect existing salt marsh creeks. Seawater was able to enter the brackish marsh and flood it with the tide, turning it into a tidal salt marsh. This new habitat, along with new associated mudflats, is attractive to many coastal bird species, and it also serves as a better natural defense against coastal erosion when combined with the sea wall (Managing the Coast in a Changing Climate, 2018).

3.4 Hybrid Elevate-in-Place and Retreat

In Germany, the HafenCity neighborhood within the city of Hamburg has begun making its climate-ready vision a reality from its 2000 Masterplan. Similar to Marin, the area is connected to the surrounding region via bridges, an established road network, and public transportation (including regional rail and buses). Areas of HafenCity are already subject to regular flooding, particularly along the canals.

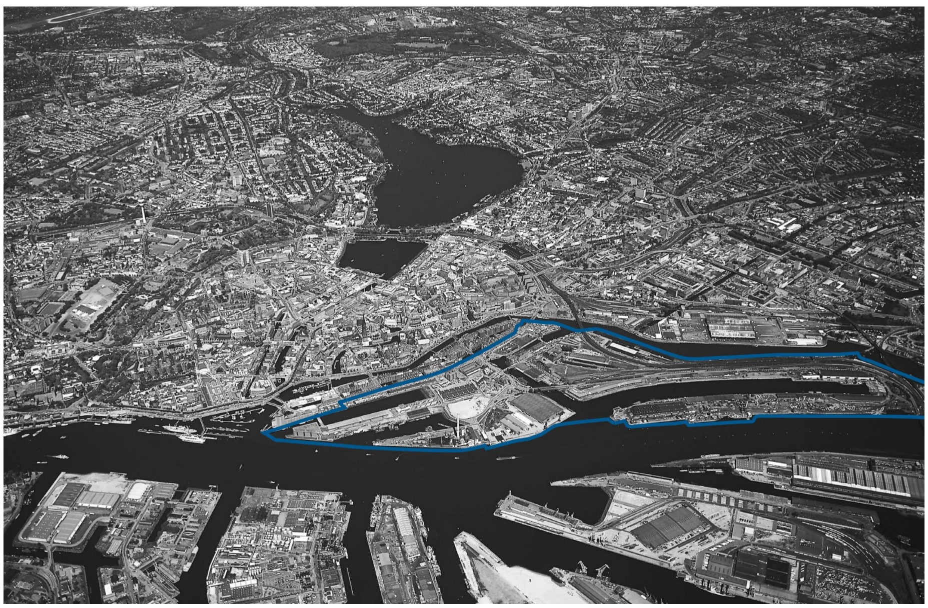

Figure 4: HafenCity area along Elbe River (HafenCity Masterplan).

Hamburg is Europe’s largest inner-city urban development area and is seen as a blueprint for the new European city on the waterfront. Due to the dynamic interplay of the water and buildings, Hamburg has identified an innovative set of practices including the use of ground floors in buildings as flood barriers.

Strategies include elevating new structures, including buildings, 25ft (7.6m) above ground (which is the expected storm surge elevation under future SLR levels), constructing elevated roadways to ensure access for emergency services during high tides or storm events, and hardening existing assets to prevent potential damage from future storm surges under higher sea levels. A setback of 66ft (20m) from the water edge has created public open space along the water and interconnected green spaces.

Figure 5: View of development happening in HafenCity. Note elevation of area above water level (Miguel Ferraz, hafencity.com).

The development of the area has been managed by a port and location development company called HafenCity Hamburg GmbH, a wholly owned subsidiary of Hamburg ("Free and Hanseatic City of Hamburg"). Its supervisory board is comprised of city officials, who oversee the development of HafenCity. As described on HafenCity's website[4],

> By concentrating non-official functions in a dedicated development company of its own, Hamburg can ensure the integrated planning and realization of the district and the efficiency and quality of the urban development project. It also creates the conditions for a strong focus on innovation while guaranteeing a high degree of public accountability.

3.5 Sponge Cities

Resilience-focused stormwater management is referenced in guidelines for many cities. The goal of stormwater management with an emphasis on resilience is to absorb runoff and allow water to circulate as naturally as possible to prevent or significantly reduce overland flooding. Several strategies focus on buildings, which might be appropriate for transportation-affiliated buildings, such as maintenance facilities or transit stops.

Copenhagen's Cloudburst program shows how beneficial it can be to prioritize rainwater capture. To address runoff during short storm events (i.e., cloudburst), adaptation strategies include designing blue/green roofs and other appropriate landscape elements to maximize onsite rainwater capture and reuse.

In Rotterdam, green roofs help absorb rainfall and reduce heat stress on the city. Rotterdam also serves as a prominent example for utilizing public spaces as water storage basins during extreme rainfall. The "Water Square" in Benthemplein holds three large rainwater collection ponds which, when the weather is dry, can be used as amphitheaters, basketball and volleyball courts, or skateboarding rinks.

[4] HafenCity Hamburg GmbH - Hafencity

Figure 6: Submerged features in the public square can act as stormwater retention basins during flood events.

Singapore's ABC Waters program has implemented many Sponge City concepts through their stormwater management practices. The program aims to reduce stormwater flooding and filter runoff before it enters Singapore's waterways. Rain gardens (bioretention basins), vegetated swales, and sedimentation basins help collect rainwater, slow runoff, and filter the water.

Figure 7: Natural drainage basins in Sg Ulu Pandan (left) and Kallang River at Potong Pasir (right) (ABC Waters).

An example strategy for roads is shown below, in which water collected from roads moves through green and blue features into the stormwater drainage pipes. The dual action of collecting excess flow and slowing runoff into the stormwater system help reduce flooding and prevent overwhelm of the drainage system.

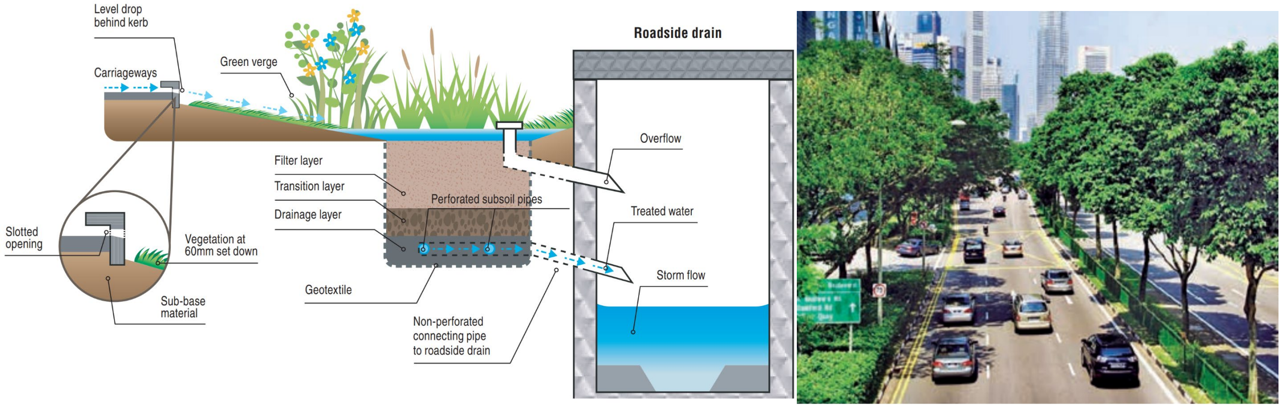

Figure 8: Bioretention system that slows runoff from roads, depicted schematically (left) and along expressway (right) (ABC Waters).

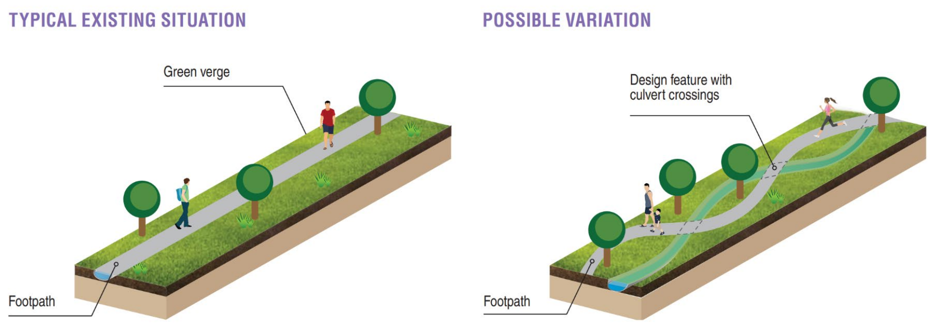

Figure 9: Strategy for incorporating water features along pedestrian walkways proposed by Singapore's ABC Waters.

3.6 Hold the Line

Some regions have employed protective strategies, like hardening buildings and armoring their coastlines, to prevent water from reaching their people and buildings. In conjunction with the other overarching themes described in this section, holding the line can be a viable option for areas of Marin County. These types of strategies have even been proposed for Corte Madera OLU and Novato OLU in the Marin County SLR Adaptation Framework report.

In New Orleans, LA, an extensive pump system maintains livability in the city, much of which lies below today’s mean sea level. The system’s buildings, power supply, and mechanical and electrical equipment should be submergible or otherwise proven to be operable in significant future flood events (i.e., including SLR) in order to protect the city. The pump strategy works in coordination with the levee system. The pumps address groundwater and stormwater flood issues, while the levees prevent coastal hazards (e.g., storm surge) from inundating the city. Other cities like New York (Urban Waterfront Adaptive Strategies, 2013), Boston (Climate Ready Boston, 2019), and Norfolk, VA (Resilient Norfolk, 2020) also reference the use of pumps as a key part of dry proofing buildings.

Norfolk, VA has identified a number of hold the line measures that includes construction new seawalls, levees, and gates. Specifically, phase 1 of the Norfolk plan identifies replacing an existing flood wall and increasing its height as well as a proposed storm surge barrier for highly sensitive areas.

During Hurricane Harvey, the Mayor of Houston, TX issued an order for all residents to shelter-in-place during the flood. Analysis after this event found that an evacuation order could have led to a significantly higher death toll[5]. As a result, Miami Beach recommends residential units should be above the first floor of a building, designed to safely accommodate shelter-in-place orders. This strategy could also be employed for buildings that act as emergency community shelters.

4. Initial Adaptation Concepts

This section distills the near- and long-term adaptation strategies collected from the review of previous studies and global precedents research into a shortlist of initial adaptation concepts that will be used in the Task 4 planning and design efforts. Here "near-term" refers to strategies that could be implemented within ten years, while "long-term" refers to strategies that take decades to implement.

