

The background image shows a coastal scene with a dark, rocky beach in the foreground. Several houses are built on stilts along the shoreline, with a dense forest of tall evergreen trees rising behind them. The sky is overcast with grey clouds. The text is overlaid on the upper portion of the image.

# Marin Ocean Coast Sea Level Rise Adaptation Report

**DRAFT**

Collaboration: Sea-Level Marin Adaptation Response Team  
Marin County Community Development Agency

July 2017 | Marin County, CA | [marinslr.org](http://marinslr.org)

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Cover Photo: Tomales Bay, December 2014. Credit: Marin County CDA

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And over 100 community members!

## List of Acronyms

BARC.....	Bay Area Regional Collaborative
BCDC.....	San Francisco Bay Conservation and Development Commission
BFE.....	Base Flood Elevation
Caltrans.....	California Department of Transportation
CalOES.....	California Office of Emergency Services
CCAN.....	California Coastal Adaptation Network
CCC.....	California Coastal Commission
CDA.....	Marin County Community Development Agency
CMAQ .....	Congestion Mitigation and Air Quality
COS.....	Center for Ocean Solutions
CoSMoS.....	Coastal Storm Modeling System
C-SMART.....	Collaboration Sea-level Marin Adaptation Response Team
CSP.....	California Department of Parks and Recreation
CWP.....	Countywide Plan
DEM.....	Digital Elevation Model
DFW.....	State Department of Fish and Wildlife
DPW.....	Marin County Department of Public Works
EPA.....	Environmental Protection Agency
ESA.....	Environmental Science Associates
FEMA.....	Federal Emergency Management Agency
FIRM.....	Flood Insurance Rates Maps
GFNMS.....	Greater Farallones National Marine Sanctuary
GGNRA.....	Golden Gate National Recreation Area
MALT.....	Marin Agricultural Land Trust
MTC.....	Marin Transportation Commission
NGO.....	Non-governmental Organization
NOAA.....	National Oceanic and Atmospheric Administration
NPS.....	National Park Service



NRC.....National Research Council  
NRCS.....Natural Resources Conservation Service  
OCOF..... Our Coast, Our Future  
OES.....Marin County Office of Emergency Services  
OWTS.....Onsite Wastewater Treatment Systems  
PATCH.....Plans for Adapting to Coastal Hazards  
PBCS.....Point Blue Conservation Science  
PWA .....Phillip Williams Associates  
SAC.....Stakeholder Advisory Committee  
SBCWD.....Stinson Beach County Water District  
SLR.....Sea level rise  
STP.....Surface Transportation Program  
SCC.....California State Coastal Conservancy  
SWRCB.....State Water Resources Control Board  
TAC.....Technical Advisory Committee  
TAM.....Transportation Authority of Marin  
USGS.....United States Geological Survey



## Executive Summary

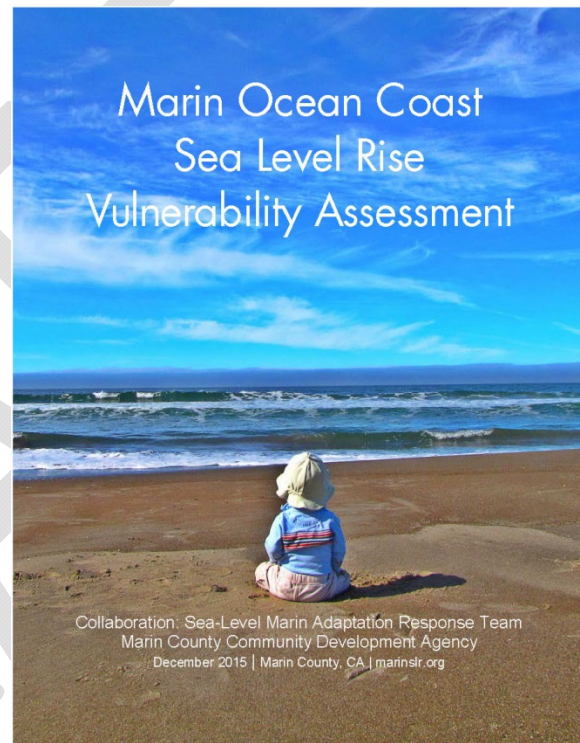
Climate experts estimate that by 2100, sea level could rise by up to 70 inches and that the frequency, intensity and flood-effects of storms could increase. People in coastal areas should understand how sea level rise (SLR) may affect their homes, schools, roads, public facilities, natural resources and habitat areas, and how to prepare for these impacts. Marin County's "Collaboration: Sea-level Marin Adaptation Response Team" (C-SMART) is a multi-stakeholder, inter-governmental partnership that is working to develop this understanding of SLR and its potential impacts for Marin's ocean coast, so that together, we can prepare to meet the challenge of SLR.

C-SMART's Stakeholder Advisory Committee (SAC) is made up of representatives from each of the West Marin communities: Muir Beach, Stinson Beach, Bolinas, Point Reyes Station, Inverness, Marshall and Dillon Beach. The Technical Advisory Committee (TAC) is made up of resource managers, utility providers, conservation scientists and other local and regional experts. Members of the public joined the conversation through a series of community workshops and meetings with local stakeholder groups, providing valuable input to the study from July 2014 – April 2016.

### Vulnerability Assessment

The [Marin Ocean Coast Sea Level Rise Vulnerability Assessment](#) identifies the vulnerability of parcels and buildings, transportation networks, utilities, working lands, natural resources, recreational activities, emergency services, and historic and archaeological resources; as well as community profiles outlining vulnerable assets for each of the West Marin communities. Information was

gathered through mapping affected assets using the United States Geological Survey (USGS) SLR model available online at Our Coast, Our Future (OCOF). C-SMART Staff conducted interviews with asset managers to identify sensitivity, adaptive capacity and planned management actions. The Vulnerability Assessment serves as the foundation for the adaptation options of this report.



In the coastal zone, over 20 percent of buildings are vulnerable at the low end of the long-term scenario, which could occur around 2100. Vulnerable buildings are concentrated in the Calles and Patios neighborhoods of Stinson Beach, Downtown Bolinas, and the Tomales Bay shorelines in Inverness and East Shore. Nearly twenty miles of public and private roadways could be compromised by flooding and permanent inundation. Roadways exposed in the short-term include Shoreline Highway between Bolinas and Stinson Beach, Calle del Arroyo, all the Calles and Patios streets, Wharf

Road in Bolinas, and several creek crossings and bridges. In addition, other low-lying portions of Shoreline Highway, Sir Francis Drake Boulevard, and local roads are vulnerable in long-term. Coastal communities also rely on septic systems, water supply systems, and shared septic or sewage systems that could be vulnerable to SLR and storms. Certain roadways and utilities are critical lynch pin assets, such that their dysfunction or destruction will likely have negative consequences for nearly all other built assets.

## Adaptation Report

This document, the *Marin Ocean Coast Sea Level Rise Adaptation Report*, presents potential actions to accommodate, protect against, or retreat from the threats of SLR and coastal hazards.

This report’s objective is not to facilitate new development in hazardous areas, but rather present options for increasing resiliency in existing natural and built assets and systems in the face of increased sea level rise and coastal storms. Identifying adaptation solutions that will be most appropriate in each location will require further continued discussion with stakeholders and technical experts, as part of an ongoing adaptive management approach. A 2008 Governor’s Executive Order states: “California must begin now to adapt and build our resiliency to coming climate changes through a thoughtful and sensible approach with local, regional, state and federal government using the best available science.”<sup>1</sup> The C-SMART project represents the foundation of the County and State agencies’ long-term

<sup>1</sup> California Governor’s Executive Order #S-13-08. November 2008.

commitment to plan for SLR and other climate change impacts.

For long-range adaptation planning and property risk disclosure, this report refers to the upper end of the National Research Council’s 2012 SLR estimate for 2100 (66 inches), which is unlikely but could occur if thermal expansion of the oceans and melting ice caps continues to accelerate. For planning purposes related to environmental review and development projects, Marin County will refer to the “most likely” SLR projection of three feet by 2100.

**Table 1. C-SMART Sea Level Rise & Storms Scenarios from CoSMoS**

Sea Level Rise Scenario	Term
1 10 inches + Annual Storm	Near
2 10 inches + 20-year Storm	Near
3 20 inches + 20-year Storm	Medium
4 40 inches + 100-year Storm	Long
5 80 inches + 100-year Storm <sup>2</sup>	Long

A possible adaptation approach for West Marin is to protect existing homes, businesses and other assets through building elevation, floodproofing, and nature-based strategies with flood protection and habitat benefits in the near- to-medium term. Additionally community-wide solutions such as elevating/armoring roads and developing shared wastewater treatment systems are recommended for consideration. In the long term, a variety of solutions including

<sup>2</sup> The upper limit for 2100, scenario 5, was selected based on: *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. The article calculate 70 inches. In the scenario options, 80 inches (rounded up from 77 inches) is the closest option.

exploring retreat alternatives are suggested. Near-term refers to 2030, medium-term refers to 2050, and long-term refers to 2100. Moreover formalizing working relationships with CDA and other government agencies/stakeholder groups is a key recommendation as a means to continue discussions and implement solutions.

In the near-term, property owners can elevate or otherwise retrofit structures to be safe from temporary flooding during storms and high tides. The County can facilitate this process through updated Local Coastal Program (LCP) policies that build upon the existing regulatory framework for Flood Hazard Areas, and that encourage additional elevation for buildings threatened by SLR. Pending LCP certification, when existing structures are elevated by the minimum amount necessary, a resulting building height of up to 30 feet above grade could be deemed to comply with coastal hazard, public view, and community character provisions of the LCP, while structures over 30 feet tall could require an individual evaluation of conformance with the relevant LCP provisions. In the medium- to long-term, communities will need to consider the tradeoffs of various adaptation approaches, and decide whether to remain in current locations or consider relocating to safer areas. Flood insurance rates and coastal armoring mitigation requirements are anticipated to increase in the coming years, which may influence property owner decisions more than development regulations.



*Stinson Beach homes at King Tide 2012.*

*Credit: J. Lamphier*

Roads vulnerable to temporary flooding will be subject to increasing temporary closures, in some cases preventing emergency access. The Local Hazard Mitigation Plan identifies near-term approaches to maintaining safety during and after disasters. General approaches and relative costs of various adaptation options for transportation infrastructure have been prepared by the Marin County Department of Public Works (DPW), and will be used to guide evaluation of actions. Standards for road flooding closure need legal definition and should be publicized with signage to alert drivers as to what they should expect. Road repairs may be an opportunity to plan for higher water levels. Design standards and best practices can help guide Capital Improvement Projects and road repairs, to ensure that roads will be more resilient to SLR and other flood events related to climate change. Permitting remains a challenge as raising roadways typically requires expanding the roadway footprint and may impact existing natural areas. In some locations, expanding the roadway footprint will not be possible.

Long term, specific stretches of roads identified as being highly vulnerable to floodwaters could be converted into recreational trails and

possibly incorporated into the California Coastal Trail.

The cost of elevating, armoring or relocating exceeds the amount of funding currently available for road repairs, and will require ongoing collaboration between California Department of Transportation (Caltrans) and the County to identify opportunities for additional funding. A formalized working agreement such as an MOU could be developed with Caltrans, Marin Transportation Commission (MTC) and Transportation Authority of Marin (TAM) for Shoreline Highway planning support as part of the Regional Transportation Plan. Capital Improvement Projects and road repairs could account for SLR when cost-effective and funded to ensure that roads are more resilient to flooding. Over time, agencies may evaluate the feasibility of relocating critical access roads upland.



*Shoreline Highway along Bolinas Lagoon*  
Credit: Bolinas PUD

As utility systems become increasingly compromised by temporary (and eventually permanent) flooding, the Community Development Agency will support ongoing efforts to elevate or otherwise protect electrical, fuel, sewage management and water

systems from high tide levels. Adaptation strategies include retrofits to water meter connections to withstand salt water, and retrofitting septic systems to meet current regulations, or flip switches that can be shut off during flooding. The Community Development Agency can continue to work with utility districts to determine a trigger point after which communities would need to develop alternatives to compromised septic leachfields, such as shared public wastewater systems. New public capital improvement projects could consider 3 feet of SLR, and development policies should be consistent with adaptation strategies (e.g. consider eliminating requirements to bury utilities in areas vulnerable to SLR). As SLR progresses, the Community Development Agency could continue to work with local service providers to determine the point at which communities need to convert to community shared public wastewater system, and explore the feasibility of relocating wells and sewage lift stations. The County can connect with the PG&E task force and other service providers to move forward with long-term, coordinated approaches for utilities.

Working lands dedicated to agriculture and mariculture will be primarily impacted by loss of road access. The County should work with farmers whose lands are vulnerable to SLR to identify appropriate solutions.

Natural resources would need to be monitored over time to better understand the impacts of SLR to beaches, wetlands, and other habitat areas. The Climate-Smart Adaptation Working Group of the Greater Farallones National Marine Sanctuary (GFNMS) Advisory Council developed a report (Appendix E) on potential strategic management actions which served as

the basis for natural resource strategies identified in this report. The County and willing partners could continue to evaluate and pursue funding opportunities for innovative living shorelines approaches to SLR protection, such as dune and wetland restoration, horizontal levees, native oyster beds, eelgrass, and bluff vegetation. Another key strategy is to enhance SLR education programs through partnerships with educational organizations and citizen science initiatives. Shoreline erosion rates would need to be monitored on a seasonal basis and before/after major storms to better understand the impacts of SLR on natural resources. Funding remains a primary challenge under all scenarios as the available resources are inadequate to meet future requirements under most scenarios.



*Western Snowy Plover*

*Credit: VanDerWal*

Water-based recreation is a key component of West Marin's economy including surfing, kayaking, fishing, birdwatching, and more. To ensure economic sustainability, other forms of recreation and tourism could be promoted including biking, hiking, and agritourism/farm trails.

Emergency access can be considered in road improvement projects, though raising roads can

be problematic for emergency access as large vehicles may need a certain grade to navigate over the roads. Alternative evacuation routes need to be developed for communities (e.g., Bolinas) with one major road that may face future chronic flooding. Water based emergency evacuation routes could be explored.

Adaptation planning should consider impacts on historic and archaeological resources. Continued discussions with the Federated Indians of Graton Rancheria should continue to ensure tribal concerns are addressed in adaptation planning processes. Marin County's 1981 Local Coastal Program Historic Study could be updated so the full extent of vulnerable properties can be assessed. Vulnerable historic structures could be documented before damaged by SLR or significantly altered by adaptation measures.

### **Community Specific Alternatives**

All West Marin communities can benefit from strategies to improve resiliency to flood events and maintain safety in coastal hazard areas. SLR will cause areas that flood temporarily now to flood permanently at daily high tides in the future.

Homeowners can prepare by elevating or otherwise retrofitting buildings and utilities in the near-term, while considering community-wide protective measures such as living shorelines, elevation/armoring of critical assets, or managed retreat over time. Understanding the implications and tradeoffs of different approaches (protect, accommodate, or retreat) will require continued study and community dialogue around adaptation.

While not all adaptation solutions are permanent, public and private projects to

address sea level rise in the near and medium term can still help with some level of protection and merit consideration. Cost estimates for various strategies are included in this report, but come from a variety of sources, could be out of date or inconsistent with one another, and further analysis is necessary to fully assess specific costs considering implementation, environmental review, permitting, maintenance and more.

### **Muir Beach**

The recently completed Redwood Creek restoration project is an example of a nature-based adaptation to SLR, which restored natural creek function in part by re-aligning vulnerable assets and infrastructure that impeded natural processes. This improved habitat function while simultaneously increasing resiliency to flooding and SLR. In the near-term, homeowners on bluffs vulnerable to erosion can improve stormwater drainage to stabilize bluffs. Revegetation and netting can also be used for bluff stabilization. It will be very difficult to obtain a permit for new shoreline armoring, although the Coastal Act allows for maintenance of existing structures under certain circumstances, and for new structures to protect existing development in danger of erosion when designed to eliminate or mitigate adverse impacts on local shoreline sand supply. Low-lying sections of Pacific Way and Shoreline Highway may be subject to closures during flood events, and may eventually need to be elevated or realigned. Resizing culverts and the Pacific Way Bridge would help to mitigate flooding as part of a suite of climate change resiliency best practices.

### **Stinson Beach**

Accommodation of vulnerable structures, roads and utilities, primarily through elevation and

retrofits, is a near- and medium-term priority for Stinson Beach. Elevation of homes would protect them from temporary flooding and permanent SLR, though road access would continue to be an issue. Many respondents of the 2015 West Marin Sea Level Rise Adaptation Poll supported “reasonable policies that allow property owners to develop in ways that protect against SLR.” However, permits for structures in vulnerable areas may be conditioned to prove that the structure will be safe from coastal hazards.

Calle del Arroyo is the County road of most immediate concern, as it frequently floods and provides the only access to Seadrift, the Patios, and many of the Calles. If Calle del Arroyo were elevated, private roads would also need to be elevated, or at least sloped up to meet Calle del Arroyo. Elevating Shoreline Highway along Bolinas Lagoon will become a priority toward the middle of the century, as access to the community becomes impaired with increasing frequency.

If not yet retrofitted, Onsite Wastewater Treatment Systems (OWTS) can be updated to include shutoff valves, meet code, which will make them resilient to saltwater intrusion in the near-term. In the medium- to long-term, development code amendments allowing for mounded septic systems, or replacement of leachfields with holding tanks could be implemented. The Stinson Beach County Water District plans to continue retrofitting water meter connections in the near-term to withstand saltwater corrosion. Electric utilities located beneath buildings will also need to be elevated or retrofitted. The Water District office will likely need to be elevated or relocated in the near-term. Fire Station #2 is already elevated on a mound and the district has plans

to relocate the facility before it is impacted by SLR in the medium-term.

A comparison of conceptual adaptation strategies for Stinson Beach is described in the Community Alternatives section and in Appendix B (ESA Adaptation Strategy Memo). A potential dune and beach protection strategy would involve placing sand on a cobble berm and adding sand at regular intervals and after major storm events, as a hybrid protection approach. The costs for these strategies is large and greatly exceeds available funding.



*Brighton Beach in Bolinas*

*Credit: S. Hutto*

### **Bolinas**

Accommodation of threatened structures and utilities through elevation and retrofitting could be priority action. Shoreline Highway and Wharf Road are of primary concern in the near-term, while Olema-Bolinas Road and the bridge at Pine Creek Gulch may need to be elevated or rerouted in the medium term. Bluff top homes may need to be removed once the bluff edge erodes to within a certain distance of the structure.

The Bolinas Public Community Utility District Sewage Treatment Facility will need to be protected, and other critical facilities and community resources like the grocery store, emergency shelter and library will need to be

elevated or relocated in the medium-term. The Post Office and Bolinas-Stinson School will need to be elevated or relocated in the long-term. Nature-based protection measures such as a native oyster reef and/or horizontal levee in Bolinas Lagoon may help protect Gospel Flats, which may eventually be conserved and returned to wetland. Wetland protection and enhancement efforts (currently underway as part of the Bolinas Lagoon Restoration Project) will also have flood protection benefits.



*Old fishing boat in Inverness*

*Credit: R. Porrata*

### **Inverness**

Homes and other structures currently near or over water could be further elevated, and portions of critical roadways like Sir Francis Drake and Shoreline Highway could also be raised to maintain access at higher water levels. In addition to protecting properties vulnerable in the near-term, converting affected segments of Sir Francis Drake Boulevard into a levee would protect the water pipeline beneath the road. Wetland restoration and native oyster reefs in the near-term and a horizontal levee in the medium-term are potential nature-based solutions.

Restoring and enhancing living shorelines along Tomales Bay offers near- to medium-term protection against temporary flooding, storm



surge, and wave impacts. Habitat restoration techniques can be used to manage the shoreline, reduce coastal erosion, and maintain coastal processes.

### **East Shore**

Homes and other structures currently over water could be raised higher, and portions of Shoreline Highway could also be raised to maintain access at higher water levels. Wetland restoration and native oyster reefs in the near-term and potentially horizontal levee in the medium-term are potential nature-based solutions. Maintaining bulkheads under homes along the East Shore and Marshall is a high priority to protect Tomales Bay from sewage.

Raising houses along the Marshall waterfront is very difficult and expensive, and creative solutions from people familiar with Tomales Bay are needed. As water levels rise, the area under houses becomes less accessible for foundation work. There is a great deal of interest from residents in developing a community-wide solution by coordinating the elevation of multiple homes. This could help provide a better economy of scale for permitting, design work and construction. Such a pilot project could be modeled after the Marshall Community Wastewater System which was a coordinated effort to protect water quality and share costs between government agencies and property owners, though specific funding sources would need to be identified.

### **Point Reyes Station**

Surrounding wetlands and marshes, including Giacomini Wetlands and Olema Marsh could be degraded by flooding, erosion, and increased salinity. Water district pipes traversing under the marsh and road could be damaged by higher groundwater and would benefit from

elevation or other protection. Flooding is probable on portions of Shoreline Highway in the long-term scenarios, however Green Bridge is vulnerable in the near-term.

### **Dillon Beach**

Priority actions for Dillon Beach are to support dune restoration efforts as a protective measure, research alternatives for managing flooding on Bay Drive, and implement policies to ensure that bluff top homes are safe from erosion. Plans for dune restoration and enhancement are being developed by Lawson's Landing owners. Planting native vegetation to augment existing beach grass may help encourage natural augmentation of the dunes. This is considered a cost-effective and environmental approach, compared to importing sand. A monitoring plan could be developed to contribute to the body of research on the efficacy of this measure at reducing coastal erosion and protecting Lawson's Landing recreational facilities from wave run up.

### **Implementation Phasing**

Strategies were prioritized based on a set of criteria determined by Marin County, with input from the SAC and TAC. The criteria include projected onset of impacts (See Chapter 3), timing and duration of the strategy, co-benefits, and legal, political and community acceptability. General cost-benefit analysis was performed on various alternative scenarios using a published range of costs to provide a basis of evaluation of next steps. Priority for adaptation alternatives ready for action, further study, or long-term implementation were further refined through working sessions with DPW and Environmental Science (ESA).

See [Table 2](#) for a summary of priority strategies. Further detail is provided in the Asset-Based

Strategies and Community Alternatives chapters.

### Next Steps

This report summarizes adaptation options that have arisen through the C-SMART process to date. These options are not endorsed by the County of Marin or project partners, are not all necessarily feasible (economically, socially, environmentally, etc.), and in some cases may conflict with one another. However, the options presented in this report have been recognized as meriting further consideration. Option inclusion in this report does not imply financial commitment by Marin County, and completion of certain tasks is dependent on acquiring additional funding, which would require exploring various funding sources/types.

The fifth set of C-SMART public workshops included the *West Marin Sea Level Rise Adaptation Plan Passport* as a survey to solicit input from residents on next steps County staff could undertake. Additionally, the passport was posted online for further distribution via traditional and social media. Participants were asked to prioritize the possible next steps listed below with a high, medium, or low ranking. Space was also provided for comments on each ranking, as well as space to suggest entirely new options.

A total of 83 passports were completed. Indicated on each bullet below is the number of High votes, and the complete response summary can be found in Appendix G.

#### Site Scale Improvements

- Develop a “**Homeowner’s Guide to Preparing for Sea Level Rise**” to help property owners navigate regulatory system and funding opportunities to elevate or otherwise retrofit homes to

accommodate sea level rise and storms. Topics could cover:

- County permitting process
- Coastal Permit Development requirements
- Agency Compliance (FEMA, California Coastal Commission, etc.)
- Potential estimated building elevation increase

*This option received **58** high votes, tying it for number 1 of the 11 options.*

- Develop and distribute technical information and guidance on **home retrofitting options** which could include elevation, wet/dry floodproofing, flood gates, drainage improvements, amphibiation, etc.

*This option received **39** high votes, making it number 5 of the 11 options.*

#### Community Scale Planning

- Develop a **subcommittee** with Marin County BOS representation and community/local agency representatives to prioritize C-SMART next steps.

*This option received **31** high votes, making it number 9 of the 11 options.*

- Initiate **Community Plans for Adapting to Coastal Hazards** (Community PATCHs) in conjunction with community members and asset managers for smaller scale planning centered around vulnerable assets of community wide importance.
  - Identify subarea boundaries for prioritization, possibly based on timing, area of impact, costs, equity, environment, economy, etc.

- Develop planning timeframes around the point at which flooding creates recurring significant problems
- Evaluate adaptation alternatives with cost estimates in more detail, which may include armoring, elevation, realignment, etc.

*This option received **48** high votes, making it number 3 of the 11 options.*

- Consider sea level rise in capital improvement projects (roads, utilities, armoring, etc.) including both incremental repairs and maintenance, and new projects. Develop financing matrix for identifying possible funding sources including federal and state grants, local assessment districts, philanthropic resources, and public-private partnerships.

*This option received **58** high votes, tying it for number 1 of the 11 options.*

- Evaluate **land use planning, zoning and legal frameworks** for addressing sea level rise which could include height limits, construction standards, and post-storm prohibitions. Such options could be integrated in the Local Coastal Plan Implementation Program and Marin Countywide Plan update.

*This option received **37** high votes, making it number 6 of the 11 options.*

- Consider sea level rise resiliency in the next update of the Marin Countywide Plan as a basis for developing countywide policies and programs.

*This option received **33** high votes, making it number 8 of the 11 options.*

### Continued Partnerships

- Develop an **interagency sea level rise task force** with membership including County Supervisor and agencies who oversee West Marin assets (transportation, utilities, public lands, natural resources, etc.). Participants could include:
  - Caltrans, MTC and TAM for transportation planning support
  - National Park Service/Golden Gate National Recreation Area/CA Department of Parks and Recreation/Marin County Parks
  - PG&E and local service providers to discuss utility adaptation

*This option received **43** high votes, making it number 4 of the 11 options.*

- Continue to work with the Sonoma/Marin County Sediment Management Working Group to assist with the development of a **Regional Sediment Management Plan** to
  - encourage beneficial reuse of available, non-polluted sediment resources;
  - restore and maintain coastal beaches;
  - reduce shoreline erosion and coastal storm damages; and
  - sustain recreation, tourism, public safety and access

*This option received **36** high votes, making it number 7 of the 11 options.*

### Public Education

- Establish a **citizen's science monitoring program** for community members to gather data on West Marin sea level rise impacts which could include measuring beach widths, documenting king tides and flooding, and monitoring wetlands.

*This option received **23** high votes, tying it for number 10 of the 11 options.*

- Continue to pursue funding and partnerships to formalize a sea level rise **public education** program for high school students.

*This option received **23** high votes, tying it for number 10 of the 11 options.*

The tables that follow are a list of near-term, medium-term, and long-term potential management actions to protect the vulnerable assets along coastal Marin County and a guide to find more detailed information in the document by page number.

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Table 2. Priority Sea Level Rise Adaptation Strategies

	Potential Management Action	Potential Partners	Resources	Page	
	<b>All Assets</b>				
Near/ Ongoing	A-1	Explore the feasibility of experimental and innovative coastal protection options, and where possible implement demonstration projects, including constructed wetlands/horizontal levees, offshore reefs/native oyster beds, and dune restoration/beach nourishment. Evaluate the effectiveness of such projects to inform future efforts across the region.	CDA, GFNMS, NPS, DFW, Universities, CCC, SCC, COS, Property Owners	Staff, partners, financial resources, agency coordination	58, 77, 77, 77, 83, 147, 149, 151, 161, 165, 182, 182, 183, 192, 193, 193, 196, 205, 205, 205, 213, 213, 218, 220
	A-2	Participate and support existing local community programs, including but not limited to education, outreach, and emergency preparedness, that promote community resilience.	CDA, Community Groups	Staff, community groups	73, 83, 182, 183, 220
	<b>PARCELS &amp; BUILDINGS</b>				
Near/Ongoing	B-1	Through LCP Environmental Hazards policies, ensure new development is safe and limit development in hazardous areas. Require property owners to assume and disclose risks from coastal hazards, including impacts from 3 feet of SLR.	CDA, CCC, Property owners	Staff, private time/financial resources	74, 87, 87, 167, 87

	Potential Management Action	Potential Partners	Resources	Page
B-2	<p>Require three feet additional elevation of structures in Special Flood Hazard Areas (in addition to Federal Emergency Management Agency (FEMA) Base Flood Elevation) to accommodate three of SLR. In areas outside FEMA Special Flood Hazard Areas that are nevertheless exposed to SLR, the 3 foot building elevation would also be required. The policy would apply when a new or remodeled building requires a Coastal Permit, based on actual conditions of the site.</p> <p>FEMA grant funding for structural elevation could be sought, possibly including the Marin County Structure Elevation program, a FEMA Hazard Mitigation Grant Program.</p>	CDA, CCC, FEMA, Property owners	Staff, Public and/or private funding	75, 87, 87, 167
B-3	<p>Pursuant to Local Coastal Program C-EH-22.a(7): Support efforts to develop and implement innovative design alternatives to elevating structures that would reduce or eliminate flood damage. Measures would need to be adopted by FEMA to qualify as acceptable alternatives to elevation under the National Flood Insurance Program (NFIP). Such alternatives could include wet/dry floodproofing, flood gates, drainage improvements, amphibiation, etc. Encourage homeowners to implement voluntary flood-proofing measures.</p>	CDA, CCC, FEMA, Property owners	Staff, Agency Coordination	77, 87, 87, 95, 96,
B-4	<p>Develop a “Homeowner’s Guide to Preparing for Sea Level Rise” to help homeowners navigate regulatory system and funding opportunities to elevate or otherwise retrofit homes to accommodate SLR and storms. Topics could cover:</p> <ul style="list-style-type: none"> <li>• County permitting process.</li> <li>• Coastal Permit Development Requirements (<a href="#">Figure 7</a>)</li> <li>• Agency Compliance (FEMA, California Coastal Commission (CCC), etc.)</li> </ul>	CDA, FEMA, CCC, Property Owners	Staff, Public outreach materials	87

	Potential Management Action	Potential Partners	Resources	Page
	<ul style="list-style-type: none"> <li>Potential estimated building elevation increase</li> </ul>			
	B-5 Use Marin Map as a platform to show regulatory boundaries (e.g., FEMA, GFNMS, CCC jurisdiction, Categorical Exclusion), County-developed "Potential Sea Level Rise Maps", and other existing coastal hazard boundaries.	CDA, CCC, FEMA, GFNMS	Staff., agency coordination, Marin Map	88
	B-6 Conduct a comprehensive finished floor elevation inventory to fully assess West Marin building vulnerabilities.	CDA, DPW	Staff, intern or volunteer time	88
Long	B-7 Explore the feasibility of programs (incentives, TDRs, Acquisition/Buyout) and potential receiving sites to relocate existing vulnerable development.	CDA, NPS, CA CSP, MALT	Staff, Legal coordination, Precedents, Upland property	59, 68, 88, , 149, 173, 184, 195, 208, 213, 219
<b>TRANSPORTATION</b>				
Near/Ongoing	T-1 Consider planning for Shoreline Highway and county-maintained roads as part of the Regional Transportation Program	Caltrans, MTC and TAM, DPW, GFNMS, community members	Staff, agency coordination	77, 78, 113, 114, 148, 159, 170, 181, 194, 194, 206, 206, 208, 213, 213, 214
	T-2 Further investigate Shoreline Highway vulnerability along Tomales Bay in the Eastshore Area. Determine if bulkheads below homes help protect highway. If so examine long term adaptation strategies for continued protection in collaboration with homeowners.	Caltrans, property owners	Staff, agency coordination, homeowner participation	114, 204
	T-3 Evaluate new capital improvement projects to account for 3 feet of SLR.	CDA, DPW, Caltrans	Staff, agency coordination	75, 78, 112, 114, 119

	Potential Management Action	Potential Partners	Resources	Page	
	T-4	Identify triggers for maximum flood depth or frequency as thresholds at which roads will need to be elevated, relocated, seasonally closed, or abandoned. This could include community surveys to understand the point at which flooding is perceived as chronic and causing public inconvenience.	CDA, Caltrans, DPW, Other technical Experts	Staff, Agency coordination, Technical assistance	68, 114, 148, 170, 184, 206, 213, 219
	T-5	Support post-disaster repairs as an opportunity to plan for higher water levels.	CDA, DPW, Caltrans	Agency coordination, Staff	112, 114
	T-6	Standards for road flooding closure need legal definition and should be publicized with signage to alert drivers as to what they should expect.	CDA, DPW, Caltrans	Agency coordination, Staff, Legal Counsel, Signage	115
Medium	T-7	Explore the feasibility of realigning vulnerable roads landward. Utilize Marin County DPW table on <i>Potential Adaptation Options - General Strengths and Weaknesses</i> to guide evaluation of transportation adaptation alternatives.	CDA, DPW, Caltrans	Agency coordination, Staff	77, 68, 114, 117, 126, 170, 184, 184, 195, 206, 208, 214,

	UTILITIES				
Near/Ongoing	U-1	Continue efforts to elevate or otherwise protect electrical, fuel, sewage management and water systems from high tide levels.	CDA, Utilities, Homeowners Associations, Property owners	Staff, Public/private funding	65, 80, 74, 105, 119, 158, 159, 181, 184, 194, 194, 206,
	U-2	Consistent with proposed LCP home elevation requirements, consider new capital improvement projects to evaluate impacts and costs for 3 feet of SLR.	CDA, DPW, Marin County Parks, other agencies as necessary	Staff, Public funding	75, 78, 74, 112, 114, 119



	Potential Management Action	Potential Partners	Resources	Page	
	U-3	Ensure that development policies are consistent with strategies for accommodating SLR (e.g., consider eliminating requirements to bury utilities in areas vulnerable to SLR).	CDA, CCC	Staff	65, 119
	U-4	Work with Stinson Beach County Water District (SBCWD) and EHS to determine if SLR will raise groundwater levels to impair OWTS.	CDA, SBCWD, EHS	Staff, agency coordination	119
Medium	U-5	Work with local service providers to determine the point at which communities would need to convert to shared public wastewater system alternatives to accommodate for SLR.	CDA, Local service providers	Staff, agency coordination	119, 149, 172, 194
	U-6	Identify potential upland areas to retreat/relocate utility systems, including wells and wastewater infrastructure which may include sewage pumps, lift stations and septic leach fields. National Park lands could be considered, in close coordination with NPS.	CDA, Local service providers, NPS, CSP, MALT	Staff, spatial data, GIS	119, 121, 149
Long	U-7	Establish community shared public wastewater systems in relevant areas.	CDA, Landowners, Local service providers, Local assessment district	Staff, upland property, private and/or public financial resources	120, 149, 172, 194

	WORKING LANDS				
Near/Ongoing	W-1	Maintain and adapt coastal armoring.	CDA, Property Owners, CCC	Staff, Private financial resources	75, 69, 122, 159, 181
	W-2	Work with agricultural interests to respond to SLR.	CDA, Property Owners, Resource	CDA, Property Owners, Farm Bureau, Land Trusts, RCD, UC Cooperative Extension Resource Conservation District	122
Medium	W-3	Work with agricultural operators and funding organizations to secure rights to allow wetlands to expand inland with SLR.	CDA, Property owners, CCC	MALT, SCC, DFW	122

	Potential Management Action	Potential Partners	Resources	Page
<b>NATURAL RESOURCES</b>				
<b>Near/Ongoing</b>	<p>N-1</p> <p>Enhance SLR education programs through partnerships with educational organizations and other public entities, including:</p> <ul style="list-style-type: none"> <li>• Partnerships with environmental education organizations, schools and other public entities</li> <li>• Social media and other communication strategies, such as SLR visualizations and crowdsourcing king tides photos</li> <li>• Interpretive signage</li> <li>• Expansion of Marin County’s existing Youth-Exploring Sea Level Rise Science (YESS) program.</li> <li>• Marsh and tidepool education and interpretation programs through training and guidance to communicate implications of climate change</li> <li>• Establish a volunteer docent program, for highly visited areas. This could augment existing programs (e.g., Duxbury Marin Reserves). Docents training could include climate change impacts on intertidal habitats, as well as tidepool etiquette and safety.</li> </ul>	<p>CDA, GFNMS, CA Academy of Sciences, NPS, CSP, County Parks, Other educational organizations</p>	<p>Financial resources, staff, volunteers, curricula trainings, classrooms</p>	<p>72, 123, 147</p>
<b>Medium</b>	<p>N-2</p> <p>Stabilize cliffs through revegetation (with native, climate appropriate species) and natural netting (e.g. jute, not chain-link fence). Design any hardening methods to take into account ecosystem needs (e.g. seabird nesting). Consider the listed Showy Rancheria Clover (<i>Trifolium amoenum</i>), including assisted migration to locations further upslope. Avoid armoring and encourage relocation of infrastructure to allow for managed retreat. Minimize non climate stressors including human and livestock access.</p>	<p>CA Conservation Corps, CA Native Plant Society, Caltrans, landowners/managers (public and private)</p>	<p>Financial resources, staff, permits, engineering studies</p>	<p>15, 86, 124, 147</p>

	Potential Management Action	Potential Partners	Resources	Page
N-3	<p>Consider nature-based adaptation options for eelgrass habitat.</p> <ul style="list-style-type: none"> <li>• In the near-term map potential landward transgressional areas and protect potential transition habitat.</li> <li>• As water rises, monitor trends in eelgrass extent; possibly plant in shallower water to kick-start colonization of areas available for landward transgression.</li> <li>• Minimize non-climate stressors including restoration of areas lost from moorings, minimizing disturbance to existing beds and monitoring changes in turbidity.</li> </ul>	<p>CDA, GFNMS, DFW, Community Members, Business owners, SF Bay Living Shorelines Projects (case study)</p>	<p>Financial resources, staff, local community involvement, mapping/monitoring equipment and software, plant propagules, possible land acquisition/assessments etc. for habitat restoration, volunteer/citizen scientist monitors</p>	<p>124, 182, 193, 196, 205</p>

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	Potential Management Action	Potential Partners	Resources	Page
	<p>Consider nature-based adaptation options for Tidal Marsh habitat.</p> <ul style="list-style-type: none"> <li>• In the near-term consider accommodation strategies including                             <ul style="list-style-type: none"> <li>○ Mapping potential landward transgressional areas and protecting potential transition habitat and allowing for habitat transition</li> <li>○ Consider removing potential barriers to landward migration (e.g, Highway 1 bridge in the Walker Creek Delta, Sir Francis Drake Blvd. between Inverness Park and Reyes Station, Bear Valley Road and Highway 1, Shoreline Highway in Marshall, Shoreline Highway in Bolinas Lagoon)</li> <li>○ Identifying ownership of and acquiring potential transition zones upstream of current marsh footprint.</li> </ul> </li> <li>• If high value resources/functions are present, consider augmenting sediment in the long-term to allow for accretion of marsh within existing footprint (e.g., Walker Creek Delta, Giacomini Wetland Restoration Footprint).</li> <li>• Non-Climate stressors such as invasive species should be minimized.</li> <li>• Allow for loss of marshes in cases that they have less high value resources (could include Tomales Bay area in Inverness). Instead, prioritizing action on more significant areas of intact marshes nearby (e.g., Pt. Reyes Station/Lagunitas Creek Delta).</li> <li>• Engage with ongoing efforts (e.g., Bolinas Lagoon Restoration Project) to ensure planning includes future SLR.</li> <li>• Engineer marshlands to enhance water flow and balance sediment transport by including design elements such as sinuous channelization.</li> </ul>	<p>CDA, Marin County Parks and open Space, Point Reyes National Seashore GFNMS,GGNR A, Community Members, Business owners, DFW</p>	<p>Financial resources, staff, local community involvement, mapping/monitoring equipment and software, plant propagules, possible land acquisition/assessments etc. for habitat restoration, volunteer/citizen scientist monitors, engineering studies, permits/environmental reviews</p>	<p>58, 77, 77, 77, 83, 123, 147, 149, 151, 161, 165, 182, 182, 183, 192, 193, 193, 196, 205, 205, 205, 213, 218, 220</p>

	Potential Management Action	Potential Partners	Resources	Page
	<b>NATURAL RESOURCES (cont.)</b>			
N-5	<p>Consider nature-based adaptation options for beach/dune habitat.</p> <ul style="list-style-type: none"> <li>• Determine if topography and land use/infrastructure allows for inland movement of beach/dune habitat. Where feasible, remove/relocate shoreward constraints to dune movement and evolution.</li> <li>• Restore/Construct/augment coastal dunes. This could include placement of sand, graded and planted to form back beach dunes or placement of cobble. Drought tolerant and heat resistant species or strains should be used. In cases where dredge materials are used, make sure materials are screened for contaminant exposure.</li> <li>• Where applicable, minimize human and pet access through dunes to protect stability and disturbance, which could include fencing, creating walkways, and informational signage. Beach grooming should be ceased as well as any activity that adversely affects the sediment supply of dunes.</li> <li>• Identify potential sources of compatible sediment (considering appropriate grain size and structure) for vulnerable beaches in order to enable potential nourishment.</li> </ul>	NPS, Landowners	Sand, Financial Resources, Staff, Permits/Environmental Review	58, 77, 83, 147, 161, 182, 218, 220
N-6	In cases that coastal armoring is exacerbating erosion, explore natural alternatives that create sloped, transitional habitat (e.g., artificial reef, horizontal levee or dune). If armoring can't be removed, implement living shoreline techniques in conjunction with new construction/repairs.	GFNMS, NPS, DFW, Universities, SCC	Financial Resources, Staff, Permits/Environmental Review, Public Outreach	125

	Potential Management Action	Potential Partners	Resources	Page
	<p>N-7</p> <p>In cases in which roads need to be realigned/relocated due to ‘trigger points’ being reached (e.g., causing public inconvenience), siting and design should allow for natural expansion of habitats. Areas should be identified that are critical for estuary expansion and roads could be realigned accordingly.</p>	<p>Caltrans, GFNMS, US Army Corps of Engineers, Regional Water Quality Control Board, Landowners</p>	<p>Agency Coordination, Financial resources, Staff, Permits/Environmental Review</p>	<p>126</p>
	<p>N-8</p> <p>Establish a monitoring program to detect impacts of climate change and management actions on natural resources including the following steps:</p> <ul style="list-style-type: none"> <li>• Postulate hypotheses of habitat change, based on scenarios and literature, of how habitats will evolve in response to climate change.</li> <li>• Design the monitoring programs to measure hypothesized changes</li> <li>• Identify indicator species for selected habitats, and set tentative population parameter goals based on current status and knowledge of the species.</li> <li>• Design the monitoring program to estimate the population parameter, and determine the extent and intensity of sampling required to achieve the monitoring goals, including sources of data, precision in parameter estimation, and costs</li> <li>• Review costs vs expected probability of monitoring goals to choose final indicator species, monitoring targets, data sources, survey effort, and costs</li> </ul>	<p>CDA, Scientific Partners, local community members, environmental non-profits</p>	<p>Financial resources, staff, mapping/monitoring equipment and software, volunteer/citizen scientist monitors</p>	<p>126</p>

	RECREATION			
<p>Near/Ongoing</p>	<p>R-1</p> <p>Increase awareness of seasonal flooding on public lands/trails through signage and social media.</p>	<p>National, State and County Parks</p>	<p>Staff, projections, Impacts to local businesses</p>	<p>134</p>

	Potential Management Action	Potential Partners	Resources	Page
Long	R-3 Retrofit or relocate recreation and visitor-serving facilities, including trails and access points, considering SLR projections. Acquire new parklands as existing parks become unusable from chronic flooding, inundation, erosion, etc.	CDA, Property/business owners, CCC, CSP, NPS, County Parks	Public/private funding, Permits, Receiving sites, Materials	78, 134, 135, 195, 206, 208, 53

	EMERGENCY SERVICES			
Near/Ongoing	E-1 Partner with Local Hazard Mitigation Plan efforts to coordinate near term disaster preparedness with long-term community resilience.	CDA, Marin County OES, State OES, Local Emergency Response Teams	Staff, Agency coordination, Outreach materials	137
Medium	E-2 Adapt or relocate vulnerable emergency facilities (e.g., fire stations, emergency generators).	CDA, OES, Stinson Beach Fire Department	Staff, property, financial resources	73, 137, 159, 181
Long	E-3 Develop additional emergency response teams and resources required for disaster response, recovery and mitigation, as well as temporary housing and other sustainability needs.	CDA, Marin County OES, Local Emergency Response Teams	Staff, Coordination, Financial resources, Housing	72, 137
	E-4 Build redundancy into the system by providing alternate evacuation routes where feasible. This is particularly critical for communities such as Bolinas with one primary access road in and out that could be inoperable from chronic flooding.	Stinson Beach, Bolinas, Inverness, Point Reyes Station, East Shore, Dillon Beach	Staff, Funding, Upland property, Permits, Environmental reviews	77, 65, 112, 118, 137, 148, 194

	HISTORIC & ARCHAEOLOGICAL RESOURCES			
Near/Ongoing	H-1 Adaptation planning/implementation efforts should consider the impacts on historic structures and archaeological sites consistent with applicable state/federal regulations as well as local community input. In cases where projects could have adverse effects, efforts should be made to avoid, minimize or mitigate the impacts consistent with relevant statutes (CEQA, Section 106, etc.).	CDA, Office of Historic Preservation, Tribal Historic Preservation Officers	Staff	78, 139, 184

	Potential Management Action	Potential Partners	Resources	Page	
	H-2	Continue discussions with the Federated Indians of Graton Rancheria for consideration of archaeological sites in future vulnerability assessments, adaptation plans, and adaptation strategy implementation.	Federated Indians of Graton Rancheria	Staff and agency coordination	78, 139
	H-3	Update the 1981 Marin County Local Coastal Program Historic Study. This could include inventorying historic sites with lists, photographs and descriptions, and revising and expanding historic district boundaries. An updated study could: <ul style="list-style-type: none"> <li>• Inform future SLR/climate change vulnerability assessments to more fully understand the extent of West Marin’s threatened historical resources</li> <li>• Inform future adaptation planning for historic resources.</li> <li>• Document the resources in case coastal hazards damage or destroy the structures.</li> </ul>	CDA, CCC	Staff, consultant assistance, financial resources	78, 139
Medium	H-4	Recognize and consider projects which protect/mitigate historic and cultural resources in Marin County’s Local Hazard Mitigation Plan. Use FEMA’s How-to-Guide “Integrating Historic Property and Cultural Resource Considerations Into Hazard Mitigation Planning”. Upon FEMA approval, such projects may be eligible for Federal Funding.	CDA, OES, DPW, FEMA	Staff, agency coordination, FEMA grant funding	78, 139
	H-5	Work with the State Office of Historic Preservation's disaster task force to assess damages to historic and archaeological sites that may occur from storm events or other disasters.	CDA, State Office of Historic Preservation, Private Property Owners, Federated Indians of Graton Rancheria	Staff, agency coordination	78, 140



## 1) Introduction

In this section you will find:

- A statement of the intention and goal of the project;
- A list of the project partners;
- The planning areas covered in the report;
- The principles that guide the planners in their efforts;
- A summary of the Vulnerability Assessment report that was published in December 2015.

### 1.1) Project Intent and Goals

Global SLR has opened questions about the wisdom of rebuilding or protecting vulnerable assets, versus relocating or abandoning them as part of a managed retreat program. With over one-quarter of properties in the Coastal Zone and hundreds of natural and community assets threatened by SLR, Marin County is engaged in the critical task of planning how to prepare for and adapt to, changing seas. SLR is a pressing global issue that locally will increase the potential for erosion, increase the extent of chronic inundation in low lying areas and result in more severe storm flooding.

The *Marin Ocean Coast Vulnerability Assessment* and this document, the *Marin Ocean Coast Adaptation Report*, lay the groundwork for an adaptive management approach to addressing SLR in Marin County. The Adaptation Report presents near, medium, and long-term options to accommodate, protect against, or relocate/ retreat from the threats of SLR and extreme events. There is no silver bullet for adapting to the changes coming to our coastline, and adaptation measures will have varying economic, environmental, and social costs and effects. The goals of adaptation

planning are to help protect human life, health and property, ensure the safety of new development, maintain public access and recreational opportunities, and protect beaches, wetlands and other natural resources on Marin's ocean coast.

This document is intended to inform the Marin County Local Coastal Program, coastal permitting and other County goals related to SLR preparation. This document would also be considered by the Local Hazard Mitigation Plan (LHMP), the Marin Countywide Plan (CWP), and Design Review process for proposed development. The adaptation options provided in this Report are intended to be useful in developing strategies throughout County operations, including securing funding and establishing ongoing programming. This Report serves as a tool for Marin County governmental departments, individual property owners, state and federal parks, state transportation agencies, asset managers, and coastal residents. Marin County's adaptation planning process may also serve as an example for other communities.

### 1.2) Project Partners

Led by the Marin County Community Development Agency (CDA), "Collaboration: Sea-level Marin Adaptation Response Team (C-SMART)" began in July 2014 with financial support from the California Ocean Protection Council (OPC) and the CCC.

Project partners include GFNMS, USGS, Point Blue Conservation Science (PBCS), Coravai, Center for Ocean Solutions (COS), and DPW. The technical advisory committee includes staff from FEMA, Caltrans, National Oceanic and Atmospheric Administration (NOAA), California CSP, and the NPS, while the stakeholder

advisory committee includes representatives from Marin's coastal communities of Muir Beach, Stinson Beach, Bolinas, Inverness, Point Reyes Station, the East Shore (including Marshall), Dillon Beach, and further north to the Sonoma County border.

### 1.3) Planning Area

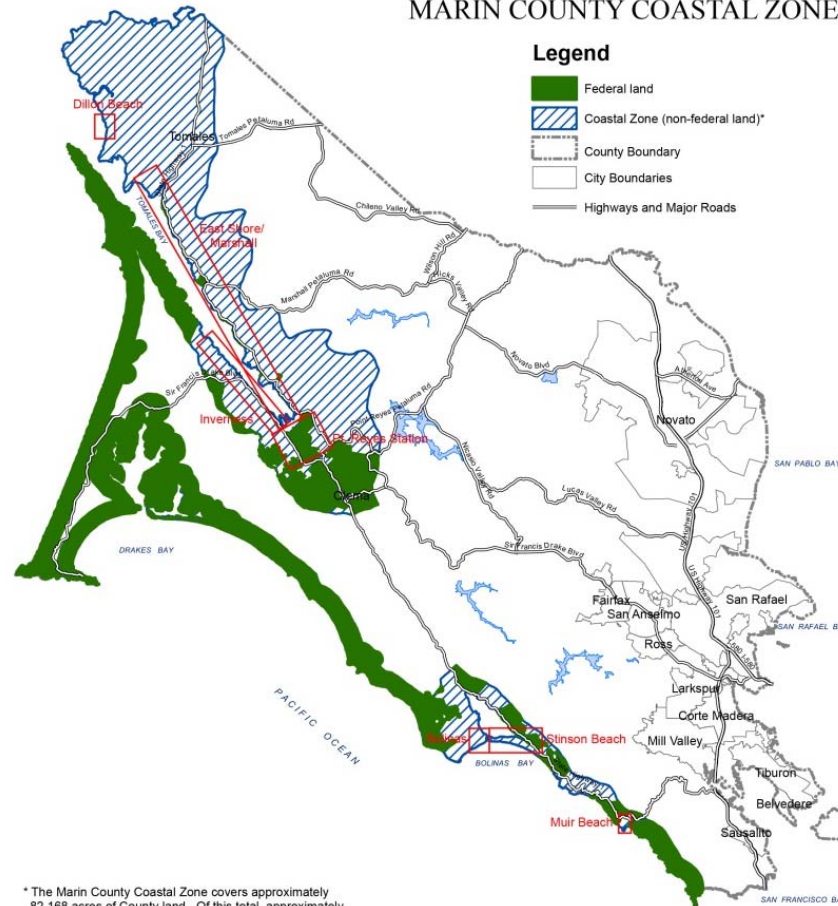
The planning area (Map 1) is Marin County's Coastal Zone (in some cases stream impacts extend beyond the eastern boundary). The Marin County Coastal Zone covers approximately 82,168 acres. Of this, approximately 33,913 acres are owned and managed by the NPS, leaving 48,255 acres of the Coastal Zone under County jurisdiction [Pursuant to the Federal Coastal Zone Management Act of 1972 (16 U.S.C. 1451, et seq.)].

**Map 1. Planning Area. Areas indicated in red are relative locations of Community Alternative sections**



State of California

**MARIN COUNTY COASTAL ZONE**



**Legend**

- Federal land
- Coastal Zone (non-federal land)\*
- County Boundary
- City Boundaries
- Highways and Major Roads

\* The Marin County Coastal Zone covers approximately 82,168 acres of County land. Of this total, approximately 33,913 acres are owned and managed by the federal government (National Park Service). This leaves 48,255 acres of the Coastal Zone under County jurisdiction.

The Coastal Zone Boundary depicted on this map is shown for illustrative purposes only and does not define the Coastal Zone. The delineation is representational, may be revised at any time in the future, is not binding on the Coastal Commission, and may not eliminate the need for a formal boundary determination made by the Coastal Commission.