Climate change adaptation strategies have typically been grouped into three categories: Protect, Accommodate, and Retreat (or Avoid). "Protect" strategies aim to reinforce existing assets against future sea levels, whereas "Accommodate" strategies allow water to move where it intends and work with the changing shoreline. When people move from flood-prone areas or assets are relocated to higher ground, the "Retreat" strategy is employed. Typically these strategies are combined into "Hybrid" approaches best suited to local conditions and community needs. The following image depicts the three strategies.

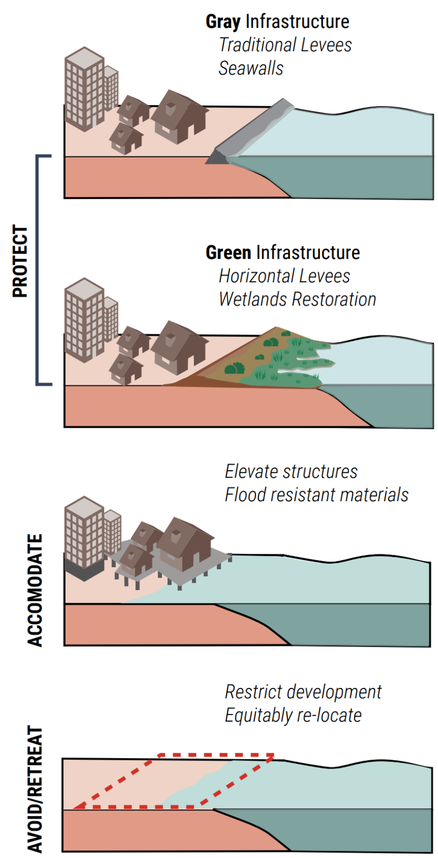

Figure 10: Three categories of adaptation strategies, as depicted in Bay Adapt (BCDC, 2021).

---

[5] https://www.npr.org/sections/thetwo-way/2017/08/28/546721363/why-didn-t-officials-order-the-evacuation-of-houston

The following table shows strategies categorized as near- or long-term solutions and whether they are structural (physical) or non-structural (policy). These strategies fall into a blend of the three categories of Protect, Accommodate, and Avoid/Retreat. The full list of strategies can be found in Appendix A.1.

Table 4: Adaptation strategies summarized as near- or long-term and as structural (physical) or non-structural (policy) solutions.

	Near-term	**Long-term**
Structural / Physical	• Elevate key assets – utility connections, mechanical equipment, etc. • Backup power – for pumps, electrical/mechanical systems, etc. • Rooftop landscaping for stormwater management • Enhance drainage, for example by upsizing pumps and pipes • Design new structures to withstand future hydrostatic, hydrodynamic, and impact loads • Plant flood-resistant vegetation (and saltwater-tolerant where applicable) • Seal utility connections • Submergible pump systems • Design pedestrian access routes to be flood-resistant • Build flood-resistant landscaping • Anchor movable components that could cause damage if moved by water (e.g., tanks, gates, ramps) • Incorporate mold-resistant, water-resistant, and corrosion-resistant materials into exposed assets • Ensure vents, drains, conduit boxes, utility manholes, and access openings are sealed or sealable and include backflow prevention • Install backflow valves in buildings at sewer lines • Dry and wet flood-proof stairs, elevators, doors, and other ingress/egress to remain operable during flood event	• Maximize infiltration and detention to delay drainage and manage stormwater runoff (sedimentation basins, bioswales, etc.) • Use parking lots and plazas for stormwater detention • Build new seawalls and revetments • Raise existing levees • Elevate key corridors and assets – roads, rail, ferry terminals, trails, etc. • Floodproof marinas to adjust to fluctuations of water level • Land reclamation or waterfront bulkheads to raise levels above future SLR • Retrofit existing buildings and structures to withstand hydrostatic, hydrodynamic, and impact loads • Realign shoreline areas with new waterfront protection features, i.e., levees • Install flood gates on tidally influenced canals or creeks to control water levels • Install new pump stations to evacuate stormwater during high tide events • Living shorelines incorporating habitat enhancement with waterfront protection • Enhance offstream detention areas along creeks to reduce peak flow events

	Near-term	Long-term
Non-Structural / Policy	• Designate shelter-in-place locations • Temporary closures and reroute traffic or provide alternative means of transportation • Public flood notices via warnings and alerts • Establish risk-based criteria for selecting projections • Determine credible climate hazards and identify climate change projections to inform design • Coastal flood zone ordinances restricting new development or requiring new flood protection for properties	• Designate all residential units to be located above first floor of buildings for shelter-in-place • Develop climate resilient design guidelines • Managed realignment or relocation and buyouts in high-risk areas

This list of strategies is by no means exhaustive, especially because areas for adaptation concept development (Task 4) will not be selected by the project team until the vulnerability study has been completed (Task 3). This initial list will help guide the project team without limiting them to the strategies herein.

5. Baseline GIS Dataset

Arup developed a baseline GIS dataset that aggregates existing transportation asset information, including data on road, transit, and bike/ped infrastructure. This baseline GIS dataset is intended to identify previously studied transportation infrastructure in previous sea level rise studies conducted throughout Marin County, including BayWAVE and C-SMART.

5.1 Approach

Arup submitted a request for information (RFI) to TAM which included a list of transportation infrastructure assets, proposed projects, right-of-way information, and other asset information that would be considered within this analysis. Data was aggregated from previous planning and GIS databasing efforts from a variety of sources including Marin County, the Metropolitan Transportation Commission (MTC), and Caltrans. Data linked or received through the RFI was downloaded and reviewed utilizing a GIS log and GIS project standards.

The GIS log included review parameters including whether the initial request had been adequately met, if the dataset covered the required extent, if the spatial accuracy of the dataset met project requirements, if the terms of the dataset were fully understood and if they permit the project to use the data, if the dataset contains attributes which meet the project requirements, if the dataset requires any processing prior to usage, if the data have a coordinate system which is correctly assigned, if the dataset naming convention has been followed correctly, if the dataset metadata had been populated correctly, and if it meets basic sense checks, spot checks, or similar.

Utilizing the Feature Manipulation Engine (FME), Arup cleaned the downloaded geospatial data, reprojected to a NAD_1983_HARN_StatePlane_California_III_FIPS_0403_Feet coordinate system, clipped to Marin County Boundary, and added attribute information related to the date.

The geospatial data was compiled into a geodatabase and shared with TAM and the project team. Data can also be viewed on the project ArcGIS Online (AGOL) site. It is recommended that TAM maintains a copy of the GIS data in a format that allows TAM to view, manipulate, and analyze the data. This analysis can be done via online GIS service, such as AGOL, or other enterprise GIS platform.

5.2 Limitations

Some documents and data were not obtained through the RFI process, but they will be incorporated into the next phase of this project. Outstanding reports include San Rafael Flood Risk and Sea Level Rise Adaptation Report, Canal Community Resilience Project, I-580/US-101 Direct Connector, Local Coastal Program Environmental Hazards Update, and Richardson Bay Shoreline Study.

Similarly, geospatial data for the following items have not been incorporated into the GIS Baseline Dataset, but will likely be incorporated as TAM identifies of vulnerability hotspots and develops initial adaptation concepts:

- Existing coastal protection infrastructure, including available information on location, asset type, performance standards & condition
- Right-of-way information for transportation infrastructure
- Facilities for service and maintenance for Bus, Ferry, and Rail lines
- Rail yards and depots
- Toll, interstate, and state bridges
- Management centers for traffic/transportation
- Sidewalk network

Asset data from the BayWAVE project was available and generously shared with the team. Vulnerability information, which connect previously used SLR scenarios to assets, was unfortunately not available at the time of this report. This data may need to be recreated in Task 3.

6. Key Take-aways

Key take-aways from the plan review include the following:

- There is a need for consistency between sea level rise scenarios and projections used within Marin County for SLR adaptation planning. Furthermore, clarity around potential tipping points (i.e., when will SLR trigger the need for local-scale and larger-scale improvements) is lacking across the various studies and plans that have been commissioned to-date.
- The protect, accommodate, and retreat framework does provide a consistent categorization of SLR interventions. In more detailed studies, many intervention concepts do fall between categories into a “hybrid” classification which is often overlooked.
- Many of Marin’s most significant flooding and SLR vulnerabilities surround existing tidally influenced creeks including Coyote Creek, Corte Madera Creek, San Rafeal Canal, Novato Creek and others; there is no clear consensus among the plans and studies reviewed with regards to the set of interventions that could reduce flood risk and address sea level rise long-term.
- Some areas in Marin County have been studied extensively and already begun SLR adaptation work. These areas include key interchanges in the county along US-101 (with SR-37 and I-580) and on/off-ramps to these corridors. Concept designs have been proposed in other areas, such as dune restoration in Stinson Beach. There does not appear to be a consistent approach to the design of interventions, as some

efforts focus on engineering upgrades to an existing system (e.g., upgrading flood protection infrastructure along Lower Corte Madera Creek) and others involve a more holistic approach with significant community feedback and larger scope (e.g., the design concept approach in The People's Plan for Resilient by Design team P+SET).

- A significant gap exists in the lack of vulnerability data in geospatial form. Individual asset layers were downloaded from publicly available sites maintained by the County of Marin, MTC, Caltrans, and others, including shared by the BayWAVE project team. Unfortunately, vulnerability data (such as inundation depth at a road asset under 3ft SLR) from the BayWAVE analysis or data from previous SLR or flood assessments were not available.
- It is recommended that TAM obtains a GIS license for viewing and analyzing the data collected from this project. The geodatabase format cannot be viewed easily without GIS software or custom scripts developed by a geospatial professional.

In the next task, hazard data will be layered onto the asset data. This hazard data will add to analysis from previous studies, and it includes layers for present-day and future groundwater, pluvial and riverine flood, coastal flood, and sea level rise hazard scenarios. Assets and communities will be evaluated for vulnerability and identified for the next scope of work, building towards an implementation plan to address these hazards and support the communities on the road to adaptation and resilience.

A.1 Adaptation Strategies

See below for excerpt of adaptation strategies identified, along with their categorization by scale (County/City/Asset) and time horizon (near- or long-term).

Scale			Time Horizon			
County	City	Asset	Near-term	Long-term	Guideline / Solution	Commentary
	X	X	X		Backup power - pumping	Consider backup power systems specifically for stormwater pumping systems, enabling the building to continue pumping operations through power outages of up to 12 hours
		X	X		Elevate mechanical equipment	All mechanical equipment and critical utility connections shall elevated to at least the minimum platform level.
		X	X		Rooftop landscaping - stormwater	Design green/blue roofs and/or other appropriate landscape elements that maximize onsite rainwater capture and reuse.
		X	X		Enhanced drainage	Design roof and site drainage to remain outside of the façade and prevent ponding and overflow into protected areas. All structures with dry-floodproofed areas should be equipped with the appropriate size sump pump. Ensure there are overflow pathways from the roof to mitigate floods caused by drains clogging.
X	X	X		X	Establish risk-based criteria for selecting projections	The selection of climate change projections depends on risk tolerance. Projects with a high risk tolerance can opt for less conservative climate change projections and those with a low tolerance would select more conservative projections. It is recommended that criteria be established to outline how risk tolerance can be assessed and how climate change projections can be appropriately matched to various tolerance levels.
		X	X		Hydrostatic, hydrodynamic, and impact loads	The structure should be designed to withstand the forces imposed by hydrostatic bodies, hydrodynamic loads, and loads delivered by objects carried by flood waters with climate change and sea level rise taken into account.
		X	X		Shelter-in-place	All residential units should be above first floor of building and designed to safely accommodate shelter-in-place orders.
X	X	X	X		Flood resistant vegetation	All outdoor spaces below the platform level will be designed with flood resistant vegetation including saltwater tolerate planting. Include high evapotranspiration-rate tree species to mitigate heat and stormwater events.
		X	X		Utility Connections	The structure should have all utility connections sealed in accordance with guidelines in Floodproofing Non-Residential Buildings (FEMA 2013). This includes utility chases on the exterior of walls for electrical lines, plumbing, gas, communications, or ductwork.
X	X	X	X		Temporary closure / rerouting traffic	A nonstructural/management option during extreme events A nonstructural/management option during extreme events could be to close part or all parts of select roadways. Planning alternative routes, or providing additional means of transportation (ferries instead of bridges) would be required
		X	X		Submersible pumps	Mechanical and electrical pumps, back-up systems, or any other mission-critical components which are needed to maintain pump functionality, including those located in other buildings, should be submergible or otherwise proved to remain operable up to the DFE+SLR.
		X	X		Below grade flood protection	Protect areas below grade from groundwater flooding
X	X	X	X	X	Maximize infiltration and detention	Minimize increases in impervious surface; Utilize strategies that infiltrate, evaporate, or reuse rainwater to achieve stormwater volume reductions; choose low impact development strategies that detain (delay drainage) to manage the rate of the stormwater flow into the utility drainage system; Install stormwater infiltration, detention, and storage
		X	X		Interior water management	When implementing perimeter protections, ensure that interior water management is also accounted for
		X	X		Underground utility protection	Explore interventions to protect underground utility and telecommunications infrastructure from water damage
		X	X		Flood resistant access ways	Any stairs, ramps or walkways in the transition zone up to platform level should be designed to resist flood loads.
		X	X		Floodproofing basements	All indoor spaces within the building below the platform level (basements) will be wet and dry floodproofed.
	X	X	X	X	Parking and/or Plazas as detention	Explore opportunities for designing underground parking garages and/or outside plazas for stormwater detention.
X	X		X	X	Public flood notices	Provide flood warnings and alerts
	X	X		X	Develop climate resiliency design guidelines	Develop climate resiliency design guidelines for design elements at the building and district scale.
		X		X	Determine minimum platform level	Platform level refers to the general ground level of a proposed development. The platform level of new developments will not be lower than the DFE+SLR elevation.
X	X	X		X	Elevate roads	Construct elevated roadways to provide access for fire and ambulance services in the event of king tides or storm tides.

Scale			Time Horizon			
County	City	Asset	Near-term	Long-term	Guideline / Solution	Commentary
X	X	X	X		Flood resistant landscaping (e.g., bioswales, sedimentation basins)	All outdoor spaces below the platform level will be designed with flood resistant landscaping with publicly accessible plaza where possible. Public spaces or temporary programmable space is acceptable below the platform level. If sited above the platform level, public spaces must provide context-sensitive, visually accessible, and gradual vertical transition up to platform level.
	X			X	Flood proof marinas	In marinas also watercrafts can be allowed to adjust to fluctuations of water level.
X	X			X	Land claim	The main objective of land claim is neither erosion nor storm reduction. The aim of land claim is to create new land from areas that were previously below high tide. These measures can be taken to reduce the exposure of these areas to coastal flooding.
X	X			X	Managed realignment	Looks to set back the shoreline and restore coastal environments. This strategy usually involves removing or deliberately breaching flood defenses to allow flooding up to higher ground or a new defense line; or realigning coastal cliff frontages to allow cliff erosion. It has advantages in removing long-term financial commitments to maintain defenses and in restoring natural environments and processes. Managed realignment can create new habitat area that acts as a natural buffer to coastal waves and is much cheaper to maintain over the long-term.
		X		X	Foundation	Design foundation elements, including mat slabs, shallow footings, and piles for the hydrostatic uplift forces corresponding to the DFE+SLR.
		X		X	Wall Systems	Wall systems below the DFE+SLR should be constructed to withstand all hydrostatic and hydrodynamic forces imposed on the wall by the DFE.
	X	X		X	Build revetments	Revetments are onshore structures with the principal function of protecting the shoreline from erosion. Revetments typically consist of a cladding of stone, concrete, or asphalt to armor sloping natural shoreline profiles.
X	X	X		X	Determine credible climate hazards	A multi-hazard assessment will be applied to an individual site in order to determine the credible threats influenced by climate. Hazards to be considered should include, but not be limited to, extreme heat, precipitation, wind, storm surge, stormwater flooding, fluvial flooding, tidal flooding, waves, sea level rise inundation, groundwater flooding.
X	X	X		X	Identify climate change projections	For each credible climate hazard, appropriate climate change projections will be collected to inform design.
		X		X	Anchor movable contents	Anchor any submersible content located below the DFE+SLR that could cause damage to the structure if moved by water. Includes tanks, ramps and gates.
		X		X	Mold resistant materials	The structure should include high strength, non-organic materials with no potential for deterioration, corrosion or warping for all structural and core elements.
		X		X	Water resistant materials (Wall Sealants)	Select waterproof exterior materials that prevent entry of water into any essential area of the building. Use sealed membranes in areas within 5ft of the DFE+SLR, including door and window openings.
		X		X	Windows and doors	On the ground floor, windows and doors should be sealed, watertight and designed to withstand high water pressures.
		X		X	Gaskets and Seals	Ensure that all vents, drains, conduit boxes, utility manholes and access openings are also sealed or sealable and include backflow prevention. Self-sealing compression seals should be utilized as they are more reliable and can be used in conjunction with pneumatic seals for a redundant configuration, which provides more protection.
		X		X	Electrical Outlets	Install electrical outlets above DFE+SLR and wire ground floor system independently to prevent short out of other building areas.
		X		X	Backflow Valves	Install check valve or similar back flow device at the point of entry into the building on the main discharge sewer line to prevent sewage from potentially flowing back into the building during a flood event.
		X		X	Envelope	Ensure building envelope is protected against any water intrusion through use of waterproofing membranes in areas within 5ft of the DFE+SLR and essential facades sealed, without openings to rainfall or wind driven rain.
		X		X	Stairs	Stair framing elements and their connections are designed and detailed to maintain support of the design dead and live loads during flooded conditions of the primary structure and external access is achievable on the second-floor level or above the DFE.
		X		X	Doors	Egress doors and first floor windows are designed to accommodate surges such that they remain operable following the design level flood.
		X		X	Elevators	Elevators that operate below the platform level will be dry and wet floodproofed to ensure resilience against flooding up to the DFE+SLR.
X	X	X		X	Categorize climate change projections based on project type	For each type of project, appropriate climate change projections should be pre-identified and recommended. Project types include infrastructure improvements, mixed use development, utility upgrades, etc.
X	X	X		X	Design based on future climate data	Identify appropriate basis of design (BOD) requirements for each credible climate hazard and incorporate climate change projections. The credibility of specific hazards will trigger hazard-specific design requirements using existing Federal, State, and Local guidance. Hazard-specific design guidelines will be combined with climate change projections to determine appropriate climate-resilience design levels.
X	X	X		X	Design for critical loads - stormwater	Increase capacity of stormwater drainage systems by designing for critical loads that incorporate future extreme climate projections for rainfall-runoff.

Scale			Time Horizon			
County	**City**	**Asset**	**Near-term**	**Long-term**	**Guideline / Solution**	**Commentary**
X	X	X		X	Build/update barriers	Construct a moveable or permanent barrier (tidal gates). Tide gates can potentially protect a significant length of upstream shoreline relative to the length of the tide gate. May be the only viable solution where right of way for other solutions cannot be obtained. These can have negative environmental impacts.
X	X	X		X	Build levees	Raise, strengthen, or build levees. Levees are not a great option on the open coast due to high wave energy environment, need to armor levee slope. Levees could be used in tidally influenced creeks and rivers though.
X	X	X	X	X	Build walls	Build new sea walls or raise the height of existing ones; can also incorporate buildings as flood protection features. Both seawalls and revetments were found to have a negative net cost benefit as a result of high construction cost in past erosion mitigation
	X	X		X	Determine minimum crest level	Crest level refers to the bottom level of any openings (including ventilation and services openings) or summit level of a ramp or accessway leading into or away from an underground or basement structure or facility, including the summit level of any exits from the underground facilities. The crest level of new developments will not be lower than the platform level plus a to-be-determined amount of freeboard.
X	X	X		X	Flood Barrier	New developments will raise the platform level and/or crest level to the highest possible levels before considering flood barriers. Where flood barriers are used, they must be designed to provide at least the same level of protection that minimum platform and/or crest levels would provide for the building.
X	X	X			Transition zone	Provide “transition zone” between the back of sidewalk up to the crest level, with deep landscape setback to provide enough horizontal space for gradual slope up to building entry with amenities including plantings, walking paths, seating and other amenities. Use planters with integrated seating to soften the transition between elevated hardscape and sidewalk
X	X			X	Land reclamation	Develop an extension of the land, natural or unnatural (port), to provide wave energy dissipation

A.2 Critical Transportation Assets and Communities by Jurisdiction[6]

6.1.1 City of Belvedere

The City of Belvedere is located in southeastern Marin County on San Francisco Bay (and offshoot Richardson Bay) and includes Belvedere Island, Belvedere Lagoon, and Corinthian Island.