THIS MAP WAS DEVELOPED FOR PLANNING PURPOSES AND IS ILLUSTRATIVE ONLY. THE COUNTY OF MARIN IS NOT RESPONSIBLE OR LIABLE FOR USE OF THIS MAP BEYOND ITS INTENDED PURPOSE. THIS MAP IS REPRESENTATIONAL ONLY. DATA ARE NOT SURVEY ACCURATE.  
Date: 12/15/2016 File: Map 2\_Marin County Coastal Zone\_rev 12.2016.mxd

SOURCE: Marin County Community Development Agency

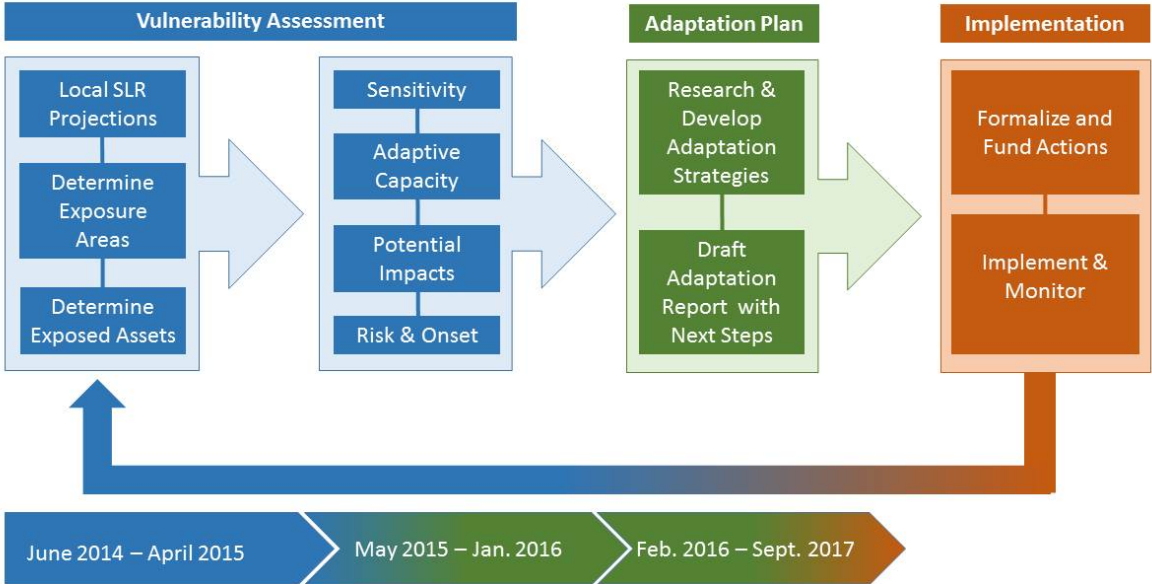
### 1.4) The C-SMART Process

The C-SMART process is in the Adaptation Plan Phase as shown in [Figure 1](#). This document incorporates findings from the *Marin Coast Sea Level Rise Vulnerability Assessment* (Assessment). The Assessment provides data and the best available science for SLR and how it could impact coastal Marin. Ideas for adaptation strategies came from a wide variety of sources. C-SMART Staff has done extensive literature review to identify potential strategies for West Marin based on comparable case studies. Insights and additional ideas were generated in engaging coastal residents in several community workshops addressing SLR vulnerability and adaptation. C-SMART’s TAC and SAC provided ideas on adaptation strategies through advisory committee meetings. Finally, this Plan utilizes the expertise of several partner organizations including ESA, the COS (Stanford University), and GFNMS, among many others. Methodologies from stakeholder, technical expert and C-SMART partner processes are described in greater detail below.

The options were gathered from the community, technical experts, and literature and case study research and vetted to answer the following questions:

1. Does the strategy:
  - a. Protect?
  - b. Retreat?
  - c. Accommodate?
  - d. Preserve? (natural resources)
2. Is the strategy suited for:
  - a. Infrastructure?
  - b. Developed properties?
  - c. Vacant properties
3. Is the strategy useful in the:
  - a. Short-term?
  - b. Medium-term?
  - c. Long-term?
4. Does the strategy have positive, neutral, or negative impacts on:
  - a. Economy?
  - b. Environment?
  - c. Social equity?
  - d. Administrative?
  - e. Legal?
5. Is the strategy suited for:
  - a. Coastal shoreline/blufftop?
  - b. Bay / estuarine environments?
  - c. Riverine environments?
6. The strategy reduce impacts of:
  - a. Temporary Flooding?
  - b. Inundation?
  - c. Erosion?
  - d. Wave Surge?
  - e. High Wind
7. Where has this strategy been implemented?
8. What are the estimated costs (administrative, capital, construction, maintenance)?

Figure 1. C-SMART Process



DRAFT

## 1.5) Guiding Principles

Principles were developed to guide the adaptation planning process and outcomes, and vetted with stakeholders through the C-SMART process. These include:

### 1.5.1 General Approach

- Recognize that West Marin is affected by the world around it.<sup>3</sup>
  - Recognize that SLR is one of several climate change and other potential coastal hazards (earthquakes, fires, sandy soils, creek and river flooding, storm winds and waves, and fluctuating tides) current and future residents will likely face. Interrelationships between these factors will impact the coast and can be monitored moving forward.
  - Facilitate adaptation of existing development to reduce vulnerability to SLR impacts over time.<sup>4</sup>
  - Prioritize SLR adaptation strategies that have co-benefits for other climate risks.<sup>5</sup> Adaptation measures should minimize adverse impacts while encouraging common benefits.<sup>6</sup>
  - Design adaptation to fit into existing programs and mechanisms where possible, so as to not create additional layers of bureaucracy
- Adaptation planning, and initial plan implementation, must begin now, and can be refined as more information becomes available.<sup>7</sup>
  - Due to the high degree of uncertainty, use an adaptive management approach, with indicators and established monitoring. Adaptation policies need to be flexible enough for circumstances that may not yet be fully predictable. Avoid unnecessarily prescriptive adaptation actions. Encourage decisions at the local level.<sup>8</sup>
  - Acknowledge that there will be losses, and rationally assign budgets and efforts to those assets that have the highest value and the best chances of survival. Discuss value of adding some life to certain assets while forgoing long-term preservation, rather than complete preservation. Strike a balance between protection of homes, infrastructure and conservation of natural resources.<sup>9</sup>
  - Utilize a precautionary approach to minimize risk borne by local communities.<sup>10</sup>
  - Avoid, and where unavoidable, minimize, significant coastal hazard risks to new development and redevelopment over the life of authorized structures.<sup>11</sup>
  - Warn property owners that they need to understand and assume the risk of development in hazardous areas.<sup>12</sup>

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3 National Adaptation Forum. *Adaptation Pledge*. [www.nationaladaptationforum.org/about/adaptation-pledge](http://www.nationaladaptationforum.org/about/adaptation-pledge)

4 ICLEI-Local Governments for Sustainability. *Sea Level Rise Adaptation Strategy for San Diego Bay*. January 2012.

5 Ibid. "Co-benefits" are the other benefits (in addition to flood and sea level rise protection) that a community may experience if an adaptation strategy is implemented. These can include greenhouse gas reduction, habitat protection/creation, economic improvement, and many other potential community goals.

6 National Adaptation Forum. *Adaptation Pledge*.

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7 Delaware Coastal Programs. *Preparing for Tomorrow's High Tide: Recommendations for Adapting to Sea Level Rise in Delaware*. September 2013.

8 ibid

9 ibid

10 ICLEI-Local Governments for Sustainability. *Sea Level Rise Adaptation Strategy for San Diego Bay*. January 2012.

11 California Coastal Commission. *Sea Level Rise Policy Guidance*. August 2015.

12 ibid

- Encourage priority for coastal-dependent and coastal-related development over other development.<sup>13</sup>
- Recognize public trust boundary changes resulting from SLR.
- Avoid “maladaptation” by avoiding actions that, relative to alternatives: increase emissions of greenhouse gases, disproportionately burden the most vulnerable, have high opportunity costs, reduce incentives to adapt, and set paths that limit the choices available to future generations.<sup>14</sup>

### 1.5.2 Available Science

- Use available science and knowledge to consider present, past, and foreseeable future conditions<sup>15</sup>, and use best available technology for decision-making and adaptation strategies and actions. Take account of locally-relevant and context-specific SLR projections in planning, project design, and permitting reviews.<sup>16</sup>
- Stay abreast of the responses of threatened areas around the globe to learn of sensible and effective strategies.<sup>17</sup>
- Consider the cumulative impacts and regional contexts of planning and permitting decisions.<sup>18</sup>



West Marin coastal marsh.

Credit: Sevin

### 1.5.3 Equity

- Promote a diversity of partners and stakeholders in conversations and decisions.<sup>19</sup>
- Work to ensure the equitable sharing of the benefits and costs of SLR. Consider equity in selection and funding of adaptation measures. Safeguard integrity: Encourage transparency, accountability & follow-through.<sup>20</sup>
- Adaptation measures should consider the distinct vulnerabilities of potentially affected subpopulations.<sup>21</sup>

### 1.5.4 Engagement

- Engage broad public participation in adaptation decisions.<sup>22</sup> Foster collaborative problem solving, involve relevant stakeholders in considering the adaptation strategy.<sup>23</sup>

13 ibid

14 Global Environmental Change. *Maladaptation Editorial*. [www.elsevier.com/locate/gloenvcha](http://www.elsevier.com/locate/gloenvcha). 2010.

15 National Adaptation Forum. *Adaptation Pledge*. [www.nationaladaptationforum.org/about/adaptation-pledge](http://www.nationaladaptationforum.org/about/adaptation-pledge)

16 California Coastal Commission. *Sea Level Rise Policy Guidance*. August 2015.

17 C. Harrington

18 California Coastal Commission. *Sea Level Rise Policy Guidance*. August 2015.

19 California Natural Resources Agency. *Safeguarding California: Reducing Climate Risk*. July 2014.

20 Natural Adaptation Forum  
<http://www.nationaladaptationforum.org/program/good-adaptation-pledge>

21 California Climate Change Center.

22 California Coastal Commission. *Sea Level Rise Policy Guidance*. August 2015.

23 Environmental Protection Agency (EPA) *National Estuary Program*. 2015.

- Strive to establish and maintain partnerships between government, tribes, businesses, landowners, and non-governmental organizations (NGOs) in the development and implementation of adaptation strategy recommendations.<sup>24</sup> Support each other in research and monitoring efforts.<sup>25</sup>
- Coordinate and consider consequences of adaptation among jurisdictions and resource types.<sup>26</sup>
- Communicate within and between the coastal communities to share information, successes, failures and funding resources. Maintain an ongoing public outreach program.

### 1.5.5 Environment

- Maximize natural shoreline values and minimize shoreline armoring.<sup>27</sup>
- Protect ocean and coastal ecosystems. Protect public access to coastal areas and beaches, natural shoreline, and park and recreational resources.<sup>28</sup>
- Address potential coastal resource impacts (wetlands, habitat, agriculture, scenic, etc.) and recognize the desirability of measures to protect coastal resources in all coastal planning and regulatory decisions.<sup>29</sup>

### 1.5.6 Economy

- Adaptation planning should identify and address potential impacts to the local and regional economy from SLR.
- Adaptation efforts that preserve and enhance habitat contribute to healthy working and living conditions, provide a continuing draw for tourism and recreational industries, and stimulates related economic opportunities.
- Appropriate and timely adaptation measures can benefit the economy by maintaining a diverse and sustainable local economy, and providing for the safe and efficient movement of people and goods.<sup>30</sup>



Sunrise at Nick's Cove.

Credit: Klingel

24 ICLEI-Local Governments for Sustainability. *Sea Level Rise Adaptation Strategy for San Diego Bay*. 2012.

25 California Coastal Commission. *Sea Level Rise Policy Guidance*. August 2015

26 Delaware Coastal Programs. *Preparing for Tomorrow's High Tide: Recommendations for Adapting to Sea Level Rise in Delaware*. September 2013.

27 *ibid*

28 ICLEI-Local Governments for Sustainability. *Sea Level Rise Adaptation Strategy for San Diego Bay*. January 2012.

29 California Coastal Commission. *Sea Level Rise Policy Guidance*. August 2015.

30 Marin Countywide Plan. Prepared by the Marin Community Development Agency. November 6, 2007.



## 1.6) Vulnerability Assessment

The [Marin Coast Sea Level Rise Vulnerability Assessment](#), published in December 2015, presents asset profiles of community assets describing their vulnerability. These assets are: parcels and buildings, transportation networks, utilities, working lands, natural resources, recreational activities, emergency services, and historic and archaeological resources. It also includes community profiles highlighting the vulnerable assets in Muir Beach, Stinson Beach, Bolinas, Inverness, Point Reyes Station, East Shore, and Dillon Beach (which includes north of Dillon Beach to the county line).

Each profile details key issues, geographic locations, existing policies, and other economic, environmental, equity, and management considerations related to SLR vulnerability. Each profile can be used independently of the others to enable asset managers to focus on their professional area, and community members, elected officials, and others to read the results by community.

Vulnerability is based on an asset's exposure, sensitivity, and adaptive capacity to rising waters and storm threats. If an exposed asset is sensitive to SLR impacts, with low to no adaptive capacity, the asset is considered vulnerable. The project team interviewed asset managers using the "[Asset Vulnerability Assessment Tool](#)", which was developed by County staff with questions for asset managers aimed to quantify assets' sensitivities and adaptive capacities to flooding (permanent and temporary), erosion and other impacts. The interview results were combined with geographic data and citizen input gathered during public workshops to develop the Vulnerability Assessment.

**Table 3** shows the range of SLR projections for California adopted by the National Research Council (NRC) in 2012.

**Table 3. 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

Given the uncertainty in the magnitude and timing of future SLR, Marin County used a scenario-based approach to assess a range of potential SLR impacts. The five scenarios selected were derived from the USGS Coastal Storm Modeling System (CoSMoS) which identified areas that may flood at 10 different sea levels (ranging from 0 to 500 centimeters) and four storm severities (none, annual, 20-year storm, 100-year storm). All of these scenarios are available on the [Our Coast, Our Future \(OCOF\) online Flood Map](#).

The key findings of the Vulnerability Assessment are based on the five sea level and storm combinations, given below in [Table 4](#), representing near-term, medium-term, and long-term futures.

Scenarios 1 and 2 represent the near-term, and correspond to the 2030 NRC projected sea level range.

Scenario 3 is considered medium-term and is within the 2050 NRC range.

Scenarios 4 and 5 represent the long-term. Scenario 4 corresponds to the 2100 NRC range.

Scenario 5 represents levels based on additional research theorizing the worst case: that by 2100

sea level rise is nearing 70 inches globally. The CoSMoS option that most closely reflects that is a rise of 200 centimeters, or 77 inches, and is referenced as 80 inches in this assessment.

The five scenarios selected for the C-SMART analysis are shown in Table 4.

**Table 4. C-SMART Sea Level Rise & Storms Scenarios from CoSMoS (OCOF)**

Sea Level Rise Scenario	Term
1 10 inches + Annual Storm	Near
2 10 inches + 20-year Storm	Near
3 20 inches + 20-year Storm	Medium
4 40 inches + 100-year Storm	Long
5 80 inches + 100-year Storm <sup>31</sup>	Long

The scenarios include SLR, tides, storm surge, El Niño effects, wave set up, and wave run up. CoSMoS scales down global and regional climate and wave models to produce local hazard projections.<sup>32</sup> High quality elevation data incorporated in the Digital Elevation Model (DEM) is used to create maps of mean higher high water (MHHW) tidal elevation plus SLR heights and provides the option to add storm impacts. Mean higher high water is the average of the higher high water height of each tidal day

<sup>31</sup> The upper limit for 2100, scenario 5, was selected based on: *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. The article calculates 70 inches. In the scenario options, 80 inches (rounded up from 77 inches) is the closest option.

<sup>32</sup> 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](http://www.pointblue.org/ocof). (Accessed: Date August 2014)).

## Sea Level Rise Science Update

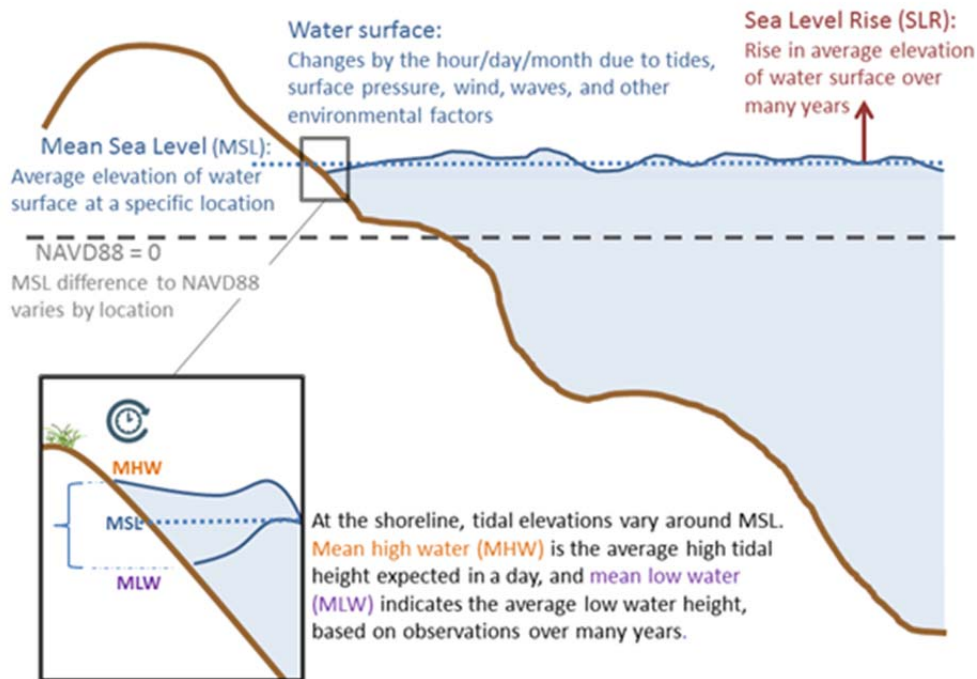
In April 2017, the California Ocean Science Trust released *Rising Seas in California: An Update on Sea-Level Rise Science* to reflect recent advances in ice loss science and sea level rise projections. The report highlights increasing ice loss from Greenland and Antarctic ice sheets which will cause higher sea level rise in California than the global average. Projections vary dramatically past midcentury and could range from 1 to 10 feet by 2100. The high range of uncertainty underscores the importance of staying abreast of continually evolving sea level rise science, maintaining flexibility in adaptation planning, and understanding site specific contexts in the decision making process.

observed over the National Tidal Datum Epoch.<sup>33,34</sup> Because the analysis uses high tide, properties nearest the limit of the exposure area exposed to MHHW could be dry at lower tides, while inundation could be deeper for the period of the cycle where water levels are above MHHW. Note that the CoSMoS model only accounts for ocean levels and does not incorporate impacts from creek flooding during storms or changes in the coast line (geomorphology) as erosion continues.

<sup>33</sup> 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.

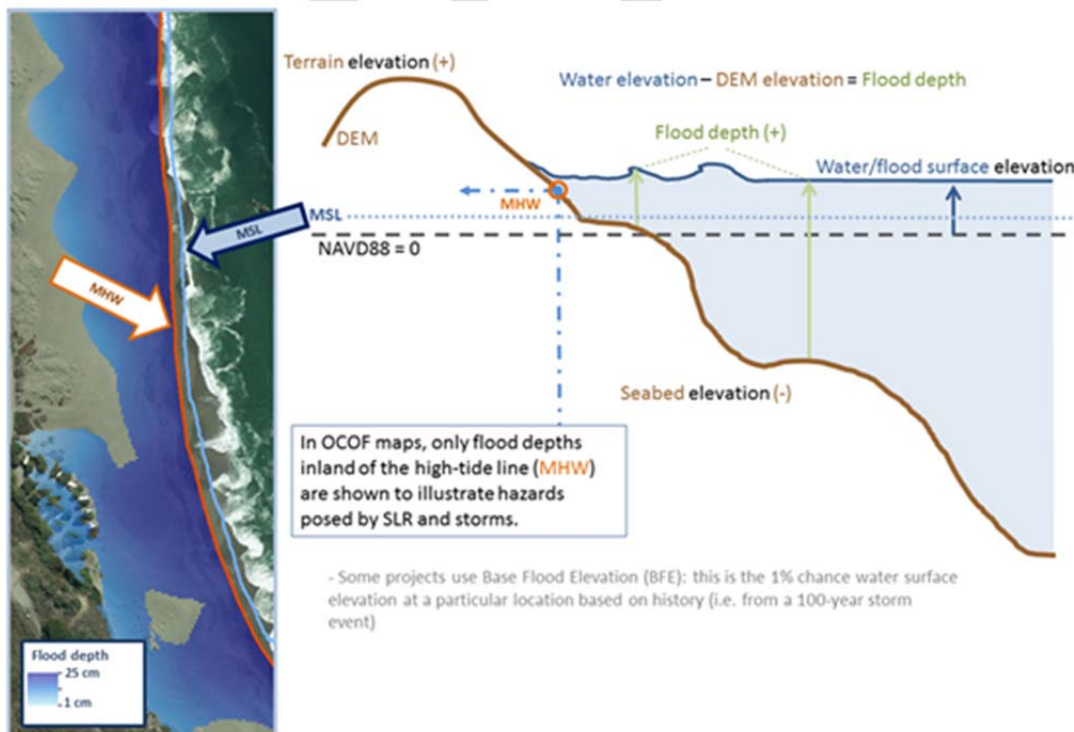
<sup>34</sup> [NOAA / National Ocean Service](http://www.noaa.gov). *Tidal Datums*. Access Oct. 19, 2015. Last updated: 10/15/2013 . Center for Operational Oceanographic Products and Services. [https://tidesandcurrents.noaa.gov/datum\\_options.html](https://tidesandcurrents.noaa.gov/datum_options.html).

Figure 2. Water Surface Diagram (OCOF 2016)



Note: While Figure 2 depicts MHW, the COSMOS model which informs OCOF maps uses MHHW including those used for this report and denotes more landward flooding than MHW.

Figure 3. Flood Depth Diagram (OCOF 2016)



Using the CoSMoS data for sea level rise and its extent into the coastal areas, the Vulnerability Assessment determined the exposure of the eight assets. **Table 4** lists the number and percentage of Parcels and Buildings in the coastal zone exposed in each of the 5 Scenarios.

**Table 4. Number of Exposed Parcels & Buildings**

	Parcels		Buildings	
	#	%	#	%
<b>Scenario 1</b>	824	16%	372	8%
<b>Scenario 2</b>	1,046	20%	588	10%
<b>Scenario 3</b>	1,085	21%	680	11%
<b>Scenario 4</b>	1,150	21%	853	14%
<b>Scenario 5</b>	1,298	25%	1,076	18%

Source: Marin Map, OCOF

In the coastal zone, over 20 percent of buildings are exposed at the low end of the long-term scenario (scenario 4), and 25 percent at the high end of the long-term scenario (scenario 5).

These buildings are concentrated in the Calles and Patios neighborhoods in Stinson Beach, downtown Bolinas, and the Tomales Bay shorelines in Inverness and East Shore (Marshall).

The VA also finds that on the East Shore, 90 to 100 percent of commercial, and 78 to 84 percent of residential parcels are exposed in the medium-term and high-end of the long-term respectively, representing the majority of buildings along the eastern shore of Tomales Bay. In Bolinas, 27 to 87 percent of commercial properties are exposed in the medium-term and high end of the long-term respectively, including both resident and visitor services. In Stinson Beach, nearly 70 percent of residential parcels are exposed in medium-term and onward.

Nearly twenty miles of public and private roadways could be compromised. Roadways exposed in the short-term include Shoreline Highway between Bolinas and Stinson Beach, which accounts for 20 percent of road length in the Coastal Zone and represents the only roadway between the two communities, not to mention the primary accessway within the coastal Zone. In Stinson Beach, Calle del Arroyo and the other Calles and Patios are compromised. In Bolinas, Wharf Road as well as several creek crossings and bridges are compromised. Other low-lying portions of Shoreline Highway, several local roads, and Sir Francis Drake Blvd. (17 percent) are vulnerable in the long-term.

Coastal communities also rely on septic systems, water supply systems, and shared septic or sewerage systems that could be exposed to SLR and storms. Roadways and utilities are lynch pin assets, such that their dysfunction or destruction will have negative consequences for nearly all other built assets.

## 1.7) Prioritize Adaptive Needs

Prioritization is based on potential impacts, existing adaptive capacity, and the risk and onset identified by the Vulnerability Assessment. For example, higher priority is assigned to strategies addressing impacts with greater potential severity or longer ramp-up times. Impacts that are predicted to arise further in the future, offering more time to mobilize a response based on ongoing monitoring, would rank with relatively lower priority.

Based on the findings of the Vulnerability Assessment, overall the most vulnerable assets (in order of timing and flood depth) of coastal Marin are listed below. The full list of exposed assets with flooding depths by scenario can be found in [Table 5](#):

#### Near-term

- Beaches, underground OWTS, buildings, and streets in Stinson Beach (west of Shoreline Highway),
- Shoreline Highway between Stinson Beach Bolinas, at Green Bridge in Point Reyes Station, the Walker Creek crossing in Marshall, and bridges on Middle Road and Valley Ford Lincoln School Road in the near-term.
- Beaches, beach front and downtown buildings and streets in Bolinas.
- Septic systems, beaches, marshes, and buildings along the eastern and western shores of Tomales bay on the East Shore and in Inverness.
- Water distribution pipe extending underneath Shoreline Highway and Sir Francis Drake serving Inverness residents.
- Intertidal rocky lands in Muir Beach, Agate Beach (Duxbury Reef).
- Fire Service facilities and tsunami routes in Stinson Beach.
- Recreational facilities at Dillon Beach Resort and Lawson's Landing.

#### Medium-term

- Olema-Bolinas Road, the primary access road to Bolinas.
- Further north into downtown Bolinas, including the historic district.
- Bolinas Public Utilities District lift station.

- Shoreline Highway in Pt. Reyes Station Sir Francis Drake Blvd. in Inverness.

#### Long-term

- Shoreline Highway along the Eastshore in the medium and long-terms.
- Buildings in Inverness west of Sir Francis Drake Blvd.
- Downtown Bolinas up to Bridgton Road along Olema-Bolinas Road, including the market, library, community center, gas station, museum, and several other valued places.

Several of these vulnerabilities will impact both human and wildlife communities. In several cases not only is the asset vulnerable, but so are the means for accessing the asset, whether it is a building at the end of a flooded road, or an access point to reach a beach or trail.

Underground resources will likely be impacted before the assets above will be (buildings, roads). Road segments were measured at a high and low depth point along the vulnerable segment described.

Community members and decision-makers will need to decide whether to adapt by protecting, accommodating, retreating, or combining strategies in the face of SLR and increased threats from extreme events. For each of these choices, several other strategies, programs, and policies will need to be established to carry out these efforts using the most equitable, environmentally friendly, and economically efficient methods possible.

[Table 5](#) shows the ranking of assets, first by chronological order of onset and, secondarily, by the highest flood depth measured.

## 1.8 Programs and Documents Referenced in the Report

### **C-SMART**

[C-SMART](#) is an effort led by the Marin County Community Development Agency to understand the potential impacts of SLR and work together with communities to prepare for a resilient future. Through developing a sound scientific and technical basis for assessing vulnerabilities, C-SMART has identified possible response and resiliency strategies, coordinated with partner agencies and local communities, and informed Marin's Local Coastal Program.

### **Vulnerability Assessment**

As the first step in planning for sea level rise impacts, the [C-SMART Vulnerability Assessment](#) identifies West Marin assets and areas that could be impacted over five sea level rise scenarios from near to long term. The report includes asset profiles describing the vulnerability of parcels and buildings, transportation networks, utilities, working lands, natural resources, recreational assets, emergency services, and historic and archaeological resources; and community profiles highlighting vulnerabilities of Muir Beach, Stinson Beach, Bolinas, Inverness, Pt. Reyes Station, East Shore, and Dillon Beach.

### **Adaptation Report (this report)**

This report presents potential actions to accommodate, protect against, or retreat from the threats of SLR and coastal hazards that can be considered by communities, homeowners, and asset managers. Possible adaptation options are broken down by the asset and community profiles categories used in the Vulnerability Assessment. Possible next steps are discussed including further planning and implementation.

### **BayWAVE**

The [Marin Bay Waterfront Adaptation Vulnerability Evaluation](#) (BayWAVE) is the parallel program for assessing Marin's bayside shoreline vulnerabilities through 2100 with asset and community profiles.

### **Local Coastal Program**

Informed by C-SMART, Marin's Local Coastal Program Environmental Hazards chapter is currently being revised. In accordance with the California Coastal Act, policies guide development in West Marin communities with the recognition of sea level rise and other coastal hazards.

## 1.8 Programs and Documents Referenced in the Report (cont.)

### **Marin County's Multi-Jurisdictional Local Hazard Mitigation Plan (MCMLHMP)**

With a five year planning cycle, Marin County's Multi-Jurisdictional Local Hazard Mitigation Plan (MCMLHMP), is part of an ongoing planning process facilitated by the OES to meet the requirements of the Disaster Mitigation Act of 2000 to maintain continued eligibility for certain FEMA Hazard Mitigation programs. The LHMP is intended to improve the ability to recover after a variety of disasters: earthquakes, fires, floods, tsunamis, and landslides. Once approved by FEMA, LHMP projects are positioned to receive Federal Funding. . LHMP's focus is on near term strategies to protect people from current threats, while C-SMART focuses on strategies to protect people from future risks.

### **Marin Countywide Plan**

The [Marin Countywide Plan](#) (CWP), last updated in 2007, is the comprehensive long-range general plan that guides land use and development in the unincorporated areas of Marin County. With the overarching theme of "planning sustainable communities", the CWP promotes leading edge strategies started in 1974 when Marin County initiated policies to constrain development and protect open space. Sustainability is emphasized as the CWP calls for environmentally friendly building techniques and energy-efficiency standards.

Table 5. Vulnerability Ranking of Exposed Assets by Scenario

Community	Asset	High Tide & Extreme Event Flooding Depth Estimates (Underlined values indicate tidal flooding at mean higher high water (MHHW) based on one geographic point located at the landward limit of the first scenario overlapping the asset. Other values represent extreme event flooding. Roads received a high, used for ranking, and low value along the line segment.)					Vulnerability TF: Temp. Flooding during extreme events; I: Inundated at mean highest high tide; E: Erosion; WT: Water Table; SI: Saltwater Intrusion; WS: Wave Surge; HW: High Wind, HS: Habitat Shift
		Scen. 1	Scen. 2	Scen. 3	Scen. 4	Scen. 5	
Stinson Beach	Septic Systems west of Shoreline Highway	underground resource			6'4"	9'7"	I, WT, WS, TF
Stinson Beach	Water Distribution Lines	underground resource			6'4"	9'7"	E, WS, TF, I, SI, ES
Inverness	NMWD Pipeline	underground resource (see Shoreline Highway Point Reyes Station to Inverness for depths)					WT, SI, E
Pt. Reyes Station	NMWD Pipeline	underground resource (see Shoreline Highway Point Reyes Station to Inverness for depths)					I, SI
Stinson Beach	Calle del Arroyo	<u>7"</u> - 6'11"	3" - <u>6'8"</u>	8" - <u>9'6"</u>	2'5" - 12'2"	5'11" - 13'9"	I, TF
Stinson Beach	Upton Beach	4'7"	6'2"	7'5"	9'8"	14'9"	I, E
Stinson Beach	Seadrift, Patios, and Calles Buildings	≤1.5' - <u>4.5'</u>	≤1.5' - <u>7.5'</u>	≤1.5' - <u>9'</u>	≤1.5' - <u>10.5'</u>	≤1.5' - <u>13.5'</u>	I, WT, WS, TF
Bolinas	Bolinas Buildings	≤1.5' - <u>4.5'</u>	≤1.5' - <u>4.5'</u>	≤1.5' - 6'	≤1.5' - <u>7.5'</u>	≤1.5' - <u>10.5'</u>	I, WT, WS, TF
Inverness	Inverness Buildings	≤1.5' - <u>4.5'</u>	≤1.5' - <u>4.5'</u>	≤1.5' - <u>6'</u>	≤1.5' - <u>7.5'</u>	≤1.5' - 10.5'	I, WT, WS, TF
Eastshore	Eastshore Buildings	≤1.5' - <u>3'</u>	≤1.5' - <u>4.5'</u>	≤1.5' - <u>6'</u>	≤1.5' - <u>7.5'</u>	≤1.5' - <u>10.5'</u>	I, WT, WS, TF
Inverness	Inverness Yacht Club	3'2"	4'1"	4'11"	6'10"	10'1"	I, WS, HW
Inverness	Brock Schreiber Boathouse	2'7"	3'6"	4'	5'10"	9'2"	I, E
Eastshore	Walker Creek Access Point	2'4"	3'3"	4'2"	6'1"	9'3"	I
Bolinas	Tsunami Evacuation Route	2'4"	1'8"	2'5"	4'2"	7'9"	TF, I, WS, E
Eastshore	Brighton Beach	2'2"	3'5"	4'11"	6'	9'11"	E, WS



Table 5. Vulnerability Ranking of Exposed Assets by Scenario

Community	Asset	High Tide & Extreme Event Flooding Depth Estimates ( <u>Underlined values</u> indicate tidal flooding at mean higher high water (MHHW) based on one geographic point located at the landward limit of the first scenario overlapping the asset. Other values represent extreme event flooding. Roads received a high, used for ranking, and low value along the line segment.)					Vulnerability TF: Temp. Flooding during extreme events; I: Inundated at mean highest high tide; E: Erosion; WT: Water Table; SI: Saltwater Intrusion; WS: Wave Surge; HW: High Wind, HS: Habitat Shift
		Scen. 1	Scen. 2	Scen. 3	Scen. 4	Scen. 5	
Eastshore	Cypress Grove Research Center with Audubon Canyon Ranch Buildings	2'1"	3'1"	3'11"	5'10"	9'2"	I
Eastshore	Hog Island Oyster	2'1"	2'1"	2'10"	4'10"	8'1"	I
Inverness	Martinelli Park	1'1"	2'	2'2"	4'1"	7'3"	I, E
Bolinas	Wharf Road	6" - 2'1"	3" - 2'4"	2" - 2'9"	1" - 5'4"	<u>10"</u> - 7'4"	I, TF
Eastshore	Shoreline Hwy	3" - 1'7"	3" - 2'4"	3" - 3'	2' - 4'6"	6" - 8'1"	I, TF
Bolinas	Agate Beach	2'1"	1'11"	2'8"	4'8"	9'3"	I
Stinson Beach to Bolinas	Shoreline Hwy.	0" - 1'8"	0" - 2'3"	0" - <u>3'1"</u>	0.4" - <u>4'10"</u>	0.4" - <u>8'6"</u>	I, TF
Eastshore	Marconi Boat Launch	1'1"	2'	2'11"	4'10"	8'2"	I
Inverness	Tomales Bay State Park	10"	1'10"	2'8"	4'7"	7'10"	I, HS
Eastshore	Tony's Restaurant	8"	1'8"	2'6"	4'5"	7'9"	I
Eastshore	Tomales Bay Oyster Company	8"	1'5"	2'3"	4'1"	7'5"	I, TF
Stinson Beach	Water Dist. Office	7"	3'3"	4'8"	6'6"	8'8"	TF, I
Stinson Beach	Walla Vista Wkwy.	3"	1'8"	2'	4'4"	10'4"	I, E
Dillon Beach	Lawson's Landing Facilities	2"	1'1"	2'11"	3'10"	7'3"	I, E, WS, HW, HS
Pt. Reyes Station	Green Bridge	No depth data	No depth data	2"	2'	9'10"	I, TF
Bolinas	Historic District		3'10"	4'8"	6'4"	10'	I, E
Stinson Beach	Stinson Fire		3'6"	5'3"	6'10"	9'1"	I, TF, WT

Table 5. Vulnerability Ranking of Exposed Assets by Scenario

Community	Asset	High Tide & Extreme Event Flooding Depth Estimates ( <u>Underlined values</u> indicate tidal flooding at mean higher high water (MHHW) based on one geographic point located at the landward limit of the first scenario overlapping the asset. Other values represent extreme event flooding. Roads received a high, used for ranking, and low value along the line segment.)					Vulnerability TF: Temp. Flooding during extreme events; I: Inundated at mean highest high tide; E: Erosion; WT: Water Table; SI: Saltwater Intrusion; WS: Wave Surge; HW: High Wind, HS: Habitat Shift
		Scen. 1	Scen. 2	Scen. 3	Scen. 4	Scen. 5	
	Department #2						
Inverness	Sir Francis Drake Blvd.			1" - 3'6"	1" - <u>4'6"</u>	1" - <u>7'10"</u>	I, TF, WS
Bolinas	Sewage Lift Station			3'3"	5'	8'7"	TF, I
Bolinas	Olema-Bolinas Rd.			2'8"	4" - 4'4"	2" - 7'11"	I, TF
Pt. Reyes Station	White House Pool/Trail			2'5"	2'3"	5'11"	I
Inverness	Inverness Store			2'5"	4'4"	7'6"	TF, I, WT
Bolinas	Bolinas Super Market			8"	2'6"	6'1"	I, E, SI
Pt. Reyes Station to Inverness	Shoreline Hwy.			6"	3" - 1'5"	1'9" - <u>9'7"</u>	I, TF
Inverness	Dana Marsh & Beach Access				3'	6'2"	I, E, SI, HS
Inverness	Motel Inverness				2'9"	5'10"	I, WS, HW
Eastshore	Nick's Cove				2'6"	5'10"	
Eastshore	Millerton Point				2'5"	5'8"	I, E
Eastshore	Historic District				2'5"	4'5"	I
Inverness	Historic District				2'1"	5'1"	TF
Bolinas	Bolinas Library				1'8"	5'3"	I, TF
Bolinas	Bo-Gas Station				1'7"	5'3"	I
Bolinas	Gospel Flats				1'7"	5'3"	I, WT, SI, TF
Bolinas	Community Center Emergency Shelter				1'7"	5'2"	I, E
Bolinas	Community Land Trust Housing				1'2"	4'10"	I

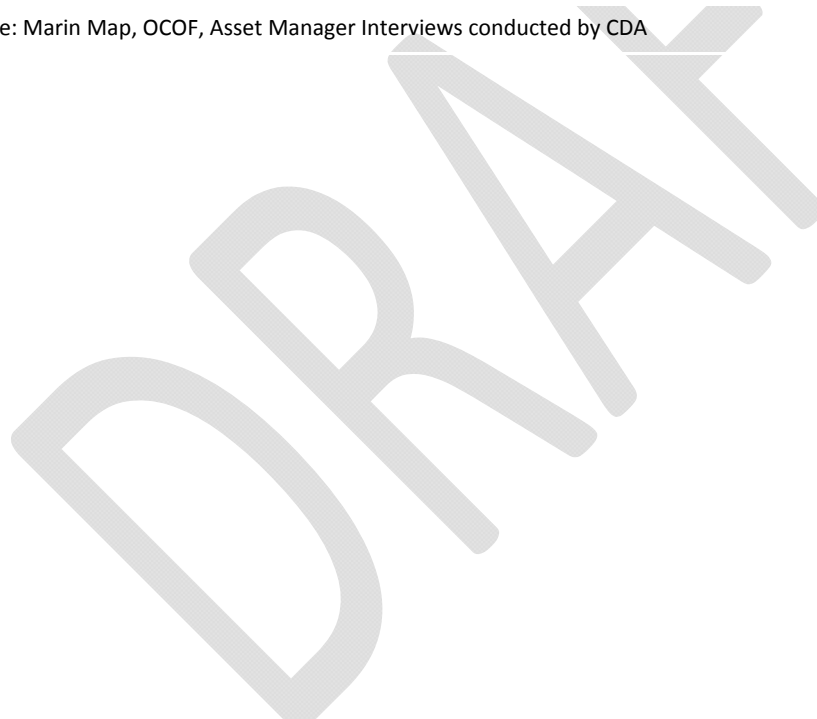
Table 5. Vulnerability Ranking of Exposed Assets by Scenario

Community	Asset	High Tide & Extreme Event Flooding Depth Estimates ( <u>Underlined values</u> indicate tidal flooding at mean higher high water (MHHW) based on one geographic point located at the landward limit of the first scenario overlapping the asset. Other values represent extreme event flooding. Roads received a high, used for ranking, and low value along the line segment.)					Vulnerability TF: Temp. Flooding during extreme events; I: Inundated at mean highest high tide; E: Erosion; WT: Water Table; SI: Saltwater Intrusion; WS: Wave Surge; HW: High Wind, HS: Habitat Shift
		Scen. 1	Scen. 2	Scen. 3	Scen. 4	Scen. 5	
Inverness	Shell Beach Tomales Bay SP				5"	3'4"	TF, I, WT
Stinson Beach	CA Coastal Trail				0.4"	1'3	TF, E
Bolinas	Calvary Church					5'10"	I, TF
Bolinas	Bob Stewart Trail					4'8"	I, TF
Inverness	Tomales Bay Resort					4'	TF
Inverness	Inverness Post Office					3'7"	TF, I, WS, E
Eastshore	Shoreline Hwy.					3'5"	I, E
Stinson Beach	Stinson Picnic Area					3'3"	TF
Bolinas	Bolinas People's Store					3'	I, TF
Bolinas	Bolinas Post Office					2'9	TF, I
Point Reyes Station	Olema Marsh Trail					2'9"	I
Bolinas	Bolinas Stinson School					2'2"	I, TF, E, WS
Dillon Beach	Dillon Beach Resort Parking Lot					1'6"	I
Pt. Reyes Station	Gallagher Well					underground resource	SI
Dillon Beach (north)	Stemple Creek Recreation Area	X	X	X	X	X	HS
Stinson Beach / Bolinas	Bolinas Lagoon	water resource					HS
Inverness / Eastshore	Tomales Bay & Marshes	water resource					HS

**Table 5. Vulnerability Ranking of Exposed Assets by Scenario**

Community	Asset	High Tide & Extreme Event Flooding Depth Estimates ( <u>Underlined values</u> indicate tidal flooding at mean higher high water (MHHW) based on one geographic point located at the landward limit of the first scenario overlapping the asset. Other values represent extreme event flooding. Roads received a high, used for ranking, and low value along the line segment.)					Vulnerability TF: Temp. Flooding during extreme events; I: Inundated at mean highest high tide; E: Erosion; WT: Water Table; SI: Saltwater Intrusion; WS: Wave Surge; HW: High Wind, HS: Habitat Shift
		Scen. 1	Scen. 2	Scen. 3	Scen. 4	Scen. 5	
North of Dillon Beach	Estero Americano	water resource					HS
Dillon Beach	Sewage Pump Station	bluff top asset					E

Source: Marin Map, OCOF, Asset Manager Interviews conducted by CDA



## 2) C-SMART Participants

### 2.1) Community Workshops

To date, C-SMART Staff has hosted four sets of public workshops throughout West Marin with various objectives to further engage local stakeholders in C-SMART and educate residents about SLR impacts and future adaptation options. Workshops were promoted extensively through both traditional outreach (fliers, posters, postcards, press releases etc.) and internet/social media (website, email lists, Facebook, Nextdoor, etc.). Workshop participation ranged from around 20 to 170 attendees. More details including methods, materials, presentations, and summary reports can be found at [marinSLR.org](http://marinSLR.org).

#### **Workshop 1 – Kickoff**

*July 10, 2014 –Point Reyes National Seashore*  
This evening meeting commenced the C-SMART public engagement process. Items included an introduction on the C-SMART timeline and scope by C-SMART Staff, plus presentations from USGS staff on the OCOF modeling methods and website tools available to the public. Participants were also invited to apply for the SAC.

#### **Workshops 2 – Vulnerability Assessment**

*October 28, 29 and 30, 2014 – Inverness, Stinson Beach and Tomales*

These evening meetings introduced the Vulnerability Assessment process with several participatory activities. On large poster boards, attendees were asked to identify what they love about West Marin as a means to spotlight local values. Next, participants were invited to mark up the draft community asset exposure maps compiled by C-SMART Staff. This crowdsourcing activity identified over 70 additional assets for consideration in the C-SMART vulnerability

assessment. Finally, facilitated small group discussions asked questions on residents' current observations of climactic impacts, future concerns, and potential strategies to address these concerns.

#### **Workshops 3 – Game of Floods and Adaptation** *May 30 and June 6, 2015 – Point Reyes Station and Stinson Beach*

These Saturday workshops educated stakeholders on adaptation strategies through “The Game of Floods”, a small group participatory activity spotlighting a wide array of strategies including traditional/hard engineering (seawalls, levees, etc.), green infrastructure (horizontal levees, wetlands, beach nourishment, etc.), managed retreat, and accommodation (retrofitting buildings, realigning roads, etc.). Centered around a game board with a map of the fictitious Marin Island, players were asked to protect an asset they valued through applying a suite of the aforementioned strategies. Information on environmental impacts, costs, effectiveness, and more were provided to inform the decision making process.

Once the game was completed, attendees were given individual workbooks with a map of the attendee's community identifying exposed assets. Participants were asked to suggest adaptation strategies for consideration to protect the vulnerable assets that they valued. Workbooks were anonymous and handed to C-SMART Staff once complete.

#### **Workshop 4 – Adaptation Polling**

*November 14, 2015 – Stinson Beach*  
This Saturday workshop included presentations from a variety of technical experts (including staff of FEMA, the CCC, Arcadis, ESA, and



*Game of Floods in Point Reyes Station. May 2015.*

*Credit: Marin County CDA*

DPW) on adaptation strategy case studies throughout California highlighting pros, cons, and lessons learned from other areas. With this plethora of information, participants were given a poll to inquire about conceptual adaptation strategies that could be applied to their community. Included were questions on local coastal program policy amendments which could guide new and existing development to accommodate for changing conditions likely to result from SLR and other climactic impacts. Poll results have informed C-SMART Staff on the general community interests and concerns for continued adaptation planning, including the Community Acceptability column in Table [6](#).

Marin County planners also presented updates on the C-SMART study in Spring 2016 at meetings with the East Shore Planning Group, Stinson Beach Village Association, Muir Beach Community Service District and residents, and Point Reyes Village Association.

### **Workshop 5 – Next Steps**

*June 8 and 14, 2017 – Point Reyes Station and Stinson Beach*

These evening meetings overviewed the draft Adaptation Report and C-SMART next steps. The workshops were held during the 30 day Adaptation Report review period and digital

copies of the report were provided for interested attendees. Marin County planners recapped the C-SMART process to date, presented the Adaptation Report's priority options and answered questions.

The primary activity was the *West Marin Sea Level Rise Adaptation Plan Passport*, a survey to solicit input from residents on next steps County staff could undertake following completion of the Report. Attendees were given time to complete this passport individually with the option of discussing responses in small neighborhood-based groups. Additionally, the passport could be taken home for submission at a later date and was also posted online for further distribution via traditional and social media.

### **Resilient Stinson Design Charrette**

February 3, 2016 – Stinson Beach  
In partnership with Gensler, Marin County CDA hosted the Resilient Stinson Design Charrette. The charrette goals were to define community character in residents' and design professionals' words, and to collect aesthetic feedback on potential flood response options. This information was used to inform both practical and aesthetic considerations of the design principles. Around 40 attendees including local residents, architects, planners, engineers and other professionals were convened.

The event began with an introduction of the challenge of SLR and Stinson Beach. Staff shared maps of flood depths in the Calles and Patios neighborhood at 2.5 feet SLR which is in the midrange of 2070 projections. Recently released FEMA Flood Insurance Rate Maps (FIRM) maps were also shared to indicate locations subject to more near term flooding and FEMA compliance requirements. A variety

of home retrofitting strategies were presented, including the innovative concept of amphibiation, in which buoyant foundations are installed, enabling homes to float when floodwaters hit.

Next local homeowners led guided walking tours of properties vulnerable to flooding (both coastal and riverine). This exposed participants to the variety of architectural styles, building heights, materials, existing retrofitting approaches, etc.

Over lunch, shared initial impressions on community character were discussed in small groups including intangible 'look and feel' to guide building elevation so it does not compromise sense of place. In advance of the workshop, Image cards had been developed with a variety of images intended to characterize Stinson Beach as a place, including different architectural styles, its relationship to nature, water, etc.



*Resilient Stinson Design Charrette. February 2016.  
Credit: Gensler*

Images that defined character elements which were more widely preferred were placed near the center of the bullseye, while elements that were not preferred were placed further out.

Each group then reported back to the large group to discuss commonalities.

The main exercise was an evaluation of different retrofitting options to accommodate homes to increased water levels including:

- Structure Elevation: Piers & Columns
- Semi-Enclosed Ground Level
- Landscaped Ground Level
- Bunker Houses
- Structure Elevation: Communal
- Breakaway Walls
- Waterproof Construction
- Amphibious Architecture
- Floating Development
- Floodable Development
- Moveable Walls
- Others?

In small groups, participants filled out pro/cons matrices of each option from an aesthetic perspective. Included in the matrices were 'maximize the pro' and 'mitigate the con'. After a couple hours of small group discussions, summary points were shared with the large group.

This event helped articulate community character from the design perspective, which helped C-SMART Staff craft urban design principles (page 81). Additionally it helped staff understand aesthetic considerations of the various home retrofitting options that could be applied for flood/SLR protection (pages [89-104](#))

**Workshops Summary**

In summary, public workshops were an effective means to educate residents on SLR impacts and possible responses, as well as the C-SMART process. Additionally, these workshops, particularly workshops 2, 3, and 4

provided a means for C-SMART Staff to better understand potential adaptation solutions from the public perspective. Such adaptation strategies have been incorporated into this report for consideration.

## 2.2) Stakeholder and Technical Advisory Committees

C-SMART SAC and TAC were developed to guide C-SMART through providing input from community and technical organization representatives. A roster of both committees can be found in the acknowledgements section of this report. Both committees met periodically throughout the process to advise C-SMART Staff on topics including public outreach activities, vulnerability assessment processes, C-SMART deliverables, and more. To further obtain input on adaptation options, a joint meeting of the SAC, TAC, and partners was held on February 10, 2016 in Point Reyes Station. Meeting products were intended to mirror the deliverables produced by the Climate-Smart Adaptation Working Group convened by the Climate-Smart Adaptation Working Group convened by the Greater Farallones Sanctuary Advisory Council to inform the GFNMS. See more details below on the working group's process and products, which serve as the basis for this report's natural resources section.

At the joint TAC/SAC/partner meeting, participants were presented with spreadsheets of adaptation options spanning seven of the eight asset categories spotlighted in this report (parcels & buildings, transportation, utilities, working lands, recreation, emergency services, and historic and archaeological resources). Natural resources were not discussed at this meeting, due to the aforementioned GFNMS Working Group's efforts. Draft spreadsheets

had been compiled by C-SMART Staff with adaptation options from staff's literature reviews, consultant deliverables, the public workshops and adaptation poll. Spreadsheet columns included the approach, strategic management action, spatial or site specific details, timeframe, impacts addressed, key partners, required resources, and other asset categories.

Strategic management actions included the spectrum of adaptation strategies (retreat, defend, accommodate, etc.), plus other activities that could be undertaken in West Marin to help minimize, avoid, mitigate SLR/storm impacts included public outreach/education, surveying/documentation, policy development and more. These ideas are not staff recommendations or in any way endorsed by Marin County or project partners, but simply a compilation of options suggested through the C-SMART process that merit further consideration. The options were not intended to be collectively viewed as a plan, are not all currently feasible, and in some cases may conflict with one another.

At a February 2016 meeting, TAC/SAC/Project Partners were asked to further elaborate on existing options or suggest new options for incorporation. After the meeting C-SMART Staff synthesized the options to finalize the spreadsheets found in section 4.3. See section 4.3 for more information on general format and content of the spreadsheet.

## 2.3) Center for Ocean Solutions

To support decision-makers in their efforts to manage coastal resources in a changing climate, the COS engaged with C-SMART Staff by mapping and assessing the presence and relative importance of coastal habitats along Marin County's Pacific coast. In addition, the



effects of coastal adaptation strategies on services provided by coastal habitats were evaluated. The role of natural habitat in providing the ecosystem service of coastal protection was assessed using the Integrated Valuation of Environmental Services and Tradeoffs (InVEST) decision support tool, a suite of tools to map and value the goods and services from nature. The InVEST Coastal Vulnerability model was specifically utilized for this assessment.

InVEST is a free and open-source suite of software models created by the Natural Capital Project at Stanford University. The InVEST Coastal Vulnerability (CV) model incorporates a scenario-based approach to evaluate the role of natural habitats in reducing exposure to coastal erosion and inundation during storms. The InVEST CV model produces a qualitative estimate of coastal exposure. The Exposure Index differentiates areas with relatively high or low exposure to erosion and inundation during storms.

Spatial data inputs include: 1) Geomorphology: 2) Coastal habitat: 3) Wind and wave exposure: 4) Surge potential 5) Relief: A DEM representing the topography and (optionally) the bathymetry of the coastal area 6) Sea-level rise: Rates of (projected) net sea-level change derived from the National Research Council 2012 report; 7) Hard Armoring: Data set inventory of man-made structures and natural coastal barriers that have the potential to retain sandy beach area in California.

Results can help evaluate tradeoffs between climate adaptation strategy approaches. In this assessment, COS compared the InVEST Exposure Index results both with and without the protective services provided by natural habitats. This approach (computing the

difference between exposure indices) provides a priority index for locations in which coastal habitats play the largest relative role in reducing exposure to erosion and inundation. These locations are then further investigated for nature-based strategies to reduce vulnerability.

The ecosystem service and adaptation policy research focuses on three specific areas of interest: Muir Beach, Dillon Beach, and Bolinas Lagoon (including Bolinas and Stinson Beach). For each location, COS mapped and assessed the natural habitats, the role of those habitats in reducing exposure to storm impacts, the potential adaptation options to address these impacts, and the policy considerations relevant for each strategy. In addition, COS identified general considerations for pursuing land-use policy approaches as well as a summary of our analysis methodology.

This assessment involved a combination of ecosystem services modeling as well as adaptation policy research to identify priority locations for nature-based strategies that reduce vulnerability of critical assets using feasible land use policy methods.

#### 2.4) Greater Farallones National Marine Sanctuary

The GFNMS Advisory Council served as a key partner in the development of climate change adaptation options for natural resources (beaches and dunes, rocky intertidal, cliffs and wetlands/estuaries). Building on Phase 1 of the GFNMS Climate-Smart Adaptation Project that assessed vulnerability to climate and non-climate stressors for select species, habitats, and ecosystem services, a Working Group of the Advisory Council undertook a yearlong multi-agency process to develop climate-smart

adaptation strategies for the Study Area, which included GFNMS, Cordell Bank National Marine Sanctuary and part of Monterey Bay National Marine Sanctuary. C-SMART Staff participated as Working Group members, alongside representatives from a variety of other local, state and federal agencies; non-profit organizations, and academic institutions. The working group was staffed and advised by sanctuary representatives, as well as members of the scientific and conservation community. Five meetings, numerous conference calls, and online discussions were held to develop the recommendations. Meetings included group brainstorming exercises to generate ideas, focused discussions to further flesh out options, and an exercise to prioritize options based upon criteria including co-benefits, and legal/economic/institutional feasibility. More details on the process can be found in the final report (Appendix E).