Asset	
Airports	0
Golden Gate Transit Stops	0
Golden Gate Ferry Terminals	0
Marin Transit Stops	1
SMART Stations	0
Caltrans Maintenance Facilities	0
Park and Ride	0
State Highway Bridges	0
Road Tunnels	0
Bikeways (Existing and Proposed)	<1 mile
HOV Lanes	0 miles
Trails	<1 mile
Roadways	26 miles

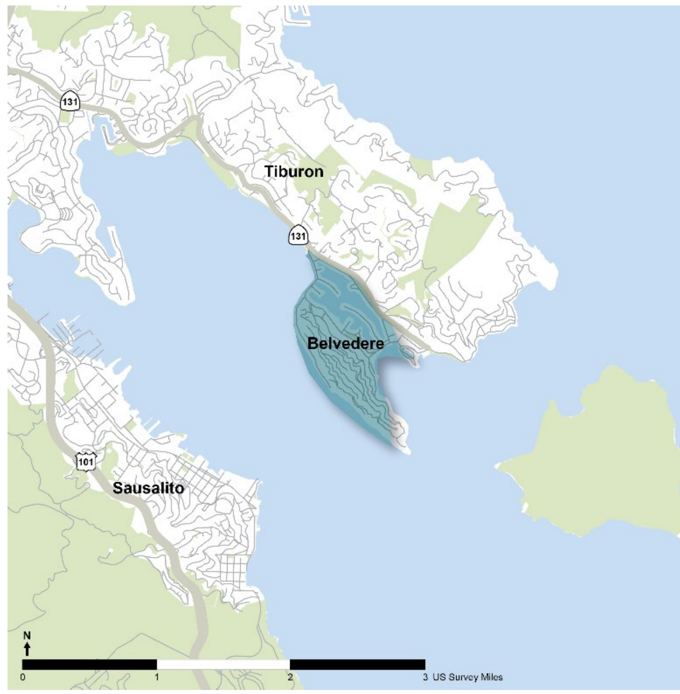

Figure 11 Belvedere City Boundary

Key focus areas, highlighting vulnerable communities or assets:

- San Rafael Ave. and Beach Rd. are the two primary ingress/egress routes connecting Belvedere Island to the Tiburon peninsula, both of which are waterfront roads on the west and east sides of the Lagoon respectively; these roads represent key vulnerable assets for Belvedere with respect to sea level rise. They are exposed to inundation under 24" (2.0ft or 0.6m) SLR (ART Bay Area, BCDC, 2020). The Protect Belvedere (Belvedere Critical Infrastructure Project) seeks to address improvements to these roads and the levees they sit atop (MTC/ABAG & BCDC Sea Level Rise Framework Shoreline Project Inventory, 2021).

[6] This list is not entirely comprehensive and is a query of the data best available.

6.1.2 City of Larkspur

The City of Larkspur, located in central Marin, encompasses Corte Madera Creek and touches San Francisco Bay, exposing it to coastal and riverine flood hazards. The Larkspur Ferry Terminal connects the area to San Francisco via ferry while US-101, which runs through the city, provides vital connection to other communities in Marin and the Bay Area. Roadways in Larkspur also provide vital connectivity to Marin General Hospital.

Asset	
Airports	0
Golden Gate Transit Stops	2
Ferry Terminals	1
Marin Transit Stops	34
SMART Stations	1
Caltrans Maintenance Facilities	0
Park and Ride	3
Transit Hubs	1
State Highway Bridges	3
Road Tunnels	0
Bikeways (Existing and Proposed)	30 miles
HOV Lanes	5 miles
Trails	21 miles
Roadways	134 miles

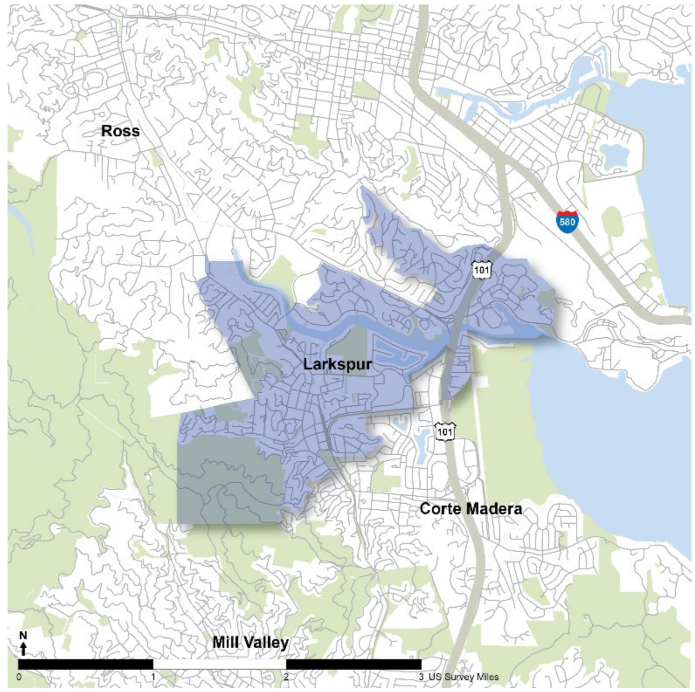

Figure 12 Larkspur City Boundary

Key focus areas, highlighting vulnerable communities or assets:

- The Larkspur Ferry Terminal was identified in the Marin Shoreline Sea Level Rise Vulnerability Assessment as vulnerable to coastal flooding. There are plans to improve the site, parking capacity, and dock operating systems in response to SLR. Identified in Marin Shoreline Sea Level Rise Vulnerability Assessment (BayWAVE, 2017).
- Lucky Drive floods during present-day king tide events and is also susceptible to riverine flooding from Corte Madera Creek. This relatively short stretch is an essential connector between Corte Madera, Larkspur, Kentfield, and other Central Marin communities to US-101 (Corte Madera Climate Adaptation Assessment, 2021) (BayWAVE, 2017).
- The US-101 corridor is known to be vulnerable to sea level rise and flooding in Marin; the section through Larkspur is mostly elevated but on/off ramps are low-lying and flood prone.

6.1.3 City of Mill Valley

The City of Mill Valley touches Richardson Bay, part of San Francisco Bay, and extends upland towards Mount Tamalpais. The coastal areas of the city, include Bothin Marsh, contain transit centers, commercial districts, and residences, among other assets and services.

Asset	
Airports	0
Golden Gate Transit Stops	26
Golden Gate Ferry Terminals	0
Marin Transit Stops	27
SMART Stations	0
Caltrans Maintenance Facilities	0
Park and Ride	0
State Highway Bridges	0
Road Tunnels	0
Bikeways (Existing and Proposed)	34 miles
HOV Lanes	0 miles
Trails	28 miles
Roadways	191 miles

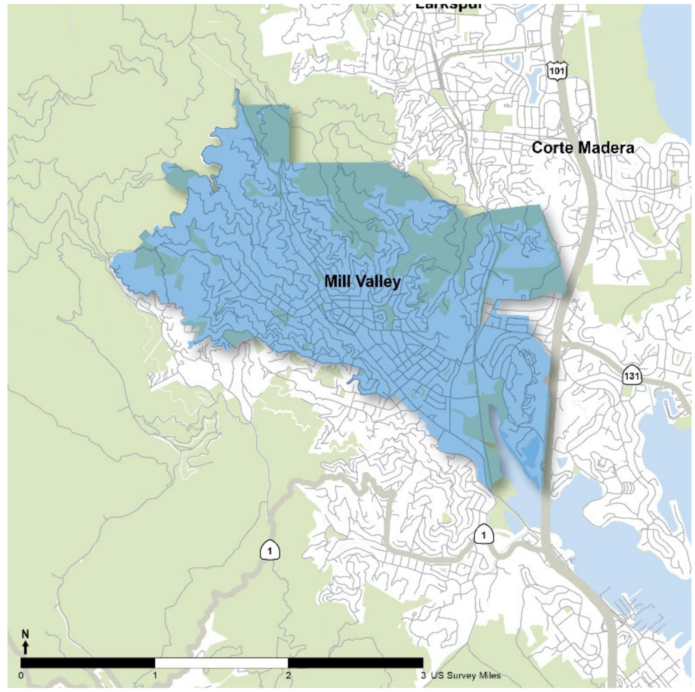

Figure 13 Mill Valley City Boundary

Key focus areas, highlighting vulnerable communities or assets:

- The US-101 corridor is known to be vulnerable to sea level rise and flooding in Marin; the section through Mill Valley is mostly elevated but on/off ramps and frontage roads are low-lying and flood prone.
- Extreme precipitation combined with drainage capacity issues, rising shallow groundwater tables, and high tides is a known issue in Mill Valley; this impacts several local roads, bridges and bus routes/stops, particularly those nearby creeks and the Richardson Bay (Shallow Groundwater Response to Sea Level Rise, 2022).
- East Blithedale Ave., Miller Ave., and Camino Alto are all key roadways for ingress/egress to and from many of Mill Valley’s main commercial and residential areas; due to elevation, existing drainage capacity, and proximity to creeks and Richardson Bay, these roads are all vulnerable to flooding and sea level rise.
- Bothin Marsh restoration work includes strategies such as ecotone levees, sediment management, and enhancement of the natural tidal marsh ecosystem (MTC/ABAG & BCDC Sea Level Rise Framework Shoreline Project Inventory, 2021).

6.1.4 City of Novato

The northernmost city in Marin, Novato sits on San Pablo Bay, part of San Francisco Bay. The city includes wetland areas and Novato Creek, which runs through the main commercial district. SR-37 and US-101 meet in the city. This interchange has been identified as a critical transportation asset vulnerable to sea level rise from previous studies, discussed below.

Asset	
Airports	0
Golden Gate Transit Stops	29
Golden Gate Ferry Terminals	0
Marin Transit Stops	126
SMART Stations	3
Caltrans Maintenance Facilities	0
Park and Ride	2
Transit Hubs	4
State Highway Bridges	26
Road Tunnels	0
Bikeways (Existing and Proposed)	118 miles
HOV Lanes	22 miles
Trails	118 miles
Roadways	564 miles

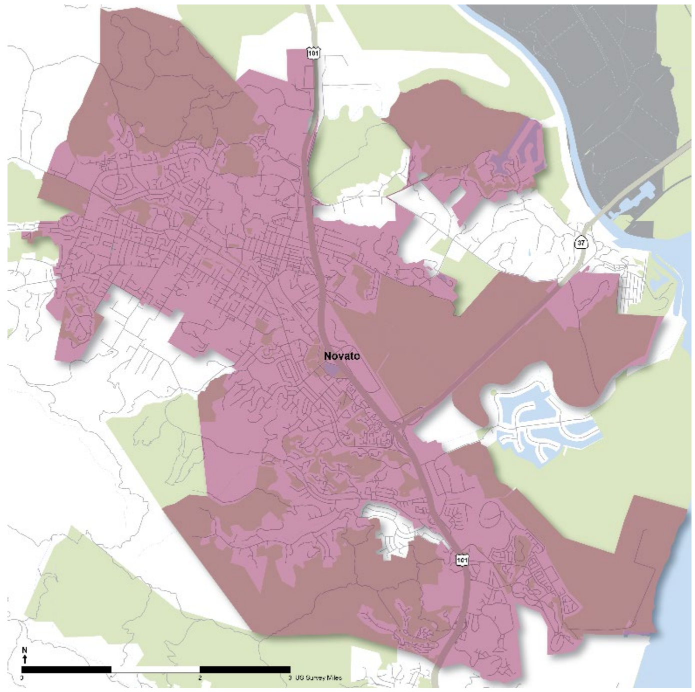

Figure 14 Novato City Boundary

Key focus areas, highlighting vulnerable communities or assets:

- The US-101 corridor is known to be vulnerable to sea level rise and flooding in Marin; the section through Novato is mostly elevated but many on/off ramps are low-lying and flood prone. Additionally, the section of US-101 passing the Gnoss Field Airport is vulnerable to flooding due to elevation and proximity to nearby wetlands and creeks.
- SR-37 connecting Novato and Vallejo was expected to be permanently submerged by 39in (3.3ft or 1.0m) SLR, according to Caltrans D4 Vulnerability Assessment (Caltrans, 2019) and SR 37 PEL Study (Caltrans, 2022). Near-term maintenance projects include SR 37 Pavement Rehabilitation between US-101/SR-37 interchange and Petaluma River and SR 37 Bridge Preservation project at Petaluma River Bridge at the border of Marin and Sonoma counties. Long-term implementation plan includes elevating SR-37 on a raised facility between US-101 and Atherton Avenue, where it meets the already elevated SR-37. Improvements to on- and off-ramps and bicycle and pedestrian facilities are also planned along the SR-37 corridor through Novato and Marin County (TAM Annual Report, 2022).
- The SMART train is vulnerable to flood issues in Novato as about 4-5mi of track is vulnerable to inundation in future SLR, as identified in Marin Shoreline Sea Level Rise Vulnerability Assessment (BayWAVE, 2017). SMART has identified opportunities along SR-37 to align rail infrastructure with

the highway between Novato and Sears Point, according to SR 37 PEL Study (Caltrans, 2022); extending SMART along the SR 37 corridor will require SMART to address known flooding and sea level rise vulnerabilities.

- The Novato Creek Flood Control Project was completed in 2006, and the Novato-Hamilton levee system is the only FEMA-accredited system in Marin, but extensive damage to the levees and stormwater pumping systems was experienced in 2014 and 2017 flood events. (Marin LHMP)
- Novato OLU Case Study in Marin County SLR Adaptation Framework (2019) calls out low-lying Highway 37 and rail lines and the Bel Marin Keys neighborhood as vulnerable. Eroding marshlands may cause issue because they protect the bayside of the levees.

6.1.5 City of San Rafael

The City of San Rafael is situated on San Rafael Bay, part of the San Francisco Bay. Approximately 60,000 people reside in the city, which contains wetlands and rivers (Gallinas Creek, South Fork Gallinas Creek, and San Rafael Creek) that border or cross important infrastructure. US-101 and I-580 converge in San Rafael, and this interchange has been identified as a critical asset in previous studies (discussed below) due to it being a low-lying asset susceptible to flooding and a key connection point for regional traffic.

Asset	
Airports	Smith Ranch
Golden Gate Transit Stops	55
Golden Gate Ferry Terminals	0
Marin Transit Stops	117
SMART Stations	2
Caltrans Maintenance Facilities	-San Rafael Landscape Storage
Park and Ride	5
Transit Hubs	1
State Highway Bridges	21
Road Tunnels	0
Bikeways (Existing and Proposed)	119 miles
HOV Lanes	22 miles
Trails	57 miles
Roadways	540 miles

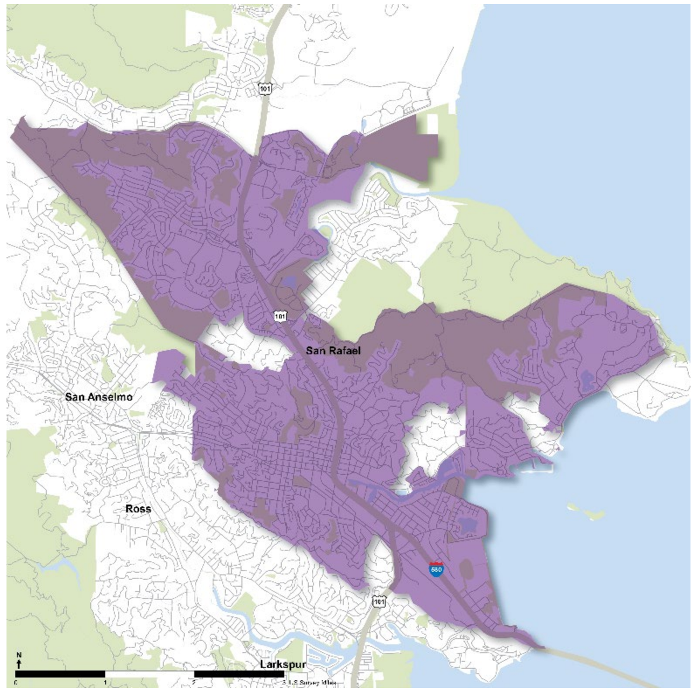

Figure 15 San Rafael City Boundary

Key focus areas, highlighting vulnerable communities or assets:

- TAM is leading project development for the US-101/I-580 interchange, which has been identified as a critical regional transportation asset vulnerable to climate hazards in the BARC Raising the Bar on Regional Resilience report, ART Bay Area (BCDC, 2020), and other studies. Though sections are elevated, many ramps and feeder roads could flood and impede travel through the city and county, and they become vulnerable to inundation by 12” (1.0ft or 0.3m) SLR (ART Bay Area, BCDC, 2020).
- The Canal District is exposed to flooding and sea level rise from the canal and bay and has been identified as a socially vulnerable neighborhood in the BARC Raising the Bar on Regional Resilience report. The Gerstle Park/Bret Harte neighborhood and Montecito/Happy Valley neighborhood are also exposed to flooding, as identified in the BARC Raising the Bar on Regional Resilience report. Portions of downtown San Rafael currently experience flooding in extreme rainfall plus high tide events.
- The SMART train may experience flood issues in San Rafael along mile posts 15.9-16.9 (San Rafael/Santa Venetia) and 19.8-20.9 (Central San Rafael). The San Rafael Transit Center was identified as the only SMART stop vulnerable to tidal flooding at 60” (5ft or 1.5m) SLR. Identified in Marin Shoreline Sea Level Rise Vulnerability Assessment (BayWAVE, 2017).

- The Golden Gate Bridge, Highway and Transportation District (GGBHTD) headquarters and depot, multiple yacht harbors, and parts of the Bay Trail in San Rafael are vulnerable to inundation under 10” (0.8ft or 0.25m) SLR, as identified in the Marin Shoreline Sea level Rise Vulnerability Assessment (BayWAVE, 2017).
- The San Rafael Airport and Loch Lomond Marina were also identified in the Marin Shoreline Sea Level Rise Vulnerability Assessment as vulnerable to medium-term SLR, experience inundation in 20” (1.7ft or 0.5m) SLR (BayWAVE, 2017).
- The San Francisco Bay Trail and Water Trail are vulnerable to flood under 12” (1.0ft or 0.3m) SLR (ART Bay Area, BCDC, 2020).
- The Irwin Street Bridge crossing San Rafael Creek/Canal, which was recently replaced and connects northbound vehicles from US-101 to downtown San Rafael currently has minimal freeboard during high tide events.
- The San Rafael Transit Center is vulnerable to flooding from extreme precipitation, existing drainage capacity and proximity to the tidally influenced sections of San Rafael Creek/Canal. This is a key transit hub for the region, including multiple bus stops and the SMART downtown San Rafael station. It is the highest ridership station in the North Bay. Note that FEIR has been completed, and design is underway.
- Key connector roads in San Rafael that are known to be vulnerable to flooding and sea level rise due to elevation, existing drainage infrastructure, and proximity to creeks and the San Francisco Bay include N. San Pedro Rd., Point San Pedro Rd., Irwin St., Grand Ave., Second St., Lincoln Ave., Anderson Dr., Francisco Blvd. E., Francisco Blvd. W., and Bellam Blvd.

6.1.6 City of Sausalito

The City of Sausalito is located along the coastline of San Francisco Bay into Richardson Bay in southern Marin. The Sausalito Ferry Terminal and the main downtown thoroughfare, Bridgeway, are key infrastructure assets that connect the city to the region. US-101 forms the western border of Sausalito, bypassing the downtown area.