In early 2016, final recommendations were presented to the GFNMS Advisory Council, who approved 78 strategies total, spanning several categories:

- Alleviate Climate Impacts
- Manage Dynamic Conditions
- Promote Education
- Protect and Restore Habitat
- Limit Human Disturbance
- Address Invasive Species
- Promote Landward Migration
- Invest in Science Needs
- Protect Species
- Manage Water Quality

Recommendations relevant to C-SMART (e.g., within the study area and addressing SLR) serve as the basis of the natural resources section of this report, along with findings from COS and PBCS. Strategies with additional co-benefits,

(e.g., protection of economic, social, infrastructure assets) were prioritized.

## 2.5) Environmental Science Associates

ESA served as project consultants with contributions including advice on trigger points and analysis of adaptation options. ESA's final deliverable is appendix B of this Report, and portions of their work have been incorporated throughout relevant sections of this report.

### *Trigger Points*

In order to shape a tiered approach to adaptation, ESA advised on the setting of 'triggers' for inundation and temporary flooding. Such an understanding can help inform plan and policy development while considering the range of near to far term impacts. Specifically ESA characterized triggers for roads and buildings answering questions such as: What flooding frequency or depth triggers the need to elevate or relocate homes or roads?

### *Broad Analysis of Adaptation Options*

ESA broadly reviewed alternative options to better understand costs, considerations and implications as follows:

- Muir Beach (Bluff top development)
  - Protect
    - Dune restoration
    - Armoring
  - Retreat
- Bolinas
  - Armoring
  - Nature based (beach nourishment and horizontal levee)
  - Accommodate
    - Elevation of homes and Wharf Road

- Culverts at streams vs causeway at sections (Shoreline Hwy Bolinas Lagoon)
- Dillon Beach
  - Dune restoration
  - Retreat (wells and road)

*Detailed Analysis of Adaptation Options*

Additionally, ESA provided detailed analysis of specific adaptation options including economic implications, specific costs, environmental impacts and other considerations for:

- Stinson Beach/Seadrift
  - Armoring approach - how do you protect homes?
  - Extending Seadrift's sand covered revetment
  - Elevating homes
  - Reroute Easkoot Creek and Calle del Arroyo (from Marin County DPW's existing Flood Study)
- East Shore/Tomales Bay
  - Elevating Homes
  - Raise/relocate road
  - Native oyster reefs for Tomales Bay

### 3) Adaptation Framework

#### 3.1) Adaptation Options

Adaptation strategy options were gathered from a variety of sources including project consultants ESA, several existing adaptation plans from other jurisdictions, and several guidance and research publications, such as the *California Coastal Commission's Sea Level Rise Policy Guidance*. Adaptation strategies generally fall into three main categories: protect, accommodate, and retreat. An approach of “no action” may be considered an option, but will likely result in greater safety hazards, economic costs, and environmental impacts in the long-run.

##### Protect

Protection strategies refer to those strategies that employ some sort of engineered structure or other measure to defend development (or other resources) in its current location without changes to the development itself. Protection strategies can be further divided into “hard” and “soft” defensive measures or armoring. “Hard” armoring refers to engineered structures such as seawalls, revetments and bulkheads to defend against coastal hazards like wave impacts, erosion, and flooding. Such armoring is a fairly common response to coastal hazards, but it can result in serious negative impacts to coastal resources, particularly as sea level rises. Most significant, hard structures form barriers that impede the ability of natural beaches and habitats to migrate inland over time. If they are unable to move inland, public recreational beaches, wetlands, and other habitats will be lost as sea level continues to rise.

Not all of these measures are favored by regulatory agencies and stakeholders that are primarily concerned with natural assets such as

beaches and wetlands. Implementing these strategies will likely follow a relatively traditional permitting process involving the local permitting agencies, CCC, California State Lands Commission, and for those located below Mean High Water (MHW) GFNMS and the U.S. Army Corps of Engineers (USACE)(ESA 2015). Regulatory requirements may deem certain protection strategies unfeasible.

Soft armoring include nature based solutions such as horizontal levees, wetland restoration, and dune restoration. As such approaches are relatively new concepts, their effectiveness has not yet been fully demonstrated. However such alternatives are favored by many over hard engineering due to potential public benefits including habitat, recreation, aesthetic, and more. For example, dune habitat in Stinson Beach and wetlands in Bolinas Lagoon help absorb energy from storms and protect against shoreline erosion.<sup>35</sup>

##### Accommodate

Accommodation strategies employ methods that modify existing developments or design new developments to decrease hazard risks and thus increase the resiliency of development to the impacts of SLR. On an individual project scale, these accommodation strategies include actions such as elevating structures, retrofits and/or the use of materials meant to increase the strength of development, building structures that can easily be moved and relocated, or requiring adequate setbacks from eroding blufftops and shorelines. On a community-scale, accommodation strategies include any of the land use designations, zoning

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<sup>35</sup> Center for Ocean Solutions. Natural Capital Project. 2016 Coastal Adaptation Policy Assessment: Marin County.

ordinances, or other measures that require the above types of actions, as well as strategies such as locating development in less vulnerable areas or requiring mitigation actions to provide for protection of natural areas even as development is protected (CCC 2015).

Structural adaptation is the modification of the design, construction and placement of structures sited in or near coastal hazardous areas to improve their durability and/or facilitate their eventual removal. This is often done through the elevation of structures or specific site placement. Structural modification entails reconfiguring development to withstand progressively increasing coastal hazards. Examples are pile foundations that allow wave run-up and erosion to progress without damage to structures, and floodproofing or reinforcing for severe events. Structural adaptation can be applied to any parcel or infrastructure although the cost and technical feasibility of an effective modification would be required. Cost may be high depending on the density of development on the coast (ESA 2015). Regulatory requirements may deem certain protection strategies unfeasible.

### Relocate/Managed Retreat

Managed retreat allows the shoreline to advance inward unimpeded. As the shore erodes, buildings and other infrastructure are either demolished or relocated inland. It can also involve setting back a line of actively maintained defenses to a new line inland of the original and promoting the creation of intertidal habitat between the old and new defenses. This can either be a complete removal or a breach of the defense (seawall, revetment, etc.).

A managed retreat approach typically involves establishing thresholds to trigger demolition or

relocation of structures threatened by erosion. Therefore, this approach is frequently coupled with several other planning and regulatory techniques including: shoreline planning to identify high-risk areas where this type of policy would be the only cost-effective, long-term solution; regulating the type of structure allowed near the shore to ensure that buildings are constructed in a way to facilitate relocation when needed; and instituting relocation assistance and/or buy-back programs to help with relocation costs or compensate property owners when their property becomes unusable.<sup>36</sup> More detail about potential mechanisms for managed retreat is provided in Appendix A.

Some challenges to implementing managed retreat programs, particularly in areas with existing development, include uncertainty over who pays and who benefits, and quantification of benefits. Another challenge is identifying sufficient space or land for the structure to be relocated. The costs for retreat in areas consisting of private property could be estimated by assessing the value of the property and identifying the compensation mechanism (e.g. purchase, easement, etc.). Managed retreat requires ongoing and long-term commitment from government agencies and citizens.

In California, managed retreat has typically been used by government agencies on public properties such as beach parks. Erosion has been a consistent problem at Surfer's Point, a popular surfing spot in Ventura, California, for

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<sup>36</sup> Columbia Center for Climate Change Law. *Managed Coastal Retreat: A Legal Handbook on Shifting Development Away from Vulnerable Areas*. October 2013.

more than 20 years. Multiple options were explored by the city and non-governmental groups, including the Surfrider Foundation. Surfrider played a critical role in the approval of a managed retreat strategy, which included relocation of a bike path and parking lot, beach renourishment, habitat restoration, and riprap removal.

Pacifica State Beach is another example of managed retreat. Despite the use of stabilizing structures, flooding of San Pedro Creek and coastal erosion at Pacifica/Linda Mar State Beach has been a recurring problem for the City of Pacifica. In the early 1990s, the city partnered with state and federal agencies, scientists, engineers, and non-profit organizations to work toward a managed retreat strategy for Pacifica State Beach as well as restore wetlands and banks along San Pedro Creek. These actions reduced flooding and erosion threats and restored habitat, which is likely to buffer the system against future climate-related changes such as SLR.<sup>37</sup>

### Hybrid Strategies

Hybrid strategies involve phased approaches combining accommodation, protection and/or relocation. Local government can update land use designations and zoning ordinances, and enact redevelopment restrictions and permit conditions to discourage the rebuilding of existing development or siting of new development in hazard areas. Recent experience indicates that hybrid approaches that include a mix of adaptation measures may be the most practical in some situations. The mix of measures in a hybrid solution varies

depending upon the conditions at that location. For example, the Ocean Beach Master Plan includes a hybrid approach in south Ocean Beach where prior development and erosion have resulted in an acute hazard to both built and natural assets. At this location, a low-height seawall is proposed but at a location established as far landward as possible which requires removal of roadway and parking within a managed retreat framework<sup>3,6</sup>. The plan also includes beach nourishment and dune construction, and includes adaptive management with revisions anticipated for higher sea level rises after 2050.

### 3.2) Prioritization Criteria

Broad strategies have been characterized in [Table 6](#) based on the projected onset of impacts; cost estimates (both initial and ongoing); calculated effectiveness; timing and duration of the strategy; full spectrum of environmental, recreational, and habitat benefits; and legal, political, and community acceptability. Cost estimates were developed by Marin County staff and should only be used generally to understand relative costs from one strategy to another. Legal acceptability is based off of project's staff interpretation of the California Coastal Act and the *California Coastal Commission's Sea Level Rise Policy Guidance*. Political acceptability is from the C-SMART Executive Steering Committee. Community acceptability is based on responses to the West Marin Sea Level Rise Adaptation Poll (See Appendix C) and feedback received from community members.

<sup>37</sup> Climate Adaptation Knowledge Exchange. *Restoration and Management of Pacifica State Beach*. [www.cakex.org](http://www.cakex.org). December 2010.



Figure 5. Conceptual Section Diagram of hybridized adaptation strategies and relative spots in the landscape.

DRAFT

Table 6. Adaptation Strategy Characteristics

Category	Strategy	Public Benefits	Environmental Impacts (+ = positive, 0 = neutral/varied, - = negative)	Cost		Flood Protection	Acceptability: H=High, M=Medium, L=Low		
				Unit	Cost (\$)		Legal	Political	Community
Hard Protection	Seawall/Revetment	Public Safety	-	Km	37,000,000 (seawall) 22,000,000 (revetment)	M	L		M
	Elevate Bulkheads	Public Safety, Recreation/ tourism	-	Km	590,000	M	L		M
	Breakwaters, Artificial Reefs and Groins	Public Safety, Recreation/ tourism	0	Km	44,000,000	M	L		M
	Traditional Levee	Public Safety, Recreation/tourism	-	Km	5,500,000	M	L		M
	Pump Station	Public Safety	-	Ea	500,000-4,000,000	L	L		N/A
	Tidal Gate	Public Safety, Recreation/ tourism	-	Ea	1,000,000 to 2,000,000	M	L		N/A
Nautre- based	Beach Nourishment	Recreation/ tourism/ aesthetic	0	Ac	500,000	M	M		M
	Dune Restoration/ Nourishment	Recreation/ tourism/ aesthetic	+		200,000	M	M		M
	Offshore structures	Public health, Recreation/ tourism, aesthetic, Carbon sequestration, Air quality, Water quality	+	Ac	2 million	M	M		M
	Wetland Creation	Public health, Recreation/ tourism/ aesthetic, Carbon sequestration, Air quality, Water quality, stormwater mgmt.	+	Ac	20,000	M	H		H
	Horizontal Levee	Public health, Public safety, Recreation/ tourism/ aesthetic, Carbon sequestration, Air and water quality,	+	Km	4,000,000 to 4,500,000	H	M		L



Category	Strategy	Public Benefits	Environmental Impacts (+ = positive, 0 = neutral/varied, - = negative)	Cost		Flood Protection	Acceptability: H=High, M=Medium, L=Low		
				Unit	Cost (\$)		Legal	Political	Community
		Stormwater mgmt.							
Accommodate	Elevate Buildings	Public safety, Seismic safety, Recreation/ tourism/ aesthetic, Stormwater mgmt.	+	sf	140 (flood zone) 250 (wave zone)	M	M		M
	Elevate Roads on trestles	Public safety, Seismic safety, Recreation/ tourism/ aesthetic, Stormwater mgmt.	+	sf	570	M to H	M		H
	Raise Grades	Public safety, Seismic safety	-	High cost - varies		M	M		M
	Floodproof Buildings	Public health, Public safety, Recreation/ tourism/ aesthetic	0	Varies (see Retrofitting Options section pages 95-110)		L	H		M
	Floodable and Floatable Development	Public safety, Recreation/ tourism/ aesthetic, Stormwater mgmt.	0	Ea	2,400,000	M	M		M
Retreat	Reconstruct Roads	Public safety, Recreation/ tourism, seismic safety	+	sf	280 (secondary roads)	H	M		M
	Managed Retreat/Relocation	Public safety, Recreation/ tourism, aesthetic, Stormwater mgmt.	+		Varies	H	L		L
	Zoning and overlay zones	Public health, public safety, recreation/tourism, aesthetic	+		Varies	H	L		L
	Setbacks for development	Public safety, recreation/tourism, aesthetic	+		Varies	H	L		L
	Siting and design requirements	Public safety, recreation/tourism, aesthetic	+		Varies	H	L		L
	Capital improvement programs	Public safety, seismic safety, recreation/tourism, aesthetic	+		varies	H	L		L
	Acquisition/buy-out	Public health, public safety, seismic safety, recreation/tourism,	+		Varies	H	L		L

Category	Strategy	Public Benefits	Environmental Impacts (+ = positive, 0 = neutral/varied, - = negative)	Cost		Flood Protection	Acceptability: H=High, M=Medium, L=Low		
				Unit	Cost (\$)		Legal	Political	Community
		aesthetic							
	Conservation easements	Public health, public safety, seismic safety, recreation/tourism, aesthetic	+		Varies	H	H		M
	Rolling easements	Public health, public safety, seismic safety, recreation/tourism, aesthetic	+		Varies	H	H		M
	Transfer of development credit/rights	Public health, public safety, seismic safety, recreation/tourism, aesthetic	+		varies	H	H		M

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### 3.3) Trigger Points for Adaptive Management

In addition to amplifying erosion hazards, SLR will increase the extent of frequent (chronic) inundation in low lying areas and result in more severe storm (event) flooding. Adaptation measures can be tailored to the governing flood hazard mechanism (chronic or event), and will be initiated at determined “trigger points.”

The concept of “trigger points” means that adaptation strategies would be initiated when projected hazards surpass a certain level of risk, either in frequency or severity. ESA described various erosion and flooding mechanisms to inform the County and its residents about potential trigger options to consider while deciding when to implement adaptation measures, such as: nourish beaches and raise or relocate homes, roads and other infrastructure.

The trigger type depends on the level of service the infrastructure provides (e.g. critical roadway versus park driveway) and what consequence (how deep/ far) and frequency of erosion or flooding impact is acceptable. The science behind both erosion and flooding triggers are summarized below. The information about potential triggers in this report is advisory only, and subject to revision based on additional information and further analysis.

#### Flooding

Triggers based on water level could be based on tide data from the Point Reyes tide gauge:

- **Mean High Water (MHW)** - Average of all high tides over the National Tidal Datum Epoch of 19 years. MHW is 5.1 feet NAVD, and occurs 1-2 times per day for a few minutes to a few hours.
- **Extreme Monthly High Water (EMHW)**

Highest high water level that is reached once in a month. EMHW is approximately 6.9 feet NAVD.

- **1-year Water Level** – Water level exceeded on average once every year, or has a 99 percent chance of being exceeded in any year from a storm event. The 1-year water level is about 7.1 feet.

Acceptable flood levels will vary by asset. For example, a road that is only used to access a beach park can tolerate flooding once a month, but flooding every other day would limit access, so the EMHW could be chosen as a trigger for raising the road. On the other hand, a critical road such as Calle del Arroyo in Stinson Beach that is the only access route to residences should have a higher level of acceptable impact so that it is operable for emergency situations. In this case, a more frequent flood level could be used to set a trigger to initiate adaptation measures.

For underground utilities such as gas and septic leach fields that could be affected by high groundwater, reaseach could be conducted to identify how MHW level could affect groundwater levels. Additional factors could play into the trigger selection, such as infrastructure materials (pavement that degrades quicker under prolonged flooding versus a building that is floodable up to a certain depth).

#### Erosion

Erosion rates and storm erosion impact distances indicate the vulnerability of beaches and waterfront property, and are used below to suggest potential triggers for adaptation measures. Erosion indicators are:

**Toe elevation** – Where the beach meets the back beach dune, cliff, or armoring structure. Toe elevation is compared to total water levels and used as an indicator of the amount of wave energy that could reach the back beach and cause erosion and overtopping. This elevation varies as the beach erodes in the winter/spring and accretes in the summer/fall. Extreme low values are an indication of erosion during heavy winter storms.

**Dry beach and dune width** – Dry beach width buffers the backshore from waves. Dry beach is defined as beach width above the shoreline (see below for definition of shoreline). Narrow beaches offer little protection, as more wave energy reaches the backshore which results in greater run-up, erosion of dunes and bluffs and impacts to coastal armoring structures.

**Shoreline position** – The shoreline location is used to track shore changes and estimate the volume of sand in the beach. In combination with the back shore location, a dry beach width can be calculated. The shoreline is typically defined as the elevation of Mean High Water (MHW), Mean Higher High Water (MHHW) or similar.

Toe elevation, beach width and shoreline position are influenced by wave exposure and littoral processes. In the case of an armored backshore (e.g. Seadrift) the beach elevation at the toe of structures indicates the exposure of the structure to wave action. As sea level rises and storm intensity increases, beach elevation drops and the structure experiences more scour from deeper and faster-moving wave run-up and reflection of wave energy by the structure. Reduced beach elevation results in more wave overtopping and degradation of the structure. To guide long-term and emergency

management activities, the following vulnerability triggers and potential actions are proposed:

### Toe Elevation Triggers

**Long-term “maintenance” trigger** = Elevation of the beach berm (break in slope) that typically occurs several feet above high tide, depending on wave exposure, at a particular location.

- Action: Increase monitoring frequency, evaluate resources at risk, consider actions (nourishment, notify residents, etc).

**Critical condition trigger** = Mean tide or sea level.

- Action: Emergency nourishment, evaluate resources at risk, consider other actions.

### Beach Width Triggers

**Long-term “maintenance” trigger** = Beach width equal to or greater than the typical summer-winter change plus an allowance for an extreme erosion event. Provisionally, this distance is about 85 feet at Stinson Beach/Seadrift beaches, based on available estimates of storm erosion (ESA, 2015a). In some areas the beach is already very narrow and a smaller distance of 50 feet may be applicable. Information on past seasonal beach width fluctuations along with future monitoring would further refine the selected trigger distance.

- Action: Increase monitoring frequency, including the use of inexpensive aerial photography to track beach width, evaluate resources at risk, consider other actions (nourish, notify residents, etc).

**Critical condition trigger** = When beach widths in the summer/fall are less than typical seasonal recession due to winter conditions, it is possible that the beach will narrow to the point of providing nearly no protection to the backshore if a severe storm or swell occurs. Monitoring surveys would inform this seasonal fluctuation distance along the beach (for example, 25 feet).

- Action – Sand placement in a berm or embankment shape to temporarily raise the backshore elevation and limit wave runup, absorb wave power as the sand erodes, and provide sand to the beach during erosion events. Consider other actions such as sand bags, blocking low areas that might be used for access but also provide a pathway for wave runup, and contingency preparation for evacuation and utility shutdown.

### Timing of Adaptation Triggers

The timing of implementation for an adaptation measure depends on the lead time required to effectively plan, permit, design and construct that particular measure. Caltrans (2011) has published guidance on planning and development of project initiation documents. A previous study by GHD, ESA, (former Phil Williams Associates (PWA)) and Trinity Associates (GHD 2014) identified and evaluated a range of adaptation options to address SLR

specific about the initiation selection. Marin County could consider adopting an evolving assessment methodology that incorporates the latest SLR and climate change science.

Figure 5. Timing of Adaptation Triggers – Suggested Methodology

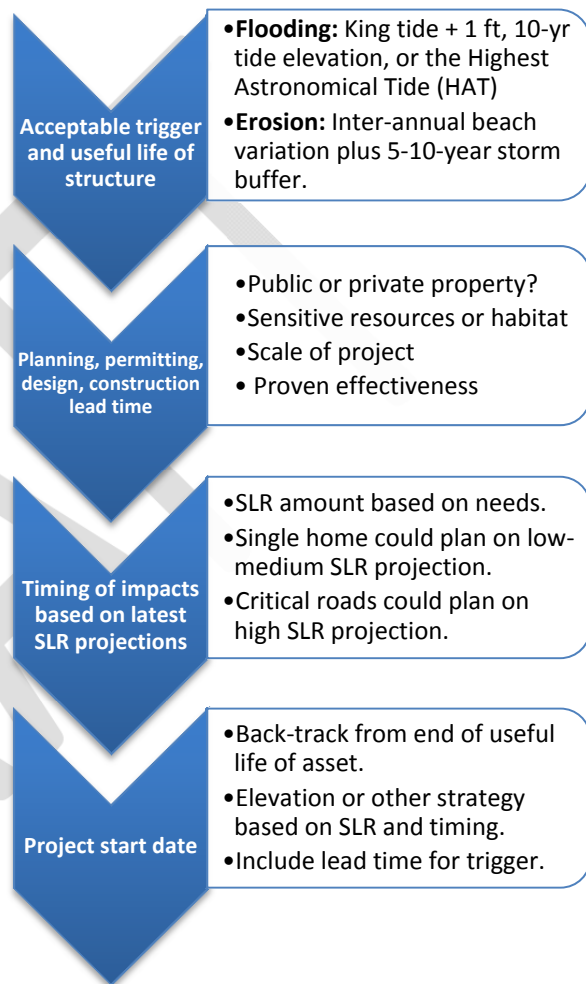


Figure 6. Example Adaptation Trigger Timeline for Road

vulnerabilities at four example locations in Northern California. For the GHD study, designs were developed to provide protection against a king tide (1-year tide) plus 1 foot, but were not

While uncertainty may be high for future water level predictions, a sufficient level of elevation could be chosen to limit the risk of planning for too little SLR. This trigger-timing process could

also be applied to shrinking beaches and backshore adaptation strategies with sea-level rise or stream bridge and culvert crossings with climate driven precipitation changes.

### Shoreline Monitoring

Due to the uncertainty of future rates of SLR and thus anticipated shoreline response, it is important to monitor the shore into the future to properly assess vulnerability to coastal hazards. A shoreline monitoring program could include periodic transect surveys along reaches of concern to track the following beach attributes: shoreline position, toe elevation at the backshore, and dry beach width or dune width.

In the case of an armored backshore (e.g. Seadrift) monitoring the beach elevation at the toe of structures will indicate the exposure of the structure to wave action. Residents in the FEMA V-Zone (with or without fronting armor structure) may consider actions to protect their home if the long-term triggers for dry beach width (or toe elevation) are reached. Homes closest to the ocean are most vulnerable to wave loads, and would benefit the most from structural modification measures such as elevation. However, the homes farther inland may be lower due to the pre-existing grades, and may be more subject to deeper flooding that may persist after a wave overtopping event. While Easkoot Creek is also a hazard source, it was not addressed in this study due to lack of models that integrate riverine and coastal sea level rise. However, Easkoot Creek hazards were considered in the Stinson Beach Flood Control Alternatives Study (Marin County DPW, 2014).

A complete shoreline monitoring program could be developed by a coastal engineer, and data could eventually be collected by County staff or

other entities. In example projects by ESA in South Ocean Beach and Surfer's Point, a survey team of at least two people is dispatched to collect topographic data at evenly spaced intervals twice a year (late summer/early fall and late winter/early spring) to capture seasonal shore changes, as well as before and after a significant coastal storm event. Approximate storm retreat amounts, scour depth, and other impacts are quantified and applied to subsequent erosion control measure implementations. Erosion control measures such as sandbag structures and sand placements are also monitored.

The Ocean Beach project establishes a framework for evaluating shoreline conditions, will inform the need for immediate interventions, and sets forth a methodology for tracking and reporting shoreline changes over the next 5 years. Environmental data including waves, tides and weather are archived annually for each monitoring period to improve the understanding of the shore response to storm events and seasonal changes over the course of a year. Additionally, aerial surveys could be conducted to generate a continuous DEM and aerial imagery for desktop analysis of structures and shoreline position.

### *Relocate/Managed Retreat*

In the absence of human development, coastal ecosystems would likely adapt to SLR by migrating inland, with sediment transport and replenishment from erosion providing some stability during these migrations. Due to human development, migration is impossible and sediment transport is inhibited in many areas. On coastlines around the world, and especially in California, there is a delicate balance between protecting private property rights by allowing homeowners to defend their properties against rising waters, while

protecting natural resources and public access to the coast.

Marin County does not promote mandatory retreat as a near-term solution to SLR. However, adaptation strategies should be developed with long-term consequences in mind, and in some areas homeowners, communities and asset managers will need to take adaptive management actions that may involve relocation or abandonment of vulnerable assets over time. The County can help facilitate an orderly and voluntary managed retreat program as a long-term strategy.

Managed retreat programs involve the purchase or abandonment of properties vulnerable to coastal hazards. Structures are typically demolished or relocated. Properties can be restored to a natural state and used for open space or recreation. As part of a land exchange or Transfer of Development Rights program, lands of lesser habitat value and hazard vulnerability could be rezoned or made available in exchange for properties in hazard areas, along with equitable financing arrangements. Managed retreat can be incorporated into other adaptation measures; for example, a road realigned inland could be protected by a horizontal levee, which requires a large right of way.

The costs for retreat in areas consisting of private property are not well known, but could be approximately estimated by assessing the value of the property, and the compensation mechanism (e.g. purchase, easement, etc.) if appropriate. One of the most difficult elements of this measure is uncertainty over who pays and who benefits, and quantification of benefits. Typically, this measure is part of a strategy that includes public cost to rebuild

public infrastructure and compensate private property owners for their property net the costs associated with shore armoring. Case studies of managed retreat projects in Ventura and Pacifica, among others, are available on the Climate Adaptation Knowledge Exchange website [www.cakex.org](http://www.cakex.org).

Although managed retreat may be the most straightforward method for protecting development that is under imminent or long-term threat of being damaged or destroyed, it is often assumed to be technically or financially infeasible. Often there is not sufficient space or land available for the structure to be relocated, and the property owner is often responsible for the full cost of the relocation. Accordingly, this approach has been most typically used for public property and by government agencies such as the CSP in this region (ESA 2015).

Removal and/or relocation of development in vulnerable coastal areas would provide important habitat and public recreation benefits, as beaches and wetlands will have space to migrate inland. Coastal armoring prevents ecosystems from migrating inland and cuts off sand supply by preventing natural erosion processes, causing beaches to narrow and eventually disappear. Statewide policies are evolving in response to concerns about the impacts of coastal armoring, essentially moving away from allowing armoring and toward natural infrastructure or managed retreat as a response to SLR. The California Coastal Armoring Report<sup>38</sup> identifies a conflict between the language in Section 30235 of the California

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<sup>38</sup> Melius and Caldwell. Environment and Natural Resources Law & Policy Program, Stanford Law School. 2015. California Coastal Armoring Report: Managing Coastal Armoring and Climate Change Adaptation in the 21<sup>st</sup> Century.

Coastal Act, which states that the CCC “shall” allow armoring to protect existing structures in danger of erosion; and the overarching goals and objectives of Chapter 3 of the Coastal Act, which call for protection of beach access, coastal resources, and scenic views. The need to avoid “maladaptive” protection measures is important to California’s natural resources and public access to the coastline. However, policies must be formulated in a way that reasonably protects private property rights and is legally defensible.

The idea of managed retreat received very little support from Marin County’s Adaptation Poll respondents, and many residents felt strongly that retreat should be voluntary. There are few examples of managed retreat in developed residential areas. A major challenge is that there is very limited space to retreat to in the coastal areas, as most land is protected or unsuitable for development.

The County could identify regulatory constraints that may conflict with SLR adaptation, potential “receiving areas” for a managed retreat program, to prepare for future implementation of this strategy (most likely after storms damage vulnerable development). The County could work with land trust organizations to convert at risk areas to open space, establish transfer of development rights programs, and work with these organizations to conduct ongoing monitoring activities. Similarly, existing open areas can be designated as conservation zones to protect and provide upland areas for wetland and habitat migration or for additional agricultural land.



### 3.4) Recent, Ongoing and Anticipated Adaptations

Because the coast is a dynamic place and changing conditions are already having impacts on coastal assets, several areas are already making improvements to reduce their vulnerability.

Most recently, homes and businesses along the East Shore have relocated and consolidated their OWTSs in a community system leach field landward, east of Shoreline Highway to maintain functioning systems and to prevent polluting Tomales Bay with wastewater.

In the low-lying areas of Stinson Beach, the Stinson Beach County Water District has and continues to work with property owners to update underground gravity fed OWTS to include an off switch that triggers during high water events. This will provide short-term improvements; however, when the water is high enough often enough, these systems will become inoperable more frequently, likely prompting a second phase of OWTS adaptation.

Stinson Beach Fire Station No. 2, which will become vulnerable, will likely relocate landward regardless of SLR because larger fire trucks require larger facilities than Fire Station No. 2 can provide.

In June 2014, the Marin County Parks and Open Space (County Parks) began developing a feasibility study and conceptual design plans for a restoration project located at the north end of Bolinas Lagoon that was recommended in the *Bolinas Lagoon Ecosystem Restoration Project, Recommendations for Restoration and Management* (2008), and by a scientific design review group. The project objectives are to alleviate chronic flooding of county and state roadways at the Bolinas Wye, improve the

function of Lewis and Wilkins Creeks, enhance riparian and wetland habitats, and allow for future expansion of Bolinas Lagoon as sea level rises. The scope of services was developed in collaboration with the DPW, Gulf of the Farallones National Marine Sanctuary, Point Reyes National Seashore, and the GGNRA. Given the status of Bolinas Lagoon as a Wetland of International Importance, strong community interest in the lagoon, and the project's potential to affect the road into Bolinas, C-SMART staff will refine a community outreach plan at the time of project initiation.

In March 2015 County Parks made an agreement with the NOAA for the management, operation, maintenance, and repair of a tide gauge at Bolinas Lagoon.

## 4) Governance

A number of other plans, policies and laws affect the choices that communities and homeowners will be able to make in response to SLR threats. Among these are local hazard and emergency evacuation plans, land use and zoning regulations, local assessment districts, and state law governing the state's jurisdiction over public waterways. All of these must be considered through the process of determining not just the best strategy for the situation but which option will be allowed under current permitting rules.

### 4.1) Public Outreach & Education

The C-SMART process built strong public engagement around planning for SLR and coastal hazards, and a number of community members, stakeholders and technical advisors suggested priority topics for ongoing public outreach. A few ideas for informational materials to be developed and disseminated to assist property owners are:

#### **Guide to Coastal Zone Regulations**

Overlapping and sometimes contradictory regulatory requirements from federal, state and local agencies can make project applications a lengthy and expensive process for property owners. Due to nuances in location, conditions, project type, etc. there is no simple or general answer for permit requirements. Getting a planning permit is usually only one step in the development process; other permits may be necessary and there are utilities and other services that must be provided. Multiple public agencies work together during the permit process, each specializing in their field of expertise.

Amendments to the Local Coastal Program (LCP), further discussed in the next section, attempt to facilitate property owners' efforts to protect their homes. In addition to information available at [www.MarinLCP.org](http://www.MarinLCP.org) and at the Community Development Agency planning counter, the County can provide further guidance to navigating coastal regulations through targeted outreach materials. The County can develop a process map for navigating the regulatory environment of Marin's ocean coast, and identify basic information homeowners will need to provide (and potential sources for that information) in order to determine what regulations may apply to their proposed project.

A diagram outlining "Development Requirements" for structures in Flood Hazard Areas is available in the Assets section of this report under "Parcels and Buildings".

#### **Homeowners' Guide to Sea Level Rise**

Homeowners could benefit from a guide and checklist for SLR and storm preparation. For example, the guide could inform property owners about: elevating their electrical and mechanical systems and openings above high tide levels; ensuring that windows, vents, doors, etc. are not below predicted flood levels; and elevating/floodproofing their homes to avoid threats from temporary flooding. Improvements to roofing, siding, and other home exteriors can reduce sensitivity to high wind and wave impacts during storms.

### 4.2) Emergency Management

Emergency preparedness is a key element of managing flood risks in vulnerable areas. Some steps that Marin County and its partners can take to help citizens prepare for disasters,

which will be magnified by the onset of SLR, include:

- Ensure emergency staging locations are not sited in areas subject to temporary/permanent flooding, landslides, tsunami zones or other hazardous areas.
- Support additional emergency response teams and subsequent resources required for response, recovery and mitigation, including temporary housing.
- Ensure redundancy through providing alternate routes for emergency evacuation. Relocate vulnerable emergency facilities (e.g., fire stations, emergency generators).
- Distribute information and technical assistance to households on emergency preparedness, response, recovery and mitigation protocols.

#### **Local Hazard Mitigation Plan**

Marin County's Multi-Jurisdictional Local Hazard Mitigation Plan (MCMLHMP), is part of an ongoing planning process facilitated by the OES to meet the requirements of the Disaster Mitigation Act of 2000 to maintain continued eligibility for certain FEMA Hazard Mitigation programs. The LHMP is intended to improve the ability to recover after a variety of disasters: earthquakes, fires, floods, tsunamis, and landslides. Once approved by FEMA, LHMP projects are positioned to receive Federal Funding.

The LHMP both identifies hazards and includes mitigation strategies such as capital improvement projects intended to protect lives, property and the environment in times of disaster. Likewise C-SMART includes two components: the vulnerability assessment which identifies assets susceptible to increased SLR; and adaptation plans with strategies to protect these assets. The MCMLHMP, with a

five year planning cycle, focuses on near term strategies to protect people from current hazards, while C-SMART focuses on strategies to protect people from future hazards. Due to the complementary nature of these efforts, they should be integrated as closely as possible. Some projects stemming from C-SMART are appropriate to consider for integration into a MCMLHMP to position them for federal funding.

#### **4.3) Local Assessment Districts**

Local assessment districts, such as Community Services Districts (CSD), Geologic Hazard Abatement Districts (GHAD), or similar neighborhood-level entities could enable communities to pool resources to obtain insurance coverage, conduct a local coastal hazards analysis, and fund local risk reduction and adaptation measures (e.g. raising private roads).

A Geologic Hazard Assessment District (GHAD) is an independent, state-enabled public agency that oversees geologic hazard prevention, mitigation, abatement and control. GHADs may offer an effective means to mitigate the effects of future sea-level rise. By accumulating a reserve for future maintenance and rehabilitation, a GHAD can provide the financial resources necessary for potential future expansion of flood control structures. However, there are no current examples of using a GHAD as a mechanism for financing SLR adaptation measures.

A CSD is typically formed to provide water, sewer or garbage services, fire protection, public recreation, street lighting, mosquito abatement, police services, library services, street improvements, conversion of overhead electric and communication facilities to

underground locations, ambulance services, airport facilities, and transportation services. The board of directors may consist of three or five members elected at large, or may be the Board of Supervisors.

The County can support property owner efforts to form local entities to plan and implement community-level adaptation measures.

#### 4.4) Interagency Governmental Collaboration

Marin County government departments and local service providers should maintain working relationships with state agencies to identify plan amendments and projects in support of SLR preparation. Building on the relationships developed during the Vulnerability Assessment and LCP Amendment, and on the work of the C-SMART TAC, SLR task forces can be formed to advance the recommendations of this study. Subgroups can be developed to focus on assets that should be addressed on similar timeframes. For example, adaptation strategies for homes may be considered on a shorter timeframe than public utilities and roadways.

In 2008, Executive Order S-13-08 required the Natural Resources Agency to prepare the state's first climate adaptation strategy which was released in 2016 as *Safeguarding California: Implementation Action Plans*. State agencies such as the CCC, State Lands Commission, State Office of Planning and Research, Caltrans, CSP, and DFW have collaborated throughout this effort. Federal agencies such as the NPS, FEMA and Environmental Protection Agency (EPA) are also developing adaptive responses to SLR. Marin County will continue to coordinate adaptation planning with other jurisdictions through regional networks such as the CCAN, Coastal Hazards Adaptation Resiliency Group,

the CA Coastal Resiliency Network, Bay Area Regional Collaborative (BARC) and Alliance of Regional Collaborative for Climate Adaptation.

Transportation infrastructure and utility systems especially require a long-term and coordinated management approach. As Marin County and Caltrans move forward with adaptation planning and capital improvement projects, it will be important to collaborate with other local and state agencies as well as private landowners, and to consider cost efficiencies and multiple benefits to other vulnerable infrastructure when planning for adaptation of the transportation system. For example, the findings of the *Marin Coast Vulnerability Assessment* could help inform a Caltrans climate vulnerability study for District 4, similar to the pilot assessment for District 1.

Resilient infrastructure can be financed through creative means such as Infrastructure Financing Districts and Tax Increment Financing. County staff should continue to explore best practices from other regions, and work with community groups to identify projects that may qualify for state or federal assistance.

#### 4.5) Land Use & Zoning

The Marin County Draft Local Coastal Program (LCP) contains policies governing development in the Coastal Zone, which includes all of the West Marin communities in this report. The following is an abridged summary of County-proposed LCP Environmental Hazards policies which were submitted to the CA Coastal Commission April 2016 to address SLR and erosion (subject to change during the LCP amendment process):

- New development must be safe and not contribute to hazards.

- Applicants for coastal permits assume liability for damage to properties from environmental hazards and acknowledge that future shoreline armoring is prohibited.
- Development in flood hazard areas must comply with existing FEMA standards, plus additional elevation to accommodate potential SLR. Structural modifications consistent with identified standards shall be facilitated through a streamlined permitting process such as Coastal Permit Exemptions, Categorical Exclusions, etc., when consistent with the requirements of these exemptions or exclusion orders.
- Ensure that new blufftop development is safe from bluff retreat and other coastal hazards without a reliance on shoreline protective devices.
- Ensure that new shoreline development is safe from shoreline erosion and flooding hazards, taking into account 3 feet of projected SLR. New development must be designed to be relocated and/or removed before new shoreline protection is needed.
- Ensure proper drainage for any development on blufftop parcels.
- Prohibit structures on bluff faces, except for public access structures where no feasible alternative means of public access exists.
- For new development within Flood Hazard Areas, building floor elevation must be high enough to accommodate flood levels identified by FEMA 2015 Base Flood Elevation (BFE) and from a SLR scenario of 3 feet, shown on “Potential Sea Level Rise Maps” to be prepared and adopted by the County of Marin.
- For new development within Flood Hazard Areas, the maximum allowable building height shall be 25 feet above grade, or 15 feet above the minimum floor elevation, whichever is greater. Where development consists solely of raising an existing structure to meet FEMA and SLR standards, a building height of up to 30 feet above grade may be allowed through the Coastal Permit process, subject to conditions of approval prohibiting future increases in the height, mass, and bulk of the structure.
- For new development within the Seadrift Subdivision located in the FEMA special flood hazard area (V zone), measure the maximum allowable building height of 15 feet from the minimum required floor elevation.
- Within Flood Hazard Areas, allow existing legal non-conforming buildings that are encroaching into a required yard setback to be raised without the need for a variance, as long as the extent of the encroachment is not extended.
- Discourage shoreline protective devices in the Coastal Zone, and encourage their removal and site restoration where feasible, due to their coastal resource impacts. Allow the construction, reconstruction, expansion, and/or replacement of a shoreline protective device only if a number of criteria are met to prevent environmental damage, and for a time

period specified by the Coastal Permit. Shoreline protective devices shall be required to mitigate impacts to shoreline sand supply, public access and recreation, and any other relevant coastal resource impacts.

- Ensure that the design and construction of any shoreline protective device shall minimize impacts to the natural environment and public access.
- Accessory structures in hazardous areas are only allowed if consistent with other LCP policies, sited no closer than 5 feet from the edge, designed to be movable, relocated when threatened by erosion, and not protected by a shoreline protective device.
- Public access facilities, including walkways, overlooks, stairways and/or ramps, may be allowed within the shoreline/blufftop setback only if they are consistent with all other applicable LCP policies; are sited and designed to be easily removable; and will not cause, expand, or accelerate instability of a bluff.
- Prohibit the division of land near the shoreline, including bluffs, areas abutting the ocean, bays, lagoons, or other coastal water bodies, unless the new or reconfigured parcels can be developed in a manner safe from geologic and other hazards, and only if shoreline protective devices are prohibited.
- To minimize visual and shoreline sand supply impacts, require that any permit granted to construct a shoreline protective device include the re-

establishment of the pre-existing dune contour and appearance, where applicable and feasible.

- Encourage property owners subject to ocean-front erosion hazards to develop individual and/or collective responses to such hazards prior to emergency conditions.
- Emergency shoreline protective devices may be approved on a temporary basis only and require removal of the structure unless a regular coastal permit is approved.
- The County will consider the best available recent scientific information with respect to the effects of long-range SLR when establishing SLR maps, scenarios, and assumptions for use in geologic, geotechnical, hydrologic and engineering investigations, including the coastal hazards analysis. Support scientific studies that increase and refine the body of knowledge regarding potential SLR in Marin, and possible responses to it. LCP Policies related to SLR shall be reevaluated and modified and readopted as necessary through an LCP Amendment in 2026.
- Building upon the C-SMART Vulnerability Assessment, continue to gather information on the effects of SLR on Marin County's Coastal Zone shoreline, including identifying the most vulnerable areas, structures, facilities, and resources.
- Update Potential Sea Level Rise Maps every 5 years or as necessary to allow for the incorporation of new SLR

science, monitoring results, and information on coastal conditions.

- Research the potential for relocation of existing or planned development to safer locations. Explore the feasibility of a managed retreat program, which may involve protecting vacant land through zoning or conservation easements and/or removing development from areas vulnerable to SLR and restoring those areas to a natural state for open space or recreation. Evaluate possible receiver sites and identify potential mechanisms and incentives for implementation. Work with entities that plan or operate infrastructure, such as Caltrans and PG&E, to plan for potential realignment of public infrastructure impacted by SLR, with emphasis on critical accessways including affected segments of Shoreline Highway and Sir Francis Drake Boulevard.
- Support efforts to monitor SLR impacts to natural resources and habitat areas, including Bolinas Lagoon, Tomales Bay, Esteros San Antonio and Americano and other wetland areas; and Lagunitas, Walker, Estero Americano, Dillon, Stemple and other creeks; rocky intertidal areas, beaches and other habitat types vulnerable to SLR. Collaborate with GFNMS, Tomales Bay Watershed Council and other local, regional, state and federal entities to establish monitoring methods and track the effects of SLR.
- Promote green infrastructure pilot projects (horizontal levees, dune restoration, etc.) with environmental

benefits that may help protect assets from SLR and increased storm surges. Study and monitor such projects over time and share lessons learned with other jurisdictions.

- Update mapping information for Environmentally Sensitive Habitat Areas (ESHA) buffers and setbacks to account for SLR, based on the best available science and considering the effects of shoreline development on landward migration of wetlands.
- Support efforts to develop and implement innovative design alternatives to elevating structures that would reduce or eliminate flood damage. Measures would need to be adopted by FEMA to qualify as acceptable alternatives to elevation under the National Flood Insurance Program (NFIP). Such alternatives could include wet/dry floodproofing, flood gates, drainage improvements, amphibiation, etc. Encourage homeowners to implement voluntary flood-proofing measures in conjunction with development that would not otherwise be required to be elevated.
- Update other relevant sections of the LCP to support SLR adaptation measures:

#### **Biological resources**

- C-BIO-9: Prohibit development that would adversely impact the natural sand dune formation and sandy beach habitat.

#### **Community Design**

- C-DES-4: Refer to Environmental Hazards policies regarding building

heights for structures elevated in response to flood hazards.

#### Community Development

- C-CD-5: Refer to Environmental Hazards policies regarding building heights for structures elevated in response to flood hazards.
- C-CD-6: Acknowledge that SLR will cause the public trust boundary to move inland. The State Lands Commission may require structures or debris to be removed in the event that they encroach on State tidelands.

#### Transportation

- C-TR-3: Address impacts of SLR on Highway One.

#### Historic and Archaeological Resources

- C-HAR-1: Maintain information on historic and archaeological resources that may be impacted by SLR.
- C-HAR-6: Provide standards for altering historic structures.
- Develop additional C-EH policies to address impacts associated with elevation of development along the shoreline. Policies may include mitigation of coastal resource impacts over time; removal and restoration triggers; public trust triggers; and policies to address continuation of public and/or private services.
- Analysis of increased erosion potential and shoreline retreat is included in the *Marin Ocean Coast Vulnerability Assessment*. The coastal erosion hazard maps present the results of models that

predict the geomorphic evolution of cliffs, beaches, and marshes. Update the shoreline retreat analysis every 5 to 10 years or as needed

#### 4.6) Public Trust Doctrine

The common law public trust doctrine requires the State of California to hold its sovereign lands—such as tide and submerged lands and the beds of navigable waterways—for the benefit, use and enjoyment of the public.<sup>39</sup> Tidelands are defined as those lands that fall between the mean high and low tide lines. The mean high tide line is the intersection of the shoreline with the elevation of the average of all high tides calculated over an 18.6-year tidal epoch.<sup>40</sup>

In a majority of cases, tidelands are owned by the State of California and managed by the State Lands Commission to promote and enhance the statewide public's enjoyment of the lands and ensure appropriate uses of public trust lands. Even where tidelands have been granted to private parties or local governments, the State generally retains a public trust easement and may limit the use of such tidelands.

As a common law doctrine, the courts have significantly shaped the geographic boundaries of sovereign land ownership and the public trust doctrine.<sup>41</sup> One notable case that explains

<sup>39</sup> Marks v. Whitney, 6 Cal.3d 251 (Cal. 1971)

<sup>40</sup> California Coastal Commission. *Sea Level Rise Policy Guidance*. August 2015.

<sup>41</sup> See e.g., People v. California Fish Co. 166 Cal. 576 (Cal. 1913); Oakland v. Buteau, 180 Cal. 83 (Cal. 1919); Borax Consol., Ltd. v. Los Angeles, 296 U.S. 10 (1935); City of Long Beach v. Mansell, 476 P.2d 423 (Cal. 1970); Lechuza Villas West v. Cal. Coastal Commission 70 Cal. Rptr. 2d 399 (Cal. Ct. App. 1997).



California’s current common law definition of the location and mobility of the landward boundary of tidelands is:

**Lechuza Villas West v. Cal. Coastal Commission** 70 Cal. Rptr. 2d 399 (Cal. Ct. App. 1997). Two variables affect the location of the mean high tide line. Those variables are (1) the height of the mean high tide and (2) the erosion or buildup of the shore. In conjunction with fluctuations in the mean high tide, the natural erosion or buildup of the shore affects the location of the mean high tide line on the shore, especially on a sandy beach.

The boundary between state owned tidelands and private or publicly owned uplands—the mean high tide line—is anticipated to continue shifting landward due to sea-level rise, affecting coastal land ownership boundaries in many circumstances. In the absence of human development, coastal ecosystems would likely adapt to sea-level rise by migrating inland, with sediment transport and replenishment from erosion providing some stability during these migrations. However, due to human development, migration is impossible and sediment transport is inhibited in many areas, thus negatively impacting the public’s interest in tidelands. State and local governments are currently determining the best way to mitigate these negative impacts of human land use by utilizing the broad authority to protect tidelands under the public trust doctrine. Marin County has determined that the best way to mitigate these negative impacts is to implement the policies outlined in this report.

Accelerating SLR will likely lead to more disputes over shoreline property boundaries. These disputes will affect determinations about what kinds of structures and uses may be

allowed or maintained in areas that, because of SLR, either are already seaward of the mean high tide line, are likely to become seaward of the mean high tide line in the future, or would be seaward of the mean high tide line if not for artificial alterations to the shoreline.

California case law does not explicitly address how shoreline structures that prevent inland movement of the mean high tide line affect property boundaries, if at all. The Ninth Circuit Court of Appeals, however, has interpreted federal common law as allowing the owner of tidelands to bring a trespass action against a neighboring upland property owner who built a revetment that prevented the natural inland movement of the mean high tide line. The court ruled that the actual property boundary was where the mean high tide line would have been if the revetment were not there, and that the owner of the tidelands could require the upland owners to remove the portions of the revetment that were no longer located on the upland owners’ properties. (*United States v. Milner* (9th Cir. 2009) 583 F.3d 1174, 1189-1190.)<sup>42</sup>

The Ocean Protection Council (OPC) is charged with coordinating all State coastal and ocean management agencies in discussions around coastal land use and SLR. The creation of OPC as a coordinating body was intended to improve governance of coastal and ocean ecosystems. The Safeguarding California Plan for Reducing Climate Risks calls upon OPC to assist the State’s Coastal Leadership Group on Sea-Level Rise in “address[ing] the issue of changing boundaries between public trust lands and private lands” and “[d]escribing a range of tools

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<sup>42</sup> California Coastal Commission. *Sea Level Rise Policy Guidance*. August 2015.

that can be utilized to reduce risk while maximizing conservation of natural resources and public access, consistent with the public trust doctrine<sup>43</sup>. The relationship between SLR and public trust is dynamic and may evolve.

As mentioned previously, the general rule of state sovereignty in tidelands does not apply in all areas. In some parts of Tomales Bay, private ownership of the tidelands extends below the mean high tide line under patents issued pursuant to authority of the California legislature. These private property owners own fee title to the tidelands that are within the deeded property boundaries, but the State owns any submerged lands below the mean low water line. Generally, the State Lands Commission requires leases for private piers or other improvements that extend either over submerged lands or in tidelands beyond the patented property boundaries. Additionally, the State retains its public trust easement over all privately owned tidelands.<sup>44</sup>



Home in Marshall on Tomales Bay. Credit: CDA

#### 4.7) County Permitting Agencies

Marin County is widely regarded as one of the most desirable areas to live in the Bay Area, with the combination of natural open areas, safe communities, high quality schools, and proximity to urban life. The Planning Division regulates real estate development in the unincorporated areas of Marin by requiring property owners to obtain permits and meet certain standards. We understand that the County's planning process can be daunting at first, which is why an application guide has been created, available on the county's [web site](#).

Getting a planning permit is usually only one step in the development process; other permits may be necessary and there are utilities and other services that must be provided. Multiple public agencies work together during the permit process, each specializing in their field of expertise. The key agencies and their roles in the development process are briefly discussed below.

The Planning Division reviews planning permit applications, such as Variances, Conditional Use Permits, and Subdivisions, to ensure that projects are consistent with the County's policies and regulations.

The Environmental Health Services Division reviews applications for individual sewage disposal systems and water wells, and conducts restaurant inspections, among other services.

The Department of Public Works (DPW) reviews site preparation details of development projects including grading plans, drainage plans, retaining walls, parking requirements and circulation requirements. DPW also reviews applications for creek permits, dam permits, encroachment permits and grading permits.

<sup>43</sup> California Natural Resources Agency. *Safeguarding California: Reducing Climate Risk*. July 2014.

<sup>44</sup> *Marks v. Whitney*, 6 Cal.3d 251 (Cal. 1971).

The Building and Safety Division is responsible for administering the provisions of the California Building Code by providing plan check and building inspection services.

The various fire districts and departments throughout the County are involved with ensuring emergency access, safe construction practices, and vegetation management.

Special districts, such as water and sanitary districts, and utility companies are responsible for connecting development to infrastructure.

The Tax Assessor's office is involved when modifications to lot lines are made and when lots are created or eliminated.

This list is intended to assist property owners, business owners, and community members to better understand the review process for planning permits. Preparation is the key to success. It's a good idea to be familiar with the possible costs and requirements for permits or hook-ups from all the relevant public agencies. It is their responsibility to gain an understanding of all the requirements that apply and how to meet them before beginning a project.

## 5) Asset Adaptation

This section looks at assets spanning the eight categories from the *Marin Ocean Coast Vulnerability Assessment*: parcels and buildings, transportation, utilities, working lands, natural resources, recreation, emergency services, and historic and archaeological resources. Within each asset category, strategies are presented that apply to that asset type. The “Strategy Options – All” chapter precedes the specific asset categories and includes strategies applicable to all eight asset categories.

Adaptation strategies presented in this section were reviewed by Marin County staff, technical and stakeholder advisors, and could be feasible and worth exploring further for the Marin Coast. The report intentionally includes alternatives that may be difficult to permit under current conditions, since the regulatory climate is subject to evolve and adapt with climate change. The goal is to identify a wide range of reasonable and effective alternatives.

The options are intended to address hazards to built and natural resources, for the near, medium, and long-term. These collective efforts are intended to be part of an iterative adaptation management strategy. The strategies are presented in a format consistent with the organization of the Local Coastal Program.

Building upon broad strategies previously mentioned (accommodate, protect, relocate/managed retreat), these options have been suggested through the C-SMART process to

date. This section organizes such options in matrices under each of the eight asset categories. Draft Spreadsheets had been compiled by C-SMART Staff with adaptation options from staff’s literature reviews, public workshops and the adaptation poll. Spreadsheet columns (consistent with the products of the GFNMS Working Group) include the approach, potential management action, spatial or site specific details, timeframe, impacts addressed, potential partners, required resources, and other asset categories. Potential management actions include the spectrum of adaptation activities that could be undertaken in West Marin to help minimize, avoid, and/or mitigate SLR/storm impacts. – General approaches include outreach, plan, policy, coordinate, manage, monitor, and inventory. These ideas are not staff recommendations or in any way endorsed by Marin County, but simply a collection of options suggested through the C-SMART process that merit further consideration. Strategies are listed as ‘priority action’ based on recommendations of individual Technical and/or Stakeholder Advisory Committee members. The compilation of options is not intended to be viewed as a plan, as not all strategies identified are currently feasible, and in some cases may conflict with one another. However, they provide a basis for discussion as Marin County and partners move forward to address the problems associated with increasing SLR as outlined in the “Next Steps” (pages 14-15).

## 5.1) Strategy Options – All

### Priority Actions

Community

Groups

**Necessary Resources:** Staff, community groups

The following are the top priority actions for consideration, with additional actions in the table below:

### Near term/Ongoing

- A-1)** Explore the feasibility of experimental and innovative coastal protection options, and where possible implement demonstration projects, including constructed wetlands/horizontal levees, offshore reefs/native oyster beds, and dune restoration/beach nourishment. Evaluate the effectiveness of such projects to inform future efforts across the region.