Asset	
Airports	0
Golden Gate Transit Stops	1
Golden Gate Ferry Terminals	20
Marin Transit Stops	14
SMART Stations	0
Caltrans Maintenance Facilities	0
Park and Ride	1
Transit Hubs	1
State Highway Bridges	5
Road Tunnels	Waldo Tunnel
Bikeways (Existing and Proposed)	11 miles
HOV Lanes	0 miles
Trails	16 miles
Roadways	98 miles

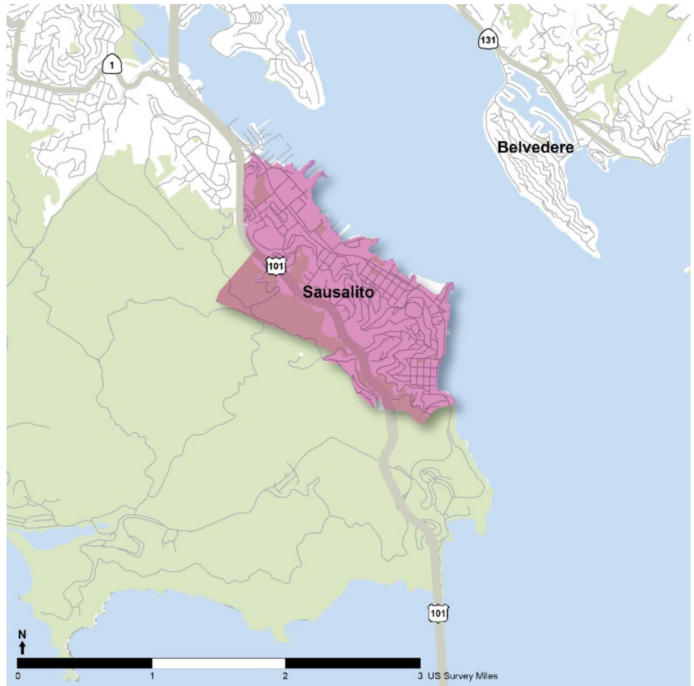

Figure 16 Sausalito City Boundary

Key focus areas, highlighting vulnerable communities or assets:

- The San Francisco Bay Trail and Water Trail are vulnerable to flood under 12" (1ft or 0.3m) SLR (Richardson Bay ART).
- The City of Sausalito is aware of flooding, land subsidence and associated impacts to infrastructure along Gate 5 Road that will only increase with further SLR.
- Bridgeway is the main connector road through Sausalito that provides a vital ingress/egress route; this roadway is vulnerable to flooding due to elevation, existing drainage infrastructure, multiple creek crossings, and proximity to Richardson Bay. On/offramps to US-101 as well as N Bridge Blvd on the north end of Sausalito are known to be vulnerable to flooding for many of these same reasons.
- The Sausalito Ferry Plaza and several waterfront marinas are also known to be vulnerable to future flooding as a result of sea level rise.
- Stormwater pump stations are also known to be vulnerable to coastal flooding in Sausalito due to elevation and proximity to Richardson Bay.
- Mill Valley to Sausalito Path and the North-South Greenway Path contain the highest usage of Marin's Active Transportation facilities.
- Infrastructure and access to the Marinship and Floating Homes Community.

6.1.7 Town of Corte Madera

The Town of Corte Madera is located on San Francisco Bay in central Marin County, along the US-101 Corridor on the San Francisco Bay. Approximately 10,000 people live in this low-lying coastal town. Historically, much of this area was marshland, which leaves most lower elevation residential and commercial areas in the Town vulnerable to coastal flooding.

Asset	
Airports	0
Golden Gate Transit Stops	2
Golden Gate Ferry Terminals	0
Marin Transit Stops	32
SMART Stations	0
Caltrans Maintenance Facilities	0
Park and Ride	1
Transit Hubs	0
State Highway Bridges	3
Road Tunnels	0
Bikeways (Existing and Proposed)	39 miles
HOV Lanes	8 miles
Trails	12 miles
Roadways	123 miles

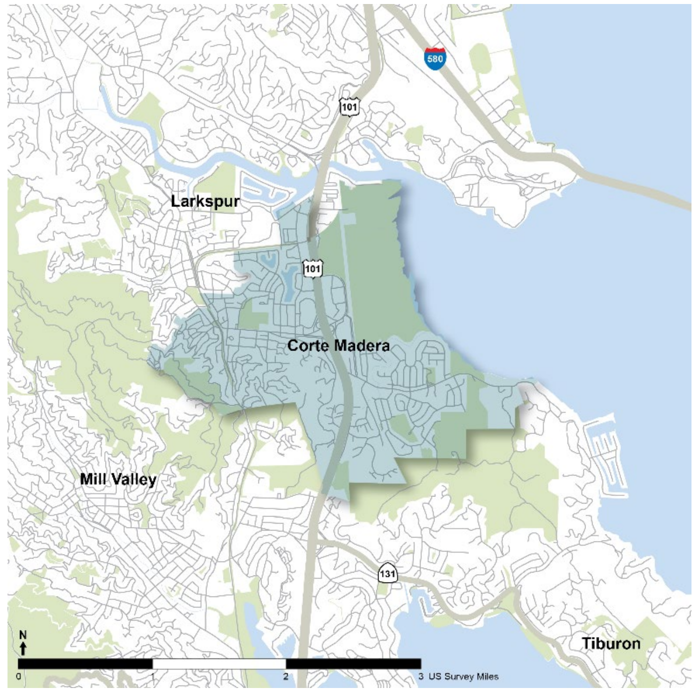

Figure 17 Corte Madera City Boundary

Key focus areas, highlighting vulnerable communities or assets:

- Wornum Drive Bridge (US-101 PM 8.02) and Tamalpais Drive Overcrossing (US-101 PM 7.37) may be exposed to scour starting in 20” (1.6ft or 0.5m) SLR and may require protection measures. Identified in Caltrans D4 Vulnerability Assessment.
- US-101 through downtown Corte Madera, extending north outside of city boundaries, has been identified as a regional “hot spot” in Bay Adapt Regional Strategy, using data from ART Bay Area Regional Sea Level Rise Vulnerability and Adaptation Study with 108” (9.0ft or 2.7m) SLR. US-101 has been identified as vulnerable in the Marin County SLR Adaptation Framework (2019) and BayWAVE (2017).
- Lucky Drive floods during present-day king tide events and is also susceptible to riverine flooding from Corte Madera Creek. This short corridor represents an essential connection between Corte Madera, Larkspur, Kentfield, and other Central Marin communities to US-101 (Corte Madera Climate Adaptation Assessment, 2021) (BayWAVE, 2017).
- Paradise Drive connects Tiburon to the County and US-101, and it is part of the Bay Trail. Parts of the road are vulnerable to flood under 66” (5.5ft or 1.7m) SLR, though may experience inundation during storm events under less SLR (Corte Madera Climate Adaptation Assessment, 2021).

- SMART and GGBHTD corridors through Corte Madera Marsh sit on elevated berms which protect parts of Corte Madera from tidal flooding. The Corte Madera Climate Adaptation Assessment has identified the marshland area for potential integrated adaptation strategies (2021).
- Casa Buena Drive floods during extreme precipitation events, and as a key connector to Tamalpais Drive for residents and businesses, it's a key vulnerable asset in Corte Madera (Corte Madera Climate Adaptation Assessment, 2021).
- Mill Valley to Sausalito Path and the North-South Greenway Path contain the highest usage of Marin's Active Transportation facilities.

6.1.8 Town of Fairfax

The Town of Fairfax sits over 100ft above sea level in inland Marin. Residents rely on the road network to access other communities in Marin and the greater Bay Area. Though none of the infrastructure in the town is exposed to coastal hazards, key connector routes may be vulnerable to sea level rise. Also Fairfax Creek, San Anselmo Creek, and their tributaries run through the town, which may expose the town to riverine flooding.

Asset	
Airports	0
Golden Gate Transit Stops	0
Golden Gate Ferry Terminals	0
Marin Transit Stops	15
SMART Stations	0
Caltrans Maintenance Facilities	0
Park and Ride	0
Transit Hubs	0
State Highway Bridges	0
Road Tunnels	0
Bikeways (Existing and Proposed)	18 miles
HOV Lanes	6 miles
Trails	12 miles
Roadways	71 miles

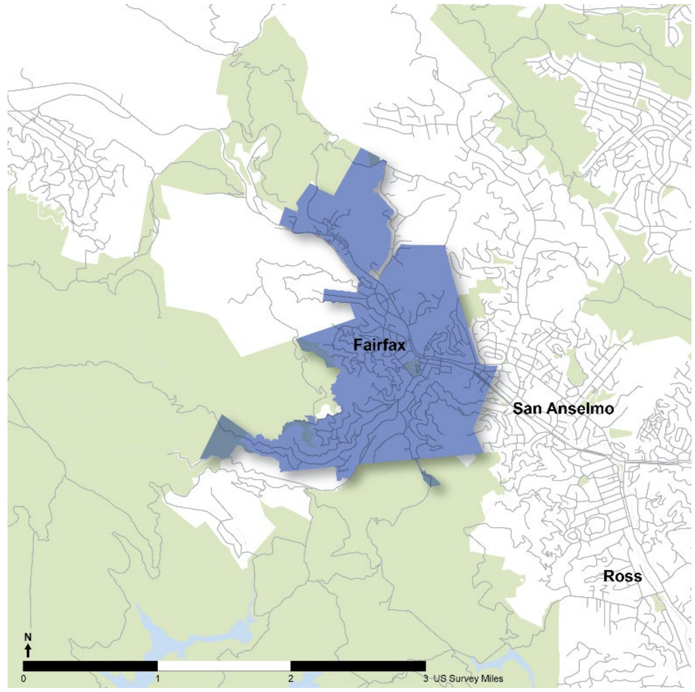

Figure 18 Fairfax City Boundary

Key focus areas, highlighting vulnerable communities or assets:

- No assets exposed to coastal hazards, but riverine flood has caused damage in the past, including to major roads (MCM LHMP).
- Key corridors that connect Fairfax to the region may be impacted by sea level rise. See San Rafael, Larkspur, and Corte Madera sections for more information on these routes. See the following plot for network link volumes, noting the significant volume from the coast inland to Fairfax.