**Possible Locations:** Offshore, Muir Beach, Stinson Beach, Bolinas Lagoon, Tomales Bay, Dillon Beach,

**Potential Key Partners:** CDA, GFNMS, NPS, DFW, Universities, CCC, SCC, COS

**Necessary Resources:** Staff, partners, financial resources, agency coordination

- A-2)** Participate and support existing local community programs, including but not limited to education, outreach, and emergency preparedness, that promote community resilience.

**Possible Locations:** West Marin Communities

**Potential Key Partners:** CDA,

Table 7. Additional Sea Level Rise Adaptation Strategies

	Strategy #	Approach	Potential Management Action	Example Location(s)	Impacts Addressed	Potential Partners	Required Resources	Other Assets	Notes
Near/Ongoing	A-3	Outreach	Continue outreach to vulnerable populations, including multi-lingual outreach to non-English speakers	West Marin	Temporary Flooding, Inundation, Erosion, Wave Surge, High Wind	CDA, Local Interest Groups	Staff, Coordination	All	
	A-4	Protect	Maintain existing seawalls and revetments throughout communities to protect existing development	Stinson Beach, Bolinas	Temporary Flooding, Inundation, Erosion, Wave Surge, High Wind	CDA, Local Assessment District	Staff, financial resources, materials/supplies	All	Could block inland migration of beaches and wetlands
	A-5	Protect	Implement floodwalls and gates in feasible locations	Stinson Beach, other possible locations	Temporary Flooding, Wave Surge, High Wind	CDA, Homeowners	Financial resources, homeowner buy-in	All	Possible environmental impacts
	A-6	Protect	Explore the feasibility of floating islands, breakwaters, constructed barrier islands, artificial reefs, or other offshore structures	Offshore	Temporary Flooding, Erosion, Wave Surge	CDA, NPS, Local Assessment District, NGOs for funding, CCC, SCC, GFNMS	Staff, financial resources, available land, materials, contractors, permits	All	Not allowed under current GFNMS regulations
	A-7	Protect	Explore the feasibility of coastal armoring (seawalls, revetments, levees breakwaters, groins)	Stinson Beach, Bolinas, Tomales Bay, Dillon Beach	Temporary Flooding, Inundation, Erosion, Wave Surge, High Wind	CDA, Local Assessment Districts, CCC	Staff, financial resources, permits, materials/supplies	All	Possible Public access and environmental impacts

Table 7. Additional Sea Level Rise Adaptation Strategies

	Strategy #	Approach	Potential Management Action	Example Location(s)	Impacts Addressed	Potential Partners	Required Resources	Other Assets	Notes
	A-8	Monitor	Update Best Available Data as it become available	West Marin	Temporary Flooding, Inundation, Erosion, Wave Surge, High Wind	CDA, Scientific Organizations (e.g., USGS, NOAA etc.)	Staff, funding for scientific research, coordination	All	
Medium	A-9	Protect	Beach nourishment and dune restoration/enhancement	Muir Beach, Stinson Beach, Bolinas, Lawson's Landing, Dillon Beach	Temporary Flooding, Erosion, Wave Surge, High Wind	CDA, CSP, NPS, Local Assessment District, Property Owners, DFW, CCC	Staff, financial resources, sand, plant material, necessary permits	All	
	A-10	Protect	Enhance and restore living shorelines in sheltered bays	Bolinas Lagoon, Tomales Bay	Temporary Flooding, Inundation, Erosion, Wave Surge, High Wind	CDA, NPS, Local Assessment District, SCC, DFW	Staff, financial resources (e.g., grant funding), fill material, plant material, permitting/environmental impact report	All	
	A-11	Monitor	Assess steep slope and high risk areas	West Marin areas with bluff	Erosion	CDA	Staff/Consultant Time, Financial Resources, equipment	All	

Table 7. Additional Sea Level Rise Adaptation Strategies

	Strategy #	Approach	Potential Management Action	Example Location(s)	Impacts Addressed	Potential Partners	Required Resources	Other Assets	Notes
Long	A-12	Protect	Use site stabilization techniques to prevent beach and bluff erosion including sloping or grading, vegetation, terracing, riprap boulders or geotextile fabric, low profile rock, etc.	West Marin	Erosion	CDA, Landowners, NGOs for funding	Staff/Consultant Time, Financial Resources, equipment	All	May have sediment supply impacts

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Table 8. Exposed buildings (SLR/Storms)  
May be considered for retrofit or retreat

Community	Scenario 1	Scenario 5
Stinson Beach	223	660
Bolinas	13	98
Inverness	23	75
Point Reyes Station	0	36
East Shore	103	163
Dillon Beach	0	5
Other	10	39
<b>Total</b>	<b>372</b>	<b>1,076</b>

## 5.2) Parcels & Buildings

The following are top priority actions for consideration (though LCP policy development is still underway):

### Near term/Ongoing

**B-1)** Through LCP Environmental Hazards policies, ensure new development is safe and limit development in hazardous areas. Require property owners to assume and disclose risks from coastal hazards, including impacts from 3 feet of SLR.

**Possible Locations:** West Marin Communities

**Potential Key Partners:** CDA, CCC, Property Owners

**Necessary Resources:** Staff, private time/financial resources

**B-2)** Require three feet additional elevation of structures in Special Flood Hazard Areas (in addition to FEMA Base Flood Elevation) to accommodate three feet of SLR. In areas outside FEMA Special Flood Hazard Areas that are nevertheless exposed to SLR, the 3 foot building elevation would also be required. The policy would apply when a new or remodeled building requires a Coastal Permit, based on actual conditions of the site.

FEMA grant funding for structural elevation could be sought, possibly including the Marin County Structure Elevation program, a FEMA Hazard Mitigation Grant Program.

**Possible Locations:** West Marin

### Communities

**Potential Key Partners:** CDA, CCC, FEMA, Property Owners

**Necessary Resources:** Staff, Public and/or private funding

**B-3)** Pursuant to Local Coastal Program C-EH-22.a(7): Support efforts to develop and implement innovative design alternatives to elevating structures that would reduce or eliminate flood damage. Measures would need to be adopted by FEMA to qualify as acceptable alternatives to elevation under the National Flood Insurance Program (NFIP). Such alternatives could include wet/dry floodproofing, flood gates, drainage improvements, amphibiation, etc. Encourage homeowners to implement voluntary flood-proofing measures.

**Possible Locations:** West Marin Communities

**Potential Key Partners:** CDA, CCC, FEMA, Property Owners

**Necessary Resources:** Staff, Agency Coordination

**B-4)** Develop “Homeowner’s Guide to Preparing for Sea Level Rise” to help homeowners navigate regulatory system and funding opportunities to elevate or otherwise retrofit homes to accommodate SLR and storms. Topics could include:

- Site vulnerability analysis checklist, mitigation measures and funding sources for flood and storm preparation
- County permitting process.
- Coastal Permit Development Requirements ([Figure 7](#))
- Agency Compliance (FEMA, CCC, etc.)
- Potential estimated building elevation increase.

**Possible Locations:** West Marin Communities

**Potential Key Partners:** CDA, CCC, FEMA, Property Owners

**Necessary Resources:** Staff, Public outreach materials

**B-5)** Use Marin Map as a platform to show regulatory boundaries (e.g., FEMA, GFNMS, CCC jurisdiction, Categorical Exclusion), County-developed "Potential Sea Level Rise Maps", and other existing coastal hazard boundaries.

**Possible Locations:** West Marin

**Potential Key Partners:** CDA, CCC, FEMA

**Necessary Resources:** Staff, agency coordination, Marin Map

**B-6)** Conduct a comprehensive finished floor elevation inventory to fully assess West Marin building vulnerabilities.

### ADAPTATION AND MITIGATION of Older Buildings

In addition to allowing communities to remain intact, continued use of older buildings has environmental benefits. Retrofitting existing homes through elevation and floodproofing 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 than 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.<sup>1</sup> Materials production and transport, building construction, and demolition waste disposal all yield environmental impacts, which could be avoided through preserving/protecting existing buildings.

<sup>1</sup>National Trust for Historic Preservation. 2011. The Greenest Building: Quantifying the Environmental Value of Building Reuse.

**Possible Locations:** West Marin Communities

**Potential Key Partners:** CDA, DPW

**Necessary Resources:** Staff, intern or volunteer time

**Medium term**

**B-7)** Explore the feasibility of programs (incentives, Transfer of Development Rights, Acquisition/Buyout, conservation/rolling easements) and identify potential receiving sites to relocate existing vulnerable development.

**Possible Locations:** *West Marin*

**Potential Key Partners:** *CDA, NPS, CSP, MALT*

**Necessary Resources:** Staff, legal coordination, precedents, upland property

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Table 9. Additional Strategies

	Strategy #	Approach	Potential Management Action	Example Location(s)	Impacts Addressed	Potential Partners	Required Resources	Other Assets	Notes
Near/Ongoing	B-8	Protect	Protect bluffs with armoring	Bolinas	Temporary Flooding, Inundation, Erosion, Wave Surge, High Wind	CDA, Local Assessment District, CCC	Staff, financial resources, materials/supplies	Transportation, Utilities	
	B-9	Accommodate	Retrofit homes for high wind and wave protection through: <ul style="list-style-type: none"> <li>• Deep pilings (also for seismic retrofitting)</li> <li>• Reinforcing garage doors</li> <li>• Protecting windows and doors with covers</li> <li>• Strengthening wall systems</li> <li>• Site preparations including removal of dead branches and potential windborne projectiles</li> <li>• Roof and siding improvements</li> <li>• Rebuilding or reinforcing foundation to address flood loads (e.g., add interior piers, bracing or tensile strengthening)</li> </ul>	Stinson Beach, Bolinas, Dillon Beach	Wave Surge, High Wind	CDA, Home/Business Owners, FEMA	Staff, private time/financial resources	Utilities	
	B-10	Accommodate	Ensure windows, vents, doors, etc. are not below predicted flood levels	Vulnerable properties in Stinson Beach, Bolinas, Inverness, East Shore	Temporary Flooding, Inundation	CDA, FEMA, Homeowners	Staff, private time/financial resources	Utilities	

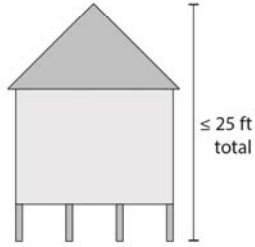
Table 9. Additional Strategies

	Strategy #	Approach	Potential Management Action	Example Location(s)	Impacts Addressed	Potential Partners	Required Resources	Other Assets	Notes
	B-11	Outreach	Develop Homeowner Lookup table for residents to look up what the projected flood depth of their property is for permitting purposes		Temporary Flooding, Inundation	CDA	Staff, web page, technical assistance		
	B-12	Inventory	Develop trigger for flood impacts. At what frequency of flooding does the community and affected agencies feel that action should be taken? homeowners feel that it is no longer acceptable?	Stinson Beach, Bolinas, Inverness, Point Reyes Station, East Shore	Temporary Flooding, Inundation, Erosion, Wave Surge, High Wind	CDA, Academic Partners, Community Members	Staff, partner participation, methods/processes, stakeholder participation	Transportation, Utilities	
Medium	B-13	Accommodate	Explore the feasibility of, and if possible move forward with adapting to houseboats.	Inverness, East Shore	Inundation	CDA, CCC, Property Owners	Private time/ financial resources, Permitting, Policy Changes (?)	Utilities	
	B-14	Protect	Construct low-profile sand-covered seawall from end of existing Seadrift revetment toward southeast end of beach ( <a href="#">Figure 11</a> )	Stinson Beach	Temporary Flooding, Inundation, Erosion, Wave Surge, High Wind	CDA, Local Assessment District, CCC	Staff, financial resources, materials/supplies	Transportation, Utilities	
	B-15	Accommodate	Limit basements and first floor habitable spaces	Stinson Beach, Bolinas, Inverness, Point Reyes Station, East Shore,	Temporary Flooding, Inundation	CDA, Homeowners	Private financial resources , design guidelines	Utilities	
	B-16	Retreat	Explore the use of conservation or rolling easements (policies that allow coastal lands and habitats to migrate landward overtime)	Stinson Beach, Bolinas, Inverness, Point Reyes Station, East Shore	Temporary Flooding, Inundation, Erosion, Wave Surge, High Wind	CDA, CCC, SCC, Property owners	Staff, legal coordination, precedents/examples	Transportation, utilities	

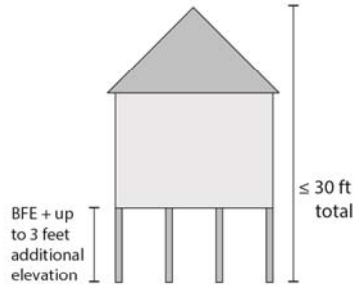
# Development Requirements

22.68.060  
(Pending Certification)  
Improvements to existing structures. Exempt if NOT in an appeal zone & NOT on a beach; in a wetland, stream or lake; seaward of the mean high tide line; in an ESHA; within 50 feet of the edge of a coastal bluff; or additions resulting in an increase of less than 10 percent of the floor area.

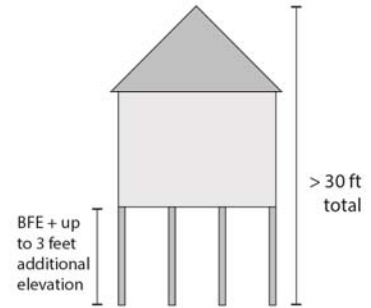
Exempt



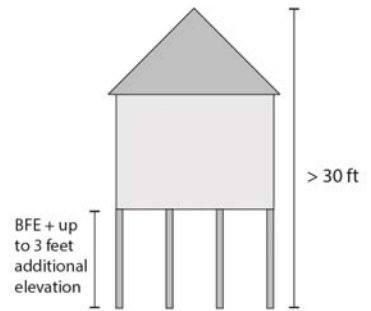
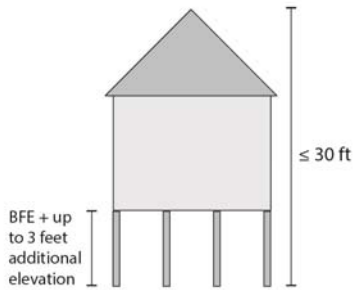
Coastal Permit  
(Standard Findings)



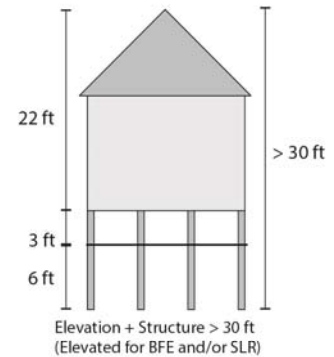
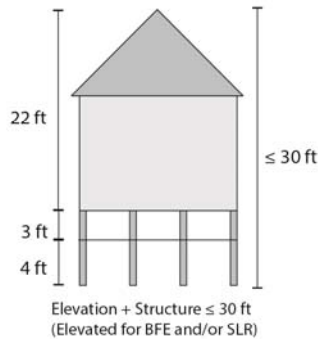
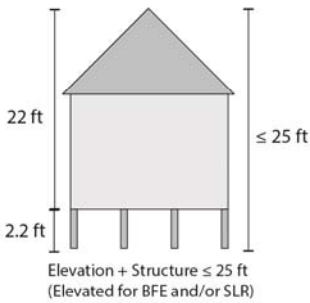
Coastal Permit



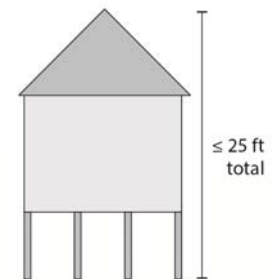
ON a beach; IN a wetland, stream or lake; seaward of the mean high tide line; IN an ESHA; or within 50 feet of the edge of a coastal bluff



IN APPEAL ZONE property that is located between the ocean and the first public road. Increase of no more than 10% of floor area of existing structure increase in height of no more than 10% of an existing structure.



New Development on Vacant Lot or Non-Exempt, Non-Excluded Expansion.



## Development Requirements

Categorical Exclusion E-82-6 additions to single-family dwellings shall be excluded when: 1. No portion of the parcel or lot...is located within: a tideland, submerged lands, public trust lands, beaches and lots immediately adjacent to the inland extent of any beach or of the mean high tide line of the ocean where there is no beach (see Categorical Exclusion maps); 2) The addition would not result in an increase of more than 50% of the floor area of the dwelling before the addition or 1,000 sq. ft., whichever is less; 3) The addition meets all zoning and development standards; and 4) The addition does not involve a structure constructed prior to 1930 or a structure located within the historic area boundaries for Tomales, Marshall, Point Reyes Station, Olema, Inverness, Bolinas or Stinson Beach. Note: this exclusion requires conformance with the LCP in effect on the date the exclusion was adopted by the Commission.

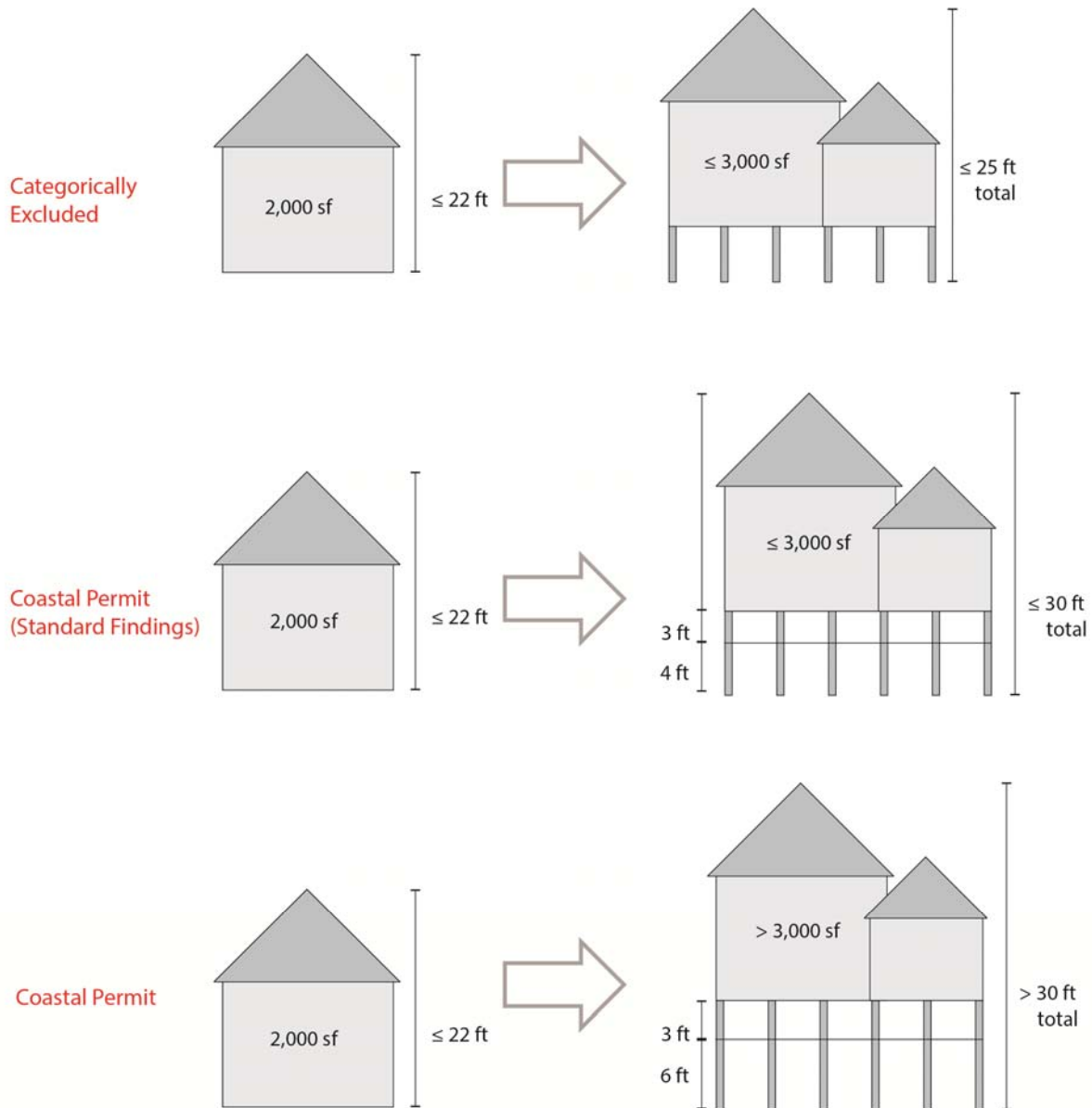


Figure 7. Coastal Permit Development Requirements based on height, square footage, and location.

## ***Design Principles***

West Marin is a region encompassing communities and environmental areas as diverse and noteworthy as anywhere in the country. Steeped in a long tradition of conservation and environmental consciousness, West Marin nevertheless finds itself vulnerable in the coming years to SLR and fluctuations in coastal and weather patterns.

West Marin features a wide range of geographic and built contexts, community aesthetics including building facades, architectural styles, and scale that collectively contribute to the region's identity. Changes to the built environment must therefore be carefully designed and formulated, maintaining the overall community appearance that draws and retains residents and visitors alike.

Although a number of adaptive contingencies and retrofitting strategies exist to address anticipated concerns of flooding and changes in water level, a concentrated effort to uphold local character and community culture must work in tandem with such projects. This set of design principles can be utilized to ensure that homes and buildings are geared to address SLR as well as preserve and promote community characteristics.

These principles were drafted by staff following the February 2016 *Resilient Stinson Design Charrette*. This event articulated community character descriptors and helped staff and project partners better understand unique and diverse attributes of the community which contribute to its sense of place.

### **Preservation of small-town character**

From Muir Beach's tight bluff-top neighborhoods to Inverness' bay shore community, West Marin towns are a unique collection of coastal areas characterized by welcoming residents and a deep seated pride in community history. Homes differ significantly and include Stinson Beach's stretch of elevated beachfront homes as well as Dillon Beach's more traditional cul-de-sacs. Throughout these areas however is a desire to preserve and maintain a small-town feel and culture. Consequently, all infrastructure projects and even home renovations should take into consideration their impact on the overall community character and remain compatible with the small-town look and feel.

### **Relationship to Nature**

West Marin is situated in an incredibly diverse environmental area, encapsulating a range of unique ecosystems and microclimates. Stretches of beaches provide both recreational opportunities as well as native flora and fauna habitat, while nationally recognized parks and wetlands provide vital habitats for dozens of species. These natural resources are deeply embedded in local culture, reflecting Marin County's long heritage of open space appreciation, and residents generally value the close connection to nature. Retrofitting should maintain buildings' relationship to environmental features such as the beach and coast as closely as possible.

### **Diverse styles and appearances**

West Marin communities such as Stinson Beach have been described by residents as "funky" and "eclectic" due the diversity of buildings. Homes, even if adjacent to one another, exhibit



significant variation in features including roof shapes, building heights, textures, details, colors, landscaping, and more. Thus visual compatibility from one home to the next currently does not exist and therefore it is not critical to maintain existing character and sense of place, and may not even be possible.

**Minimize intrusiveness**

Retrofitting systems and techniques such as stilts, floodgates and floodwalls have the potentially to be aesthetically intrusive which could detract from sense of place, community characters, and/or property values. To the fullest extent possible, structures should be modified in ways that protect them from future flood events while minimizing any negative visual impacts. Mitigation techniques could be integrated such as screening, panels, vegetation, landscaping, etc. that soften/avoid such impacts, and unnecessary retrofitting (e.g., excessive elevation) should be avoided altogether.

## *Retrofitting Options*

Pursuant to Local Coastal Program C-EH-22.a(7) (Page 67, bullet 4) this section explores various methods for retrofitting homes to protect against SLR and flooding.

Currently, elevation is the only technique permitted under the County's Floodplain Ordinance. Elevation is a viable approach for protecting units from structural damage, and allows communities in West Marin to remain intact as economic and social hubs. However, there are a number of drawbacks including costs, possible ADA accessibility challenges, and potential aesthetic and community character impacts.

As elevation may not be feasible in every situation, other alternatives must be explored to protect life and property. Given that communities and homes in West Marin vary significantly in size, architectural style, and flood zone classification, it is worth considering an array of retrofitting methods that cater to specific needs.

Alternative strategies outlined in this section are intended to be site-specific and may not represent long-term, singular solutions given uncertainties in SLR projections and the anticipated lifespan of homes. Despite this, these strategies merit consideration as near term alternatives, and could be combined with other strategies that consider regional and community-wide policies. Financial incentives are also factors, as some methods may be eligible for assisted funding or reduced flood

insurance premiums. Unless indicated otherwise, cost estimates in this section come from FEMA, and may be inconsistent with Marin County's estimates in other parts of this report.

In Marin County's unincorporated areas, the County's Community Development Agency regulates development, requiring permits and certain standards to be met. Specifics will vary depending the nature and extent of development.

Typical West Marin dwelling units are 1 or 2 story woodframed structures, and all retrofitting strategies presented in this section are structurally feasible for such types of homes. Strategies for structures built with other materials (e.g., brick/stone masonry), or greater than 2 stories are not outlined here. This section is only intended to provide a general overview of different options, and more details about several of these options and others can be found in the following FEMA manuals:

- Homeowner's Guide to Retrofitting : Six Ways to Protect Your House From Flooding. June 2013.
- Above the Flood: Elevating Your Floodprone House. May 2000.
- Selecting Appropriate Mitigation Measures for Floodprone Structures. March 2007.
- Engineering Principles and Practices of Retrofitting Floodprone Residential Structures. January 2012.
- Reducing Flood Risk to Residential Buildings That Cannot be Elevated. September 2011.










Construction Type	Existing Foundation	Measure	Retrofit	Relative Cost
Frame, Masonry Veneer, or Masonry	Crawlspace or Basement	Wet Floodproofing 	Wet floodproof crawlspace to a height of 4 feet above lowest adjacent grade or wet floodproof unfinished basement to a height of 8 feet above basement floor	<p>Lowest</p>  <p>Highest</p>
Masonry Veneer or Masonry	Slab-on-Grade or Crawlspace	Dry Floodproofing 	Dry floodproof to a maximum height of 3 feet above lowest adjacent grade	
Frame, Masonry Veneer, or Masonry	Basement, Crawlspace, or Open Foundation	Barrier Systems 	Levee constructed to 6 feet above grade or floodwall constructed to 4 feet above grade	
Frame, Masonry Veneer, or Masonry	Basement, Crawlspace, or Open Foundation	Elevation 	Elevate on continuous foundation walls or open foundation	
Frame, Masonry Veneer, or Masonry	Basement, Crawlspace, or Open Foundation	Relocation 	Elevate on continuous foundation walls or open foundation	
Frame, Masonry Veneer, or Masonry	Slab-on-Grade	Elevation 	Elevate on continuous foundation walls or open foundation	
Frame, Masonry Veneer, or Masonry	Slab-on-Grade	Relocation 	Elevate on continuous foundation walls or open foundation	
Frame, Masonry Veneer, or Masonry	Slab-on-Grade, Crawlspace, Basement, or Open Foundation	Demolition 	Demolish existing building and buy or build a home elsewhere	

Table 10. Building Retrofitting Options<sup>45</sup>

<sup>45</sup> FEMA. 2014. Homeowner's Guide to Retrofitting

**Relocation**

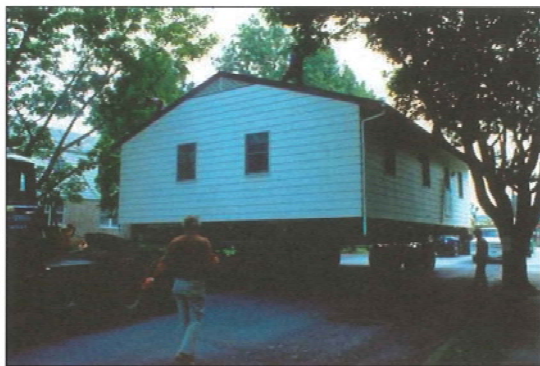
Relocation includes moving houses to higher ground, and could include moving houses to another location on the same property, or to a new property altogether. Abundant land for mass relocation is likely not present in all West Marin communities, but specifics are still outlined below for consideration. Where flood hazards are most severe or areas that could be subject to future severe flood hazards, relocation may be particularly appropriate.

**Process:**

The basic process includes jacking houses up and placing them on wheeled vehicles for delivery to new sites. At the new site, the house is installed on a new foundation and connected to utilities.<sup>46</sup>

**Application:**

While one-story houses are easiest to move, larger houses of all types can also be relocated, though masonry homes are more costly. Home contents can often remain in the house. Routes should be charted in advance and narrow boards, bridges and overpasses can be restrictive.



Source: FEMA

**FEMA Compliance:**

Relocation is considered the most effective retrofitting methods by FEMA.<sup>47</sup>

Table 11. Relocation Costs<sup>48</sup>:

Construction Type	Existing Foundation	Cost (per square footprint or house footprint)
Frame	Basement	\$32
	Crawlspace	\$27
	Slab-on-Grade	\$51
Masonry	Basement	\$49
	Crawlspace	\$32
	Slab-on-grade	\$61

**Other Considerations:**

While relocation can be a permanent solution to move houses out of hazardous areas, it can break up existing communities, thus detracting from local economies and sense of place. Sufficient land must be available for relocation, and infrastructure including roads and utilities would need to be in place with sufficient capacity for increased useage. Developable land in West Marin is generally sparse and therefore community-scale feasibility of this option is questionable. Additionally as West Marin roads are relatively narrow, clearance would likely be a major constraint.

<sup>46</sup> FEMA 1998. Homeowner’s Guide to Retrofitting

<sup>47</sup> Ibid.

<sup>48</sup> Ibid.

## Elevation

Elevation refers to a technique where a structure is raised and suspended upon a foundation of piles, thereby protecting it from anticipated floodwater levels. Especially in areas prone to ocean flooding such as Marin's Pacific Coast, elevating structures above expected floodwater levels is an effective and proven strategy to combat flooding, and ensures homeowners that property and possessions will be safe from not only flooding, but also coastal erosion.

Structures are elevated using jacks to meet or exceed the BFE – a measured point that indicates anticipated floodwater levels. Depending on local conditions, environmental factors, and structural considerations, heights typically range from 3 to 15 feet above the ground. Once raised, the structure is placed upon a foundation of piles: long columns driven deep into the ground which provide not only stability but also a buffer zone between inhabitable space and floodwaters. The area below can remain exposed or partially enclosed for alternative use as storage or parking.

There are 2 types of elevation techniques to consider:

- Open Foundations: the entire structure is lifted and placed on a new elevated foundation supported by piers, columns, or piles.
- Continuous foundation walls: only the interior floor of the building is raised above anticipated water levels, and the walls are built up to match the new elevation.



*Elevated beach home with open foundation*



*Open foundation featuring lower-level parking space*



*Continuous foundation wall – note new elevation walls in white*

**Process:**

1. All utility lines (water, sewage, gas, electric, phone, etc.) are disconnected, to be re-connected once the elevation process is complete
2. Holes are drilled at regular intervals in the foundation and steel I-beams inserted along the entire span of the structure
3. Hydraulic jacks are used to raise the beams and the structure they're supporting to the desired height
4. Once the structure has been elevated, a new foundation is constructed and the structure is then lowered and brought to rest upon the new foundation. If enclosed, this foundation will feature flood openings that allow water in during the event rising water levels

Beyond supporting the weight of the structure, the foundation must be able to withstand anticipated wave impacts, water pressure brought on by flooding, debris impact, and erosion.



*Home resting on temporary beams and foundations*

**Application:**

An open foundation is recommended for structures located directly along coastlines, where prolonged exposure to waves or high-velocity floodwaters is expected.

- Eligible neighborhoods include: Stinson Beach, Muir Beach, Inverness, Dillon Beach, East Shore

A continuous foundation wall method is recommended for structures located further inland from coasts, where the chances of prolonged exposure to waves or high-velocity floodwater are lower.

- Eligible neighborhoods include: Bolinas, Point Reyes Station

**FEMA compliance:**

Elevation is FEMA's predominant method for addressing flooding. Elevating the lowest floor above the BFE will reduce flood insurance premiums (through NFIP), and federal funding is available for projects that satisfy certain requirements. Eligible foundation types are categorized based on A and V-Zone classification. Estimated costs provided recently from ESA are \$140/ft<sup>2</sup> (AO and AE zones)<sup>49</sup> and \$250/ft<sup>2</sup> (V and VE zones)<sup>50</sup>, while FEMA's general estimates from 2007 based on building materials are listed in [Table 12](#). It is important to remember that actual home elevation costs will vary depending on project, site characteristics, building condition and other factors.

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<sup>49</sup> ESA. 2015. Personal Communications.

<sup>50</sup> ESA. 2016. Marin County Hazards and SLR Adaptation Strategies.

**Table 12. General Estimates of the Unit Costs for Typical Elevation Projects.<sup>51</sup>**

Wood frame building on piles, posts, or columns	\$36/square foot
Wood frame on concrete or block foundation walls	\$32/square foot
Brick Walls	\$43/square foot
Slab-on-grade	\$45/square foot

*Note: Above estimates are from FEMA and vary from County estimates. Estimates only provide a general sense of relative costs and should not be used solely as a basis for making home retrofitting decisions.*

**Aesthetic Considerations:**

Visual mitigation techniques for pier foundations include lattice screening, or breakaway walls that create usable enclosed space. Landscaping could also be used to soften visual impacts, though design techniques can mimic natural conditions, which could include the use of sand dunes and native vegetation. No precedents have yet been identified of places with similar environmental condition and elevated homes that have used such mitigation measures.



*Wood slats installed over pilings to hide open foundation*

**Other Considerations:**

- **Accessibility:** elevated homes can cause challenges for people with limited mobility, including elderly and disabled.
- **Sense of place:** elevating structures may distance residents from a close physical proximity to water, diminishing a highly desirable amenity of beach-front property.
- **Shadow:** Elevation can increase shadow impacts to neighboring areas.
- **Views:** Elevated homes could block views from neighboring properties.



*Coastal home with slight raise, masked with landscaping and wood-lattice*

<sup>51</sup> FEMA. 2007. Selecting Appropriate Mitigation Measures for Floodprone Structures.

### Amphibiation

An amphibious structure is a building that rests on the ground but floats upon a dock or flotation system whenever flooding occurs. A unique base serves as a foundation as well as flotation system designed to be buoyed by floodwaters. Unlike houseboats, amphibious structures are built on solid ground and designed to float only when conditions are appropriate. To prevent the structure from floating indiscriminately, the structure is anchored to long piles at the corners of the house which serve to guide the structure upwards in the event of rising water. Guided by these piles, structures can rise up to 15 ft above the base elevation.

In most applications, the ground floor of the structure is raised approximately 3 ft and rests upon a dock which is specifically designed to fill gradually as floodwaters rise. Ordinarily, the structures only require 3 to 5 ft of water in order to float, depending on the weight of the structure and the design. The flotation system itself can take several forms depending on the design: specialized concrete, pre-fabricated pontoons, and styrofoam held together by a steel frame have all been successfully applied in different contexts.

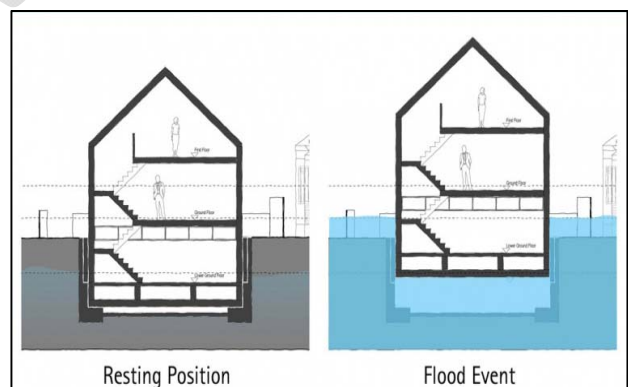


*Home placed upon a steel pontoon flotation network (MOS Architects)*

### Process:

Amphibiation strategies can either be employed during initial construction, or retrofitted onto existing structures. For existing homes, the process is as follows:

1. All utility lines (water, sewage, gas, electric, phone, etc.) are disconnected, to be reconnected once the flotation system is in place. Utilities are eventually stored in designated compartments (i.e., inside the anchor piles), or re-designed and repurposed to allow for vertical extension.
2. The structure is lifted using beams and hydraulic jacks so that a new foundation can be laid underneath.
3. Special buoyancy blocks are incorporated into the foundation to allow flotation in the presence of rising water. Anchor piles are also drilled and attached to the structure with flexible chains.
4. Once the foundation is completed, the structure is brought to rest upon the new flotation system.



*Diagram demonstrating a house's ability to float in the presence of floodwaters (BACA Architects)*



**Application:**

Current designs are not intended for coastal regions subject to storm surge inundation or wave action with high velocity flow. Rather, amphibiation is intended for homes in non V-Zones located further inland from coasts, or adjacent to more sheltered bodies of water including rivers, creeks or bays without dramatic waves and not subject to permanent inundation from SLR. Based on building material, amphibiation can be applied to any structure that can be elevated.

**FEMA Compliance:**

Amphibiation is not compliant with current FEMA regulations, and therefore does not qualify for the National Flood Insurance Program.

**Costs:**

Amphibious foundation costs are dependent on a variety of local environmental contexts, as well as materials used. Generally building amphibiation can cost between 30-60% less than elevation.<sup>52</sup> Permanently elevated homes are vulnerable to wind damage, and elevations are expensive. Retrofitting an existing house with a floating foundation costs up to \$25,000 compared with the \$40,000 to \$60,000 it can cost homeowners to elevate. Adding an elevator for elderly or disabled residents makes it even more expensive.”<sup>53</sup>

**Aesthetic Considerations:**

- Aesthetics and Local Character: as structures remain in place most of the time, amphibiation has little to no visual or aesthetic effects on the community.

**Other Considerations:**

- Flexibility: because the structure is not built at a fixed level, the house can float above water even if the flood level is higher than the anticipated BFE.
- Accessibility: structures remain low to the ground, except during flood events, so flights of stairs are not required, aiding in accessibility.
- Earthquake: Amphibiation is as yet untested in seismic zones. Lateral stability during seismic events should be engineered by a professional which will add cost, though this is likely minimal for small structures. Regulatory approvals may require variances as the method is not covered under current local codes.

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<sup>52</sup> English, Elizabeth. (Buoyant Foundation Project) 2015. Personal Communications

<sup>53</sup> Buskey. 2009. 1 (appendices, 340); and Elizabeth English, “Amphibious Foundations and the Buoyant Foundation Project: Innovative Strategies for Flood-Resilient Housing,” (paper presented at the International Conference on Urban Flood Man-

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agement, Paris, France, November 25-27, 2009), 7 (appendices, 412).

## Floodproofing

Floodproofing describes techniques designed specifically to reduce or eliminate flood damage to a structure, its contents, and accompanying utilities and equipment. Although these techniques do not completely eliminate the potential for all flood damages, such retrofits can be effective temporary and cost-efficient measures installed without significant intrusion upon existing structures and systems. Floodproofing is effective for depths up to 6 ft from seasonal temporary inundation, but less applicable to properties subject to permanent inundation from SLR.

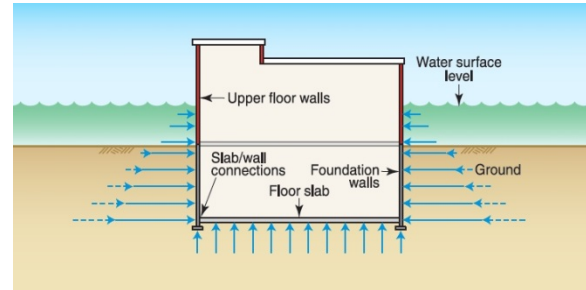
There are two types of floodproofing: dry and wet. Dry floodproofing entails making a building watertight and resistant to anticipated flood loads, while wet floodproofing uses construction techniques to intentionally allow areas of the structure to flood.

### Dry Floodproofing

The goal of dry floodproofing is to retrofit structures so that they are both impermeable to floodwater and resistant to flood loads. In general, this entails the reinforcement of walls to withstand water and impact forces caused by floating debris, and the installation of shields and barriers designed to keep floodwater from entering openings. When successfully applied, dry floodproofing can sustain up to 3 ft of standing floodwater.

Dry floodproofing is especially applicable for commercial buildings which can employ a number of measures and combinations simultaneously. However, because the walls are exposed to floodwaters for an extended period of time, dry floodproofing is practical for residential homes with masonry or poured

concrete walls only. Dry floodproofing is also not recommended for homes featuring crawlspace foundations.



*Diagram of water pressure upon a structure in the presence of floodwater (FEMA)*



*Successful application of dry floodproofing barrier in North Dakota*



*Hinged flood shield designed to protect utility systems at a moment's notice*

Dry floodproofing takes several forms, contingent on the makeup of the existing structure as well as anticipated flood levels.

- Sealants: sealants can be applied to exterior or interior walls, and serve to reinforce structural integrity as well as protect against seepage. They can also be applied to utility systems and prevent water intrusion at utility connections. Sealants usually come in the form of lacquers or waterproof paint.
- Flood barriers and shields: shields and walls constructed of corrosion and rust-resistant aluminum and steel can seal off exterior doors or windows from floodwater. Such shields are either mounted manually prior to imminent flooding, or exist on rail or hinged systems that allow for quick and easy installation. Watertight doors can also be installed in interior settings to protect entire rooms.
- Drainage systems: when paired with other techniques such as sealants or floodwalls, drainage systems like sump pumps and backflow valves are an effective way of removing intruding water and allowing existing sewage and water systems to operate even in the event of a flood.



*Sealant applied like paint on exterior walls*

**Process:**

1. Complete a thorough site and building evaluation to determine viable options: structural engineers and licensed professionals will determine if the existing structure can be cost-effectively retrofitted based on anticipated flood activity, environmental factors, and current structural conditions.
2. Based on recommendations from the site evaluation, appropriate materials and methods will be selected and properly installed.
3. Depending on scope of renovations and retrofitting, utility lines may need to be temporarily disconnected, spaces emptied of contents, or buildings left unoccupied for a period of time while retrofits are properly installed.

**Application:**

Dry floodproofing techniques can be applied to any existing structure, residential or commercial, located within A-Zones. In residential applications however, FEMA states that dry floodproofing is only appropriate for homes with masonry or poured concrete walls.

Furthermore, dry floodproofing is not designed to accommodate floodwaters long term (defined by FEMA as longer than 12 hours), or areas prone to frequent and regular flooding (which may include places subject to increased tidal flooding from SLR). It will also not protect against potential damage from high-velocity flood flow and wave action.

Wall heights must be consistent and in scale with neighboring structures and landscaping.

**FEMA Compliance:**

Dry floodproofing techniques are prohibited in all V-Zones (coastal areas subject to inundation by the 1% annual chance flood event with additional hazards associated with storm induced waves) and Coastal A-Zones (areas subject to inundation by the 1% annual chance flood event). In addition, dry floodproofing techniques may not be used to bring substantially damaged or improved residential homes into compliance with community floodplain management ordinances. Non-residential and commercial buildings may however employ dry floodproofing techniques regardless of existing conditions.

**Costs:**

Costs are contingent upon several factors, including the quality of materials selected, existing structural conditions, and scope of work. [Table 13](#) may be used as a general reference.

Table 13. Cost of Dry Floodproofing<sup>54</sup>

Waterproofing a concrete block or brick-faced wall by applying a polyethylene sheet or other impervious material and covering with a facing material such as brick	\$3.50/ft <sup>2</sup>
Acrylic latex wall coating	\$3.00/ft <sup>1</sup>
Caulking/sealant – a high performance electrometric “urethane” sealant is recommended	\$2.50/linear foot
Bentonite grout (below grade waterproofing, 6 feet deep)	\$20/linear foot

**Aesthetic Considerations:**

- Flood shields may not be visually pleasing or in keeping with the overall exterior character of a structure

**Other Considerations:**

- Systems require regular maintenance and testing in order to confirm effectiveness: materials may need to be replaced over time if effectiveness is shown to have diminished
- Flood shields may require manual installation, a potentially hazardous activity that may not be feasible without adequate warning
- Typically less costly than other retrofitting methods
- Home exteriors are still susceptible to damage during floods
- Dry floodproofing reduces airflow. This can lead to mold and air quality issues if it is used on walls of enclosed occupied spaces.



*Low-tiered flood wall and gate installed at a commercial building in Marinship. Opening allows for manual insertion of a flood barrier.*

<sup>54</sup> FEMA 2007. Selecting Appropriate Mitigation Measures for Floodprone Structures



*Flood wall and gate applied in a residential setting and masked with landscaping*

### Wet Floodproofing

Wet floodproofing is a technique characterized by allowing portions of structures to intentionally flood during temporary flood events, rather than work to keep water out (dry floodproofing). Small exposed openings placed at intervals along the foundation wall intentionally allow in water which rises and falls at the same rate as exterior floodwaters. By allowing water to enter the uninhabited areas of the structure, wet floodproofing is designed to counteract water pressure upon walls, floors, and supports by equalizing interior and exterior water levels. Once floodwaters recede, the flooded area underneath the structure dissipates accordingly, or is pumped out with the aid of a sump pump.

In some instances, the entire first floor of an existing structure can be converted into uninhabitable, floodable space. Especially in areas expecting floodwaters whose levels exceed narrow crawl spaces, an additional story can be constructed, consistent with height limits, to replace the loss of previously habitable space. The retrofitted first floor may

then be used for parking or temporary storage, and allow for higher floodwater levels.

Utilizing water-resistant materials is also a passive form of wet floodproofing. Traditional materials used in ordinary construction such as carpet, dry wall, or plywood are all vulnerable in the presence of standing water. These materials can be replaced in all areas below anticipated water levels with flood damage-resistant materials such as tile, masonry and non-paper-faced gypsum board that will neither deteriorate nor be damaged if exposed to or submerged by water.



*Bunker style coastal homes in Santa Cruz feature elevated ground floors that are intentionally allowed to flood*

**Table 14. Examples of flood damage-resistant materials**

Material Type	Acceptable	Unacceptable
Structural Floor Materials	Concrete, Naturally decay-resistant lumber; Pressure-treated plywood	Engineered wood or laminate flooring; Oriented-strand board (OSB)
Finish Flooring Materials	Clay tile; ceramic or porcelain tile; Terrazo tile; Vinyl tile or sheets	Engineered wood or laminate flooring; Carpeting; Wood Flooring

Structural wall & Ceiling Materials	Brick face, concrete; Cement board; Pressure-treated plywood; Structural lumber	Fiberglass insulation; Paper-faced gypsum board; OSB
Finish Wall & Ceiling Materials	Glass blocks; Metal cabinets or doors; Latex paint	Wood or particleboard cabinets and doors; Non-latex paint; Wallpaper



*Specialized hinged vents are designed to allow water in once specific pressure loads are met*



*Openings incorporated into a garage door allow for entry of water*

**Process:**

1. Complete a thorough site and building evaluation to determine viable options: structural engineers and licensed professionals will determine if the existing structure can be cost-effectively retrofitted based on anticipated flood activity, environmental factors, and current structural conditions.
2. Based on recommendations from the site evaluation, appropriate materials and methods will be selected and properly installed.
3. Depending on scope of renovations and retrofitting, utility lines may need to be temporarily disconnected, spaces emptied of contents, or buildings left unoccupied for a period of time while retrofits are properly installed.

**Application:**

As structures retrofitted with wet floodproofing techniques are typically designed to accommodate floodwaters typically limited between 3 to 5 ft, wet floodproofing is only allowed in A-Zones. Furthermore, wet floodproofing loses effectiveness if the duration of the flood is longer than one day. Consequently, it cannot be applied where inundation will occur due to SLR.

**FEMA compliance:**

Wet floodproofing does not reduce flood insurance premium rates on residential structures. Wet floodproofing techniques are also largely restricted to uninhabitable areas such as spaces used for parking, accessibility, or storage.

**Costs:**

debris may enter the house along with floodwaters

Costs are contingent upon several factors, including the existing foundation type, scope of work, and local environmental factors. The following table may be used as a general reference:

**Table 15. Costs of Wet Floodproofing<sup>55</sup>**

Height of Wet Floodproofing (feet above basement floor or lowest adjacent grade)	Existing Foundation	Cost (per square foot of house floodproofed)
2	Basement*	\$1.70
	Crawlspace	\$1.30
4	Basement*	\$3.50
	Crawlspace	\$3.25
8	Basement*	\$10.00
	Crawlspace	NA

\* Unfinished

**Aesthetic Considerations:**

- Aesthetics: minimal aesthetic impacts as the floodable areas is typically out of view, and doesn't require extensive landscaping or exterior work to mask

**Other Considerations:**

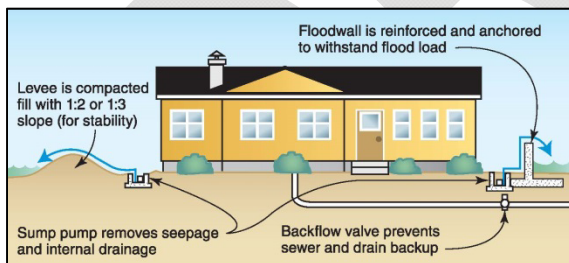
- Typically less costly than other retrofitting methods
- Home exteriors are still susceptible to damage during floods
- Extensive cleanup may be require once floodwaters have receded: excess water may need to be pumped out of flooded area; contaminated sewage, chemicals, or

<sup>55</sup> FEMA 1998. Homeowner's Guide to Retrofitting

## Site Improvements

Aside from significant construction renovations to existing structures, a number of smaller scale measures can be implemented to address anticipated flooding issues. These techniques can be applied as standalone improvements or as part of a larger floodproofing plan, and usually require a smaller investment of time and resources than other retrofitting options. They are however limited in their scope and effectiveness and generally only address occasional flooding. Caution should be used when considering these strategies for properties subject to more frequent flooding or inundation from SLR. Options also vary in terms of cost and applicability, and may not reduce flood insurance premiums.

Alternative retrofitting options can be particularly relevant to both residential and non-residential applications, especially when other methods such as elevation or floodproofing are not feasible or applicable based on structural or economic considerations.



*Home protected by multiple retrofits including a levee, drainage systems, and a floodwall (FEMA)*

## Floodwalls, Levees, and Floodgates

- Floodwalls and levees both act as protective barriers against temporary floodwaters. Floodwalls are built with flood-damage resistant materials while levees are compacted soil.
- These barriers are usually constructed away from the main buildings along property lines, and unlike dry floodproofing are designed to combat floods greater than 4 ft.
- Gates and openings along walls or levees allow for regular access and are designed to be easily sealed in anticipation of flooding



*Temporary floodwall represents an alternative to sandbagging*



*Gaps between buildings/walls such as this one at Stinson Beach represent possible locations for floodgates.*

## Landscaping

- Passive floodproofing techniques aid in water infiltration, erosion control, and floodwater management.



- Rain gardens, grassy swales, and bioswales constructed on sidewalks, embankments, or yards offer aesthetic and functional flood control.
- Permeable concrete applied on sidewalks, driveways, and parking lots reduce water runoff and reduce the need for separate stormwater retention areas.



*Sidewalk rain garden in San Francisco*

#### **Home Improvements**

- Mini floodwalls protect openings using cost-effective materials like brick or concrete.
- Electric utilities (including telephone, TV, internet), HVAC ductwork, and mechanical equipment (water heaters, air conditioning units, exhaust fans) should be placed behind floodwalls or elevated above anticipated water levels.
- On-site sump pumps and toilet and sink backflow valves can be installed to prevent plumbing systems from being overwhelmed.



*Mechanical equipment relocated to higher*

### 5.3) Transportation

Temporary closure of flooded roadways is a potential adaptation measure. Roadway closure can be a major concern for emergency services and agencies are legally required to maintain roads for emergency access purposes. However, agencies may cease maintenance of a road if the reasons are sufficiently documented.

The goal to limit water intrusion and avoid damage to the roadway system, including drainage facilities, is not easily met. Raising a road, pumping water, adding a seawall or levee system, or developing an alternate route are solutions usually involving land acquisition and/or work outside the existing road right-of-way. In addition, measures to ensure that adjacent properties are not impacted by the proposed improvements must also be identified. Environmental review would also likely be required to implement any of the adaptation alternatives. Identification of cost effective and environmentally feasible solutions will require a site-specific engineering study with partnerships from local stakeholders and permitting agencies. The typical fee for a feasibility study for each asset is between \$50,000 to \$250,000 and maybe more depending on the scope of the study to identify an appropriate solution/improvement and to prepare a cost estimate. It is anticipated that the cost to implement adaptation alternatives will be high.<sup>56</sup>

Most impacts to roadways occur during extreme events, and policies will play out in post-disaster recovery. Road repairs are an

opportunity to plan for higher water levels. Design standards and best practices can help guide Capital Improvement Projects and road repairs, to ensure that roads will be more resilient to SLR and other flood events related to climate change. Following established guidelines may also improve funding opportunities. The requirement to meet design standards could be triggered by a set number of days per year that “total water levels” exceed a certain amount.

In 2012, Caltrans issued Director’s Policy 30 (DP-30) on Climate Change, which directs the coordination of climate change mitigation and adaptation across all Caltrans programs, to include design and construction of transportation infrastructure, support of climate change-related research, ensuring that adequate resources are allocated toward project-level climate change-related studies, and further development, coordination, and implementation of Caltrans Climate Change policy.

Despite efforts to plan for climate change, there may be discrepancies between existing guidelines and the implementation of adaptation measures such as roadway elevation. The Marin State Route 1 Repair Guidelines<sup>57</sup> adopted in July 2015 provide Caltrans staff and stakeholders with a consistent vision and direction when working on or reviewing damage repair projects. Design guidelines are as follows: “the character of the existing horizontal and vertical alignment should be generally maintained. Where alterations may be warranted, primarily

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<sup>56</sup> Marin County Department of Public Works. *Memorandum on Completion of Asset Vulnerability Assessment Tool for Collaboration: Sea-Level Marin Adaptation Response Team (C-SMART)*. May 2015.

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<sup>57</sup> California Department of Transportation (Caltrans). *Final Marin State Route 1 Repair Guidelines*. July 2015.

because of a demonstrated crash history, any necessary new alignment should avoid and mitigate resource impacts and be carefully fitted and blended in with the existing topography. Repair projects should consider alternatives that provide for staying within the existing roadway bench and right-of-way. Encroachments into NPS or CSP lands should be avoided. Preserving the existing, scenic two-lane character of Shoreline Highway is the primary goal; less than 12-foot lane widths may be considered.” Raising a roadway also requires widening the roadbed (typically a 3:1 ratio), so elevation as an adaptation measure is constrained by the above design guidelines which do not consider future SLR and by the realities of road maintenance. Furthermore expanding roadway footprints in some locations will be constrained/prohibited by permitting requirements which protect archaeological and/or natural resources. Despite the such concerns, widening a road adds the potential benefits of safety and space for bike lanes.

The Caltrans District 1 Climate Change Vulnerability Assessment and Pilot Studies<sup>58</sup> for Del Norte, Humboldt, Mendocino, and Lake Counties provides a framework to evaluate adaptation alternatives that defend the road (i.e. armoring), adapt the road (i.e. elevate), or plan for retreat out of hazard zones (i.e. relocation). This framework also included consideration of a “do nothing” scenario, and policy changes that could have bearing on future project decisions.



The *Marin Ocean Coast Sea Level Rise Vulnerability Assessment* identifies roads that merit near-term consideration for adaptation.

**Maps 2-3. Exposed Roads in Stinson and Bolinas**

<sup>58</sup> California Department of Transportation (Caltrans). *District 1 Climate Change Vulnerability Assessment and Pilot Studies*. December 2014.

The following are top priority actions for consideration, with additional options outlined on pages 63-68.

**Near term/Ongoing**

**T-1)** Consider planning for Shoreline Highway and county-maintained roads as part of the Regional Transportation Plan

**Possible Locations:** *Stinson Beach, Bolinas, Marshall*

**Potential Key Partners:** *Caltrans, DPW, Residents, MTC, TAM, GFNMS*

**Necessary Resources:** Staff, agency coordination

**T-2)** Further investigate Shoreline Highway vulnerability along Tomales Bay in the East Shore area. Determine if bulkheads below homes help protect the highway. If so examine long term adaptation strategies for continued protection in collaboration with homeowners.

**Possible Locations:** *East Shore*

**Potential Key Partners:** *Caltrans, property owners*

**Necessary Resources:** Staff, agency coordination, homeowner participation

**T-3)** Require new capital improvement projects to account for 3 feet of SLR.

**Possible Locations:** *West Marin*  
**Potential Key Partners:** *CDA, DPW, Caltrans*

**Necessary Resources:** Staff, agency coordination

**T-4)** Identify triggers for maximum flood depth or frequency as thresholds at which roads will need to be elevated, relocated, seasonally closed, or abandoned. This could include community surveys to understand the point at which flooding is perceived as chronic and causing public inconvenience.

**Possible Locations:** *West Marin*

**Potential Key Partners:** *CDA, Caltrans, DPW, Other technical Experts*

**Necessary Resources:** Staff, Agency coordination, Technical assistance

**T-5)** Support post-disaster repairs as an opportunity to plan for higher water levels

**Possible Locations:** *West Marin*

**Potential Key Partners:** *CDA, DPW, Caltrans*

**Necessary Resources:** *Agency coordination, Staff*

**T-6)** Standards for road flooding closure need legal definition and should be publicized with signage to alert drivers as to what they should expect.

**Possible Locations:** *West Marin*

**Potential Key Partners:** *CDA, DPW, Caltrans*

**Necessary Resources:** *Agency coordination, Staff, Legal Counsel, Signage*

**T-7)** Explore the feasibility of realigning vulnerable roads landward. Utilize Marin County DPW table on *Potential*

*Adaptation Options - General Strengths and Weaknesses* to guide evaluation of transportation adaptation alternatives.

**Possible Locations:** *Stinson Beach, Bolinas, Tomales Bay*

**Potential Key Partners:** *CDA, DPW, Caltrans*

**Necessary Resources:** *Agency coordination, Staff*

DRAFT

Table 16. Additional Strategies

	Strategy #	Approach	Potential Management Action	Example Location(s)	Impacts Addressed	Potential Partners	Required Resources	Other Assets	Notes
Near/Ongoing	T-8	Accommodate	Install box culverts under roads to allow for larger passage for high flow events	West Marin	Temporary Flooding, Erosion	CDA, Caltrans	Agency Coordination, Staff, materials	Parcels & Buildings, Utilities, Emergency Services	
	T-9	Plan	Set priorities for adaptation planning through identification of most vulnerable road segments.	West Marin	Temporary Flooding, Inundation, Erosion, Wave Surge, High Wind	CDA, Caltrans	Agency Coordination, Vulnerability assessment		
	T-10	Manage	Temporary road closures during flood events.	West Marin	Temporary Flooding, Wave Surge	CDA, Caltrans	Public outreach, staff		
	T-11	Plan	Analyze regulatory constraints and recommend policy changes to support adaptation measures.	West Marin	Temporary Flooding, Inundation, Erosion, Wave Surge, High Wind	CDA	Staff	Parcels & Buildings, Utilities	
Long	T-12	Protect	Convert vulnerable roads to levees	Sir Francis Drake Blvd. in Inverness, Calle del Arroyo, Olema-Bolinas Road	Temporary Flooding, Inundation, Erosion, Wave Surge, High Wind	CDA, CCC, Caltrans, Local service providers, Regional Water Quality Control Board, GFNMS, Army Corps of Engineers	Staff, public financial resources, permits, materials/supplies, base for road	Parcels & Buildings, Utilities, Recreation, Emergency Services	When roads are raised, they also need to be widened. This conflicts with Caltrans design guidelines for Hwy 1 to maintain narrow, rural character.

Table 17. Potential Adaptation Options for Transportation Systems: General Strengths and Weaknesses

<i>Marin County Department of Public Works 2/19/16</i>				
<i>Adaptation Concept *</i>	<i>Relative Construction Cost</i>	<i>Strengths</i>	<i>Limitations</i>	<i>Primary Design Considerations</i>
Construct a seawall system	High	Protect road infrastructure from SLR; Can be constructed within a limited right of way; proven engineering technology	Difficult to fund and get approval for. Potential environmental impacts to coast. May also require a complex drainage/pumping system.	Requires a foundation design that accounts for wave action and erosion. Account for ground vibrations in construction especially when in close proximity to existing structures. Materials shall be highly corrosive resistant.
Raise road facility by rebuilding on top of a levee system	High	Protect road infrastructure from sea-level rise. Could protect residences and structures in addition to roads.	Difficult to fund and could require additional right of way (land acquisition). May also require detailed environmental review with possible mitigation costs.	Roadway slopes would expand the footprint as each side slope is recommended to achieve 4:1 (width:height) to be considered traversable and recoverable in a vehicle or 3:1 (width:height) to be considered traversable. Any new embankment slopes would need to be treated for future erosion control by seeding, vegetation planting, erosion blankets, straw waddles, etc. Could necessitate retaining walls and/or new guardrails. Would likely affect adjacent driveways, drainage facilities, intersections, etc. Would likely result in completely new structural pavement section. Could require significant utility adjustments.
Add levee system	High	Protect road infrastructure from sea-level rise	Difficult to fund and maintain. Potential environmental impacts. Would generally require additional right of way (land acquisition) and a complex drainage/pumping system; may have impacts to habitat depending on location.	Levee should have a minimum 2 feet of freeboard with side slopes typically 3:1 (width:height); FEMA accreditation may require more conservative design.

<b>Marin County Department of Public Works 2/19/16</b>				
<i>Adaptation Concept *</i>	<i>Relative Construction Cost</i>	<i>Strengths</i>	<i>Limitations</i>	<i>Primary Design Considerations</i>
Provide an alternate route	High to Very High	Provide access between communities/locations with expected SLR	Assume alternate route would not have a significant delay from the existing route. Availability of existing roads to provide an alternate route. Very difficult to fund and get agreement/approval for new roadway if suitable land is available (see abandon and relocate roadway adaptation concept). To date in West Marin no alternate routes for the roads impacted by sea level raise have been identified; however, any private roads that could be considered would need to become part of the County maintained system and brought up to County standards.	Alternate route would comply with all current County design and safety standards.
Abandon and relocate roadway	Very High	Where feasible, would provide an alternative transportation route more resilient to SLR.	In many locations of West Marin, there are no lands suitable for alternative routes. Building in steep terrain is prohibitively expensive.	ROW acquisition. Anticipate full EIR. Anticipate environmental mitigation. Road to comply with all current County design and safety standards.
Construct a causeway	Extremely High	Provide access between communities/locations with expected SLR. Would likely eliminate or allow the existing roadway to be submerged for increased wet lands.	Very difficult to fund. New construction with environmental, right of way, permitting reviews and costs. Removal of abandonment of existing roadway and construction of a bridge with abutments and approaches will be very costly. Must identify acceptable location to redirect water to.	Drainage should be reviewed since water blocked by the road would be free to expand with the existing roadway barrier removed or the sea level overtopping it. Requires detailed geotechnical assessment for deep foundations. Deep foundations that are built in saturated soils are more difficult to construct leading to increased cost. Significant coordination with utility agencies that have facilities present in the roadway.
* Maintenance Cost of Adaptation Concepts will be a long term cost beyond any capital expense for which existing gas tax revenue is insufficient. These separate maintenance cost would be beyond existing levels and potentially increase a shortfall in deferred maintenance.				



## 5.4) Utilities

Of West Marin’s utilities, septic systems have been recognized as meriting highest priority for adaptation due to high vulnerability and high negative impacts of failure (e.g., sewage entering the ocean). Currently coastal residences and businesses dispose of their wastewater through privately owned OWTS; small waste water systems with Waste Discharge Permits from the State Regional Water Quality Control Board or public wastewater systems. In Stinson Beach’s Calles, Patios, and Seadrift neighborhoods, approximately 20 of the 700 OWTS per year are upgraded to turn off when flood waters are too high.<sup>59</sup>

The following are top priority actions for consideration, with additional actions on the table to follow:

### Near term

**U-1)** Continue efforts to elevate or otherwise protect electrical, fuel, sewage management, and water systems from high tide levels. Retrofit OSWTs with flipswitch that turn off automatically when flooded.

**Possible Locations:** West Marin  
**Potential Key Partners:** CDA, Utilities, Homeowners Associations, Property owners  
**Necessary Resources:** Staff, Public/private funding

**U-2)** Require new capital improvement projects account for 3 feet of SLR.

**Possible Locations:** West Marin

**Potential Key Partners:** CDA, DPW, Marin County Parks, other agencies as necessary

**Necessary Resources:** Staff, Public funding

**U-3)** Ensure that development policies are consistent with strategies for accommodating SLR (e.g., consider eliminating requirements to bury utilities in areas vulnerable to SLR).

**Possible Locations:** West Marin  
**Potential Key Partners:** CDA, CCC  
**Necessary Resources:** Staff

**U-4)** Work with SBCWD and EHS to determine if SLR will raise groundwater levels to impair OWTS.

**Possible Locations:** Stinson Beach  
**Potential Key Partners:** CDA, SBCWD, EHS  
**Necessary Resources:** Staff, agency coordination

### Medium term

**U-5)** Work with local service providers to determine the point at which communities need to convert to shared public wastewater system alternatives to accommodate for SLR.

**Possible Locations:** Stinson Beach, Bolinas, Dillon Beach  
**Potential Key Partners:** CDA, Local service providers  
**Necessary Resources:** Staff, agency coordination

**U-6)** Identify potential upland areas to retreat/relocate utility systems,

<sup>59</sup> Marin County Community Development Agency. *Marin Ocean Coast Sea Level Rise Vulnerability Assessment Public Review Draft*. December 2015.

including wells and wastewater infrastructure which may include sewage pumps, lift stations and septic leach fields. National Park lands could be considered, in close coordination with NPS.

**Possible Locations:** *Stinson Beach, Bolinas, Dillon Beach*

**Potential Key Partners:** *CDA, Local service providers, NPS, CSP, MALT*

**Necessary Resources:** *Staff, spatial data, GIS*

**Long term**

**U-7)** Establish community shared public wastewater systems in relevant areas.

**Possible Locations:** *Stinson Beach, Bolinas, Dillon Beach*

**Potential Key Partners:** *CDA, Landowners, Local service providers, Local assessment district, NPS*

**Necessary Resources:** *Staff, agency/community coordination, financial resources, upland receiving sites.*

Table 18. Additional Strategies

	Strategy #	Approach	Potential Management Action	Example Location(s)	Impacts Addressed	Potential Partners	Required Resources	Other Assets	Notes
Near/Ongoing	U-8	Accommodate	Update substandard pre-treatment septic units to accommodate for three feet SLR including infiltration and disinfection	Stinson Beach, Inverness	Temporary Flooding, Inundation	CDA, Property Owners	Staff, private time/financial resources	Parcels & Buildings	
	U-9	Outreach	Develop a homeowner guide and checklist for SLR and storm preparation	Stinson Beach, Bolinas, Inverness, East Shore	Temporary Flooding, Inundation	CDA, OES, FEMA	Staff/Consultant time	Parcels and Buildings	
	U-10	Inventory	Identify trigger points for flood impacts to determine at what point flooding causes public inconvenience.	Stinson Beach, Bolinas, Inverness, Point Reyes Station, East Shore	Temporary Flooding, Inundation, Erosion, Wave Surge, High Wind	CDA, Academic Partners, Community Members	Staff, partner participation, methods/processes, stakeholder participation	Parcels & Buildings, Transportation	
Long	U-11	Retreat	Relocate septic leach fields	East Shore	Temporary Flooding, Inundation	CDA, Landowners	Staff, Upland property, Willing Homeowners, Financial Resources, Plans and Programs		
	U-12	Coordinate	Maintain working relationships with state agencies to identify plan amendments and projects in support of SLR preparation	Vulnerable state roadways/utilities	Temporary Flooding, Inundation, Erosion, Wave Surge, High Wind	CDA, Caltrans, PG & E, DPW	Staff	Transportation	

## 5.5) Working Lands

The following are top priority actions for consideration:

### Near term

**W-1)** Maintain and adapt coastal armoring. In some cases, consider removal for natural protection.

**Possible Locations:** *Bolinas, Tomales Bay, Dillon Beach*

**Potential Key Partners:** CDA, property owners, CCC

**Necessary Resources:** *Staff, private financial resources*

**W-2)** Work with agricultural interests to respond to SLR.

**Possible Locations:** *West Marin, specific locations unknown*

**Potential Key Partners:** CDA, Property Owners, Farm Bureau, Land Trusts, RCD, UC Cooperative Extension Resource Conservation District

**Necessary Resources:** *Staff, Spatial data, GIS, Upland property*

### Medium Term

**W-3)** Work with agricultural operators and funding organizations to secure rights to allow wetlands to expand inland with SLR.

**Possible Locations:** *Low lying areas along Tomales Bay and in Arroyos*

**Potential Key Partners:** Property owners, MALT, SCC, DFW

**Necessary Resources:** *Willing landowners, Public/private funding*

## 5.6) Natural Resources

### Priority Actions

Natural resources strategies have come from a variety of expert sources, including GFNMS, COS, and PBCS. Highest priority options have additional co-benefits such as the protection of economic, social or infrastructure assets in West Marin. Such options could receive strong community support and be attractive to a variety of funding sources. Strategies which don't conflict with the protection of other resources have been given medium priority.

### High Priority

**N-1)** Enhance SLR education programs through partnerships with educational organizations and other public entities, including:

- Partnerships with environmental education organizations, schools and other public entities
- Social media and other communication strategies, such as SLR visualizations and crowdsourcing king tides photos
- Interpretive signage
- Expansion of Marin County's existing Youth-Exploring Sea Level Rise Science (YESS) program.
- Marsh and tidepool education and interpretation programs through training and guidance to communicate implications of climate change
- Establish a volunteer docent program, for highly visited areas. This could augment existing programs (e.g., Duxbury Marin Reserves). Docents training could include climate change impacts on intertidal habitats, as well as tidepool etiquette and safety.

**Possible Locations:** High school environmental education classrooms, highly visited beaches, estuaries and tidepools.

### ADAPTATION AND MITIGATION

Green infrastructure such as restored wetlands and horizontal levees have a myriad of public benefits including habitat, flood protection, recreation and aesthetic/sense of place. Additionally, research shows that restoring marshes is incredibly effective for removing carbon from the atmosphere through a process known as sequestration, thus helping to curb the accelerating rate at which climate change is occurring.<sup>2</sup> Tidal marshes, such as those found in Tomales Bay and Bolinas Lagoon, are extremely productive habitats that can capture large amounts of atmospheric carbon for storage in marsh soils.

<sup>2</sup>Trulia, L., J. Callaway, S. Crooks. 2007. White Paper on Carbon Sequestration and Tidal Salt Marsh Restoration. 4 pp.

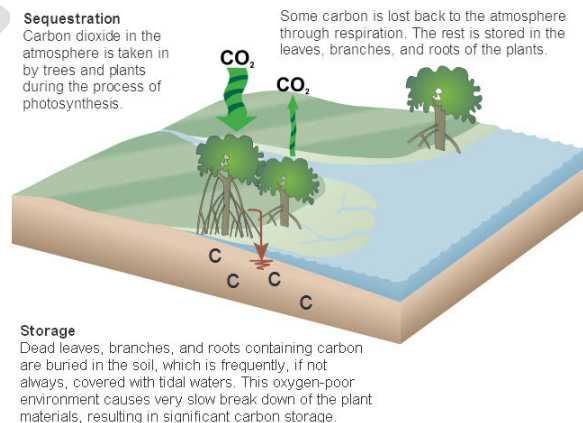


Figure 8) Carbon Sequestration Process Source: NOAA

**Potential Key Partners:** CDA, GFNMS, CA Academy of Sciences, NPS, CSP Marine Mammal Center, Headlands Institute, other existing education programs.

**Necessary Resources:** Financial resources, staff, volunteers, curricula trainings, classrooms

**N-2)** Stabilize cliffs through revegetation (with native, climate appropriate species) and natural netting (e.g. jute, not chain-link fence). Design any hardening methods to take into account ecosystem needs (e.g. seabird nesting). Consider the listed Showy Rancharia Clover (*Trifolium amoenum*), including assisted migration to locations further upslope. Avoid armoring and encourage relocation of infrastructure to allow for managed retreat. Minimize non climate stressors including human and livestock access.

**Possible Locations:** Muir Beach, Bolinas, and Stinson Beach to Rocky Point (Cliff Locations)

**Potential Key Partners:** CA Conservation Corps, CA Native Plant Society, Caltrans, land owners/managers (public and private)

**Necessary Resources:** Financial resources, staff, permits, engineering studies

**N-3)** Consider nature-based adaptation options for Eelgrass habitat.

- In the near-term map potential landward transgressional areas and protect potential transition habitat.
- As water rises, monitor trends in eelgrass extent; possibly plant in shallower water to kick-start colonization of areas available for landward transgression.
- Minimize non-climate stressors including restoration of areas lost from moorings, minimizing disturbance to existing beds and

monitoring changes in turbidity.

**Possible Locations:** Tomales Bay eelgrass beds including the Walker Creek Delta

**Potential Key Partners:** CDA, GFNMS, CA DFW, Community Members, Business owners, SF Bay Living Shorelines Projects (case study)

**Necessary Resources:** Financial resources, staff, local community involvement, mapping/monitoring equipment and software, plant propagules, possible land acquisition/easements etc. for habitat restoration, volunteer/citizen scientist monitors

**N-4)** Consider nature-based adaptation options for Tidal Marsh habitat.

- In the near-term consider accommodation strategies including
  - Mapping potential landward transgressional areas and protecting potential transition habitat and allowing for habitat transition
  - Consider removing potential barriers to landward migration or accommodating transgression through modifications such as culverts and causeways (e.g, Highway 1 bridge in the Walker Creek Delta, Sir Francis Drake Blvd. between Inverness Park and Reyes Station, Bear Valley Road and Highway 1, Shoreline Highway in Marshall, Shoreline Highway in Bolinas Lagoon)
  - Identifying ownership of and acquiring potential transition zones upstream of current marsh footprint.
- If high value resources/functions are present, consider augmenting sediment in the long-term to allow for accretion of marsh within

- existing footprint (e.g., Walker Creek Delta, Giacomini Wetland Restoration Footprint).
- Non-Climate stressors such as invasive species should be minimized.
  - Allow for loss of marshes in cases that they have less high value resources (could include Tomales Bay area in Inverness). Instead, prioritizing action on more significant areas of intact marshes nearby (e.g., Pt. Reyes Station/Lagunitas Creek Delta).
  - Engage with ongoing efforts (e.g., Bolinas Lagoon Restoration Project) to ensure planning includes future SLR.
  - Engineer marshlands to enhance water flow and balance sediment transport by including design elements such as sinuous channelization.

**Possible Locations:** Walker Creek Delta, Tomales Bay (Inverness and Marshall), Pt. Reyes Station/Lagunitas Creek Delta, Bolinas Lagoon

**Potential Key Partners:** CDA, Marin County Parks and open Space, Point Reyes National Seashore GFNMS, GGNRA, Community Members, Business owners, CA DFW

**Necessary Resources:** Financial resources, staff, local community involvement, mapping/monitoring equipment and software, plant propagules, possible land acquisition/easements etc. for habitat restoration, volunteer/citizen scientist monitors, engineering studies, permits/environmental reviews

### Medium Term

N-5) Consider nature-based adaptation options for beach/dune habitat.

- Determine if topography and land use/infrastructure allows for inland movement of beach/dune habitat. Where feasible, remove/relocate shoreward constraints to dune movement and evolution.
- Restore/Construct/augment coastal dunes. This could include placement of sand, graded and planted to form back beach dunes or placement of cobble. Drought tolerant and heat resistant species or strains should be used. In cases where dredge materials are used, make sure materials are screened for contaminant exposure.
- Where applicable, minimize human and pet access through dunes to protect stability and disturbance, which could include fencing, creating walkways, and informational signage. Beach grooming should be ceased as well as any activity that adversely affects the sediment supply of dunes.
- Identify potential sources of compatible sediment (considering appropriate grain size and structure) for vulnerable beaches in order to enable potential nourishment.

**Possible Location:** Muir Beach, Stinson Beach, Dillon Beach

**Potential Key Partners:** NPS, Landowners

**Necessary Resources:** Sand, Financial Resources, Staff, Permits/Environmental Review

- N-6) In cases that coastal armoring is exacerbating erosion, explore natural alternatives that create sloped, transitional habitat (e.g., artificial reef, horizontal levee or dune). If armoring can't be removed, implement living shoreline techniques in conjunction with new construction/repairs.

**Possible Locations:** Bolinas Lagoon, Stinson Beach, Tomales Bay

**Potential Key Partners:** GFNMS, NPS, CDFW, Universities, SCC

**Necessary Resources:** Financial Resources, Staff, Permits/Environmental Review, Public outreach

- N-7)** In cases in which roads need to be realigned/relocated due to ‘trigger points’ being reached (e.g., causing public inconvenience), siting and design should allow for natural expansion of habitats. Areas should be identified that are critical for estuary expansion and roads could be realigned accordingly.

**Possible Locations:** Bolinas Lagoon

**Potential Key Partners:** Caltrans, GFNMS, US Army Corps of Engineers, Regional Water Quality Control Board, Landowners

**Necessary Resources:** Agency coordination, Financial Resources, Staff, Permits/Environmental Review

- N-8)** Consider a monitoring program to detect impacts of climate change and management actions on natural resources including the following steps:

- Postulate hypotheses of habitat change, based on scenarios and literature, of how habitats will evolve in response to climate change.

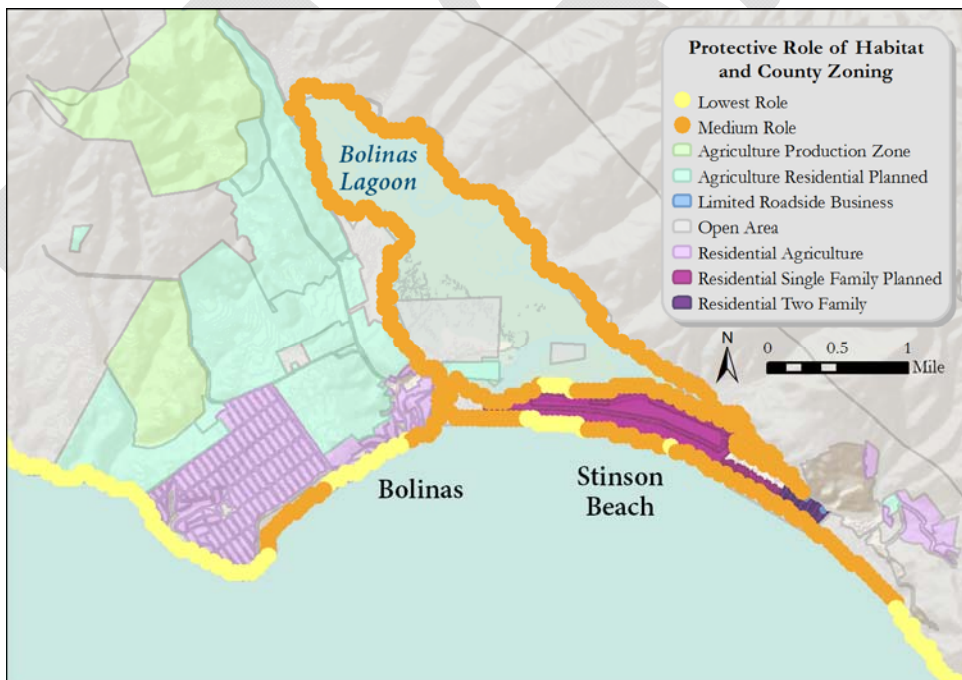
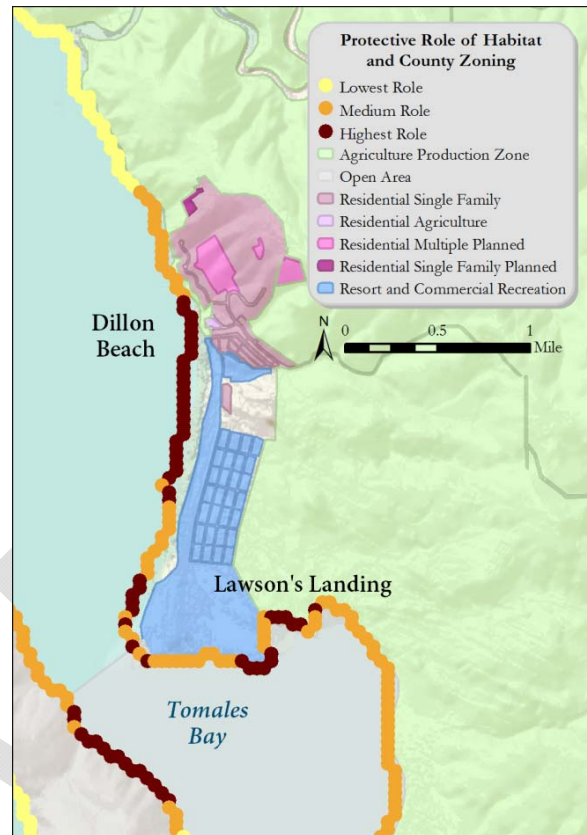
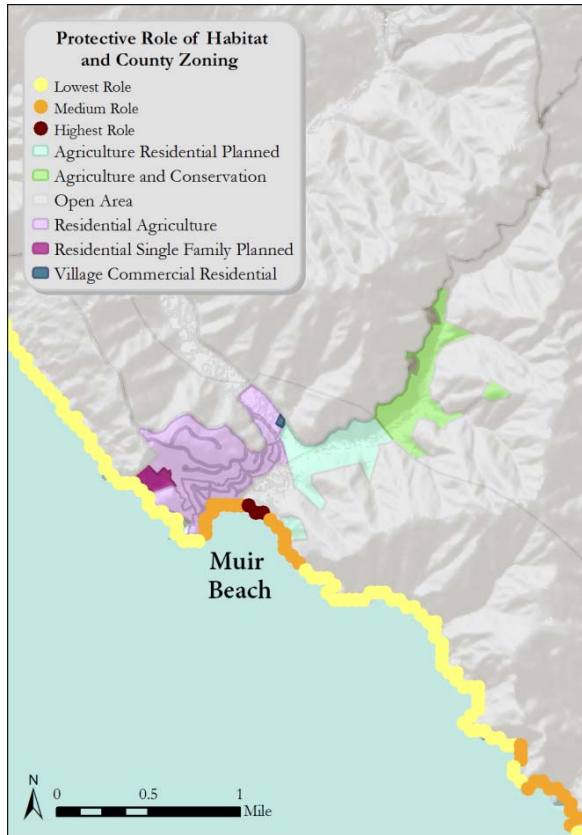
- Design the monitoring programs to measure hypothesized changes
- Identify indicator species for selected habitats, and set tentative population parameter goals based on current status and knowledge of the species.
- Design the monitoring program to estimate the population parameter, and determine the extent and intensity of sampling required to achieve the monitoring goals, including sources of data, precision in parameter estimation, and costs
- Review costs vs expected probability of monitoring goals to choose final indicator species, monitoring targets, data sources, survey effort, and costs

**Possible Location:** Countywide  
**Potential Key Partners:** CDA, Scientific Partners, local community members, environmental non-profits

**Necessary Resources:** Financial resources, staff, mapping/monitoring equipment and software, volunteer/citizen scientist monitors.

More details can be found in Appendix F, *Natural Resource Vulnerabilities, Potential Adaptation Strategies and Monitoring Framework for Main County’s outer coast SLR vulnerability assessment.*





Maps 4-6. Locations where habitat can play the highest relative role in coastal protection (based on the InVEST Coastal Vulnerability Model). Credit: Center for Ocean Solutions

Table 19. Additional Strategies

Strategy #	Approach	Potential Management Action	Example Location(s)	Impacts Addressed	Potential Partners	Required Resources	Other Assets	Notes
Near /Ongoing	N-9	Plan	Encourage a climate-smart response to erosion events that smother the rocky intertidal by developing a diagnostic decision support tool so management agencies know how to respond to either 1) recover the habitat by removing material, 2) leave material and encourage surfgrass growth or 3) leave material and take advantage of the new situation due to erosion events. Ideally would have some options with the ultimate goal of leveraging resources to provide the best response.	Muir Beach, Duxbury Reef (Bolinas) and Estero Americano (north of Dillon Beach)	Erosion, Wave Surge	USGS	Modeling done by USGS	Consider what actions could avoid impending collapse of structures onto the intertidal.
	N-10	Plan	Create climate informed local and regional sediment management plans.	County-wide	Erosion, Wave Surge, High Wind	U.S. Army Corps of Engineers, Coastal, Sediment Management Workgroup, CSP, BCDC, local flood control, districts, National Marine Fisheries Service, DFW, CCC, NPS, local cities and counties	Funding and staff	All
	N-11	Plan	In the aftermath of a spill of oil or other contaminant, ensure that restoration of affected areas takes into account climate	County-wide	Temporary Flooding, Erosion,	DFW, Office of Spill Prevention and Response,	Collaboration of the responsible party with federal, State,	

Table 19. Additional Strategies

Strategy #	Approach	Potential Management Action	Example Location(s)	Impacts Addressed	Potential Partners	Required Resources	Other Assets	Notes
		considerations (type of restoration, location of restoration, what should actually be restored based on climate envelope modeling to predict what species will likely become dominant).		Wave Surge	NOAA Restoration Office, NPS, US Fish and Wildlife Service (USFWS),	and tribal trustee agencies. Climate change modeling.		
N-12	Retreat	Research a coastal protection tax credit which incentivizes the waiving of rights to future sea walls in permits for shoreline habitat protection		Temporary Flooding, Inundation, Erosion, Wave Surge	CCC, land owners	Agency coordination		
N-13	Monitor	Conduct regional modeling to identify how existing estuaries may change and identify areas for estuary expansion; use this information to set regional adaptation priorities. This effort includes: -identifying where future estuary habitat may move -better understand how habitat types may change, and -better understanding and modeling system dynamics, and how they may change (e.g, how tidal prism may change)	Regional	Temporary Flooding, Inundation, Erosion	GFNMS to convene regional partnership of numerous land management agencies, scientists and funders.	Funding: variety of sources/joint venture (NOAA, NPS, Stanford Natural Capital Project, Universities/Academics, Federal Highways, foundations)  Modeling: leverage current data from existing regional efforts and combine with new modeling. Will need someone to lead data aggregation, plus someone to model (consider PBCS and/or USGS)  - OCOF: use to identify what areas will be flooded; combine with salt water intrusion		

Table 19. Additional Strategies

Strategy #	Approach	Potential Management Action	Example Location(s)	Impacts Addressed	Potential Partners	Required Resources	Other Assets	Notes
						<p>modeling, riverine flooding modeling (e.g., FEMA flood maps). Build in uncertainty by using max/worst case scenario projections</p> <p>- pollutant hotspots (critical to know if polluted area will be inundated; get data from EPA and regional/local environmental health agencies)</p> <p>- historic/archeological resources NPS, CSP, counties)</p> <p>-sediment availability (identify if each estuary requires more/less sediment)</p> <p>- location of berms/levees/existing infrastructure/armoring</p> <p>- demonstration projects/lessons learned from regional projects (e.g.,Muir Beach,</p>		

Table 19. Additional Strategies

Strategy #	Approach	Potential Management Action	Example Location(s)	Impacts Addressed	Potential Partners	Required Resources	Other Assets	Notes
						Giacomini, South Bay Salt Ponds)  Can create a decision matrix to go along with this process to facilitate future updates/repetitions		
N-14	Monitor	Capitalize on natural extreme events to increase monitoring and knowledge of estuary processes and climate change impacts to inform adaptive management (e.g., monitor impacts of projected El Nino, study close/open estuaries).	Study Area	Inundation, Erosion, Wave Surge	GFNSM, DFW, Ocean Science Trust, NPS, landowners	Data management/acquisition staff (GFNMS), rapid response teams, standardized monitoring framework, Identify sites through monitoring and inventorying action		
N-15	Manage	Within public lands, designate, expand, and increase enforcement of resource management areas/sensitive habitat/off limit zones to enhance and support special protections for target species	Study Area	Inundation, Erosion	USFWS, GFNMS, NPS, CSP, relevant land managers	permitting		
N-16	Manage	For sediment-heavy estuaries, conduct instream and upstream restoration work throughout the watershed to reduce sediment delivery and flash floods. For all activities listed, note that environmental conditions (e.g., storms, flooding, erosion, drought, SLR) can shift areas within estuaries between sediment-starved and sediment-heavy, so this action will need to be dynamic and respond to changing estuary conditions. Activities could include:	Bolinas Lagoon, Tomales Bay	Inundation	Land Owners (Natural Resources Conservation Service (NRCS), Resource Conservation District, local cities (up the watershed), SWRCB (TMDL info), SCC,	Site specific research to avoid invasive species introduction (vegetation management, impact assessments), education and outreach for public buy-in, possible permitting/environmental review		

Table 19. Additional Strategies

Strategy #	Approach	Potential Management Action	Example Location(s)	Impacts Addressed	Potential Partners	Required Resources	Other Assets	Notes
		<ul style="list-style-type: none"> <li>Restore impaired and incised creeks – add large woody debris</li> <li>Reconnect creeks to floodplain</li> <li>Restore incised creeks by raising elevation to allow overflows/sediment deposition</li> <li>Dechannelize upstream segments</li> <li>Restore stream complexity</li> <li>Remove old road crossings and legacy roads, parking lots and other impervious surfaces</li> <li>Plant vegetation (e.g., drought/heat tolerant native species)</li> <li>Incentivize best land management practices that enhance soil health and decrease runoff and erosion (e.g., rotate land uses on agricultural upland properties, plant drought-tolerant natives, forest management)</li> <li>Build retention ponds/catchments</li> <li>Create a climate-informed sediment management plan (including reconsideration of TMDLs)</li> <li>Develop a sediment monitoring plan</li> </ul>			upland managers			
N-17	Accommodate	Augment haul-out and nesting sites: floating haul-outs, larger buoys, offshore structures	Study Area	Inundation, Erosion	USFWS, National Marine Fisheries Service, United States Coast Guard, GFNMS, NPS, CSP, County Parks, CDFW, Boating and Waterways	CCC Permitting		

Table 19. Additional Strategies

Strategy #	Approach	Potential Management Action	Example Location(s)	Impacts Addressed	Potential Partners	Required Resources	Other Assets	Notes
	N-18	Monitor/Manage	Confirm suitable habitat within 200 cm SLR exposure zone, and if suitable habitat exists monitor for Yellow Larkspur. If species is present, consider assisted migration to locations further upslope.	Esteros Americano and San Antonio	Inundation	CDA, Scientific Partners	Financial resources, staff, mapping/monitoring equipment and software, volunteer/citizen scientist monitors	
Long	N-19	Inventory	Identify future viable locations for rocky intertidal habitat migration inland either through modeling or known information (how to rocky intertidal areas form, and would there be available rock under the cliff bluffs or under the sand?). Identify future viable locations for seabird and marine mammal breeding/haulouts.	TBD through modeling analysis and site analysis	Erosion, Wave Surge, High Wind	USGS, universities	Modeling, coordination,	

## 5.7) Recreation

### Near term/Ongoing

- R-1)** Increase awareness of seasonal flooding on public lands/trails through signage and social media.

**Possible Locations:** Muir Beach, Stinson Beach, Tomales Bay

**Potential Key Partners:** National, State and County Parks

**Necessary Resources:** Staff, public outreach materials and tools

### Long term

- R-2)** Retrofit or relocate recreation and visitor-serving facilities, including trails and access points. Acquire new parklands as existing parks become unusable from flooding, inundation, erosion, etc.

**Possible Locations:** Stinson Beach, Bolinas, Tomales Bay, Point Reyes Station

**Potential Key Partners:** CDA, Property/business owners, CCC, National, State and County Parks

**Necessary Resources:** Public/ private funding, Permits, Receiving sites, Materials



Table 20. Additional Strategies

	Strategy #	Approach	Potential Management Action	Example Location(s)	Impacts Addressed	Potential Partners	Required Resources	Other Assets	Notes
Near/Ongoing	R-3	Plan	Encourage the diversification of West Marin's recreation/tourism opportunities to ensure economic resiliency in the face of climate impacts. Projects and policies which support agritourism (dairies, farm tours), and mariculture tourism (oyster farms) could be explored and promoted.	West Marin	Temporary Flooding, Inundation, Erosion, Wave Surge, High Wind	CDA, Business/property owners, farmers.	Staff, interested business owners		
	R-4	Plan	If roads are abandoned, but only subject to occasional storm flooding, explore the feasibility of conversion to recreational trails. Efforts could be modeled after CSP established strategies and processes for successful conversion of abandoned roads where feasible.	West Marin	Temporary Flooding, Inundation, Erosion, Wave Surge, High Wind	CDA, County Parks, NPS, CSP	Staff, roadways, bike trail infrastructure		
Long	R-5	Retreat	Relocate visitor parking lots	Dillon Beach	Temporary Flooding, Inundation	CDA, Landowners, Marin County Parks	Staff, property, financial resources		

Table 20. Additional Strategies

Strategy #	Approach	Potential Management Action	Example Location(s)	Impacts Addressed	Potential Partners	Required Resources	Other Assets	Notes
	R-6	Monitor	Support research on climate change impacts to recreation and public access	West Marin	Temporary Flooding, Inundation, Erosion, Wave Surge, High Wind	CDA, NPS, Academic partners, Funding entities	Staff, Agency coordination, Grants/funding mechanisms	

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## 5.8) Emergency Services

### Near term

**E-1)** Partner with Local Hazard Mitigation Plan efforts to coordinate near term disaster preparedness with long-term community resilience.

**Possible Locations:** West Marin

**Potential Key Partners:** CDA, Marin County OES, State OES, Local Emergency Response Teams

**Necessary Resources:** Staff, agency coordination

### Medium term

**E-2)** Adapt or relocate vulnerable emergency facilities (e.g., fire stations, emergency generators).

**Possible Locations:** Stinson Beach, Bolinas, Inverness

**Potential Key Partners:** CDA, OES, Stinson Beach Fire Department

**Necessary Resources:** Staff, property, public financial resources

### Long term

**E-3)** Develop additional emergency response teams and resources required for disaster response, recovery and mitigation, as well as temporary housing and other sustainability needs.

**Possible Locations:** West Marin

**Potential Key Partners:** CDA, Marin County OES, Local Emergency Response Teams

**Necessary Resources:** Staff,

*coordination, financial resources, temporary housing*

**E-4)** Build redundancy into the system by providing alternate evacuation routes where feasible. This is particularly critical for communities such as Bolinas with one primary access road in and out that could be inoperable from flooding.

**Possible Locations:** Stinson Beach, Bolinas, Inverness, Point Reyes Station, East Shore, Dillon Beach

**Potential Key Partners:** Stinson Beach, Bolinas, Inverness, Point Reyes Station, East Shore, Dillon Beach

**Necessary Resources:** Staff, financial resources, adequate space for alternate routes, materials/supplies, permits, Environmental reviews

Table 21. Additional Strategies

	Strategy #	Approach	Strategic Management Action	Example Location(s)	Impacts Addressed	Potential Partners	Required Resources	Other Assets	Notes
Near/Ongoing	E-6	Outreach	Distribute information and technical assistance to households on hazard mitigation, emergency preparedness, evacuation and recovery protocol	Stinson Beach, Bolinas, Inverness, Point Reyes Station, East Shore, Dillon Beach	Temporary Flooding, Erosion, Wave Surge, High Wind	CDA, OES, California Office of Emergency Services (CalOES), Local Emergency Response Teams	Staff, distribution materials		
	E-7	Plan	Ensure emergency staging locations are not sited in areas subject to temporary/permanent flooding, landslides, tsunami zones or other hazardous areas	West Marin	Temporary Flooding, Inundation, Erosion, Wave Surge, High Wind	CDA, OES, CalOES, Local Emergency Response Teams	Staff, coordination		
Long	E-10	Plan	Protect residential buildings from increased building system outages which may happen with increased storm severity	West Marin	Temporary Flooding, Erosion, Wave Surge, High Wind	CDA, OES, Local Emergency Response Teams	Staff, financial resources		

## 5.9) Historic and Archaeological Resources

The following are top priority actions for consideration, with additional options outlined on pages 97-100

### Near term/Ongoing

**H-1)** Adaptation planning/implementation efforts should consider the impacts on historic structures and archaeological sites consistent with applicable state/federal regulations as well as local community input. In cases where projects could have adverse effects, efforts should be made to avoid, minimize or mitigate the impacts consistent with relevant statutes (CEQA, Section 106, etc.).

**Possible Locations:** West Marin  
**Potential Key Partners:** CDA, Office of Historic Preservation, Tribal Historic Preservation Officers  
**Necessary Resources:** Staff

**H-2)** Continue discussions with the Federated Indians of Graton Rancheria for consideration of archaeological sites in future vulnerability assessments and adaptation plans.

**Possible Location:** West Marin  
**Potential Key Partners:** Federated Indians of Graton Rancheria  
**Necessary Resources:** Staff and Agency Coordination

**H-3)** Update the 1981 Marin County Local Coastal Program Historic Study. This could include inventorying historic sites

### ADAPTATION AND MITIGATION

Through analysis of elements such as pollen, seeds, shells, and bones, archaeological data can reveal which plants and animals thrived during past climactic periods (e.g., the mid Holocene) with land and water temperatures comparable to potential future conditions.<sup>3</sup> Such data could be of great value to inform future ecosystem restoration and land management plans. Thus it is critical to inventory archaeological sites that may be vulnerable to SLR, and avoid maladaptation which damages these sites.

<sup>3</sup> Newland, Michael (Sonoma State Anthropological Studies Center). 2015. Personal Communications

with lists, photographs and descriptions, and revising and expanding historic district boundaries. An updated study could:

- Inform future SLR/climate change vulnerability assessments to more fully understand the extent of West Marin's threatened historical resources
- Inform future adaptation planning for historic resources.
- Document the resources in case coastal hazards damage or destroy the structures.

**Possible locations:** West Marin  
**Potential Key Partners:** CDA, CCC, architectural commission  
**Necessary Resources:** Staff, consultant assistance, financial resources

**H-4)** Recognize and consider projects which protect/mitigate historic and cultural

resources in Marin County's Local Hazard Mitigation Plan. Use FEMA's How-to-Guide "Integrating Historic Property and Cultural Resource Considerations Into Hazard Mitigation Planning". Upon FEMA approval, such projects will be eligible for Federal Funding.

**Possible Location:** West Marin

**Potential Key Partners:** CDA, OES, DPW, FEMA

**Necessary Resources:** Staff, agency coordination, FEMA Grant Funding

- H-5)** Work with the State Office of Historic Preservation's disaster task force to assess damages to historic and archaeological sites that may occur from storm events or other disasters.

**Possible Location:** West Marin

**Potential Key Partners:** CDA, State Office of Historic Preservation, Private Property Owners, Federated Indians of Graton Rancheria

**Necessary Resources:** Staff, agency coordination

Table 22. Additional Strategies

	Strategy #	Approach	Strategic Management Action	Example Location(s)	Impacts Addressed	Potential Partners	Required Resources	Other Assets	Notes
Near/Ongoing	H-6	Inventory	Conduct comprehensive archaeological survey to document vulnerable sites before lost to SLR, erosion or other climate impacts.	Vulnerable areas including low-lying sites threatened by SLR and storms, and higher bluffs threatened by coastal erosion	Temporary Flooding, Inundation, Erosion, Wave Surge, High Wind	CDA, Federated Indians of Graton Rancheria, Sonoma State Anthropological Studies Center	Financial resources, archaeological consultant, staff, tribal coordination		
Medium	H-7	Inventory	Collaborate with Federated Indians of Graton Rancheria to identify/rank archaeological sites based on highest intrinsic value	Vulnerable archaeological sites	Temporary Flooding, Inundation, Erosion, Wave Surge, High Wind	CDA, Federated Indians of Graton Rancheria	Financial resources, archaeological consultant, staff, tribal coordination		
	H-8	Protect	Develop plan to protect highest priority archaeological sites	Vulnerable archaeological sites identified as highest priority for protection	Temporary Flooding, Inundation, Erosion, Wave Surge, High Wind	CDA, Federated Indians of Graton Rancheria	Financial resources, archaeological consultant, staff, tribal coordination		



## 6) Community Alternatives

A possible approach for adapting to near term SLR and storm flooding in West Marin is to protect existing homes and businesses with elevation and retrofits, and protect assets in the near- to-medium term (with a preference for nature-based protection strategies), while considering additional options over the long-term. Hybrid approaches that include a mix of adaptation measures may be the most practical in many situations. Adaptive management over time will allow for response to changing conditions (ESA 2015). Each community profile includes a No Action section which describes general sea level rise impacts if adaptation is not undertaken along with community alternative options spanning the categories of protect, accommodate and relocate/managed retreat. Priority adaptation actions for each West Marin community are based on the findings of the Vulnerability Assessment, input from stakeholders and technical advisors and the guiding principles in this report.



*Adaptation workshop in Stinson Beach, November 2015. Credit: Marin County CDA*

A series of public meetings were held in West Marin during fall 2015 and spring 2016, and

over 200 residents participated in the West Marin Sea Level Rise Adaptation Poll (See Appendix C). The level of potential community support for each strategy is expressed as percent of total respondents for that community's section of the poll, expressed as strong, moderate or little support. The poll results should be considered as one indicator of public support, but not as a definitive measurement.

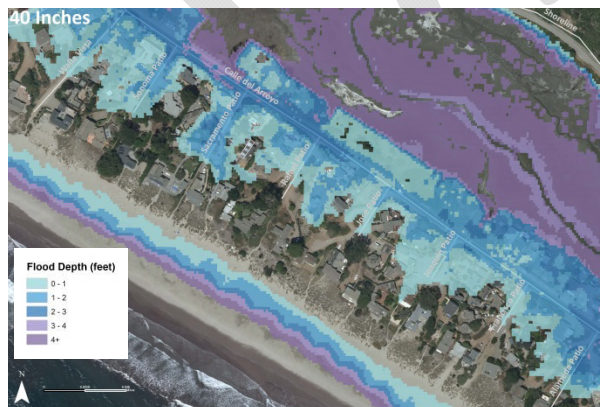
NOTE: The Community Alternatives section of this Adaptation Report provides an overview of possible measures to address the impacts of sea level rise, with examples of potential locations for implementation. The strategies presented below do not necessarily reflect the position of Marin County, but are included for discussion purposes. Further feasibility analysis and context-sensitive design is a necessary next step in developing any of the strategies.



## 6.1) Community PATCHs (Plans for Adaptation To Coastal Hazards)

As next steps to move adaptation options outlined in this report forward, community-scale plans could be undertaken for each of West Marin’s seven communities. Plans would focus on adapting infrastructure of community wide importance to coastal hazards. Plans would identify funding mechanism, and implementation opportunities. These Plans for Adaptation to Coastal Hazards (PATCHs) would be for specified timeframes based on best available sea level rise/storm projections and trigger points at which flooding becomes chronic. PATCHs would be conducted in conjunction with partners such as DPW or Caltrans. A proposed process to develop PATCHs is as follows:

- 1) Using the C-SMART Vulnerability Assessment, identify vulnerable infrastructure assets of community wide importance.
- 2) With the use of CoSMOS, determine flooding frequency, intensity, and duration for the identified assets under different future scenarios.
- 3) Survey community members to determine ‘trigger points’ for vulnerable infrastructure. Trigger points would be the frequency/intensity/duration points at which flooding becomes nuisance, causing public inconveniences which may include frequent road closures, overwhelmed storm drains and compromised infrastructure.
- 4) Use the most recent adopted state policy to link the trigger points to specific timeframes (e.g., 2030, 2050)
- 5) In conjunction with community members and asset managers initiate PATCHs around the identified timeframe (the planning horizon) with the objective of PATCH implementation prior to chronic flooding occurring.
- 6) Develop adaptation alternatives for evaluation (e.g., elevation, relocation, alignment). Populate matrices with information including costs, impacts and benefits. The matrices would guide the determination of a preferred alternative based on maximizing public benefits while minimizing costs and negative impacts.
- 7) Collaborate with partners such as DPW or Caltrans to implement the preferred alternative through a capital improvement program.



Above – Stinson Beach’s calles and patios with Calle Del Arroyo at 40 inches (3.3 feet) SLR/no storms (CosMos)

As the only road through Stinson Beach’s calles and patios and into Seadrift, Calle del Arroyo is of community-wide importance for both daily use and emergency access. A PATCH could focus on adaptation alternatives for the roadway with a time horizon for preferred project implementation in advance of chronic flooding. Stinson Beach residents would be consulted with through the planning process and asset managers would serve as project partners.

## 6.2) Muir Beach

### PRIMARY VULNERABILITIES

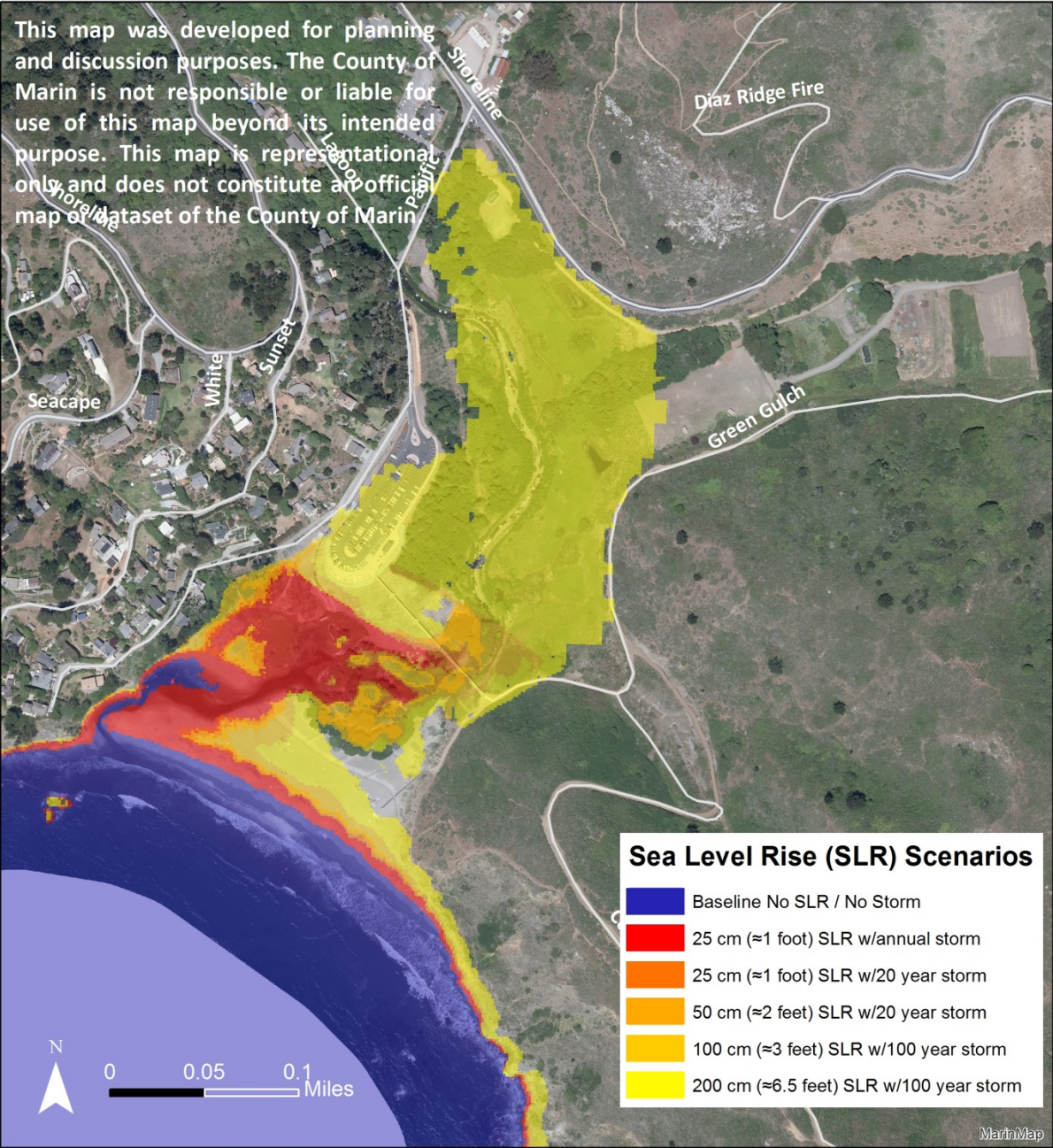
- Flooding during extreme events already occurs
- Long-term impacts will compromise beach access and tourism
- Those impacted include one business, property owners, Muir Beach Home Owners Association, and Muir Beach Fire Department

### PRIORITY ACTIONS

- Ensure safety of bluff top development
- Improve bluff stability by following best practices for drainage and vegetation
- Continue outreach and education around SLR and coastal hazards

Strategy	Timeframe/Term: NT=Near MT=Medium LT=Long	L=Low 0-40% M=Moderate 41-70% S=Strong 71%+ NA=Not available
<b>PROTECT</b>		
• Research dune maintenance	• NT	• M to S
• Research beach nourishment	• NT	• M to S
• Maintain existing armoring	• NT	• S
<b>ACCOMMODATE</b>		
• Convene working group to explore solutions for Pacific Way bridge vulnerability	• NT	• S
• ID triggers for elevating Shoreline Highway and Pacific Way	• LT	• S
• Elevate buildings in flood plain	• MT	• M
• Monitor Redwood Creek restoration	• NT	• M
• Monitor water quality and require wastewater systems to meet code	• NT	• S
• Monitor water quality and move wells upland	• MT	• S
<b>RELOCATE/MANAGED RETREAT</b>		
• Research managed retreat program including buy out option	• LT	• M
• Remove seawall to maintain sediment supply	• NT	• L
• Implement a rolling conservation easement program to prevent new shoreline armoring	• LT	• L to M

# Muir Beach



Map 7. Muir Beach Exposure Map. Does not include geomorphic change.