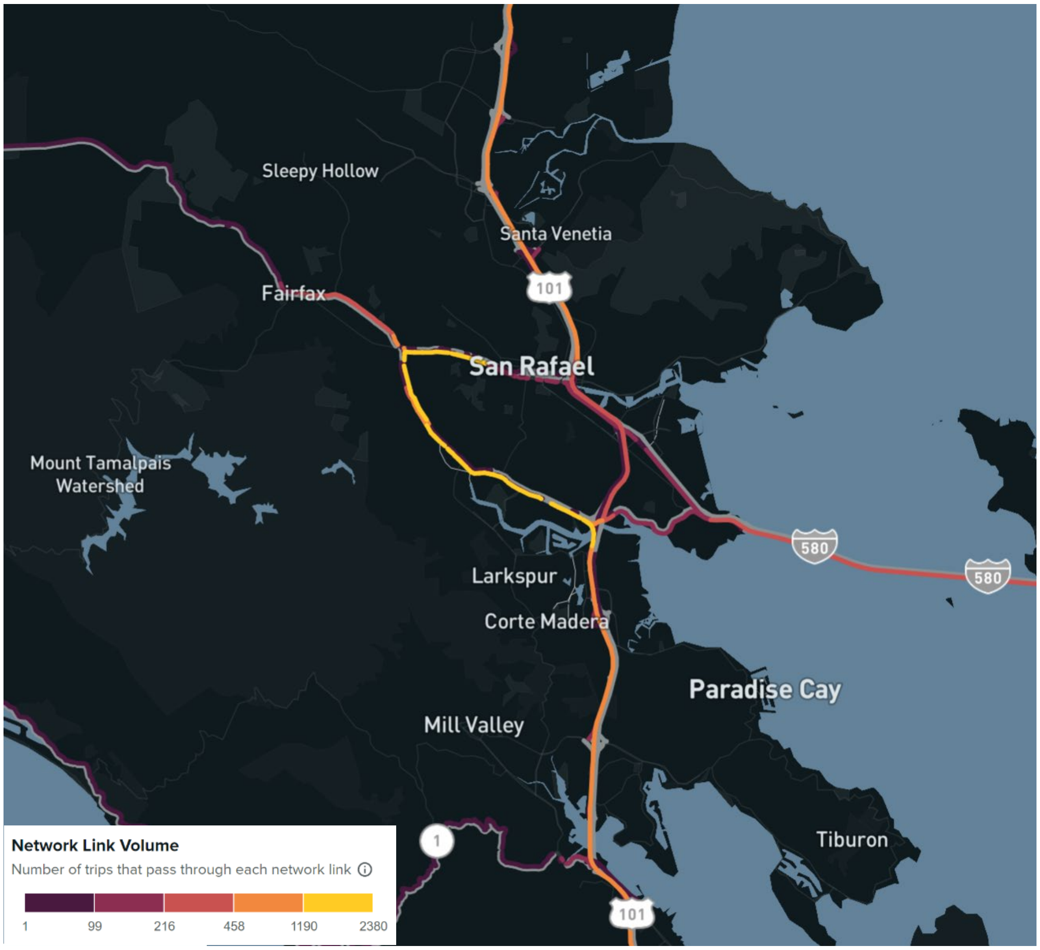

Figure 19: Network Link Volume data from Replica (replicahq.com).

6.1.9 Town of Ross

The town of Ross is a small, inland community of roughly 2,000 residents. It is located along the Corte Madera Creek, upstream of Larkspur. It is connected to nearby communities via Sir Francis Drake Boulevard, a major corridor that connects to US-101. None of the infrastructure in Ross is exposed to coastal hazards although the tidal influence from the San Francisco Bay is expected to extend upstream in Corte Madera Creek as a result of future sea level rise which could worsen the existing riverine flood issues along this creek during future extreme rainfall and high tide events.

Asset	
Airports	0
Golden Gate Transit Stops	0
Golden Gate Ferry Terminals	0
Marin Transit Stops	4
SMART Stations	0
Caltrans Maintenance Facilities	0
Park and Ride	0
Transit Hubs	0
State Highway Bridges	0
Road Tunnels	0
Bikeways (Existing and Proposed)	5 miles
HOV Lanes	0 miles
Trails	2 miles
Roadways	44 miles

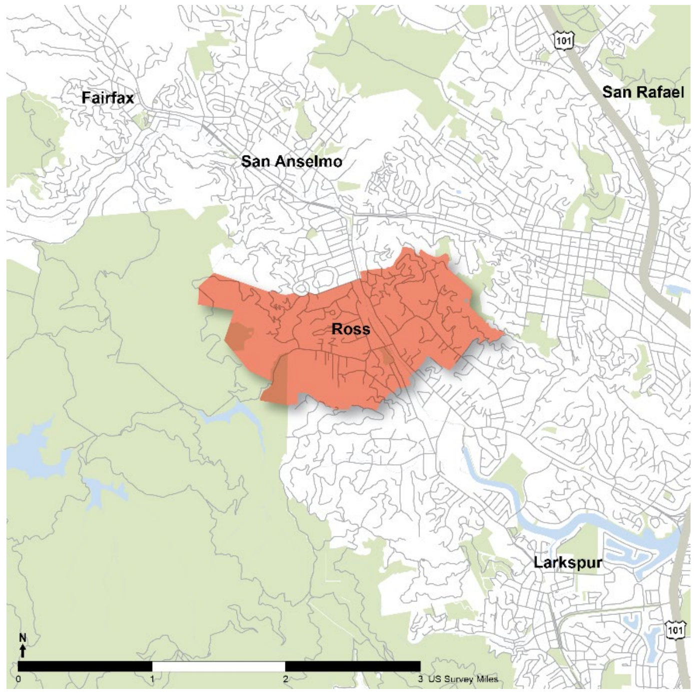

Figure 20 Ross City Boundary

Key focus areas, highlighting vulnerable communities or assets:

- No assets exposed to coastal hazards, but riverine flood has caused damage in the past, including to major roads (MCM LHMP).
- Key corridors that connect Ross to the region may be impacted by sea level rise. See San Rafael, Larkspur, and Corte Madera for more information. See the following plot for network link volumes, noting the significant volume from the coast inland to Ross (due south of where it says 'San Anselmo' in the image).

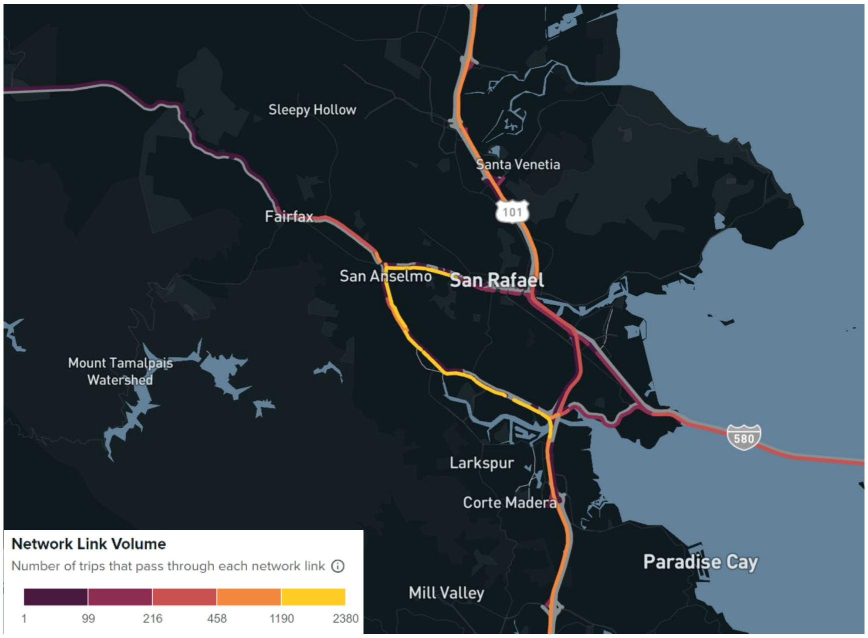

Figure 21: Network Link Volume data from Replica (replicahq.com).

6.1.10 Town of San Anselmo

The Town of San Anselmo sits about 50ft above sea level in inland Marin. Residents rely on the road network to access other communities in Marin and the greater Bay Area, though none of the infrastructure in the town is exposed to coastal hazards like sea level rise. San Anselmo Creek and its tributaries run through the town, which expose the town to riverine flooding. The tidal influence from the San Francisco Bay is expected to extend upstream in Corte Madera Creek as a result of future sea level rise which could worsen the existing riverine flood issues in San Anselmo during future extreme rainfall and high tide events.

Asset	
Airports	0
Golden Gate Transit Stops	3
Golden Gate Ferry Terminals	0
Marin Transit Stops	20
SMART Stations	0
Caltrans Maintenance Facilities	0
Park and Ride	0
Transit Hubs	1
State Highway Bridges	0
Road Tunnels	0
Bikeways (Existing and Proposed)	25 miles
HOV Lanes	0 miles
Trails	4 miles
Roadways	108 miles

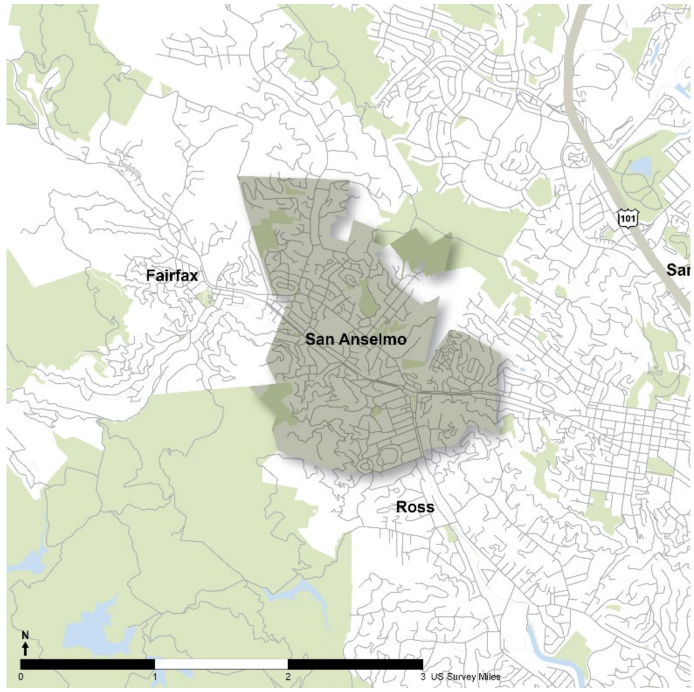

Figure 22 San Anselmo City Boundary

Key focus areas, highlighting vulnerable communities or assets:

- No assets exposed to coastal hazards, but riverine flood has caused damage in the past, including to major roads (MCM LHMP).
- Key corridors that connect San Anselmo to the region may be impacted by sea level rise. See San Rafael, Larkspur, and Corte Madera for more information. See the following plot for network link volumes, noting the significant volume from the coast inland to San Anselmo (located at the intersection west of San Rafael).