### No Action

Bluff top buildings could be impacted by erosion under all scenarios. Temporary flooding on Pacific Way may worsen with SLR, and the perimeter road around the edge of the restored wetland may flood in the long-term. Habitats in Redwood Creek and Green Gulch Creek may shift landward with increased salinity downstream.



Muir Beach during King Tide. Lighthawk Aerial, 2015

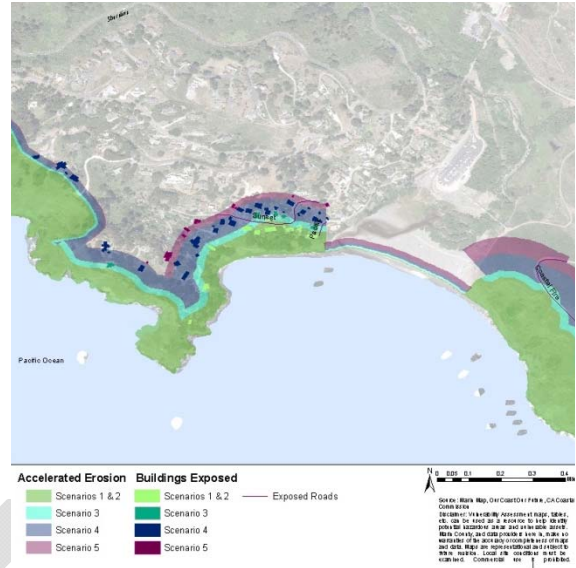
#### MUIR BEACH: LONG-TERM SLR IMPACTS

Beach access compromised	Property Owners MB HOA MB Fire Department
Extreme event impacts already occur	
1 business      Tourism	

Source: Marin Map, OCOF, Asset Manager Interviews

### Priority Actions

In the near-term, bluff top development should comply with applicable setback standards in the Local Coastal Program Environmental Hazards policies. Existing information about coastal erosion potential can be found in the *Marin Ocean Coast Vulnerability Assessment*. In many cases erosion rates are uncertain, and a site-specific analysis is necessary to determine the safety of a structure from cliff erosion.



Map 8. Muir Beach Buildings Exposed to Erosion

Table 23. Muir Beach Blufftop Buildings Vulnerable to Accelerated Erosion\*

	Buildings
Scenarios 1&2	12
Scenario 3	17
Scenario 4	49
Scenario 5	53

\* This analysis does not include storms

Source: Marin Map, CoSMoS

### Ensure safety of blufftop development

New development must be set back from the bluff edge a sufficient distance to ensure its stability and structural integrity for a minimum of 100 years, and to eliminate the need for shoreline protective devices. Coastal hazards analyses for individual sites must include a slope stability analysis that considers historical bluff retreat data as well as accelerated erosion

due to SLR.<sup>60</sup> For informational purposes and to guide the identification of potential planning triggers for removal of existing structures in hazardous areas, ESA utilized past model input data from the OPC study (PWA 2009)<sup>61</sup> to model and map coastal erosion amplified by the various SLR scenarios. For further discussion of blufftop setbacks, see the “Bolinás” section of this report. This strategy received moderate support from poll respondents (58%).

***Improve bluff stability by following best practices for drainage and vegetation***

Homeowners can improve bluff stability by following best practices, which include: limiting surface and shallow subsurface drainage to the bluff edge that can cause erosion and slides; limit disturbance caused by vertical access, and identification of preferred vegetation for bluff stability, and slope stabilization. These approaches are highlighted in “Green Strategy: Bluff Management in Muir Beach” in this section. This strategy received strong support from poll respondents (92%).

***Continue public outreach and education around sea level rise and coastal hazards***

Muir Beach residents, led by the CSD, expressed interest in continuing to engage with government agencies to explore solutions to flooding and bluff erosion. For example, residents would like more information about the community’s ability to maintain long-term safety, and the tradeoffs of maintaining vs. removing hard protective structures.

The community is well-organized for emergency preparedness. The CSD Board is committed to furthering public engagement around the management of community assets such as water, roads and recreation. Poll respondents requested that the County notice the CSD of any changes so they can bring it to the attention of residents most affected in a timely manner - to continue to work collaboratively with the CSD and partner with both the CSD and Fire District on continued public outreach around SLR and coastal hazard preparedness.

The following sections provide additional information about strategies considered during the C-SMART project. They are grouped according to general approach: protect, accommodate, or relocate/ managed retreat.

**Protect**

In Muir Beach, low dunes and surfgrass immediately surrounding the beach play a significant role in helping reduce beach exposure to erosion and inundation. Recently, the NPS completed the Redwood Creek Restoration at Muir Beach. The project objectives were to create a natural creek system, reconnect the floodplain, reduce flooding, improve access along Pacific Way, and create habitat for Coho salmon, steelhead trout, and red-legged frog. The beach and tidal lagoon were allowed room to migrate landward with SLR and the parking lot was reconfigured away from direct wave action to minimize storm surge impacts<sup>62</sup>.

***Research feasibility of dune maintenance***

Potential short- and medium-term opportunities for habitat-based protection

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<sup>60</sup> Marin County Community Development Agency. [Draft Local Coastal Program, Environmental Hazards Chapter LUPA](#). April 2016

<sup>61</sup> PWA. *CA Coastal Erosion Response to Sea Level Rise – Analysis and Mapping*. March 2009

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<sup>62</sup> National Park Service. *Redwood Creek Restoration and Muir Beach*. [www.nps.gov/goga/learn/nature/muir-beach.htm](http://www.nps.gov/goga/learn/nature/muir-beach.htm). Accessed January 2016.

include dune maintenance, which would build upon the Redwood Creek restoration project, and/or beach nourishment.

Dune restoration may not be an effective solution for protecting blufftop homes at Muir Beach, as the beach is already squeezed or absent in front of the bluff toe and sand placed for dune creation would likely not last. Additionally, nourishments would not affect the erosion processes at the bluff top. This strategy received moderate support from poll respondents (62%).

***Maintain existing seawalls and other existing hard protection***

Some armoring structures are already in place at the bluff toe fronting homes at Muir Beach. This solution could be effective in limiting erosion of the bluff face, but will result in less sediment delivery, lead to local scour at the toe of structure and ultimately lead to rapid degradation and failure of the structure. Furthermore, a toe revetment may not prevent additional erosion of the upper bluff face. Armoring requires maintenance and sea-level rise will result in increased loadings that will likely require reconstruction. Therefore, armoring may not be a sustainable approach (ESA, 2015). However, the ideas of maintaining existing hard protection received strong support from poll respondents (73%).

In addition to protection strategies that address erosion of the bluff toe, elements of drainage control, disturbance avoidance, vegetation management and slope stabilization could be employed to limit (but not completely prevent) erosion of the bluff top and face.

**Accommodate**

Regular impacts to the perimeter road around the edge of the restored wetland may not be felt until the long-term, but storms may interrupt road access at any time, and residents should be prepared with emergency supplies.

***Convene a working group of County and local stakeholders to brainstorm a resolution to the Pacific Way bridge vulnerability***

Earlier plans to widen and elevate the Pacific Way bridge were considered too large-scale by the community. However, flooding exacerbated by the current bridge continues to be a problem. Further collaborative work between government agencies and residents is needed to find an appropriate solution. One idea was to have a separate pedestrian and bicycle bridge parallel to the main auto bridge, to reduce the necessary width. The idea of convening a working group around this issue received strong support from poll respondents (85%).

A related medium-term strategy is to explore the feasibility of constructing a new Pacific Way bridge appropriate to the community character and to accommodate Redwood Creek floodplain. This idea received strong support from the community (92%).

***Identify triggers for elevation of vulnerable sections of Pacific Way and Shoreline Highway***

Water levels for daily high tides or extreme high tides could be identified to determine when Pacific Way would need to be adapted to allow for continued access to homes and the public beach. While the road sometimes floods during storms, it is not expected to be impacted by “permanent inundation” (daily during high tide) until later in the century. This strategy received strong support from poll respondents (92%).

***Elevate buildings in the floodplain to meet FEMA safety requirements plus additional height for SLR***

Draft Local Coastal Program policies follow the approach of requiring additional elevation for homes in the FEMA coastal flooding zones that are also projected to be impacted by SLR. Floodproofing is an alternative way to maintain home safety from storm events. This strategy received moderate support from poll respondents (62%).

***Support efforts to monitor Redwood Creek restoration project as a nature-based adaptation to SLR***

Continued monitoring of the Redwood Creek project may provide evidence about the resiliency and protective effects of restored natural habitats, building support for other restoration projects. This strategy received strong support from poll respondents (69%).

***Continue to monitor water quality and require onsite wastewater systems to meet code and adapt to saltwater intrusion as needed***

As saltwater intrusion leads to degradation and ultimately failure of septic systems, it will be important to monitor water quality and ensure that septic systems continue to meet codes. Over time, affected septic systems may need to become above-ground mound systems, have a flip switch to prevent environmental contamination during flood events, or sealed tanks that are pumped out periodically. Ultimately, affected homeowners might consider developing a community wastewater system on higher ground, similar to the system developed in Marshall along Tomales Bay. This strategy received strong support from poll respondents (85%).

A related strategy is to monitor water quality and move wells upland if needed, which

received strong support from poll respondents (85%).

***Relocate/ Managed Retreat***

Any managed retreat strategy to remove or prevent development in vulnerable areas would need to be carefully tailored and defined in consultation with the community.

***Research feasibility of a managed retreat program to provide property owners with options for moving out of hazardous areas, especially after damaging storms***

Marin County could research potential costs and community interest in a long-term buyout or property acquisition strategy if rising sea levels or erosion impacts become imminent threats to homeowners in Muir Beach. The County could also consider having a plan and specific proposals in place in case of a major storm/flood event that makes homeowners more likely to be interested in the buyout.<sup>63</sup> This strategy received moderate support from poll respondents (62%).

***Remove seawall to maintain sediment supply***

The existing seawall may be effective in limiting erosion of the bluff face, but reduces sediment delivery to the beach, which could eventually disappear with SLR. Local scour at the toe of the seawall could ultimately lead to degradation and failure of the structure. The idea of removing the existing seawall received low support from poll respondents (19%).

***Implement a rolling conservation easement program to prevent new shoreline armoring***

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<sup>63</sup> Center for Ocean Solutions, Natural Capital Project. *Coastal Adaptation Policy Assessment*. 2016.

Because Muir Beach is bordered by land under state and federal protection and by lands protected by a conservation easement, over the long term there is a potential opportunity in the area zoned as “Residential Agriculture” for property acquisition/buyouts or purchasing conservation or rolling easements to allow for natural erosion. This strategy received moderate support from poll respondents (46%).

The following section highlights a few best management practices for bluff management.

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## Green Strategy: Bluff Management in Muir Beach



Muir Beach from public parking lot. CDA, 2015

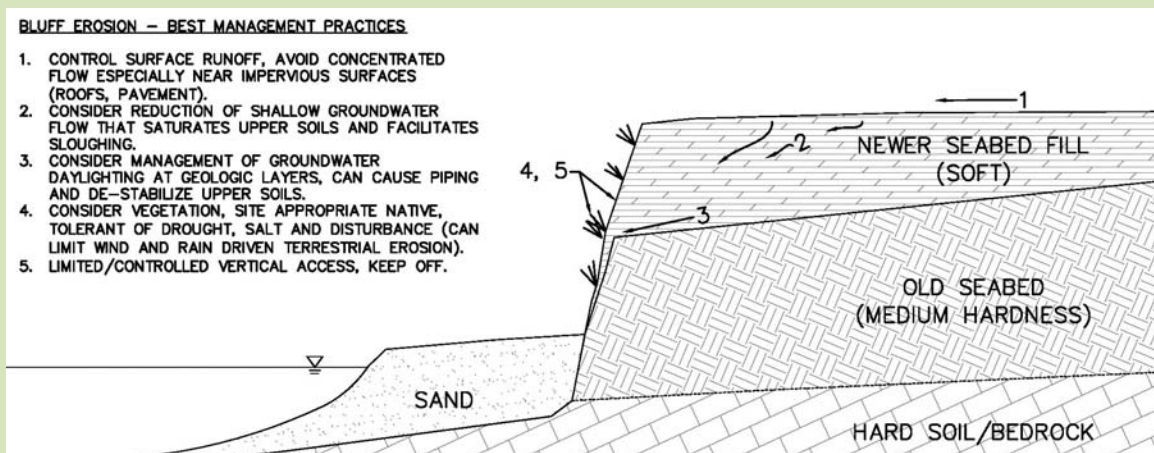
Muir Beach is characterized by low lying floodplain surrounding Redwood Creek flanked by steep eroding bluffs. Homes built on the tops of bluffs will continue to be at risk as sea-level rise accelerates erosion of bluffs.

There are a few general best management practices that can be followed to reduce erosion of the blufftop and face. Finding appropriate solutions to these processes depends on local geology and existing drainage patterns that must be gathered through site-specific analysis. Example solutions include drains to intercept and reroute groundwater from the bluff top. Eroding bluffs will continue to supply sand

to the beach, in turn increasing the buffer the beach provides from wave action on the bluff toe. A planned retreat, realignment or landward redevelopment strategy may include one or more of the following:

- **Drainage control:** Limited surface and shallow subsurface drainage to the bluff edge that can cause erosion and slides;
- **Disturbance avoidance:** Limit access, especially uncontrolled vertical access;
- **Vegetation management:** Identify preferred vegetation for bluff stability;
- **Slope Stabilization:** Surface and shallow stabilization techniques help slow the pace and extent of bluff recession. Interim approach before implementing a longer-term retreat strategy;
- **Structure Modification or Relocation:** Structures can be moved landward or modified to allow for bluff recession.
- **Land use measures:** Mechanisms like rolling easements and development regulations can facilitate fair and orderly landward relocation.

Figure 9. Bluff erosion best management practices. (Source: ESA 2015)





**Flood Depth (feet)**

- 0 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- 4+

**Maps 9-12 Muir Beach 1 Exposure** Source: CoSMos

### 6.3) Stinson Beach

#### PRIMARY VULNERABILITIES

- Storm and tidal flooding already occur
- Long-term flooding will impact 773 homes (55 percent vacation rentals), 630 people, six businesses, and two principle access roads.
- Costs of long-term flooding will reach nearly \$200 million of assessed value and \$1.5 billion in market value.
- Those impacted will include property owners, Seadrift Association, Stinson Beach Fire Department, Stinson Beach Water District, County DPW, and residential tourism.

#### PRIORITY ACTIONS

- Elevate homes subject to temporary flooding
- Elevate or reroute roads and utilities
- Update onsite wastewater treatment systems
- Elevate or relocate Water District Office
- Relocate Fire Station #2

Strategy	Timeframe/Term: NT=Near MT=Medium LT=Long	Support: L=Low 0-40% M=Moderate 41-70% S=Strong 71%+ NA=Not available
<b>PROTECT</b>		
Maintain existing Seadrift revetment and nourish beach	NT	NA
Extend revetment along Stinson Beach	MT	NA
Artificial reef funded by special assessment district	MT	L
Enhance living shoreline in Bolinas Lagoon funded by special assessment district	NT	L
Horizontal levee with impervious barrier	NT-MT	L
<b>ACCOMMODATE</b>		
Elevate existing homes to comply with FEMA and Local Coastal Program	NT-MT	NA
Elevate Shoreline Hwy along Bolinas Lagoon	NT	S
Realign Shoreline Hwy along Bolinas Lagoon	NT	L
Elevate Calle del Arroyo	MT	S
Elevate local roads in a coordinated neighborhood approach	MT	L
Construct a flood bypass across Stinson Beach to convey storm runoff	NT	NA
Boardwalk entire neighborhoods	MT	L
Upgrade substandard septic systems	NT	L
Convert septic tanks to holding vessels	MT-LT	L
Develop community wastewater system	LT	L
<b>RELOCATE/MANAGED RETREAT</b>		
Research long-term buyout and rolling easement options	NT	NA
Prevent total erosion of beach by removing all armoring and homes in path of inland migration	LT	L

# Stinson Beach

## Vulnerable Assets

Site Specific Assets Identified on Map

- ① Calle del Arroyo
- ② Upton Beach
- ③ Shoreline Highway
- ④ Water District Office
- ⑤ Walla Vista Walkway
- ⑥ Stinson Fire Department
- ⑦ CA Coastal Trail
- ⑨ Stinson Picnic Area
- ⑩ Bolinas Lagoon

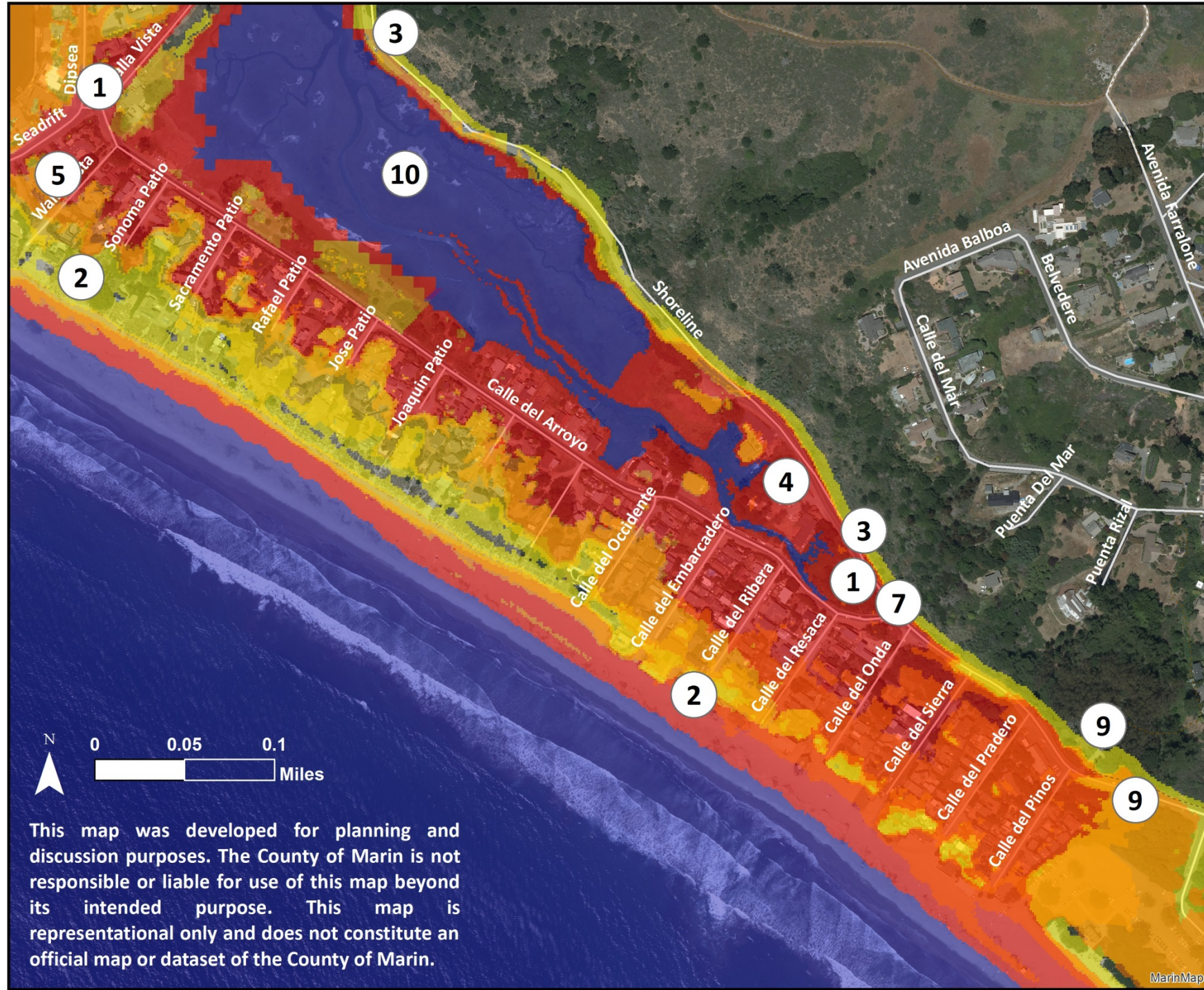
Buildings Potentially Facing Hazardous Conditions plus some septic systems and water distribution lines

Includes Seadrift



### Sea Level Rise (SLR) Scenarios

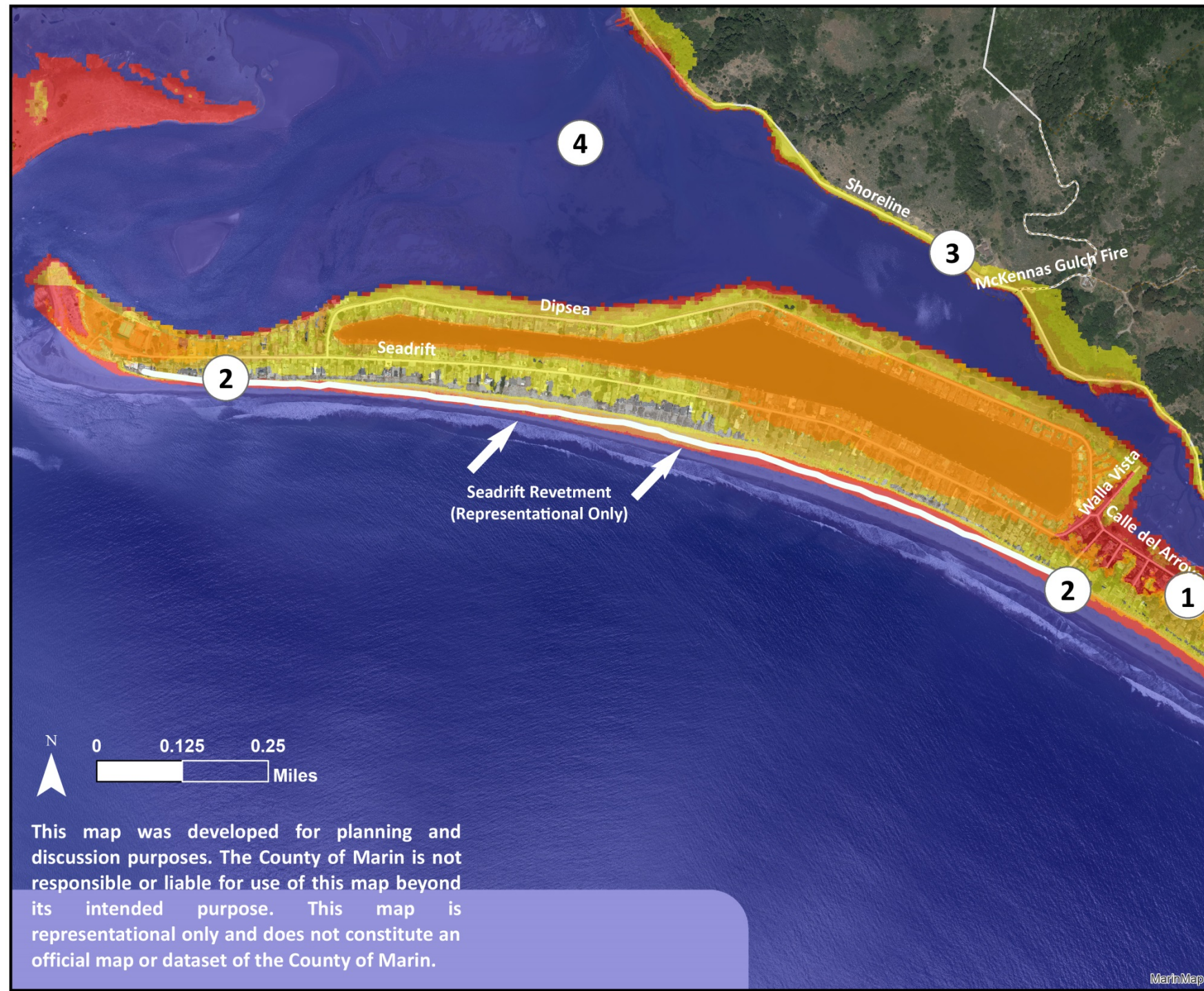
- Baseline No SLR / No Storm
- 25 cm (≈1 foot) SLR w/annual storm
- 25 cm (≈1 foot) SLR w/20 year storm
- 50 cm (≈2 feet) SLR w/20 year storm
- 100 cm (≈3 feet) SLR w/100 year storm
- 200 cm (≈6.5 feet) SLR w/100 year storm



This map was developed for planning and discussion purposes. The County of Marin is not responsible or liable for use of this map beyond its intended purpose. This map is representational only and does not constitute an official map or dataset of the County of Marin.

Map 13. Stinson Beach Exposure Map. Does not include geomorphic change.

# Seadrift



## Vulnerable Assets

Site Specific Assets Identified on Map

- ① Calle del Arroyo
- ② Seadrift Beach
- ③ Shoreline Highway
- ④ Bolinas Lagoon

Buildings Potentially Facing Hazardous Conditions plus some septic systems and water distribution lines

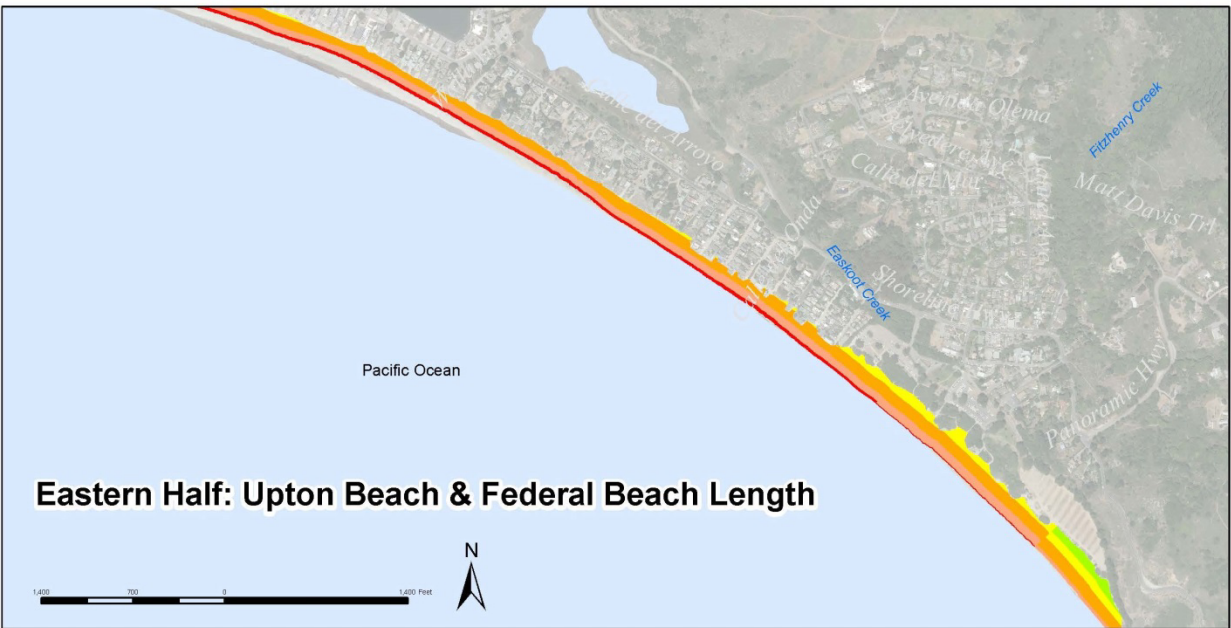
Includes Stinson Beach's Calles and Patios neighborhood



## Sea Level Rise (SLR) Scenarios

- Baseline No SLR / No Storm
- 25 cm (≈1 foot) SLR w/annual storm
- 25 cm (≈1 foot) SLR w/20 year storm
- 50 cm (≈2 feet) SLR w/20 year storm
- 100 cm (≈3 feet) SLR w/100 year storm
- 200 cm (≈6.5 feet) SLR w/100 year storm

Map 14. Seadrift Exposure Map. Does not include geomorphic change.

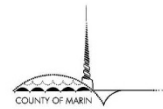


- Beach Loss @ 10 inches SLR
- Beach Loss @ 20 inches SLR
- Beach Loss @ 40 inches SLR
- Beach Loss @ 80 inches SLR
- Beach around end of century)

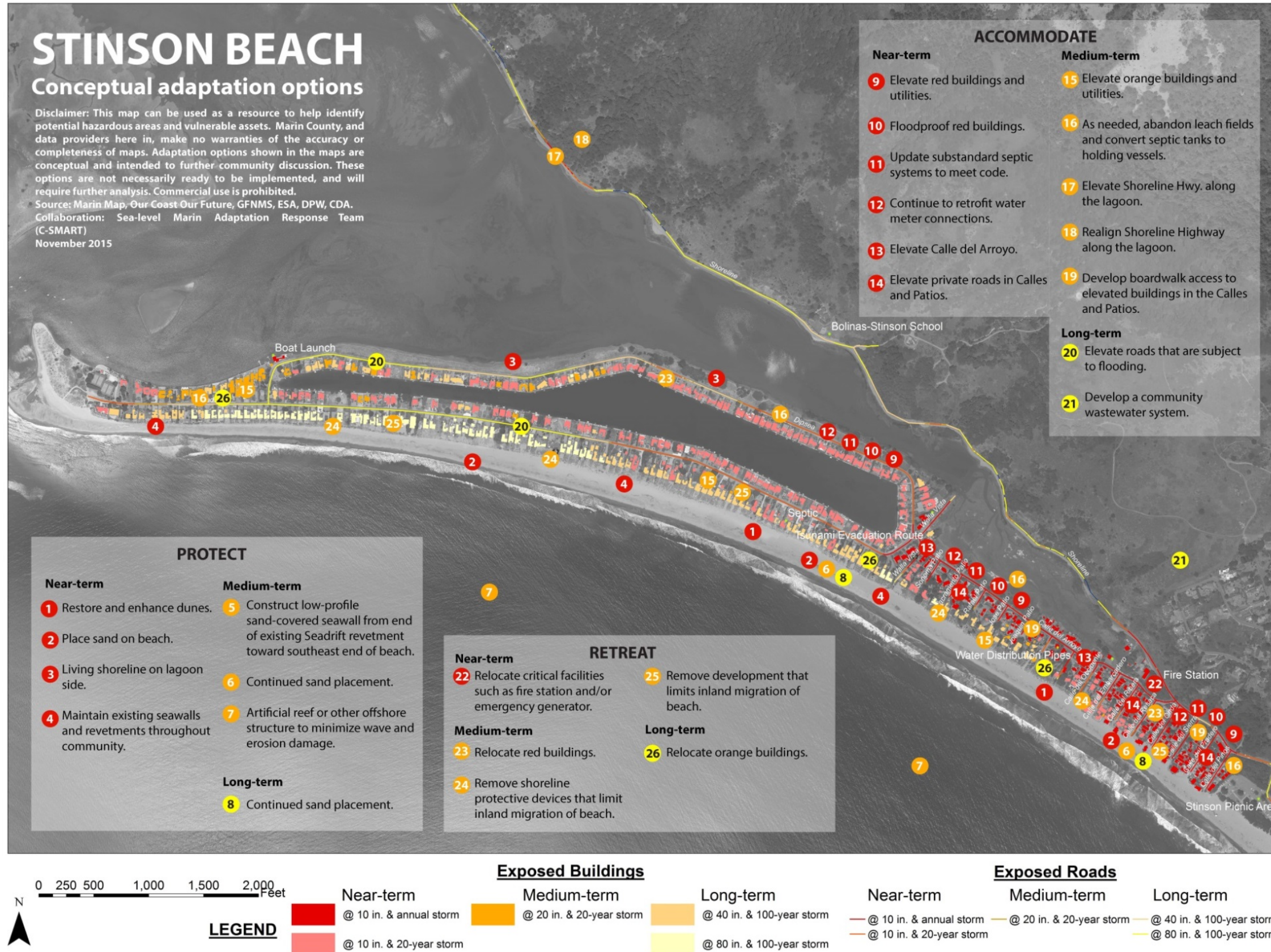
Source: Marin Map, Our Coast Our Future, ESA

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: 4/4/2016



**Map 15. Stinson Beach Beach Loss by Sea Level Rise Amount (no storms)**



Map 16. Stinson Beach Adaptation Map

### 6.3) Stinson Beach

#### No Action

Homes, buildings, and facilities west of Shoreline Highway could be exposed to storm impacts, septic failure, water distribution pipe failure, and flooding. Calle del Arroyo, a principal access road to the Calles, Patios, and Seadrift neighborhoods, may face increased flooding in the near term, and eventually permanent inundation, severely limiting access to portions of the community. Flooding from Bolinas Lagoon and Easkoot Creek already occur and will likely worsen with more extreme climate patterns and as they are combined with rising sea levels. Incremental beach loss due to erosion is likely to occur by the end of the century if development remains in its current location.<sup>64</sup>

The damage or destruction of Stinson Beach’s buildings and natural resources would have devastating impacts on the local economy, people’s lives, and sense of place. Excluding the effects of storm waves, homes on the Easkoot Creek side of the Calles and Patios neighborhood may be vulnerable to permanent SLR sooner than homes on the beach side. Due to topography, homes near Easkoot Creek sit approximately five to ten feet lower than those directly on the beach. Also, homes on the beach tend to be already elevated or otherwise fortified against storms.



Stinson Beach from above. Lighthawk Aerial, 2015.

#### STINSON BEACH: LONG-TERM SLR IMPACTS

773 homes, 55 percent vacation rental	630 people
Storm and tidal impacts already occur	6 businesses
Nearly \$200 million of assessed value and \$1.5 billion in market value exposed	Residential Tourism Property Owners Seadrift Association SB Fire Department SB Water District County DPW

#### Priority Actions

Accommodation of vulnerable structures, roads and utilities, primarily through elevation and retrofits, is a near- and medium-term priority for Stinson Beach. Elevation of homes would protect them from temporary flooding and permanent SLR, though road access would continue to be an issue. Many poll respondents supported “reasonable policies that allow property owners to develop in ways that protect against SLR.” However, permits for

<sup>64</sup> Environmental Science Associates (ESA). *Sea Level Rise Adaptation Options for Marin County*. 2015.



structures in vulnerable areas may be conditioned to prove that the structure will be safe from erosion over a set timeframe.

Calle del Arroyo is the County road of most immediate concern, as it frequently floods and provides the only access to Seadrift, the Patios, and many of the Calles. The Stinson Beach Flood Study<sup>65</sup> identified the potential construction cost of elevating the entire length of Calle del Arroyo between State Highway 1 and Seadrift Road as between \$1-\$2 million, along with several other flood control and mitigation options. Private roads would also need to be elevated, or at least sloped up to meet Calle del Arroyo. Elevating Shoreline Highway along Bolinas Lagoon will become a priority toward the middle of the century, as access to the community becomes impaired with increasing frequency.

OWTS can be updated to meet code, which will make them resilient to saltwater intrusion in the near-term. In the medium- to long-term, code revisions allowing for mounded septic systems, or replacement of leachfields with holding tanks could be implemented. The Stinson Beach County Water District plans to continue retrofitting water meter connections in the near-term to withstand saltwater corrosion. Electric utilities located beneath buildings will also need to be elevated or retrofitted. The Water District office will likely need to be elevated or relocated in the near-term. Fire Station #2 is already elevated on a mound and the district has plans to relocate the facility before it is impacted by SLR in the medium-term.

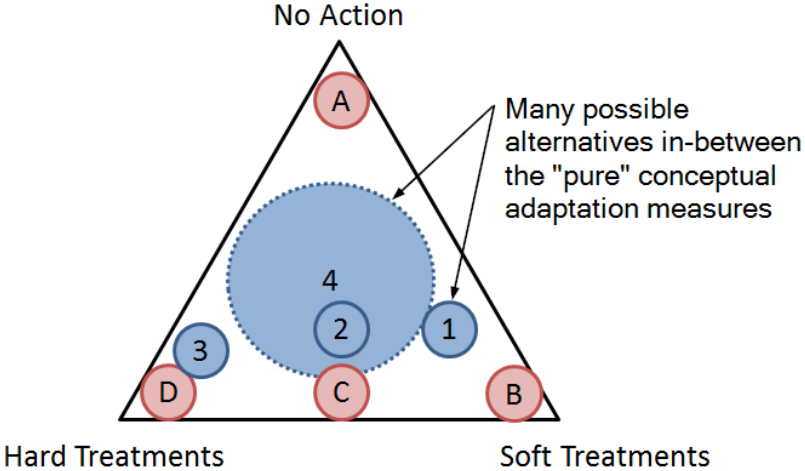
Maintenance of existing protective structures is allowed by law under certain circumstances, but permitting the construction of new shoreline armoring can be very difficult. In the long-term, as accommodation and protection of existing buildings becomes increasingly costly, exposure to coastal hazards grows, and negative impacts to coastal ecosystems mount, homeowners and government officials will need to identify alternatives. This could involve major beach restoration and nourishment, prohibitions on rebuilding structures destroyed by storms, more restrictions on new development allowed in hazard zones, buyout, relocation and/or removal of structures.

The following sections provide additional information about strategies considered during the C-SMART project. They are grouped according to general approach: protect, accommodate, or retreat. Unless otherwise indicated, cost estimates in this section are from ESA, and more details can be found in Appendix C.

It is beneficial to consider a range of adaptation measures to evaluate and select a preferred strategy, which may be a “hybrid” of hard or soft protection strategies.

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<sup>65</sup> Marin County Department of Public Works. *Stinson Beach Watershed Program Flood Study and Alternatives Assessment*. 2014.



- | <i>Measures</i>                  | <i>Implementation Strategies</i>    |
|----------------------------------|-------------------------------------|
| <b>A</b> No Action               | <b>1</b> Beach Nourishment          |
| <b>B</b> Sand Placement          | <b>2</b> Beach Nourishment w/ Reefs |
| <b>C</b> Sand Placement w/ Reefs | <b>3</b> Armor                      |
| <b>D</b> Hold the Line           | <b>4</b> Hybrids                    |

Figure 10. Example Solution Space of Adaptation Strategies

DRAFT

## Green Strategy: Beach and Dune Nourishment at Stinson Beach



Stinson Beach at King Tide. Lighthawk Aerial, 2015.

**Benefits:** Recreation, Tourism, Habitat

**Cost:** \$44M+ over long-term

Beach and dune nourishment provides protection against coastal storm erosion while maintaining natural habitat and geomorphic response mechanisms. Dune restoration would include placement of sand, graded and planted to form dunes. A variant of the beach and dune nourishment strategy includes placement of cobble (rounded rock), which can then be covered with sand. The cobble berm would be as far landward as possible. Details, including costs are from ESA, and more details can be found in Appendix B.

Along Stinson Beach (3450 ft) a **13-ft tall, 50-ft wide dune nourishment** would cost

roughly \$6M while a **50-ft wide beach nourishment would cost roughly \$11M each time the beach is nourished.** The dunes and beach would need nourishment after extreme storms. A **cobble berm would cost roughly \$6M**, and could be designed high enough to limit excess erosion if the entire dune is sacrificed during a large storm.

Due to uncertainties around the availability of local, clean sand, cost estimates are very approximate. This analysis assumes a cost of \$61 per cubic yard to import sand from the central San Francisco bay, truck it to Stinson, and spread by bulldozer. Further analysis could estimate costs via a barge and slurry pipe.

Potential problems with beach nourishment include the near-term construction impact to people and beach ecology, and long-term changes to shore conditions. The success of the nourishment depends on the volume of material, the grain size, and sand retention structures. As sea-level rises, the frequency of required nourishment increases unless the beach is allowed to retreat landward.

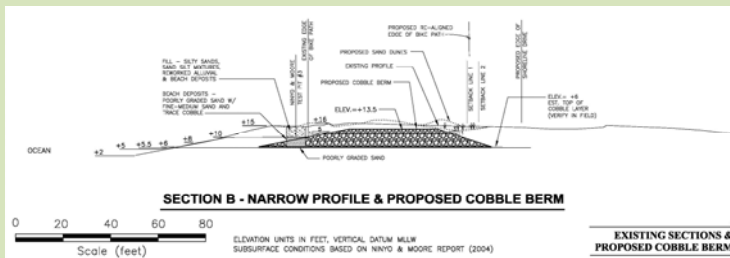


Figure 11. Example section profile of dunes and cobble berm. (Source: PWA, 2005)

Sand placement provides a temporary benefit until the sand erodes and migrates. Some of the sand potentially placed on Stinson Beach could end up in Bolinas Lagoon, and some may migrate south toward Muir Beach (PWA 2006). In general, increased sand supply is considered beneficial to most beach areas, but can be problematic at harbors and drain outlets. Whether the sand could be dredged and retrieved and recycled is not known, due to the potential for impacts from dredging. With sea-level rise, increased sediment supply may be a net benefit to mitigate rapid changes.

Monitoring will play an important role in determining the timing of the first potential sand placement, and identifying the need for additional nourishments in the future. Monitoring could focus on the annual minimum beach width and dune width. The storm erosion buffer for Stinson Beach for a 2- to 5-year recurrence storm is 43-52 ft.<sup>66</sup> Triggers and potential actions:

- **Maximum seasonal beach width** (end of summer) drops below 50 feet trigger:
  - **Beach nourishment of affected reach.** Implications: temporary construction impact to people and ecology, cost (\$2-\$11M for 50-ft wide beach along Stinson Beach)
- **Dune width** drops below 2-year storm buffer (50 ft) trigger distance:
  - **Replenish and revegetate dune system.** Implications: temporary

construction impact to people and ecology, cost about \$1-\$6M for 50-ft wide dune nourishment along Stinson Beach depending on local free sand availability (\$6M cost assumes dredged and imported sand).

Since the initial dune nourishment would occupy existing beach, the trigger distance is reached more quickly, requiring nourishment of the beach in 2040. Subsequent nourishments are applied on a 30-year interval. Future nourishments will likely need to be more frequent. At any time a major storm erosion event may require beach nourishment. Beyond 2100, the first seaward row of homes and utilities may be severely exposed.

#### San Andreas Graben?

While much more research is necessary to assess its feasibility, further investigation could be done on the San Andreas Graben as a sediment source for nourishment of Stinson and other West Marin Beaches. The Graben lies between two strands of the San Andreas Fault, with 55-60 m of sediment in 20 m of water (Sam Johnson, USGS). C-SMART staff are currently discussing the Graben as a sediment source through participation in the Sonoma/Marin County Sediment Management Working Group.

<sup>66</sup> Environmental Science Associates (ESA). *Marin County Coastal Hazards and SLR Adaptation Strategies*. (2016)

**Table 24. Cost Estimate for Beach/ Dune Nourishment at Stinson Beach**

Year	Cost Estimate	Note
2015	\$ 12,000,000	Nourish 50 ft dune with cobble toe (takes up 50 feet of existing beach)
2040	\$ 11,000,000	Nourish 50 ft beach when beach drops below trigger
2070	\$ 11,000,000	Nourish 50 ft beach after 30 years
2100	\$ 40,000,000	Nourish 50 ft beach after 30 years, raise homes in FEMA V-zone
<b>Total net present value (2015)</b>	<b>\$ 44,000,000</b>	Assumes 1% discount rate
*anytime	\$ 11,000,000	<i>Emergency 50 ft beach nourishment if extreme storm erosion occurs; dune nourishment not considered (add \$6M)</i>

NOTE: The table above does not include the area fronting Seadrift, which is shown in Table .

### Protect

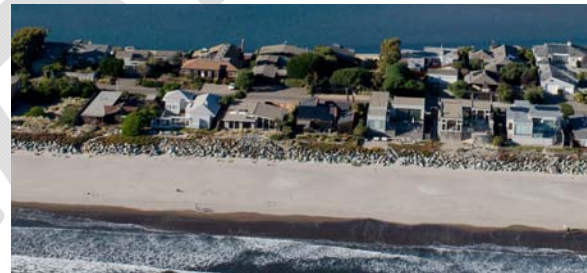
Stinson is a partially dune-backed beach, with either homes or park facilities built behind. It is a major recreational attraction, and thus preserving the beach can be a priority when developing adaptation strategies.<sup>67</sup> In Stinson Beach a potential short-term option is to “hold the line” or protect existing green and gray infrastructure in place by using physical barriers. These could include enhancement of shoreline vegetation along the Bolinas Lagoon side and beach nourishment and/or dune

<sup>67</sup> Environmental Science Associates (ESA). *Sea Level Rise Adaptation Alternatives for Marin County*. 2015.

restoration along the Stinson Beach coastline. Coordination with NPS should be integrated into strategy evaluation to understand potential effects from strategies to NPS beach downdrift of revetment.

### **Maintain Seadrift revetment**

The existing bulkhead and seawall around Seadrift is maintained by residents. Individual homeowners in other areas of the community also maintain protective structures, many of which were constructed prior to the Coastal Act. The continued presence of seawalls and revetments could accelerate beach erosion, which would need to be evaluated to better understand. Shoreline protective devices contribute to erosion but SLR can drown beach altogether. This strategy would continue to be implemented by property owners or local assessment districts, and received strong support from poll respondents (100%).



*Seadrift rock revetment.* Copyright (C) 2002-2017 Kenneth & Gabrielle Adelman, California Coastal Records Project, [www.Californiacoastline.org](http://www.Californiacoastline.org)

Rebuild/upgrade of the Seadrift rock revetment would cost approximately **\$51M**, every 30 years. Beach nourishment along the 7,500 foot stretch would cost roughly **\$24M**. The beach is projected to surpass the critical trigger width at 2050, requiring a 50-ft beach nourishment. This is repeated after 30 years in 2080. See [Table](#) The appropriate frequency of future nourishments will likely be higher in reality. As

the required backshore modifications become increasingly intensive, the homes will need to be raised (assumed at 2100). At any time, a major erosion event may erode the beach to a dangerous condition requiring revetment repairs and or beach nourishment.

**Extend revetment along Stinson Beach**

Some community members expressed interest in extending revetment from Seadrift southeast to Calle De Pinos to protect homes along Stinson Beach. Drawing on cost estimates previously developed for Marin County (ESA 2015), **a revetment extension of 3,540 ft would cost around \$24 million.**

The revetment could be built along the alignment of the existing dune face from Walla Vista to the residence at the end of Calle Del Embarcadero, and sand excavated for the revetment could be placed in front and on top of the revetment for aesthetic improvement, but additional sand may be required if complete burial of the revetment is desired.

For the remaining stretch of homes from Calle Del Embarcadero to Calle De Pinos, a new revetment would have to occupy existing beach area, and sand would need to be imported to cover the structure, increasing cost. This approach could limit erosion and wave run-up on homes in the near term. However, without increased maintenance of the revetment and fronting beach, long term sea-level rise will eventually overload the revetment as the fronting beach is eroded and waves damage and overtop the revetment. To remedy this, subsequent beach nourishments will be required to maintain the beach fronting the revetment. Narrow sections of beach in front of Seadrift serve as an example of possible future conditions in Stinson Beach without continued beach nourishment. See [Table 26](#).

To be consistent with GFNMS regulations, revetment could not extend into the mean high water.

Table 25. Cost Estimate for Revetment Maintenance at Seadrift Beach

Year	Cost Estimate	Note
2015	-	Assume revetment was adequately maintained
2045	\$ 51,000,000	Rebuild/upgrade revetment after 30-yr life
2050	\$ 24,000,000	Nourish 50 ft beach when beach drops below trigger
2075	\$ 51,000,000	Rebuild/upgrade revetment after 30-yr life
2080	\$ 24,000,000	Nourish 50 ft beach after 30 years
2100	\$ 81,000,000	Raise homes in FEMA V-zone
<b>Total net present value (2015)</b>	<b>\$ 130,000,000</b>	Assumes 1% discount rate
<b>*anytime</b>	<b>\$24,000,000</b>	<i>Emergency 50-ft beach nourishment if extreme storm erosion occurs; revetment repair not estimated</i>

**Low-profile wall and cobble berm**

An alternative adaptation measure to a rock revetment, the low profile wall and cobble berm may be preferable owing to less wave reflection, flatter slopes, and easier walking under eroded conditions if the beach drops. This estimate was modified from the Ocean Beach Master Plan, and the cost equals **\$55M per mile**. Considering construction of just the cobble berm that acts as a last defense behind a



Mouth of Bolinas Lagoon. Lighthawk Aerial, 2015.

**Table 26. Cost Estimate for Revetment Strategy at Stinson Beach**

Year	Cost Estimate	Note
2015	\$ 24,000,000	Construct revetment along Stinson Beach
2045	\$ 24,000,000	Rebuild/upgrade revetment after 30-yr life
2060	\$ 11,000,000	Nourish 50 ft beach when beach drops below trigger
2075	\$ 24,000,000	Rebuild/upgrade revetment after 30-yr life
2090	\$ 11,000,000	Nourish 50 ft beach after 30 years
2100	\$ 29,000,000	raise homes in FEMA V-zone
<b>Total net present value (2015)</b>	<b>\$ 80,000,000</b>	Assumes 1% discount rate
<i>*anytime</i>	\$ 11,000,000	<i>Emergency 50 ft beach nourishment if extreme storm erosion occurs; revetment repair not considered</i>

NOTE: The table above does not include the area fronting Seadrift. dune (no wall), the cost equals **\$8M per mile**.

**Offshore structures**

Offshore breakwaters and artificial reefs are large coastal engineering structures that are often used in conjunction with large beach nourishment to retain sand. Offshore breakwaters are effective at preventing erosion because wave sheltering and diffraction reduces sand transport directly. They consist of fill in the surf zone, typically quarry stone arranged in a mound that penetrates the water surface. These solutions were found to net negative cost benefit in Southern Monterey Bay primarily due to high construction cost of \$44 million per kilometer.<sup>68</sup> Offshore structures are currently prohibited by GFNMS regulations.

Offshore artificial reefs consist of fill in the surf zone that reduces the wave power reaching shore and changes the pattern of sand transport, thereby conceptually reducing transport of sand from the beach. Offshore reefs are considered less effective than offshore breakwaters because the wave sheltering is reduced by the low crest height which allows wave overtopping.

<sup>68</sup> Environmental Science Associates (ESA). *Ocean Beach Master Plan*. 2012.

Artificial reefs installed to act as submerged breakwaters have received increased attention in recent years as a means of shore stabilization and erosion control, primarily due to their low aesthetic impact and enhanced water exchange relative to traditional emergent breakwaters and the potential to enhance local surfing conditions.<sup>69</sup> If constructed offshore from Stinson Beach, an artificial reef could reduce wave impacts, but would not provide protection from permanent SLR. This strategy received low support from poll respondents (13%).

### ***Enhance living shorelines***

Enhancing the living shoreline of Bolinas Lagoon could help with temporary flood protection. However, shoreline vegetation alone does not protect against permanent inundation that would become an issue in the medium and long-term. This measure would likely be funded by a government grant or local assessment district, and received moderate support from poll respondents (28%).

A horizontal levee, with an impervious barrier on the landward side of the wetland, would require a large right of way. Further considerations for horizontal levees are discussed in the Bolinas section, since it may be an option for the Gospel Flats area. This strategy could be implemented through a local assessment district, and received moderate support from poll respondents (33%).

## **Accommodate**

### ***Elevate homes***

Most parcels in Stinson Beach are already developed, and many structures are vulnerable to flooding in their current condition. New

structures must meet flood protection standards, and in many cases there is a need to elevate existing structures. Instead of constructing new revetment/dunes along the Calles, homes could be raised to limit wave run-up and erosion damages to homes as the dune is allowed to erode during coastal storms. Applying the cost estimate of \$250 per square foot, to lift Stinson homes in the effective/preliminary FEMA V-Zone (89 individual structures), the **total cost would equal roughly \$29M**. It is important to remember, however, that actual project costs will vary depending on building condition, site characteristics and more.

One advantage of raising homes over building a revetment is it allows limited migration and persistence of a fronting beach in the near term. If additional measures such as beach and dune nourishment are not taken in the future, the shoreline may continue to migrate past homes and potentially damage roads, infrastructure and even the homes if the pilings are undermined. Still, this option could have advantages over armoring in the sense that the back beach is allowed to evolve naturally. As the backshore migration approaches property lines, dunes could be replenished to improve the aesthetics and habitat function at the backshore, as well as limit future damages in areas that are eroded during storm events.

A quantitative trigger for dune/ beach replenishment could be tied to estimated storm erosion mentioned above:

Dune width fronting a home shrinks below the threshold distance (50 feet)

- Beach/dune replenishment needed.
  - Implications: temporary construction impact to people and ecology, cost of

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<sup>69</sup> Environmental Science Associates (ESA). *Sea Level Rise Adaptation Alternatives for Marin County*. 2015.



about \$12M for 50-ft wide dune and 50-ft beach along Stinson Beach.

Table 27 shows an approximate cost schedule for structure elevation. Initially, homes in the FEMA V-Zone would be lifted. As the beach narrows with SLR, beach nourishments will be needed to maintain a buffer to the back beach as well as for recreation and ecological function. The first nourishment occurs at 2060 and again at 2090. The appropriate frequency of future nourishments will likely be higher in reality. At any time a major storm erosion event may require beach/dune nourishment. Beyond 2100, the first seaward row of homes will likely need relocation as they may be severely exposed.

**Table 27. Cost Estimate for Home Elevation Strategy at Stinson Beach<sup>70</sup>**

Year	Cost	Note
2015	\$ 29,000,000	raise homes in FEMA V-zone
2060	\$ 11,000,000	Nourish 50 ft beach at Stinson when beach drops below trigger
2090	\$ 11,000,000	Nourish 50 ft beach after 30 years
<b>Total net present value</b>	<b>\$ 41,000,000</b>	
<i>*anytime</i>	<i>\$ 11,000,000</i>	<i>Emergency 50-ft beach nourishment if extreme storm erosion occurs, dune nourishment not considered (add \$6M)</i>

The cost of elevating homes and associated utilities would likely be borne by individual homeowners though within West Marin’s Flood Control Districts (Zones 5 and 10, Stinson Beach

<sup>70</sup> Estimates from ESA (2016) and actual costs may vary depending on building condition, site characteristics and other factors.

and Inverness, respectively) property owners may be eligible for the Marin County Structure Elevation program, a FEMA Hazard Mitigation Grant Program. Many Stinson Beach homeowners would like to be able to elevate their homes to meet FEMA standards to be safe from storm flooding and SLR without facing onerous permitting requirements. Some poll respondents indicated that they would want to make significant improvements to their home when they elevate it, especially for older homes in poor condition. This would extend the life of structures in known hazardous areas. Residents felt that elevating structures would be consistent with the existing eclectic community character.

Many Stinson Beach homes are located within the FEMA special flood hazard area, or 100-year floodplain – in which case elevating the home results in a lower flood insurance rate for the homeowner. Homes are required to meet FEMA standards if a proposed remodel or building project exceeds 50% of the property’s market value.

Development in flood hazard areas is regulated through the Local Coastal Program and Title 23 of the Marin County Code, administered by the Department of Public Works. FEMA FIRM maps in 2015 that identify BFEs for structures in coastal areas, incorporating coastal wave hazards.

LCP Program Policy C-EH-8 – *Minimum Floor Elevations in Flood Hazard Areas*, would apply when a new or substantially improved building requires a coastal permit, based on actual site conditions. This policy requires subject building elevations to accommodate three feet of SLR above and in addition to the FEMA Base Flood Elevation requirements, as described below. This would apply to properties within Special

Flood Hazard Areas (Areas VE, AO or AE as indicated on the Potential Sea Level Rise Maps (Appendix E)). In areas outside FEMA Special Flood Hazard Areas that are nevertheless subject to SLR, the 3 foot building elevation would also be required to accommodate for future SLR (Base SLR Elevation).

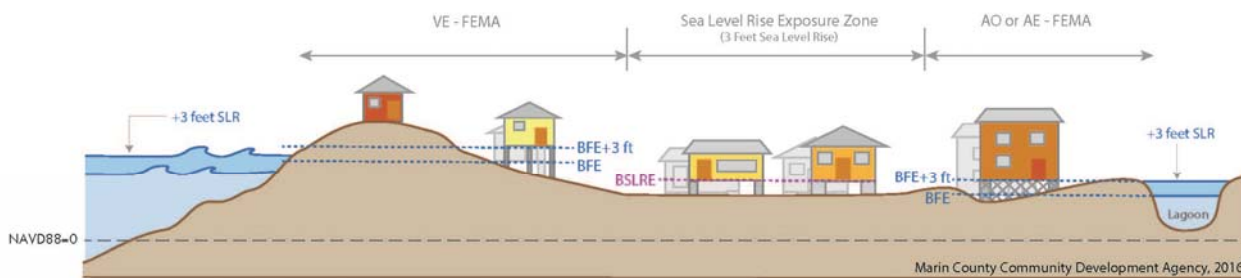
The FEMA Base Flood Elevation is an existing regulatory requirement for elevating and flood-proofing of structures located within Special Flood Hazard Areas based upon high-intensity storm floodwater elevations that have a projected 1% chance to occur in any given year (commonly referred to as the “100-year flood”). Special Flood Hazard Areas include lands that would be impacted by floodwaters, and for West Marin consist of “VE Zones” (subject to wave velocity) and “AE”/“AO” Zones (subject to rising waters without waves) (see Appendix D for West Marin maps with FEMA Flood Zones). Special Flood Hazard Areas are delineated and Base Flood Elevations are determined based upon historical flooding trends and do not account for future SLR which is currently not reflected in FEMA’s Flood Insurance Rate Maps.

The intent of the proposed County policy is to fully prepare for future SLR conditions by requiring buildings to elevate 3 feet above the

required Base Flood Elevation in Special Flood Hazard Areas (VE, AO or AE as indicated on the Potential Sea Level Rise Maps) and 3 feet above existing underlying topography in areas projected to be affected by SLR located outside of Special Flood Hazard Areas (SLR Exposure Zones as indicated on the Potential Sea Level Rise Maps). Three feet approximately equals 100 cm, which is a midpoint projection of SLR for the year 2100 based upon the National Research Council’s *Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present, and Future*, which provides state level guidance for SLR adaptation.

FEMA’s Flood Insurance Rate Maps identify Base Flood Elevations used for National Flood Insurance Program regulatory purposes. Base Flood Elevations used to inform the “Potential Sea Level Rise” maps are from FEMA’s 2015 Preliminary Flood Insurance Rate Maps for Marin County.

The Potential Sea Level Rise maps illustrate Special Flood Hazard Areas, as well as areas exposed to 3 feet of SLR outside of Special Flood Hazard Areas (SLR Exposure Zone). Numeric values in parenthesis represent Base Flood Elevations based on an official vertical datum related to current sea level (referred to



### Example of Future Building Elevation with 3 feet of Sea Level Rise

BSLRE = Base Sea Level Rise Elevation  
BFEs are based on high-intensity storm floodwater elevations that have a projected 1% chance to occur in any given year (commonly referred to as the “100-year flood”)

Figure 12. Section Diagram of Potential Building Elevation for 3 feet of SLR

as NAVD88) plus three additional feet to account for future SLR. Required building elevations would be determined by actual measurements on a case by case basis taking into account a building's existing elevation above sea level (NAVD88). In "VE" Zones, measurements are made from the sea level (NAVD88) to the lowest horizontal structural member (e.g., floor joists). In the "A" zones, the measurement is to the lowest finished floor. In Special Flood Hazard Areas, the values in goldenrod represent the approximate difference in elevation between the required BFE + 3 feet and the average underlying topography shown on County base maps. Where the proposed County policy would apply to lots located outside of Special Flood Hazard Areas (i.e., no Base Flood Elevation requirement), those values represent the height distances based on 3 feet of SLR alone. Most if not all existing buildings are already elevated above the underlying grade, so the actual height to which existing buildings would have to be raised to meet the proposed policy is less than the values shown in goldenrod (for example, if a remodel project is subject to a required elevation of 9 NAVD88 pursuant to the proposed policy, and the existing home is currently at elevation 4 NAVD88, the remodeled home would be elevated 5 feet to satisfy the proposed policy). Finally, the white numbers show the elevation of the white topographic lines.

**California Coastal Analysis and Mapping Project  
(CCAMP) Open Pacific Coast Study**

The Federal Emergency Management Agency (FEMA) completed detailed coastal engineering analysis and mapping of the Pacific coast of California in 2015. The analysis and mapping are used to update the flood and wave data for Flood Insurance Rate Map (FIRM) panels along the open coast. Public workshops were held in Stinson Beach and Marshall in Spring 2016.

To learn more about Open Pacific Coast Study, visit: [www.r9map.org/Pages/CCamp-Main.aspx/](http://www.r9map.org/Pages/CCamp-Main.aspx/)

For more information about flood protection and FEMA standards, visit: [www.floodsmart.gov/floodsmart/](http://www.floodsmart.gov/floodsmart/)

Data are not comprehensive, and this analysis is only intended to give a general sense of how many homes would potentially need to elevate in order to meet FEMA and County requirements for flood safety. A group of homes Stinson Beach were selected for this visualization based on the availability of data on Finished Floor Elevations (FFE) gathered during a 2012 survey.

Building improvements and designs should take a holistic approach which includes connection to the existing infrastructure/utilities. The current use of individual OWTS may not be a viable long-term solution for treatment and dispersal of wastewater with a significant rise of sea level which causes homeowners to raise their homes. Before looking at building solutions, there should be a review of the existing infrastructure: gas, septic, water, electric utilities, and roadways. Homeowners seeking to make improvements to their homes are advised to consult with SBCWD staff before going to the County Community Development Agency, since building improvements are

limited by infrastructure (Stinson Beach County Water District, 2015).



*Stinson during King Tide. Light Hawk Aerial. 2015.*

***Elevate Shoreline Highway, Calle del Arroyo, and private roads***

General approaches for adapting roads to SLR include identifying water level triggers for management actions, and coordinating with the DPW and Caltrans. They are further described in the “Transportation” section of this report.

Even if homes are elevated, access will remain a challenge during temporary flooding and a severe problem with permanent inundation during daily high tides. Low-lying sections of Shoreline Highway along the Bolinas Lagoon could flood temporarily in the near-term scenario, and progressively larger sections will flood and eventually become permanently inundated in the long-term.

Elevating the entire stretch of Shoreline Highway that borders Bolinas Lagoon would cost approximately \$50 million<sup>71</sup>. While critical for accessing coastal Marin communities, this project must compete with many others statewide for limited Caltrans funding. Alternatively, low-lying road segments identified through the Vulnerability Assessment

and site-specific analysis could be elevated or otherwise protected. The concept of elevating Shoreline Highway along Bolinas Lagoon received strong support from poll respondents (81%). Realigning Shoreline Highway received much less support (22%).

Local roads do not qualify for Federal Transportation Bill funding with Congestion Mitigation and Air Quality (CMAQ) & Surface Transportation Program (STP) funds and are considered off system roads. Panoramic Highway and Shoreline Highway do qualify for CMAQ & STP federal funding; however, these roads have difficulty rising to the top when competing with roads in the urban areas for limited funds. For emergency repairs, a local road would need to be covered under disaster assistance where FEMA could provide funding. FEMA typically funds less than the 88.53 percent that the Federal Highway Administration (FHWA) does for on system roads. Also, adding improvements for SLR would be considered an enhancement and not eligible with today’s FEMA rules.

The Stinson Beach Watershed Program *Flood Study and Alternatives Assessment* (DPW 2014) determined that a preliminary estimated cost to elevate Calle del Arroyo and provide required drainage features is on the order of \$1.0 million<sup>72</sup>. Local roads in the Calles and Patios would need to be elevated as well, or engineered to slope up and meet Calle del Arroyo. This strategy would be most effective if all homeowners in the Calles, Patios and Seadrift neighborhoods agree to pursue this strategy in a coordinated approach. However,

<sup>71</sup> Caltrans, Personal communication. 2015.

<sup>72</sup> Marin County Department of Public Works. *Stinson Beach Watershed Program Flood Study and Alternatives Assessment*. 2014.

the idea of elevating local roads received low support from poll respondents (23%). Residents in the Calles and Patios currently pool resources to pay for maintenance of private roads, and could choose to elevate the road level by adding additional fill material. An extension of this idea would be for homeowners in the affected areas to form a local self-funded assessment district to finance the elevation of Calle del Arroyo. Elevating Calle del Arroyo received strong support from poll respondents (94%). GFNMS would need to be actively involved in new road design and implementation in cases that the footprint extends into GFNMS boundaries.



*Calle del Arroyo at King Tide, 2015. Credit: Loomans*

### **The Stinson Beach Watershed Program Flood Study and Alternatives Assessment**

*Marin County Department of Public Works, 2014*

This study describes the flood conditions existing along Easkoot Creek in the Stinson Beach community, and develops a series of possible alternatives for mitigating these conditions. Besides the alleviation of flood conditions, one of the primary concerns of the study is the preservation of the creek as a habitat for spawning steelhead salmon. Ten alternatives are evaluated for effectiveness in achieving these goals, as well as for cost, possible permitting and other issues. The full study is available at: [www.marinwatersheds.org/stinson\\_beach.html](http://www.marinwatersheds.org/stinson_beach.html)

### ***Easkoot Creek flooding***

In addition to coastal hazards, Stinson Beach is subject to fluvial flooding hazards from Easkoot Creek. Three of the ten strategies in the *Flood Study and Alternatives Assessment* (DPW 2014) included a flood bypass across the beach that would convey enough flow during a storm event to reduce flooding of the Calles and restore or enhance wetland habitat that once existed in the NPS south parking lot.

The preferred strategy identified in the DPW study is consistent with SLR adaptation planning. The restoration of a lagoon wetland feature and overflow to the Pacific across the beach is particularly attractive as it reduces the need for structural modification of homes while provides ecological benefits in a sustainable manner, and is consistent with restoration of historic conditions, and may have a broader potential for funding. Structural adaptation to use pile foundations and raise homes above flood levels is also potentially viable, and complementary to other strategies as well as responsive to coastal flooding.

***Boardwalk entire neighborhoods***

Construction of boardwalk access to elevated homes would alter the community character, but reduce the need to place large amounts of fill on roads to maintain access under permanent SLR inundation scenarios. Some examples of boardwalk-type communities exist on Marin’s bayside in Sausalito, Corte Madera and Larkspur, with elevated homes built on poles over tidal salt marshes. This strategy allows structures to be built upon an encroaching shoreline or in a vulnerable area, with a low risk of flooding and may be a good tool for retrofitting certain low-lying infrastructure. Elevated development has the advantage of avoiding SLR threats for a longer time.<sup>73</sup> Vehicular access could be restricted to portions of the community. This strategy could be funded by a local assessment district, and received low support (5%).

***Elevate entire neighborhoods on fill***

Elevating entire neighborhoods on fill would require a great deal of agreement and coordination among homeowners. “Super-levees” in Japan have removed existing development, added fill to create a large elevated surface, and provided attractive financing options for displaced homeowners to live in the new development. However, this approach would be extremely costly if applied to protecting existing homes, or would require an intensification of development that is highly unlikely to occur in Marin’s coastal zone. Elevation of entire neighborhoods on fill would also have negative environmental impacts.

***Update substandard septic systems***

Onsite wastewater treatment systems (OWTS) west of Shoreline Highway are vulnerable to saltwater intrusion and failure, leading to potential contamination of surface water. The (SBCWD) recommends that homeowners continue upgrading substandard septic systems to meet current codes. This strategy received moderate support from poll respondents (34%). An option for the medium and long-term is to abandon leachfields and convert septic tanks to holding vessels that would need to be pumped out periodically or connected to a community wastewater system. This strategy received low support from poll respondents (15%), though the SBCWD supports this option. Elevating septic systems in earthen mounds would reduce the impact of saltwater intrusion.

***Develop community wastewater system***

The Marshall Community Wastewater System is an example of this strategy, with a centralized treatment facility serving a neighborhood on Tomales Bay. Such a strategy could be pursued in the long-term by SBCWD and/or a local assessment district. The idea received low support from poll respondents (9%).

***Retrofit potable water pipes and connections***

Beginning 2014, SBCWD began a program to replace all water pipelines in the Calles and Patios. SBCWD received a grant in 2015 to continue retrofitting potable water meter connections to resist corrosion from saltwater.

***Allow small-scale desalination plants***

SLR can contaminate groundwater supplies with saltwater due to landward and upward movement of sea water in coastal aquifers<sup>74</sup>. Community members suggested that allowing

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<sup>73</sup> Sustainable Planning and Urban Research. 2009. *Strategies for Managing Sea Level Rise*.

<sup>74</sup> US Geological Survey (USGS). *Coastal Groundwater Systems*. Accessed August 2016. <http://wh.er.usgs.gov/slr/coastalgroundwater.html>

small-scale desalination plants could improve resilience without negatively impacting the environment. Desalination could also reduce the demand on wells facing increased salinity.

#### **National Parks Service beach**

The National Parks Service beach that extends southeast of Calle Del Pinos is backed by nourished dunes and parking/ amenities. The low lying area was once a lagoon, and is subject to flooding from Easkoot Creek. Landward of the Parks land are non-NPS public or private County assets that will become at risk if the natural shoreline defense is compromised. Adaptation alternative cost schedules were not developed for the National Parks Service beach. However, National Parks is unlikely to armor to protect the backshore, but would instead facilitate the natural development of future habitat (Caffrey and Beavers 2013). Coordination will be required between federal and local jurisdictions in the future to ensure effective risk management of Stinson assets that exist inland of NPS land.

NPS will likely employ a retreat strategy that may include maintaining the dunes/beach and reduce parking and amenities as the shore migrates inland with sea-level rise. In 2015, NPS replaced the beach park's four septic drain fields with a centralized drain field located inland where groundwater and anticipated SLR are not an issue. Septic systems at each Park facility will provide primary treatment and settlement of raw sewage, then each facility's lift station will pump effluent to a centralized drain field system for disposal.<sup>75</sup>

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<sup>75</sup> Stinson Beach County Water District. *Onsite Wastewater Management Program Report*. 2015.

#### **Relocate/ Managed Retreat**

Marin County could research potential costs and community interest in a long-term buyout or property acquisition strategy if rising sea levels or storm impacts become imminent threats to homeowners. The County could also consider having a plan and specific proposals in place in case of a major storm/flood event that makes homeowners more likely to be interested in the buyout.<sup>76</sup> Rolling easements and other land use policies could be used to limit further construction and investment in the most hazardous areas.

Removing seawalls, bulkheads, homes and other development that would limit the inland migration of the beach and marsh would allow these habitats to shift in response to SLR, and support continued public access and recreational opportunities. Otherwise, without beach nourishment, the beach is predicted to erode almost completely by 2100.<sup>77</sup> However, this strategy would endanger and ultimately eliminate, existing homes, and received low support (2%).

Potential locations for adaptation strategies are shown in [Map 16](#). Stinson Beach Adaptation Map. These strategies respond to vulnerabilities based on the C-SMART scenarios using the CoSMOS model. It is important to keep in mind that additional geomorphological changes, such as beach erosion, are not reflected in the CoSMOS models and therefore community vulnerabilities may be more extreme. Future community scale analysis could combine all relevant models to date including coastal and

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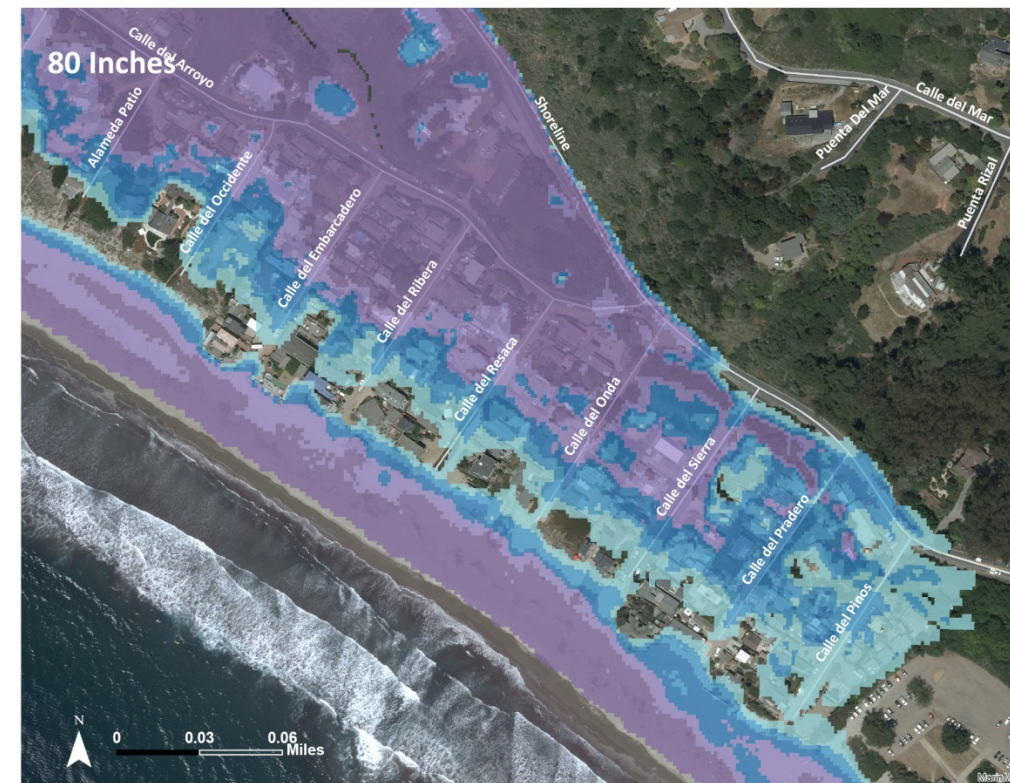
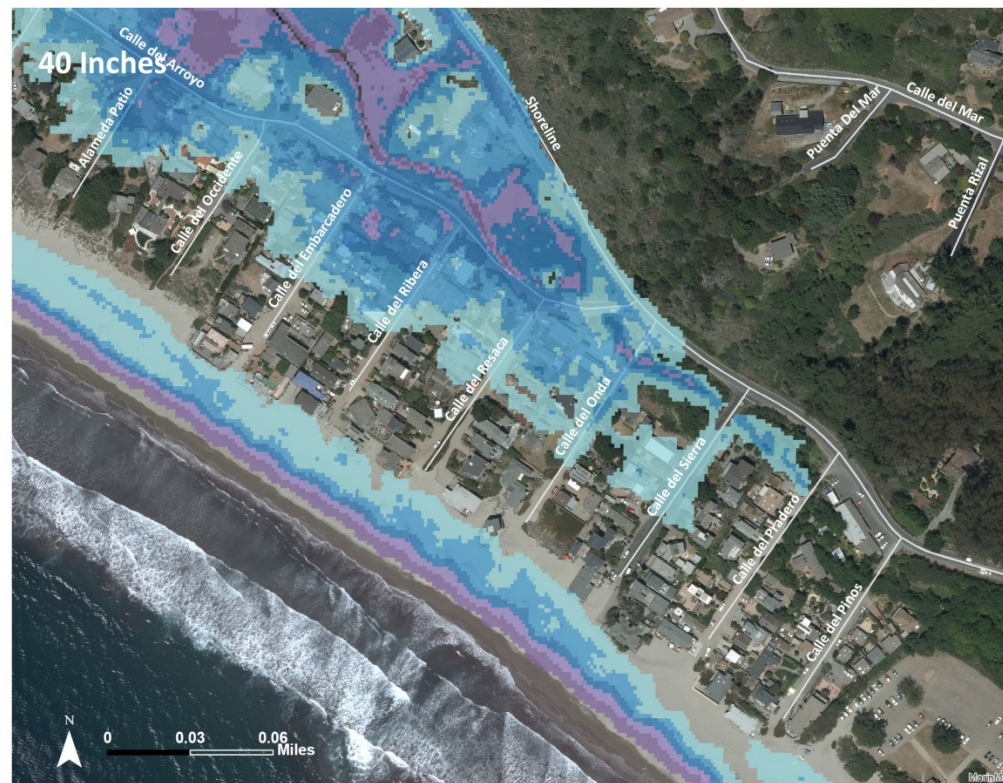
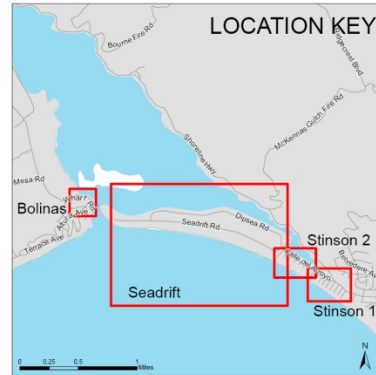
<sup>76</sup> Sustainable Planning and Urban Research (SPUR). *Strategies for Managing Sea Level Rise*. 2009.

<sup>77</sup> Environmental Science Associates (ESA). *Sea Level Rise Adaptation Alternatives for Marin County*. 2015.

riverine sea level rise and storm surge, and coastal erosion.

DRAFT

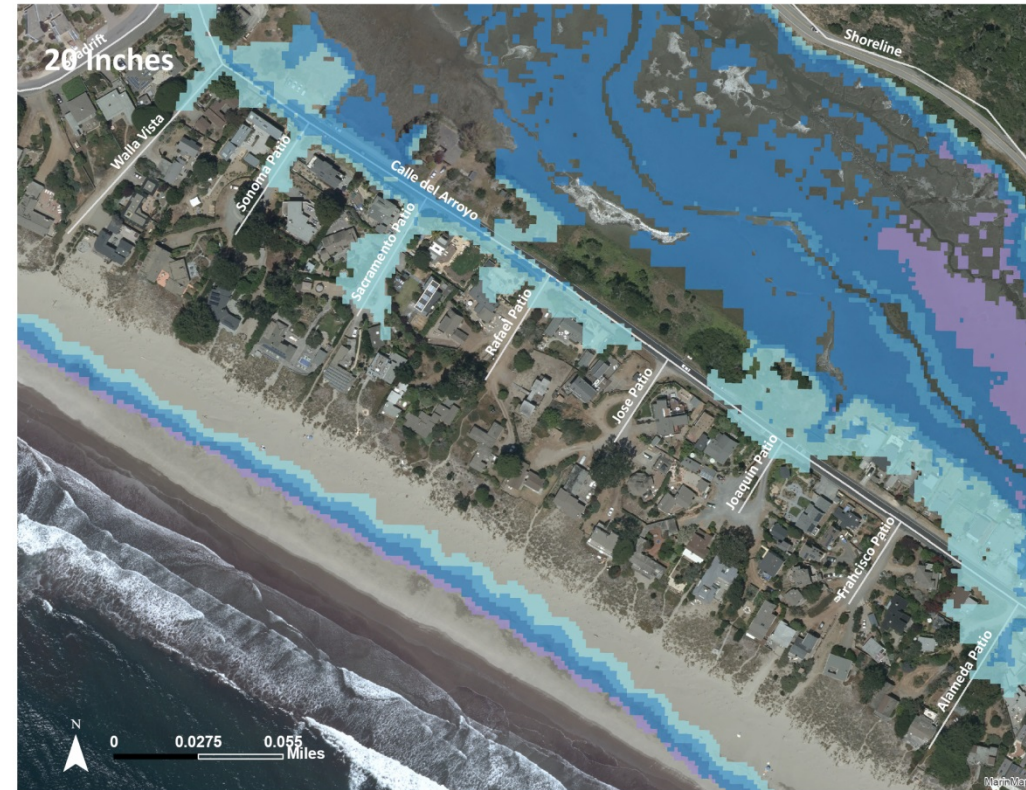
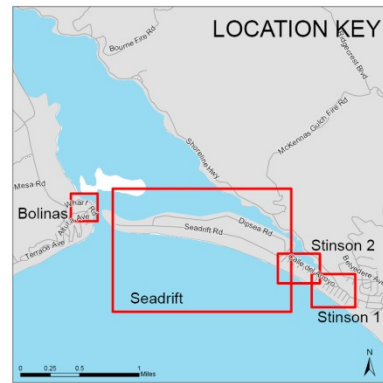




**Flood Depth (feet)**

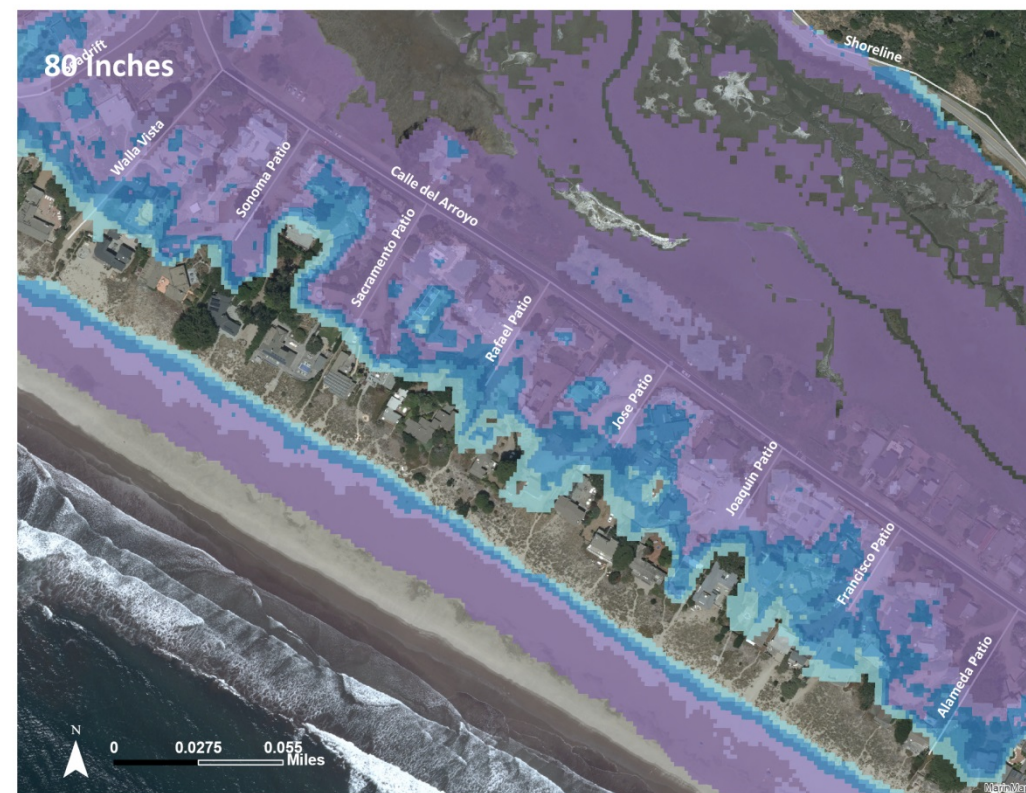
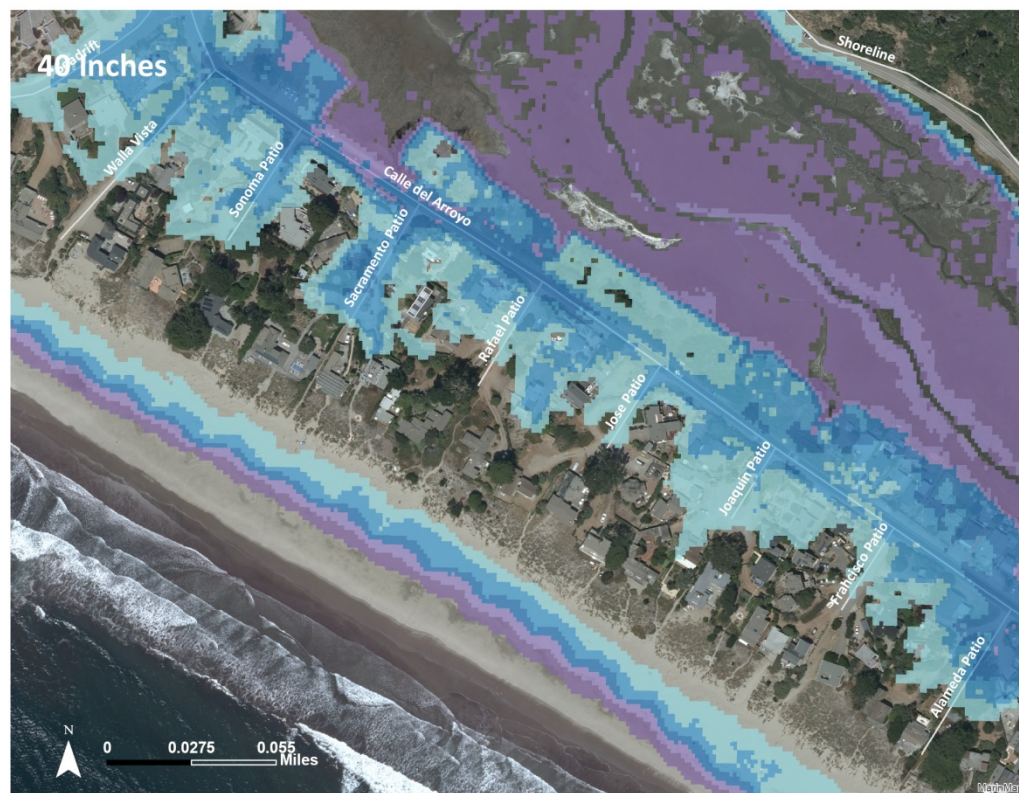
- 0 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- 4+

Maps 17-20 Stinson Beach 1 Exposure Source: CoSMos

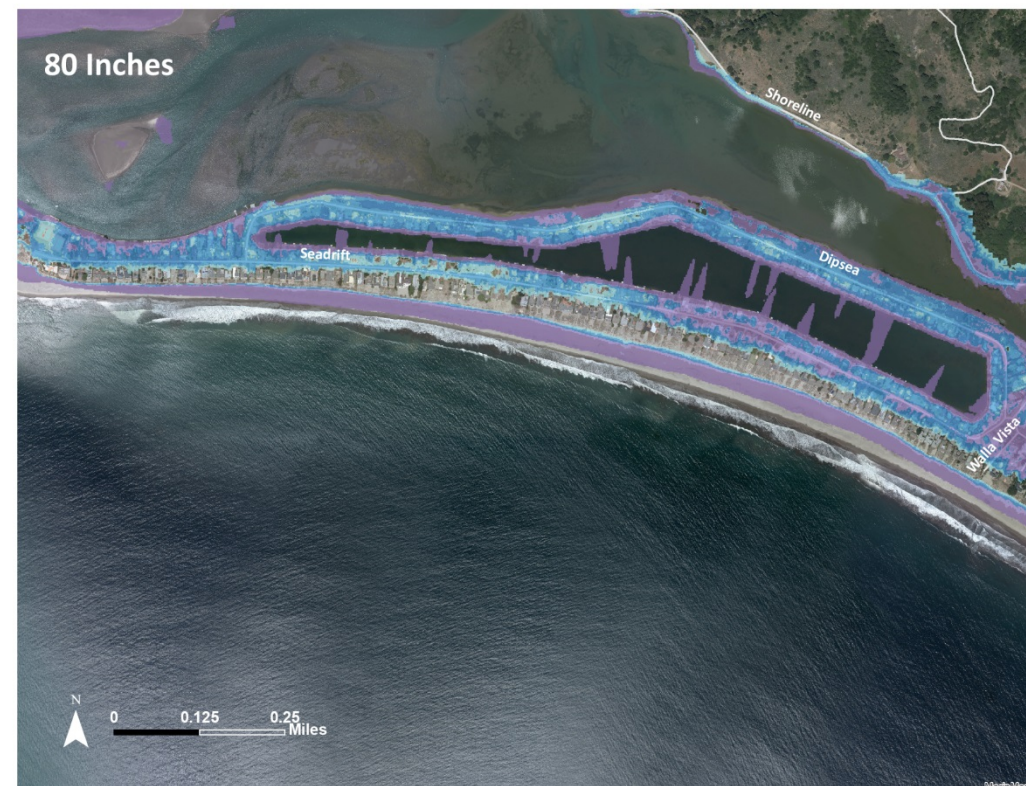
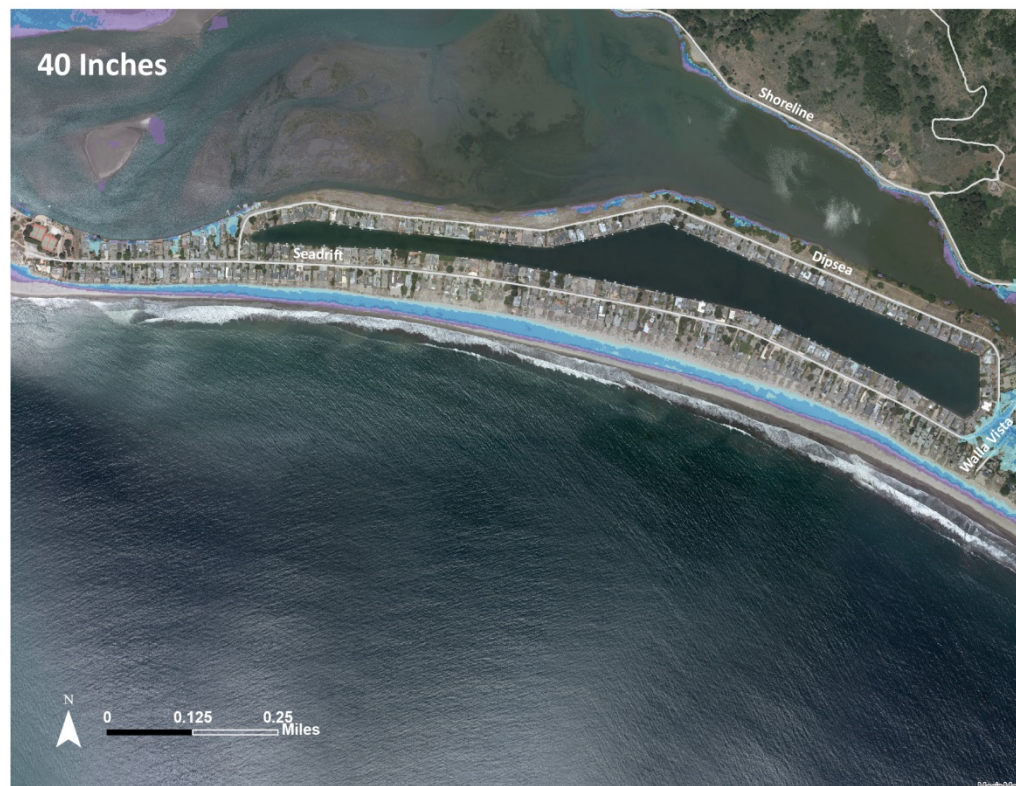
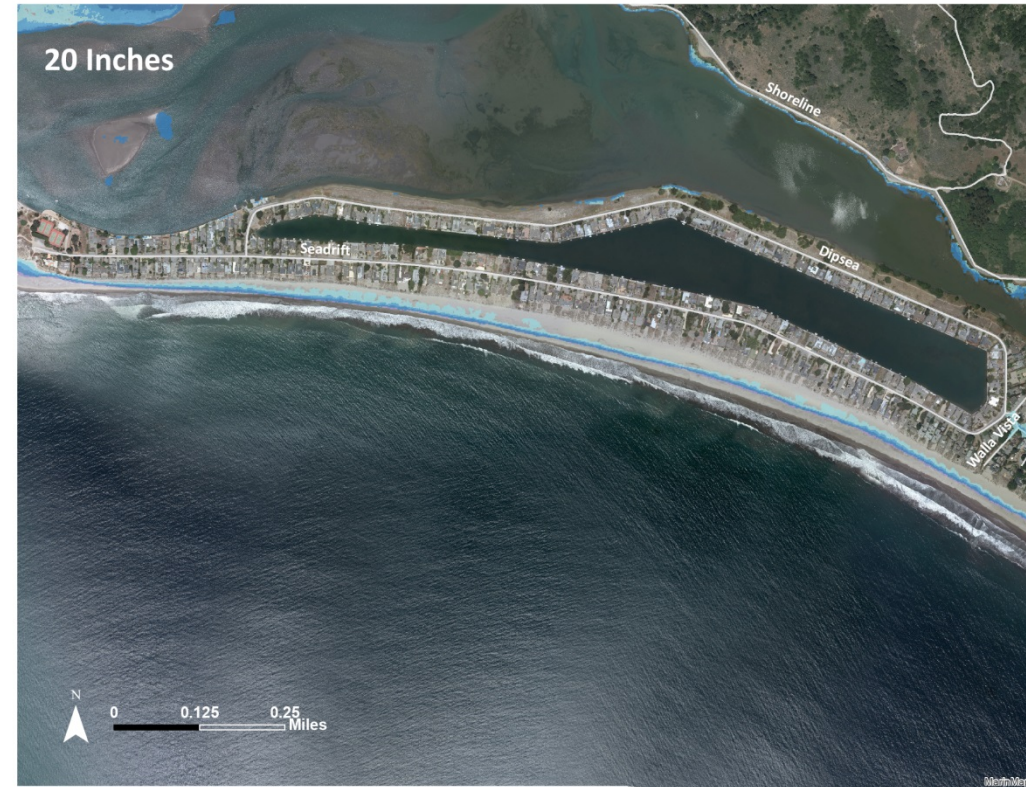
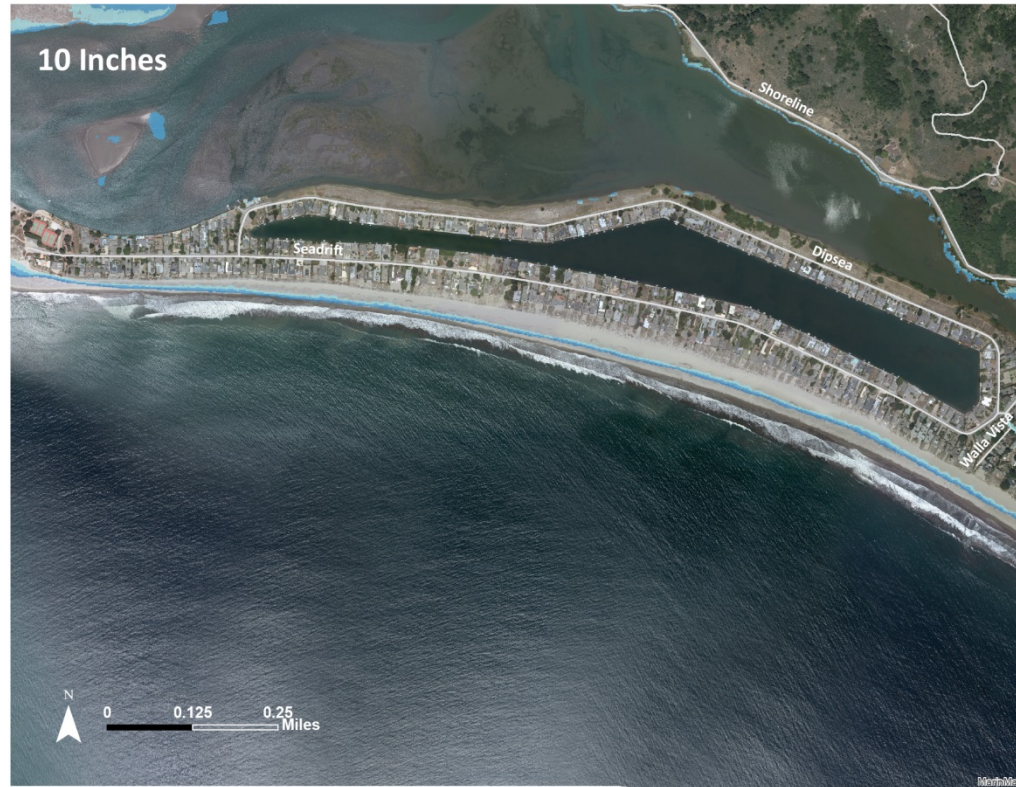
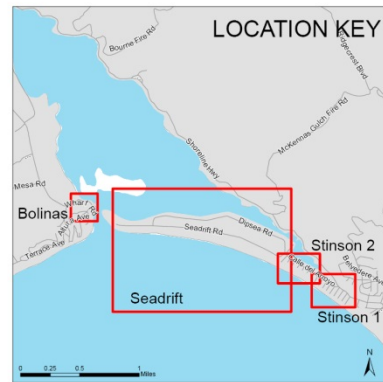


**Flood Depth (feet)**

- 0 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- 4+



Maps 21-24 Stinson Beach 2 Exposure Source: CoSMos



**Flood Depth (feet)**

- 0 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- 4+

**Maps 25-28 Seadrift Exposure** source: CoSMos

## 6.4) Bolinas

### PRIMARY VULNERABILITIES

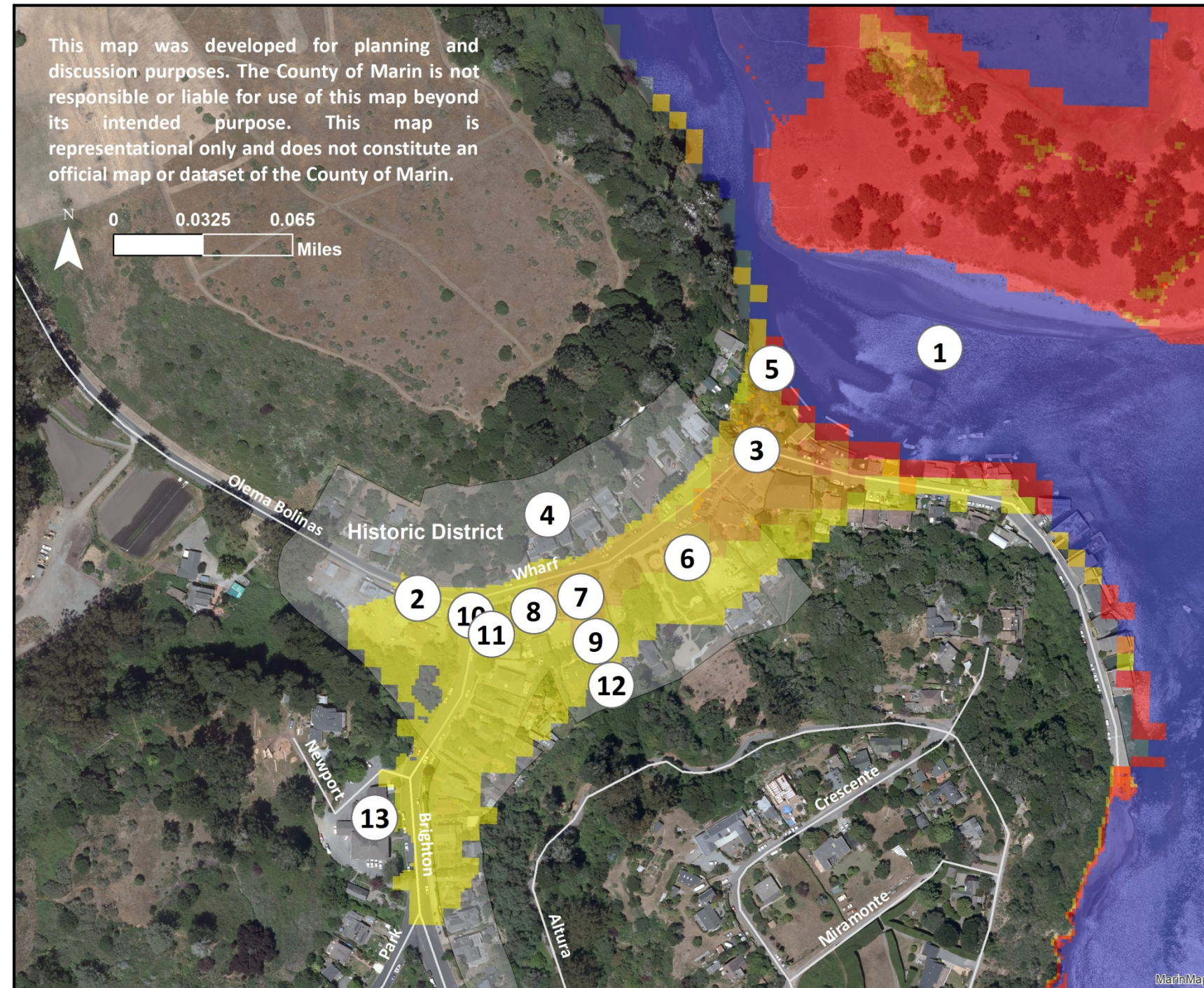
- Storm and tidal impacts already occur
- Long-term flooding will impact 98 buildings and 1,620 people
- Costs of long-term impacts to exposed assets will be \$18 million
- Those impacted will include the crabbing and tourism industries, Bolinas Public Utilities

### PRIORITY ACTIONS

- Protect sewage treatment facility
- Continue restoring wetlands in Bolinas Lagoon
- Accommodate threatened structures through elevation and retrofitting
- Elevate or reroute threatened roads
- Elevate or relocate grocery store, emergency shelter, and library

Strategy	Timeframe/Term NT=Near MT=Medium LT=Long	Support L=Low 0-40% M=Moderate 41-70% S=Strong 71%+ NA=Not available
<b>PROTECT</b>		
• Maintain existing shoreline armoring at risk of causing more bluff and beach erosion	• NT	• NA
• Install new armoring along cliffs	• NT	• L
• Beach nourishment, especially along Brighton Beach	• NT	• L
<b>ACCOMMODATE</b>		
• Elevate development, particularly in downtown area	• MT	• L
• Elevate or realign Wharf Rd and Olema-Bolinás Rd at the bridge over Pine Gulch Creek	• NT-MT	• L
<b>RELOCATE/MANAGED RETREAT</b>		
• Research costs and interest of long-term buyout or acquisition strategy	• LT	• NA
• Remove armoring at Brighton Beach, relocate structures inland, allow inland migration of beach	• LT	• M
• Require bluff top setbacks based on 50-year timeframe and analysis	• NT	• NA
• Establish a bluff top erosion trigger for removal of structures	• NT	• NA

# Bolinas



## Vulnerable Assets

Site Specific Assets Identified on Map

- 1 Bolinas Lagoon
- 2 Olema-Bolinas Road / Tsunami Evacuation Rte.
- 3 Wharf Road
- 4 Historic District
- 5 Sewage Lift Station
- 6 Bolinas Super Market
- 7 Bolinas Library
- 8 Bo-Gas Station
- 9 Bolinas Community Center/ Emergency Shelter
- 10 Bolinas Community Land Trust
- 11 Calvary Church
- 12 Bolinas People's Store
- 13 Bolinas Post Office

Buildings Potentially Facing Hazardous Conditions plus some septic systems and water distribution lines



### Sea Level Rise (SLR) Scenarios

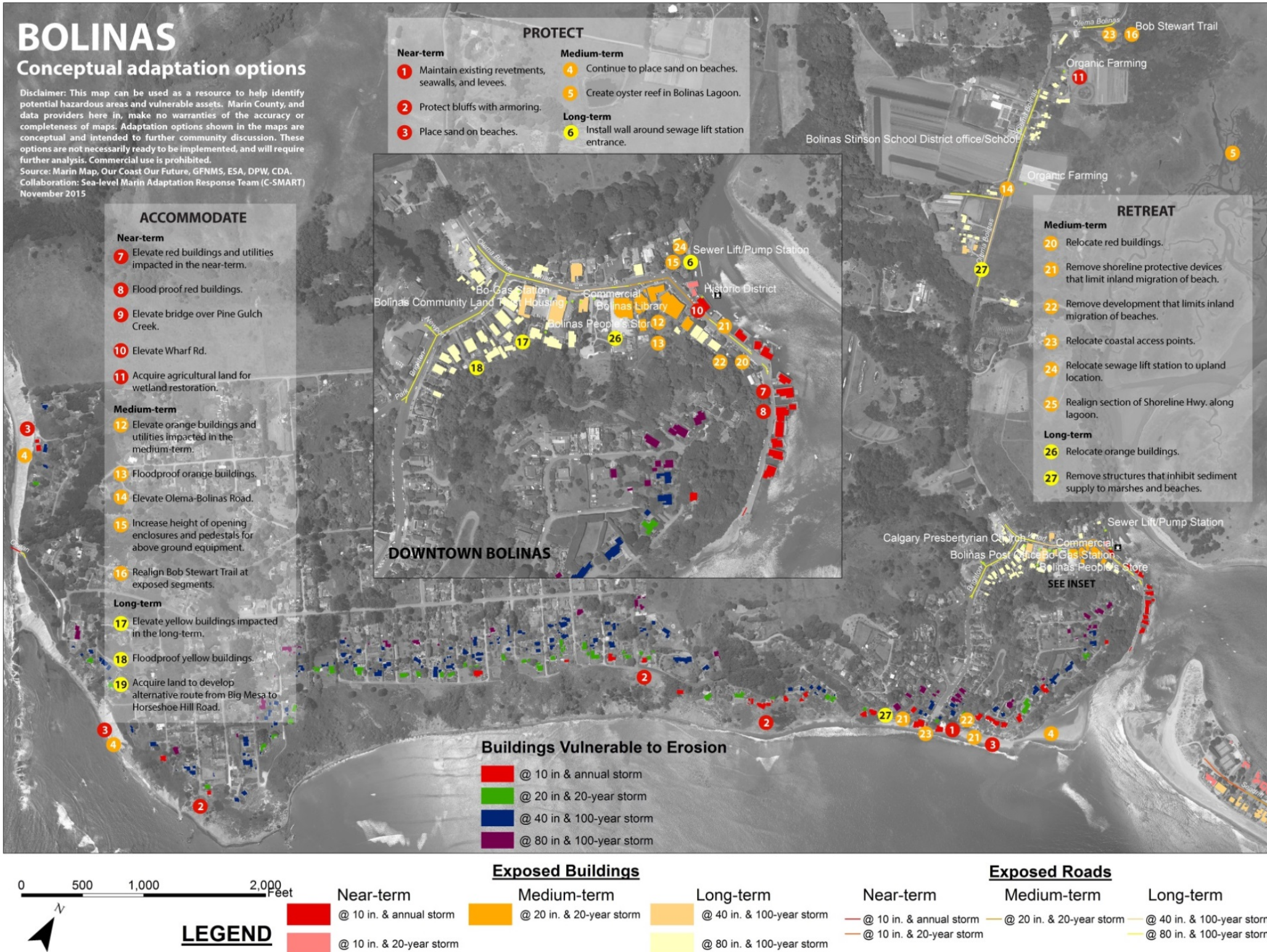
- Baseline No SLR / No Storm
- 25 cm (≈1 foot) SLR w/annual storm
- 25 cm (≈1 foot) SLR w/20 year storm
- 50 cm (≈2 feet) SLR w/20 year storm
- 100 cm (≈3 feet) SLR w/100 year storm
- 200 cm (≈6.5 feet) SLR w/100 year storm

Map 29. Bolinas Exposure Map. Does not include geomorphic change.

# BOLINAS

## Conceptual adaptation options

Disclaimer: This map 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. Adaptation options shown in the maps are conceptual and intended to further community discussion. These options are not necessarily ready to be implemented, and will require further analysis. Commercial use is prohibited.  
Source: Marin Map, Our Coast Our Future, GFNMS, ESA, DPW, CDA.  
Collaboration: Sea-level Marin Adaptation Response Team (C-SMART) November 2015



to be planned for, incorporating future SLR and storm surge scenarios.