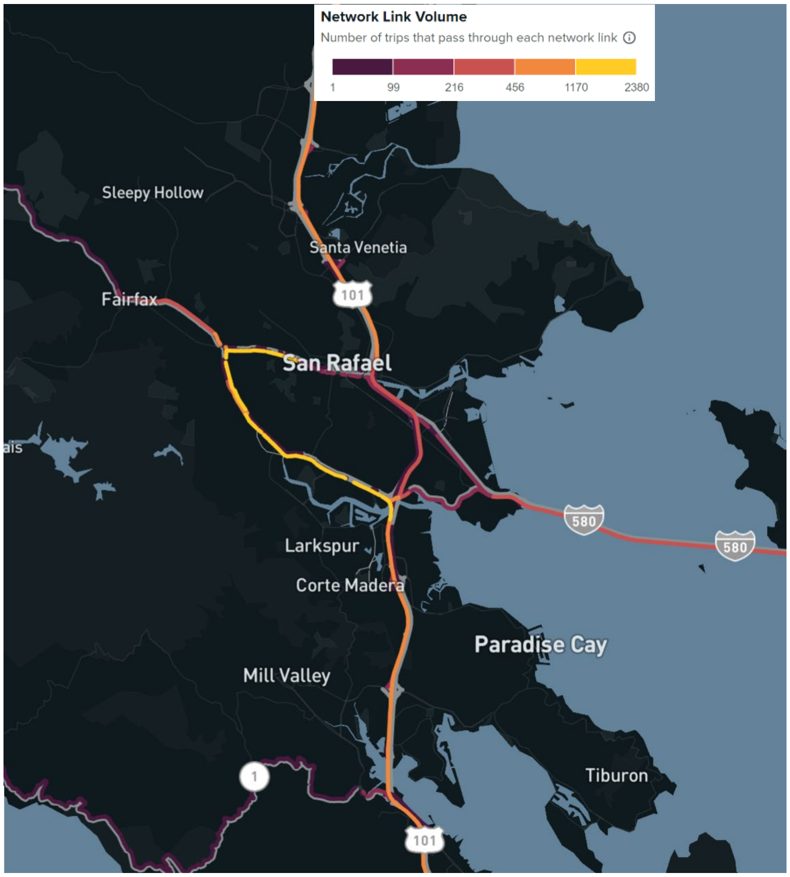

Figure 23: Network Link Volume data from Replica (replicahq.com).

6.1.11 Town of Tiburon

The Town of Tiburon comprises a peninsula that extends from main Marin into the San Francisco Bay. Tiburon Boulevard (CA-131), which connects the town (and adjacent Belvedere) to the mainland, is a key transportation asset exposed to coastal hazards like sea level rise.

Asset	
Airports	0
Golden Gate Transit Stops	0
Golden Gate Ferry Terminals	2
Marin Transit Stops	23
SMART Stations	0
Caltrans Maintenance Facilities	0
Park and Ride	1
Transit Hubs	0
State Highway Bridges	0
Road Tunnels	0
Bikeways (Existing and Proposed)	13 miles
HOV Lanes	0 miles
Trails	45 miles
Roadways	112 miles

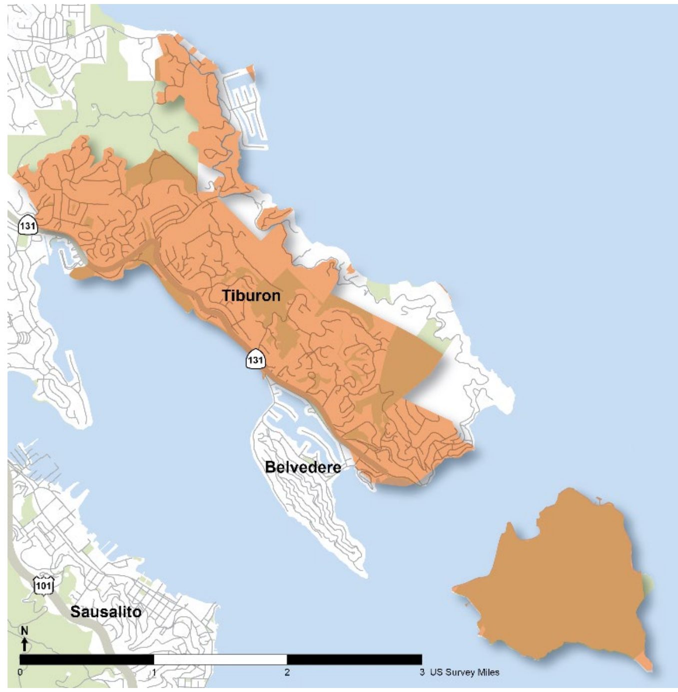

Figure 24 Tiburon City Boundary

Key focus areas, highlighting vulnerable communities or assets:

- Ferry landings in Tiburon have been identified as vulnerable to near-term SLR in the Marin Shoreline Sea Level Rise Vulnerability Assessment (BayWAVE, 2017).
- Paradise Drive connects Tiburon to the County and US-101, and it is part of the Bay Trail. Parts of the road are vulnerable to flood under 66" (5.5ft or 1.7m) SLR, though may experience inundation during storm events under less SLR (Corte Madera Climate Adaptation Assessment).

6.1.12 Unincorporated Communities

Unincorporated communities in the County of Marin include Greenbrae, Kentfield, Marin City, Bolinas, Dillon Beach, Forest Knolls, Inverness, Lagunitas, Marshall, Nicasio, Olema, Point Reyes, San Geronimo, Stinson Beach, and Tomales.[7]

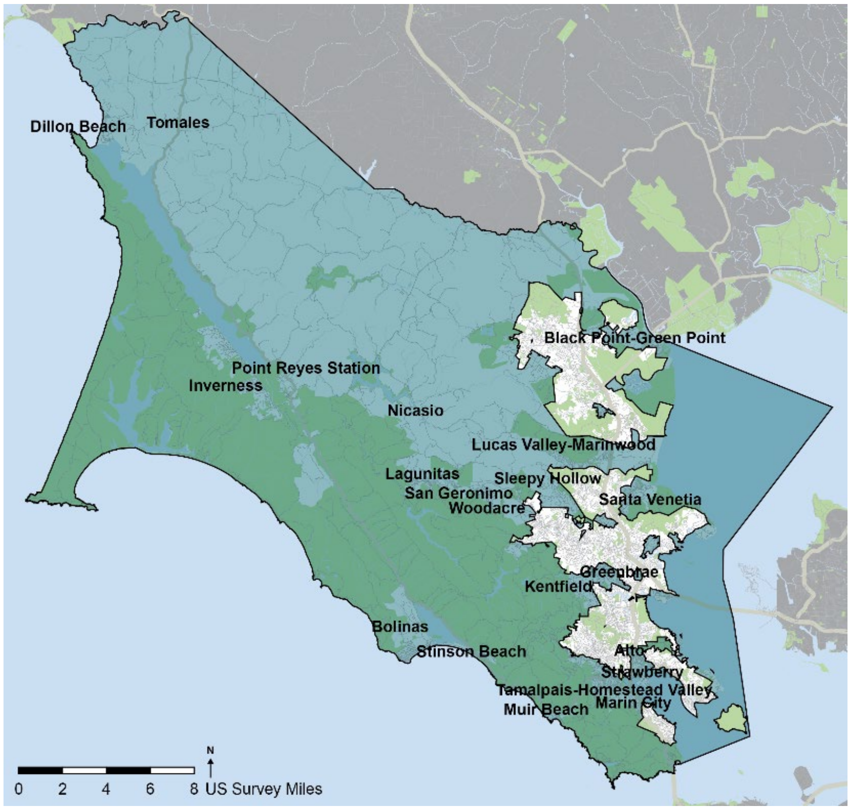

Figure 25 Unincorporated Marin County Boundary

Asset	
Airports	Gnoss Field
Golden Gate Transit Stops	18
Golden Gate Ferry Terminals	1
Marin Transit Stops	136
SMART Stations	0
Caltrans Maintenance Facilities	- Manzanita Maintenance Station - Point Reyes Maintenance Station -San Rafael Paint Shop
Park and Ride	5
Transit Hubs	6
State Highway Bridges	32
Road Tunnels	4

[7] Marin Communities - County of Marin (marincounty.org)

Bikeways (Existing and Proposed)	224 miles
HOV Lanes	7 miles
Trails	683 miles
Roadways	1,461 miles

Key focus areas, highlighting vulnerable communities or assets:

- The Manzanita Park & Ride, Shoreline Highway (Almonte) and US-101 (Strawberry) already experience flooding at high tides, which is expected to worsen under SLR (Marin Shoreline SLR Vulnerability Assessment, BayWAVE, 2017) (C-SMART, 2018) (ART Richardson Local Assessment, BCDC, 2020) (TAM Annual Report, 2022).
- SR-37 – See details in 'City of Novato' section.
- Shoreline Highway (SR-1) – This critical asset already experiences flooding during present-day storms, and portions of it are vulnerable to inundation under future 10" (0.8ft or 0.25m) SLR conditions. It connects most of the communities in western Marin to the rest of the county and the region. Particularly exposed sections can be found in Bolinas, Stinson Beach, and Point Reyes Station (C-SMART, 2018).
- Stinson Beach – Low-lying parts of Stinson Beach are located in FEMA VE zones, which is a 100-yr flood zone exposed to tsunamis and/or wave action (MCM LHMP). A key corridor, Shoreline Highway (SR-1) is the only access road to the community, and it is vulnerable to inundation during storm events with as little as 10" (0.8ft or 0.25m) SLR (C-SMART, 2018).
- Santa Venetia – flat, low-lying terrain in this community leads to drainage challenges, especially during high tides. The community relies on a system of pumps and levees to protect infrastructure and buildings (MCM LHMP). An ongoing project to replace wooden structure part of the levees will improve flood protection in the area (Santa Venetia Floodwall Project, 2023).
- Kentfield – Lucky Drive floods during present-day king tide events and is also susceptible to riverine flooding from Corte Madera Creek. This short corridor represents an essential connection between Corte Madera, Larkspur, Kentfield, and other Central Marin communities to US-101 (Corte Madera Climate Adaptation Assessment, 2021) (BayWAVE, 2017) (Corte Madera Creek Flood Risk Management Project, 2020).
- Muir Beach – Shoreline Highway (SR-1) is vulnerable to inundation under 80" (6.7ft or 2.0m) SLR, according to C-SMART (2018). The community also relies on the vulnerable US-101 / SR-1 Manzanita Interchange to connect to the county and region, particularly to the south.
- Inverness – Sir Francis Drake Boulevard has present-day risk to flooding during storm events, which are expected to worsen with climate change. Living shoreline solutions are being explored for this community and others along Tomales Bay (Tomales Bay Living Shoreline Feasibility Study, 2022).
- Marin City – This Priority Development Area on Richardson Bay is exposed to sea level rise and flooding along the coast, particularly US-101 which connects the region and Donahue Street which is the only road in and out of the community (ART Richardson Local Assessment, BCDC, 2020). The Marin City population has been identified as socially vulnerable, discussed in Resilient by Design Bay Area Challenge report for Permaculture + Social Equity Team (P+SET) (2018). As identified by the community, local flooding locations, which have been inundated in previous storms or experienced drainage issue from sediment and debris, include Cole Drive west of US-101, at the foot of Olio St. and Waldo Ct., foothill of Burgess Ct., and the intersections of US-101, Donahue St., and Drake Avenue (Marin City Drainage Study, 2018).