### No action

In the near-term, downtown buildings could be affected by temporary storm flooding. More intense storms and wave action may hasten bluff erosion, jeopardizing bluff-top homes. Beaches trapped by armoring and development could disappear. SLR and erosion could significantly impact sewage collection and water distribution systems in downtown and on the Little Mesa. Inundation of the Olema-Bolinās Road or its bridges for extended periods of time could have drastic impacts for both emergency access and regular usage by residents and visitors.

### Priority Actions

Accommodation of threatened structures and utilities through elevation and retrofitting could be a priority action. Shoreline Highway and Wharf Road are of primary concern in the near-term, while Olema-Bolinās Road and the bridge at Pine Creek Gulch may need to be elevated or rerouted in the medium term. Bluff top homes may need to be removed once the bluff edge erodes to endanger the structure and those living in it.

The Sewage Treatment Facility will need to be protected, and other critical facilities and community resources like the grocery store, emergency shelter and library will need to be elevated or relocated in the medium-term. The Post Office and Bolinās-Stinson School will need to be elevated or relocated in the long-term.

Wetland protection and enhancement efforts (currently underway as part of the Bolinās Lagoon Restoration Project) will also have flood protection benefits and should continue



Bolinās at King Tide. Lighthawk Aerial, 2015

### BOLINAS: LONG-TERM SLR IMPACTS

98 buildings	1,620 people
Storm and tidal impacts already occur	12 businesses
18 million worth of assets exposed	Residential, crabbing, tourism
	Property Owners BPUD County Public Works

The following sections provide additional information about strategies considered during the C-SMART project. They are grouped according to general approach: protect, accommodate, or retreat.

### Protect

#### Maintain seawalls and revetments

Homes built at the top of steep eroding cliffs in Bolinās will become increasingly jeopardized. Existing hazards are apparent from the rock revetment and seawalls presently built in front of homes and along bluff toes in the area. In the near-term, property owners could maintain existing revetments, seawalls, and levees. However, if shoreline protective

devices remain along the cliffs in Bolinas, the beach can be expected to erode and be inundated by SLR and eventually disappear, affecting recreational opportunities and ecological function. If further armoring measures are taken along the cliffs in Bolinas, the supply of sediment from the cliffs to the beach will be further reduced, likely accelerating beach loss. Reduced beach widths result in increased loadings and structural requirements on seawalls, and maintenance/improvement costs may outweigh the values of the properties.<sup>78</sup> This strategy received moderate support from poll respondents (40%).

#### ***Place sand on beaches***

Beach nourishment could provide short-term benefits of maintaining a beach for ecology and recreation services, while reducing wave run-up on seawalls and bluffs along the south-facing shores of Bolinas west of the Bolinas Lagoon mouth. For example, beach nourishment could be used to maintain Brighton Beach and the protection it provides to oceanfront homes.

In the long term, beach nourishment will become more expensive as sand sources are limited and the amount of sand required increases with sea-level rise. The presence of seawalls along the western-facing stretch near the Brighton Avenue beach access has contributed to accelerated erosion. As in Stinson Beach, this strategy would require continued sand placement over time, and is not a sustainable long-term solution. Beach nourishment could be financed through a local

assessment district, and received moderate support from poll respondents (40%).

Inside the lagoon mouth along Wharf Road, nature-based strategies for managing SLR may be difficult to implement. This would require an evaluation of how the lagoon mouth is likely to evolve, how it interacts with the lagoon and the cliffs and what opportunities or constraints this might create. The lagoon mouth configuration and slough channel along Wharf Road are hurdles to implementing an adaptation measure such as a horizontal levee. The slough channel would need to be realigned, limiting boat access from Wharf Road homes.

#### ***Support Bolinas Lagoon Restoration efforts***

Many of the recommendations of the [Bolinas Lagoon Ecosystem Restoration Project](#) focus on removing impediments to the exchange of flow and sediment from the lagoon and its watershed and enhancing wetland habitats using natural processes to allow the lagoon to move inland where possible, and to preserve the adaptive capacity of the lagoon. Other key recommendations for restoration include: Remediate watershed disturbances; Restore Kent Island as a dynamic flood shoal island; Restore eelgrass, if suitable habitat is available in Bolinas Lagoon; Investigate managing tidal exchange of Seadrift Lagoon to promote tidal circulation; and actively plan and manage for SLR (see next page). The County and Caltrans could plan for roadway and culvert improvements, including possible elevation of roadways to reduce impacts to the lagoon and improve habitat connectivity.<sup>79</sup>

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<sup>78</sup> Environmental Science Associates (ESA). *Sea Level Rise Adaptation Alternatives for Marin County*. 2015.

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<sup>79</sup> Gulf of the Farallones National Marine Sanctuary (GFNMS). [Bolinas Lagoon Ecosystem Restoration](#)



The San Francisco Bay Joint Venture sponsored a scientific panel of experts to evaluate the Bolinas Lagoon Restoration Project. Marin County Parks hired one of the participants, Dr. Peter Baye, to summarize the meeting. The following are the general recommendations which emerged from this group<sup>80</sup>:

**The important new perspectives from the meeting are as follows:**

- Accelerated SLR replaces previous concerns over the loss of tidal prism as the overriding impact to the lagoon’s ecosystem structure and function.
- In the context of SLR, sediment can be an important asset to the lagoon.
- Accommodation room for the lagoon to migrate inland as sea level rises is necessary for the long-term health and stability of Bolinas Lagoon.
- Bolinas Lagoon’s barrier spit and tidal inlet are essential components of its evolution and response to SLR.

**The DRG also made the following general recommendations:**

- Revised conceptual models of Bolinas Lagoon should be developed to guide ecosystem planning, project prioritization, public education, and project re-evaluation.
- Planning for various SLR and storm surge scenarios should be

incorporated into the restoration project.

- Armoring is a liability for lagoon resilience and adaptation to rising sea level.

**Finally, the DRG made the following project and area specific recommendations:**

- There was consensus that maintaining the channelization of Pine Gulch Creek was detrimental to the long-term evolution of the lagoon.
- The Pine Gulch Creek delta and its floodplain are essential for the future rising lagoon edges and may provide area for habitat to shift and evolve as sea levels rise.
- There was no consensus about whether the Pine Gulch Creek delta is a liability to the lagoon’s resilience to SLR.
- The Lewis and Wilkins Gulches (the area known as the “Y”) is another highly important zone for lagoon accommodation space, tidal marsh and floodplain migration, and sediment management opportunities in response to SLR.
- The drainages of the eastern shore of Bolinas Lagoon are also important to accommodate the lagoon’s inland migration.
- The DRG noted that Marin County and the GGNRA evaluated potential alternatives to address flooding along Easkoot Creek through a separate process.

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[Project. Recommendations for Restoration and Management.](#) August 2008.

<sup>80</sup> Conclusions and Recommendations of the Bolinas Lagoon Restoration Project Design Review Group (DRG). March 2014

## Accommodate

### **Elevate homes**

Many structures in Bolinas, particularly in the historic downtown area, are vulnerable to flooding in their current condition. The typical cost of elevating a structure ranges from \$140 per square foot in the flood zone to \$230 in the wave zone.<sup>81</sup> The cost of elevating homes and associated utilities would be borne by individual homeowners. Buildings on Wharf Road could be further elevated on their existing pier foundations. By including proper stormwater features such as flap gates, an elevated Wharf Road could also protect the low lying neighborhood behind it. See the Stinson Beach section for a discussion of FEMA requirements and potential impacts of home elevation. This strategy received moderate support from poll respondents (40%).

### **Elevate roads**

General approaches for adapting roads to SLR include identifying water level triggers for management actions, and coordinating with DPW and Caltrans. They are further described in the “Transportation” section of this report.

Elevation (or realignment) could be considered for County-owned roads, including Wharf Road and Olema-Bolinas Road at the bridge over Pine Gulch Creek. However, these projects must compete with many others for limited funds. This strategy received moderate support from poll respondents (40%).

Shoreline Hwy along Bolinas Lagoon will be impacted by SLR. If anticipated precipitation patterns change with climate change to more flashy storms, culverts on many streams will

need to be upgraded to convey higher peak flows. This requires either larger culverts or raising the roadway on piles to allow conveyance of storm runoff. In the context of sea-level rise, a piled causeway design could provide further ecological benefit by allowing migration of habitat under the roadway and upland.

Road elevation is preferred in Bolinas by [GFNMS to allow for wetland migration](#). GFNMS would need to be involved in new road design and construction review including avoiding risks of materials entering the sanctuary.

## Relocate/ Managed Retreat

Marin County could research potential costs and community interest in a long-term buyout or property acquisition strategy if rising sea levels or storm impacts become imminent threats to homeowners. The County could also consider having a plan and specific proposals in place in case of a major storm/flood event that makes homeowners more likely to be interested in a buyout.<sup>82</sup> Rolling easements and other land use policies could be used to limit further construction and investment in the most hazardous areas.

To maintain Brighton Beach, existing armoring could be removed and development removed or relocated. Services such as utilities and roads could be realigned in an orderly manner over time to limit costs and avoid catastrophic failure and hazardous conditions. The idea of removing shoreline protective devices that limit the inward migration of beaches received moderate support from poll respondents (60%).

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<sup>81</sup> Environmental Science Associates (ESA). *Sea Level Rise Adaptation Alternatives for Marin County*. 2015.

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<sup>82</sup> Center for Ocean Solutions, Natural Capital Project. *Coastal Adaptation Policy Assessment Marin County*. 2016.

### **Blufftop development setbacks**

Under the County's proposed LCP standards, new development must be set back from the bluff edge a sufficient distance to ensure its stability and structural integrity for a minimum of 100

years and to eliminate the need for shoreline protective devices. Coastal hazards analyses for individual sites must include a slope stability analysis that considers historical bluff retreat data as well as accelerated erosion due to SLR.<sup>83</sup>

For informational purposes and to guide the identification of potential planning triggers for removal of existing structures in hazardous areas, ESA produced bluff erosion hazard zones for both projected historic rates and amplified rates from SLR. These rates and buffers are summarized and compared against other suggested values in Table below. Setbacks are specified for each planning timeframe; ESA setbacks are referenced to 2010 conditions. Corresponding erosion rates are reported for historic and 2100 accelerated conditions from the 2009 Pacific Institute study<sup>84</sup> that considers high SLR.

The ESA setbacks for each reach were determined using the average erosion rate plus one or two standard deviations within each reach. It is helpful to think about the average and standard deviations of erosion rates as the likelihood of exceedance; the average plus two standard deviations describes a setback that is not likely to be exceeded (around 2% of locations/ times), whereas adding one standard deviation indicates exceedance may occur

around 15% of the locations/ times, and use of the average (no additional standard deviation) indicates the distance could be exceeded at about 50% of the locations/ times. Thus, there is uncertainty in all estimates of future erosion distances, and selection of the distances is affected by tolerance for risk such as loss of property or infrastructure.

Setbacks for development and planning in Bolinas (and elsewhere) should use a minimum 100 year analysis timeframe and apply SLR-accelerated erosion rates with a factor of safety (1-2 standard deviations of the erosion rate, with an additional landslide offset where applicable). Site-specific evaluation of erosion rates is required; the average values in Table could be considered as a minimum.

**New Construction:** Setback that considers long term erosion plus accelerated erosion due to sea-level rise (sea-level rise rate to be determined by County) plus factor of safety that includes erosion variability and/or landslides or block failure widths where applicable. For the example of a new structure with a structure life of 50 years, this setback could be 225 feet (50 year offset from average erosion plus 2 StDev).

**Existing Structures (planning trigger):** The County could consider identifying a minimum distance between existing structures and bluff edge, at which point planning for structure removal would be initiated. Local studies are required to assess local geologic conditions and characteristic block failure (or landslide) widths. Generally, a planning timeframe could be established that determines a distance set by long term plus accelerated erosion and a factor of safety. For example, assume it takes 5 years for permitting/planning to remove or relocate a structure: using a near term retreat rate of 3.7

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<sup>83</sup> Marin County Community Development Agency. [Draft Local Coastal Program, Environmental Hazards Chapter LUPA](#). April 2016

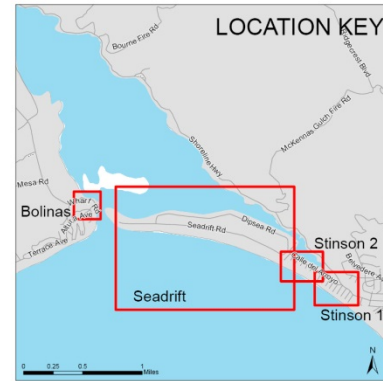
<sup>84</sup> Pacific Institute. [The Impacts of Sea Level Rise on the California Coast](#). 2009.

feet per year (average plus 2 StDev) and a 45 foot block failure factor, the trigger distance (from structure to bluff edge) to start planning

would be 64 feet (3.7 ft/yr times 5 years = 18.5 feet, plus 45 feet).

Table 28. Bolinás Open Coast Bluff Erosion Setbacks Considering Various Guidelines

Erosion Buffers and Rates	40 yrs (2050)	50 yrs (2060)	100 yrs (2110)	150 yrs (2160)	Erosion Rate (R)	FOS (+X StDev)	Equivalent Rate (R+FOS)
<b>Coastal Commission Interpretive Guidelines for Marin County:</b>							
Minimum setback for new construction:	(120 ft)	150 ft	(300 ft)	(450 ft)	<b>3 ft/yr</b>	-	-
<b>Environmental Hazards Element of the Marin Countywide Plan:</b>							
Little Mesa to Duxbury Reef	80 ft	(100 ft)	(200 ft)	(300 ft)	<b>2 ft/yr</b>	-	-
Duxbury Reef to Point Reyes	120 ft	(150 ft)	(300 ft)	(450 ft)	<b>3 ft/yr</b>	-	-
<b>Bolinás Gridded Mesa Plan (1985):</b>							
Overlook to Duxbury Point	-	145 ft	245 ft	345 ft	<b>2 ft/yr (+45 ft)</b>	-	-
Duxbury Point to Poplar Road	-	170 ft	295 ft	415 ft	<b>2.5 ft/yr (+45 ft)</b>	-	-
<b>ESA - considering only USGS historic (1929-1998) erosion rates:</b>							
Little Mesa to Duxbury Reef (+1 StDev)	116 ft	145 ft	290 ft	435 ft	1.5 ft/yr	1.4 ft/yr	<b>2.9 ft/yr</b>
Duxbury Point to Poplar Road (+1 StDev)	80 ft	100 ft	200 ft	300 ft	1.3 ft/yr	0.7 ft/yr	<b>2 ft/yr</b>
Little Mesa to Duxbury Reef (+2 StDev)	172 ft	215 ft	430 ft	645 ft	1.5 ft/yr	2.8 ft/yr	<b>4.3 ft/yr</b>
Duxbury Point to Poplar Road (+2 StDev)	108 ft	135 ft	270 ft	405 ft	1.3 ft/yr	1.4 ft/yr	<b>2.7 ft/yr</b>
<b>ESA - considering accelerated erosion rates due to SLR (PWA 2009):</b>							
Little Mesa to Duxbury Reef (+1 StDev)	212 ft	160 ft	475 ft*	N/A	1.5-4.3 ft/yr**	1.1-3.1 ft/yr**	<b>2.6-7.3 ft/yr**</b>
Duxbury Point to Poplar Road (+1 StDev)	82 ft	104 ft	228 ft*	N/A	1.3-1.5 ft/yr**	0.7-0.9 ft/yr**	<b>2.0-2.6 ft/yr**</b>
Little Mesa to Duxbury Reef (+2 StDev)	171 ft	225 ft	671 ft*	N/A	1.5-4.3 ft/yr**	2.2-6.2 ft/yr**	<b>3.7-10.5 ft/yr**</b>
Duxbury Point to Poplar Road (+2 StDev)	110 ft	140 ft	309 ft*	N/A	1.3-1.5 ft/yr**	1.4-1.8 ft/yr**	<b>2.7-3.3 ft/yr**</b>
*Extrapolated to 2110 using 2100 rate							
**Range: historic to SLR-amplified rate at 2100							



**Flood Depth (feet)**

- 0 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- 4+

**Maps 31-34 Bolinas Exposure** Source: Coastal Storm Modeling System (CoSMos)

## 6.5) Inverness

### PRIMARY VULNERABILITIES

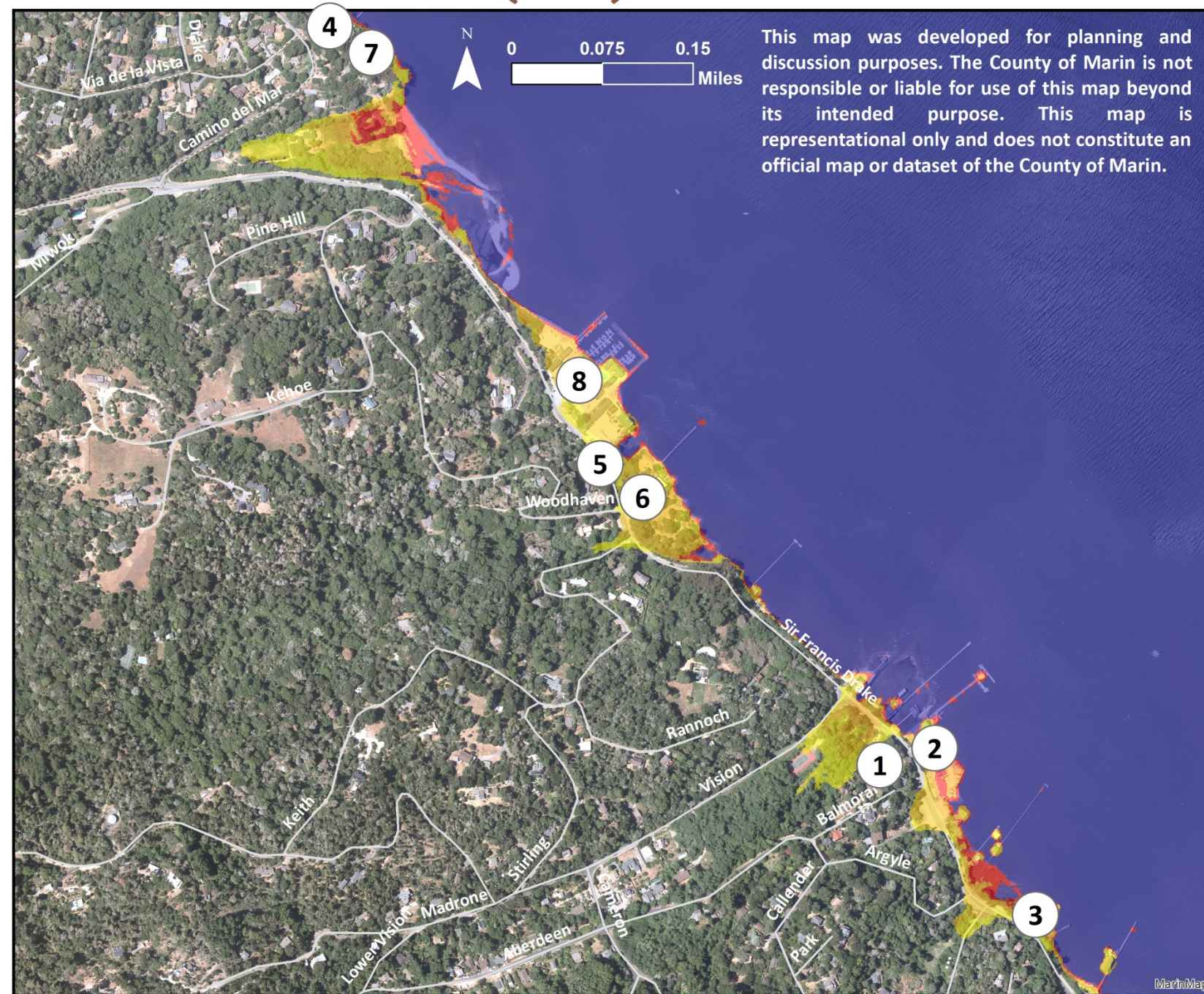
- Storm and tidal flooding already occur
- Long-term flooding will impact 1,130 buildings, 10 businesses, and 1,304 people
- Costs of long-term impacts to exposed assets will be \$11 million
- Others impacted will include the residential tourism industry, DPW, Inverness PUD, NMWD, and property owners

### PRIORITY ACTIONS

- Accommodate existing development by elevating and retrofitting
- Protect assets with nature-based strategies

Strategy	Timeframe/Term NT=Near MT=Medium LT=Long	L=Low 0-40% M=Moderate 41-70% S=Strong 71%+ NA=Not available
<b>PROTECT</b>		
• Restore/enhance wetlands along Tomales Bay shoreline	• NT-MT	• S
• Create a native oyster reef in Tomales Bay	• NT-MT	• L
• Construct horizontal levees in Tomales Bay	• MT	• L
<b>ACCOMMODATE</b>		
• Elevate buildings and utilities	• MT	• M
• Flood proof existing buildings	• NT	• M
• Elevate Sir Francis Drake Blvd on a levee to prevent flooding and protect existing water pipeline under road	• MT	• M
• Elevate Shoreline Hwy	• MT	• M
• Update old septic systems prior to saltwater intrusion	• NT	• S
• Develop a community wastewater system	• MT	• M
• Create offshore boat moorings as marinas become inundated	• NT	• M
<b>RELOCATE/MANAGED RETREAT</b>		
• Relocate coastal access points	• MT	• M
• Remove shoreline protective devices that limit inland migration of shoreline habitats	• MT	• M
• Remove development that limits inland migration (phased based on triggers)	• MT-LT	• M
• Realign Sir Francis Drake Blvd.	• MT	• M

# Inverness (N)



## Vulnerable Assets

Site Specific Assets Identified on Map

- ① NMWD Pipeline
- ② Inverness Yacht Club
- ③ Brock Schreiber Boathouse
- ④ Tomales Bay State Park
- ⑤ Sir Francis Drake Blvd.
- ⑥ Dana Marsh / Beach Access
- ⑦ Shell Beach
- ⑧ Tomales Bay Restort and Marina

Buildings Potentially Facing Hazardous Conditions plus some septic systems and water distribution lines

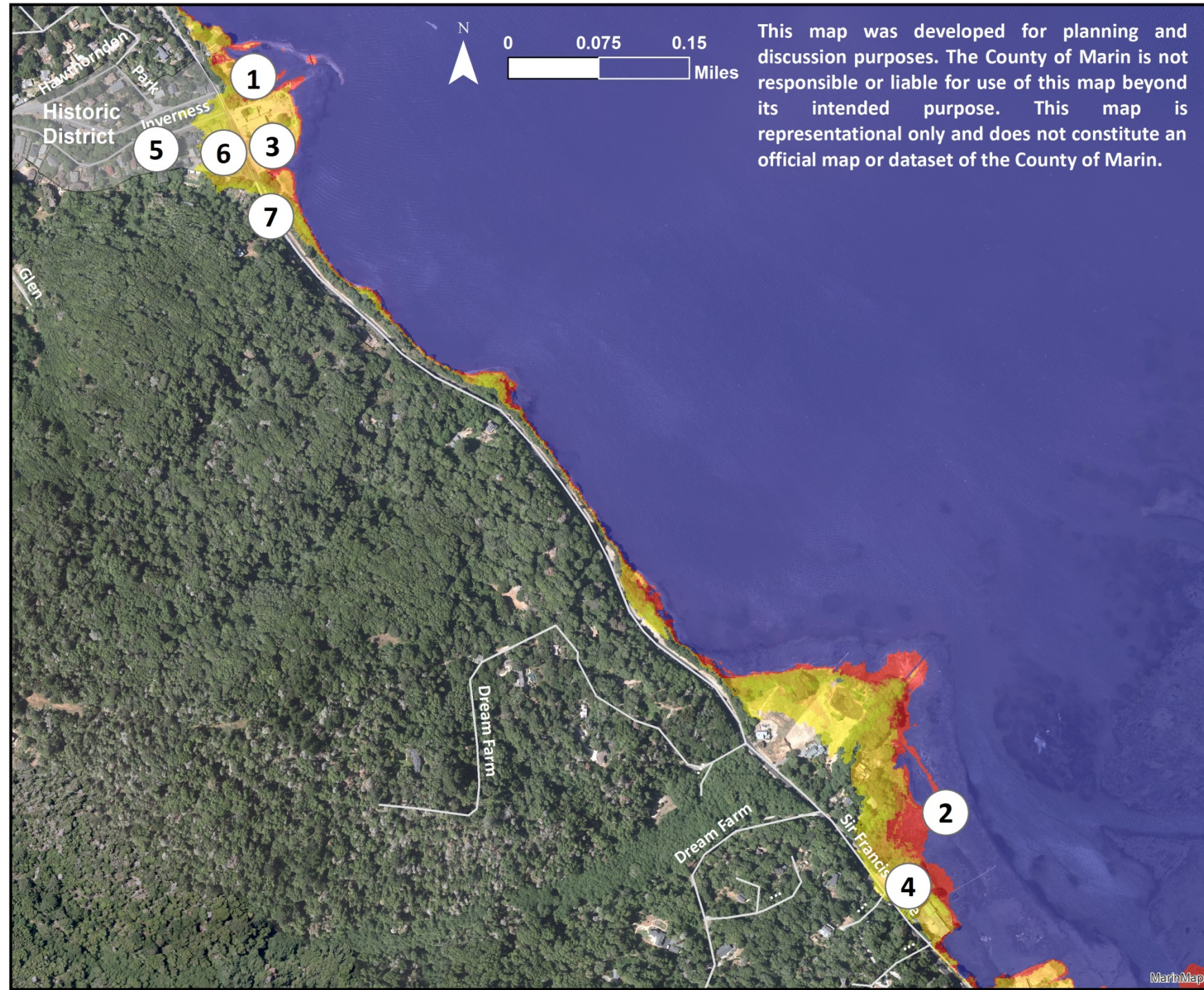


## Sea Level Rise (SLR) Scenarios

- Baseline No SLR / No Storm
- 25 cm (≈1 foot) SLR w/annual storm
- 25 cm (≈1 foot) SLR w/20 year storm
- 50 cm (≈2 feet) SLR w/20 year storm
- SLR100Wave100\_fldhazd\_Erase1
- 200 cm (≈6.5 feet) SLR w/100 year storm

Map 35. Inverness Exposure Map. Does not include geomorphic change.

# Inverness (S)



## Vulnerable Assets

Site Specific Assets Identified on Map

- ① Martinelli Park
- ② Estuarine and Marine Wetlands
- ③ Inverness Store
- ④ Motel Inverness
- ⑤ Historic District
- ⑥ Inverness Post Office
- ⑦ Sir Francis Drake Blvd.

Buildings Potentially Facing Hazardous Conditions plus some septic systems and water distribution lines

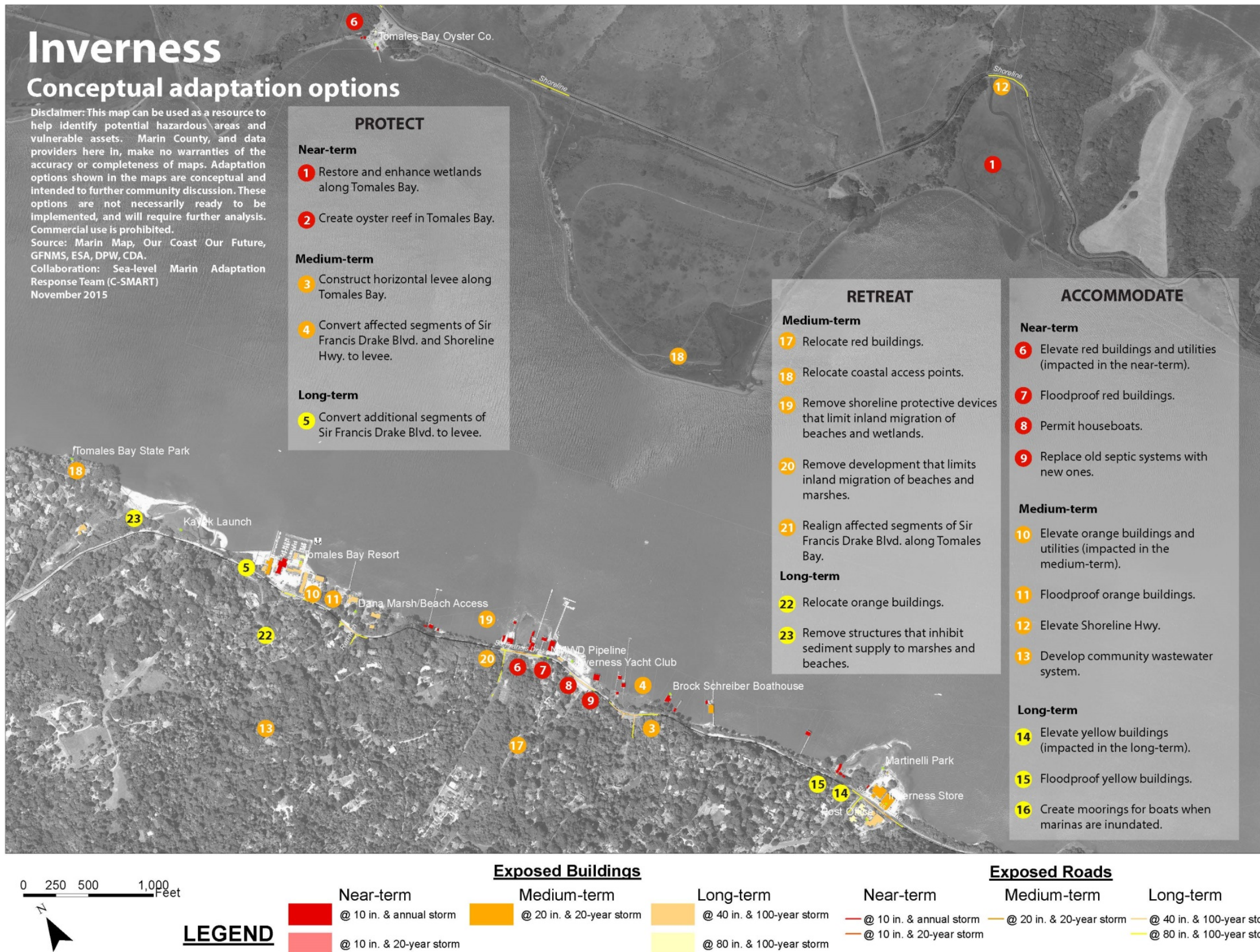


## Sea Level Rise (SLR) Scenarios

- Baseline No SLR / No Storm
- 25 cm (≈1 foot) SLR w/annual storm
- 25 cm (≈1 foot) SLR w/20 year storm
- 50 cm (≈2 feet) SLR w/20 year storm
- SLR100Wave100\_fldhazd\_Erase1
- 200 cm (≈6.5 feet) SLR w/100 year storm

Map 36. Inverness Exposure Map. Does not include geomorphic change.





Map 37. Inverness Adaptation Map

## Inverness

### No action

The main access road, Sir Francis Drake Blvd., could experience frequent flooding and erosion, impeding access for residents, tourists, and emergency responders. Erosion of Sir Francis Drake Blvd. could lead to damage and disruption to drinking water distribution pipelines serving Inverness Park. Several shoreline and pier developments are vulnerable to rising waters and storm impacts.

#### INVERNESS: LONG-TERM SLR IMPACTS

1,130 buildings		1,304 people
Storm and tidal impacts already occur		10 businesses
11 million worth of assets exposed	Residential Tourism	Marin DPW Inverness PUD NMWD Property Owners

### Priority Actions

A possible adaptation approach is to accommodate development with elevation and retrofits, and protect assets with nature-based strategies in the near- to-medium term, while planning for other adaptation measures in the long-term. Homes and other structures currently over water could be raised higher, and portions of roadways like Sir Francis Drake and Shoreline Highway that are critical roads for emergency access could also be raised to maintain access at higher water levels. In addition to protecting properties vulnerable in the near-term, converting affected segments of Sir Francis Drake Boulevard into a levee could

protect water pipeline beneath the road. Wetland restoration and native oyster reefs in the near-term and potentially horizontal levee in the medium-term are potential nature-based solutions.

### Protect

#### Restore/enhance wetlands along Tomales Bay

Restoring and enhancing living shorelines along Tomales Bay offers near- to medium-term protection against temporary flooding, storm surge, and wave impacts. Habitat restoration techniques can be used to manage the shoreline, reduce coastal erosion, and maintain coastal processes. Such techniques enhance habitat values and increase connectivity of wetlands and deeper intertidal and subtidal lands, while providing some amount of shoreline protection. Wetland creation could be effective in limiting erosion of otherwise exposed road embankments (ESA 2015).

Wetland creation involves placing fill in a manner that enhances wetlands but may result in a conversion of wetlands type from subtidal to mudflats or mudflats to tidal marsh. This strategy may not be permitted by GFNMS at this time. Another approach to creating wetlands, usually preferred by permitting agencies, is to excavate soils from existing vacant uplands down to the appropriate grades to allow for tidal or seasonal wetlands to form (DPW 2015). Wetlands projects are complex to design and permit since they must accommodate habitat and flood protection needs. This strategy may involve a moderate to high cost, and will not prevent inundation of low-lying areas unless it is backed by a flood protection levee (CDA, DPW 2015). The effectiveness of wetland solutions will diminish with higher levels of SLR unless grades are raised as the wave dampening ability of tidal

wetlands diminishes with increased water depth (DPW 2015). Wetland restoration could be funded by a local assessment district or government grant, and received strong support from poll respondents (100%).

#### **Create native oyster reef in Tomales Bay**

Another component of living shorelines, native oyster reefs can mitigate erosion and flood hazards where waves are small and weak enough to be dissipated by the limited reef structures. Oyster reefs consist of a hard oyster settlement substrate placed onto a supporting structure, such as wooden pallets or a PVC base, with eelgrass beds later planted between the oyster structures. Scientists and engineers are studying pilot projects near San Rafael through the San Francisco Bay Living Shorelines project to monitor biological recruitment, as well as sedimentation rates behind the oyster reefs to evaluate their erosion protection efficacy (ESA 2015). A native oyster reef could be funded by a local assessment district or government grant, and received moderate support from poll respondents (33%). GFNMS could also strongly support native oyster reef demonstration projects and provide information to help inform the most ideal locations.

#### **Construct horizontal levee along Tomales Bay**

“Horizontal levees” are earthen levees with flatter side slopes towards the water’s edge that use the wave attenuation benefits of expanded wetlands in front of the levee. Horizontal levee projects combine flood protection benefits with habitat benefits, and are frequently discussed by bay scientists and environmental engineers as a viable approach to multi-objective flood protection.

However, there are a number of challenges and uncertainties associated with horizontal levees.

In addition to permitting challenges associated with any fill of Tomales Bay, there are also uncertainties associated with how much flood protection, water quality, and habitat benefits horizontal levees provide. Significant wave attenuation across a tidal marsh requires a minimum width of several hundred feet. Costs for importing and placing fill vary significantly depending on the location and quality of the borrow source of sediment. Generally, the estimated cost is medium-to-high relative to other strategies.

In the medium-term, horizontal levees may serve as protection against SLR where land use, space and habitat allow. All the marshes in Inverness are vulnerable because they are confined by the roadway. As sea levels rise, much of the low salt marsh will be converted to mud and sand flats. Because the Inverness shore is steep, marsh transition areas shrink with elevating sea levels. Areas near Martinelli Park and Dana Marsh may be good candidates for assessing the feasibility of a horizontal levee.

To the extent that other natural habitats in Tomales Bay can be protected, restored, or enhanced, Marin County may bolster the benefits provided by a horizontal levee project and mitigate some of the technical and financial risks associated with the project.<sup>85</sup> The Bay itself is zoned as Open Area, though more detailed analysis would be required to understand if a horizontal levee would impose upon the surrounding residentially-zoned parcels.

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<sup>85</sup> Center for Ocean Solutions, Natural Capital Project. *Coastal Adaptation Policy Assessment Marin County*. 2016.

## Accommodate

### ***Elevate buildings and utilities***

Cost estimates for structural elevation are around \$140/sf for structures in the flood zone, and \$230/sf for structures in the wave zone. Continued livability within elevated structures would also require elevation of associated utilities and roads, which could increase the overall cost significantly. This strategy would be implemented by property owners, and received moderate support from poll respondents (67%). One respondent commented that they only support this strategy if financial assistance is provided to homeowners.

### ***Flood proof buildings***

This strategy would be implemented by property owners, and received moderate support from poll respondents (50%).

### ***Permit houseboats***

Houseboats are not recommended as an adaptation strategy due to strong wind and wave action during storms, increased threat of discharges and marine debris, and lack of houseboat marinas and services. This strategy received no support from poll respondents.

### ***Elevate Sir Francis Drake Boulevard***

Like other SLR road adaptation efforts, approaches include identifying water level triggers for management actions, and coordinating with DPW and Caltrans. They are further described in the "Transportation" section of this report.

Sir Francis Drake Boulevard could be elevated on an earthen levee to protect access to the communities, utilities under the roads, and assets on the landward side of the road. Conversion of affected segments of Sir Francis Drake Blvd. to levee would also protect the NMWD water pipeline in Inverness Park and

downtown. Levees require a large right of way, and costs vary significantly based on the type and location of fill material. This measure could be implemented by the County and/or local service providers, and received moderate support from poll respondents (67%).

### ***Elevate Shoreline Highway***

This strategy would be implemented by Caltrans, and received moderate support from poll respondents (67%). See the East Shore section of this report for further discussion of options for Shoreline Highway.

### ***Update old septic systems***

Saltwater intrusion due to rising sea levels can lead to septic failure, especially for older systems. Updating old septic systems would be implemented by property owners, and received strong support from poll respondents (83%). Across Tomales Bay in East Shore, the Marshall Community Wastewater system is a model for coordinated effort to protect water quality and share costs between government agencies and property owners.

### ***Develop community wastewater system***

This strategy would be implemented by local service provider or a local assessment district, and received moderate support from poll respondents (50%). The recently installed Marshall Community Wastewater System relocated several independent leach fields to a shared leach field east of Shoreline Highway due to water quality violations. However, individual septic tanks and the pipes connecting these homes to the community system will still be vulnerable to corrosion in the long-term.

**Create boat moorings**

Once marinas become unusable due to inundation, the State, County or boat owners could create offshore moorings. This measure received moderate support from poll respondents (50%). Currently the Marina at the Tomales Bay Resort is often silted in, so would potentially benefit from SLR. In 2014, GFNMS and State Lands Commission commenced the [Tomales Bay Mooring Program](#) to permit and lease moorings in Tomales Bay. By November 2016 all abandoned moorings were removed by GFNMS, which contributed to the decrease in the total number of moorings. Although this decrease could be due to the program's costs and requirements, this action freed up space for more moorings on the Bay.

**Ferry on Tomales Bay**

There is some interest among residents in bringing back the ferry from Point Reyes Station to Inverness.

**Relocate/ Managed Retreat**

In the long-term, realignment of development farther landward within a managed retreat context is an option that would maintain no net loss of ecological function of coastal assets, limit costs and increase resilience. For example, the cost associated with structural modification is reduced if the structure is moved inland, though moving costs would need to be considered to fully determine net savings/losses.

Relocation of coastal access points would be implemented by the County, and received moderate support from poll respondents (67%). Removing shoreline protective devices that limit inland migration of beaches and wetlands would be implemented by property owners, and received moderate support from poll

respondents (67%). Removal of development that limits inland migration of beaches and marshes is noted in the horizontal levee discussion above. Relocation of buildings could be phased according to identified triggers, and would be implemented by property owners, and received moderate support from poll respondents (50%). Realignment of affected segments of Sir Francis Drake Blvd. along Tomales Bay would be implemented by the County in collaboration with affected landowners, and received moderate support from poll respondents (50%).

Marin County could research potential costs and community interest in a long-term buyout or property acquisition strategy if rising sea levels or storm impacts become imminent threats to homeowners. The County could also consider having a plan and specific proposals in place in case of a major storm/flood event that makes homeowners more likely to be interested in the buyout.<sup>86</sup> Easements and other land use policies could be used to limit further construction and investment in the most hazardous areas. These easements would move (or "roll") with bluff and shore erosion.

Potential locations of adaptation strategies are shown in [Map 37](#).

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<sup>86</sup> Natural Capital Project, Center for Ocean Solutions. *Coastal Adaptation Policy Assessment*. 2016.

## Green Strategy: Offshore Bio-beds in Tomales Bay



*SF Bay Living Shorelines project. Kiriakopolos, 2014.*

**Benefits:** Public health, Recreation, Tourism, Carbon sequestration, Water quality.

**Costs:** Unknown

Living Shorelines projects use habitat restoration techniques to manage the shoreline, reduce coastal erosion, and maintain coastal processes while protecting, restoring, and creating natural habitat for aquatic flora and fauna. Such techniques enhance habitat values and increase connectivity of wetlands and deeper intertidal and subtidal lands, while providing some amount of shoreline protection.

ESA is currently monitoring the San Francisco Bay Living Shorelines project<sup>87</sup>. This pilot project is investigating the ideal configurations and size scales of oyster reefs and eelgrass beds for habitat enhancement. Oyster and eelgrass reefs were constructed at two sites in San Francisco Bay in 2012 (China Camp State Park in San Rafael, and near Eden Landing in Hayward).

Oyster elements all consist of a hard oyster settlement substrate of some type placed onto a supporting structure. In past

projects, a wooden pallet has been used to support oyster shell or other substrates, while this project uses a PVC base structure. Oyster bag mounds were then placed on the base as an oyster recruitment structure (other small pilot cases use inexpensive modular cement structures).

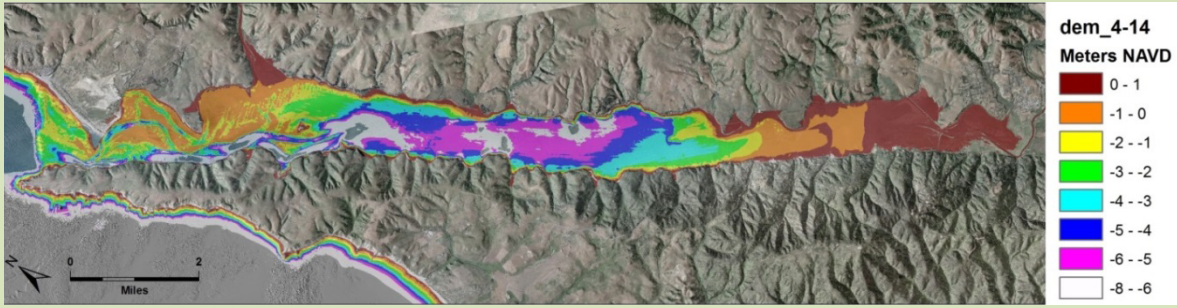
Experimental treatment plots of 32 by 10 meters were constructed parallel to shore, approximately 250 m from the shore, with eelgrass beds later planted between the oyster structures using shoot transplants as well as buoy-deployed seeding. In addition to biological recruitment monitoring by others, ESA is actively monitoring the sedimentation behind these oyster reefs to evaluate the erosion protection efficacy (ESA 2015).

Oyster reefs are considered potential erosion and flood hazard mitigation measures where waves are small and weak enough to be dissipated by the limited reef structures. Hence, this measure is potentially viable only in estuarine areas such as Tomales Bay and Bolinas Lagoon (ESA 2015).



*Oyster Bag mounds. M. Latta, 2012.*

<sup>87</sup> San Francisco Bay Living Shorelines Project. [http://www.sfbaylivingshorelines.org/sf\\_shorelines\\_about.html](http://www.sfbaylivingshorelines.org/sf_shorelines_about.html)



Map 38. Bathymetry of Tomales Bay

Source: ESA (2015), DEM source: USGS (Foxgrover & Barnard 2012)

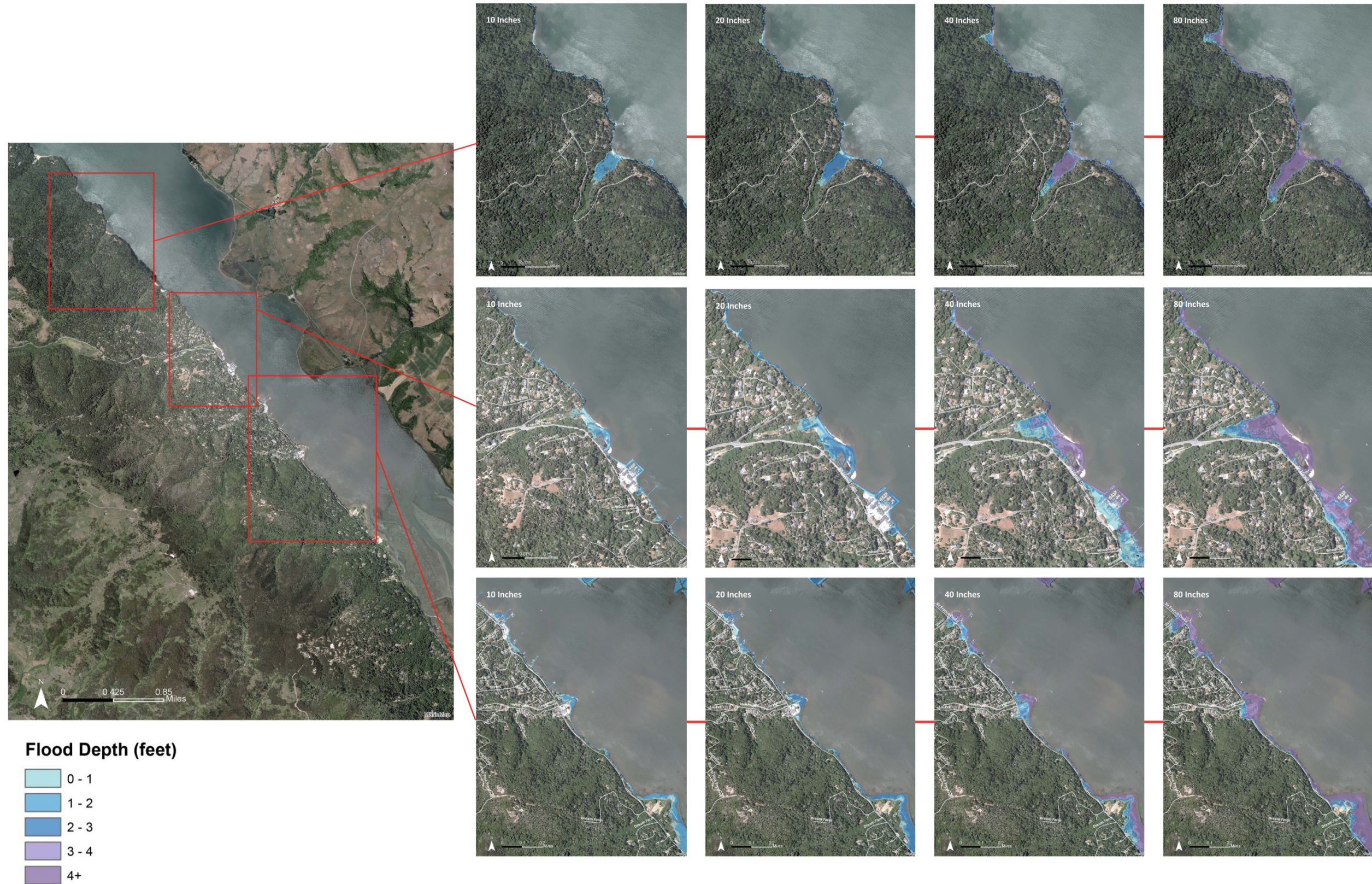
Oyster reefs may not be a viable solution to erosion and flooding hazards in deeper bay areas. However, relatively shallow areas may be suitable for oyster reefs as a nature-based erosion mitigation alternative to shoreline revetment. Oyster reef growth also has specific water flow and clarity requirements which may further restrict applicability. In the absence of detailed bathymetric data in Tomales Bay, the DEM utilized in the OCOF hazard mapping study was used to identify potential areas where relatively shallow slopes exist near human development. These areas mostly occur along the Inverness shoreline and Millerton. A detailed feasibility analysis could be conducted to fully understand the possible opportunities and constraints to using oyster reefs in Tomales Bay.

Also studied in the San Francisco Bay Living Shorelines study, eelgrass beds are another possible means of wave energy attenuation. Various studies have examined wave attenuation from sea grasses in low-energy environments (Bradley & Houser 2009; Fonseca & Calahan 1992; Wu & Cox 2015). Similar to oyster reefs, seagrass beds require shallow water among other factors to flourish, and are thus limited in applicability to wide shallow areas in

Tomales Bay., including the Walker Creek Delta area.



Eelgrass in Tomales Bay. Kinyon 2009.



**Maps 39-51 Inverness Exposure** Source: Coastal Storm Modeling System (CoSMos)



## 6.6) East Shore

### PRIMARY VULNERABILITIES

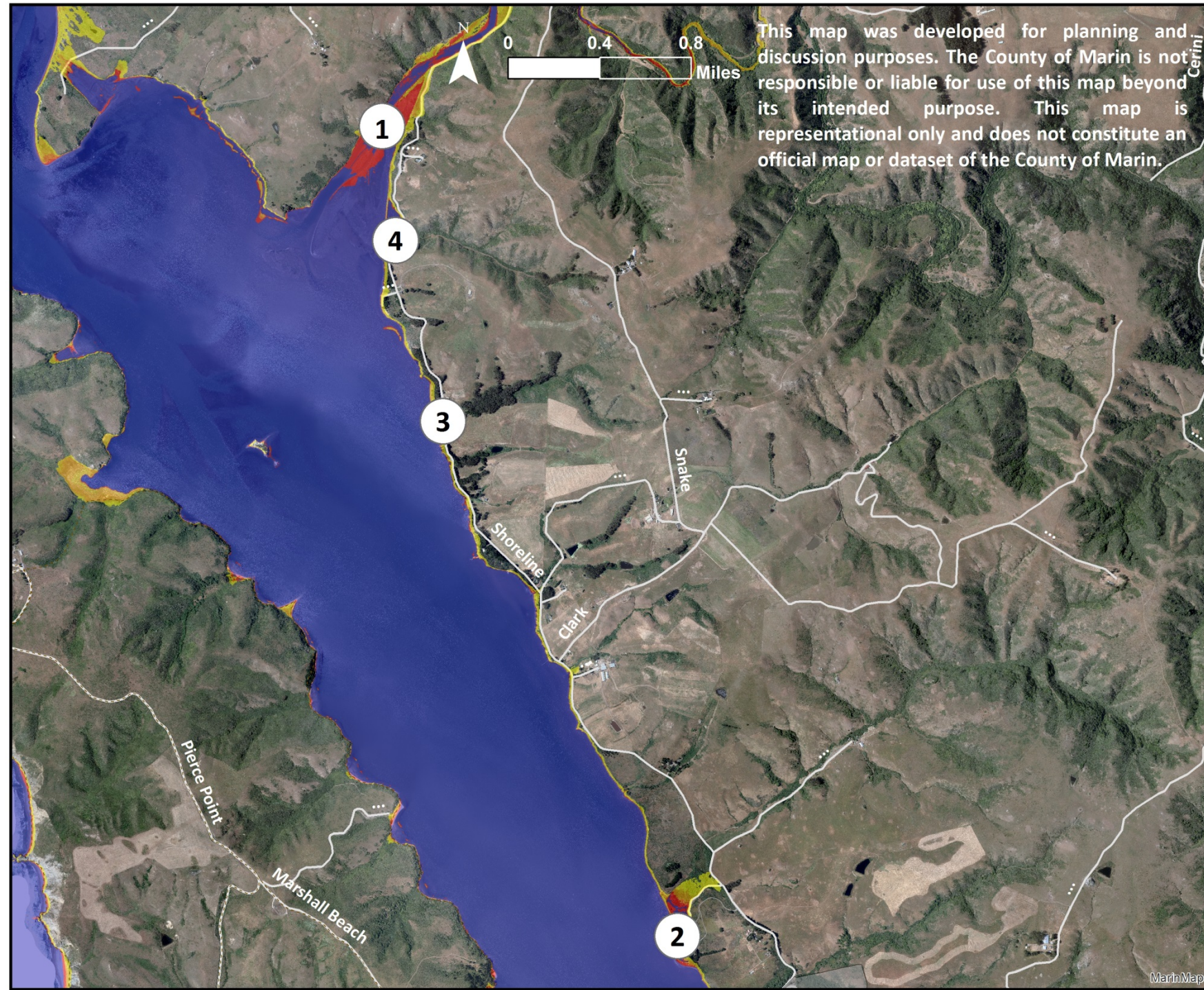
- Storm and tidal impacts already occur
- Long-term flooding will impact 163 buildings and 10 businesses
- The cost of impacts to exposed assets will be \$14 million
- Others impacted will be the residential tourism and aquaculture industries, Caltrans, and property owners

### PRIORITY ACTIONS

- Elevate and retrofit existing development
- Protect assets with nature-based strategies

Strategy	Timeframe/Term NT=Near MT=Medium LT=Long	L=Low 0-40% M=Moderate 41-70% S=Strong 71%+ NA=Not available
<b>PROTECT</b>		
• Restore/enhance wetlands along Tomales Bay	• NT-MT	• S
• Create an oyster reef in Tomales Bay	• NT-MT	• M
• Construct horizontal levee in Tomales Bay	• MT	• L
• Armor segments of Shoreline Hwy	• NT	• S
<b>ACCOMMODATE</b>		
• Redesign/relocate Walker Creek Coastal Access Point	• NT	• S
• Elevate Shoreline Hwy	• NT	• S
• Elevate existing buildings and utilities	• NT-MT	• S
• Flood proof existing buildings	• NT	• M
• Create offshore boat moorings	• NT	• NA
• Develop a community wastewater system	• MT	• NA
<b>RELOCATE/MANAGED RETREAT</b>		
• Research costs and interest of long-term buyout or acquisition strategy	• LT	• S
• Relocate coastal access points	• NT	• M
• Realign Shoreline Hwy	• MT	• M

# East Shore (N)



## Vulnerable Assets

Site Specific Assets Identified on Map

- 1 Walker Creek Access Point
- 2 Cypress Grove Research Center with Audubon Canyon Ranch Buildings
- 3 Nick's Cove
- 4 Shoreline Highway

## Eastshore Buildings Potentially Facing Hazardous Conditions

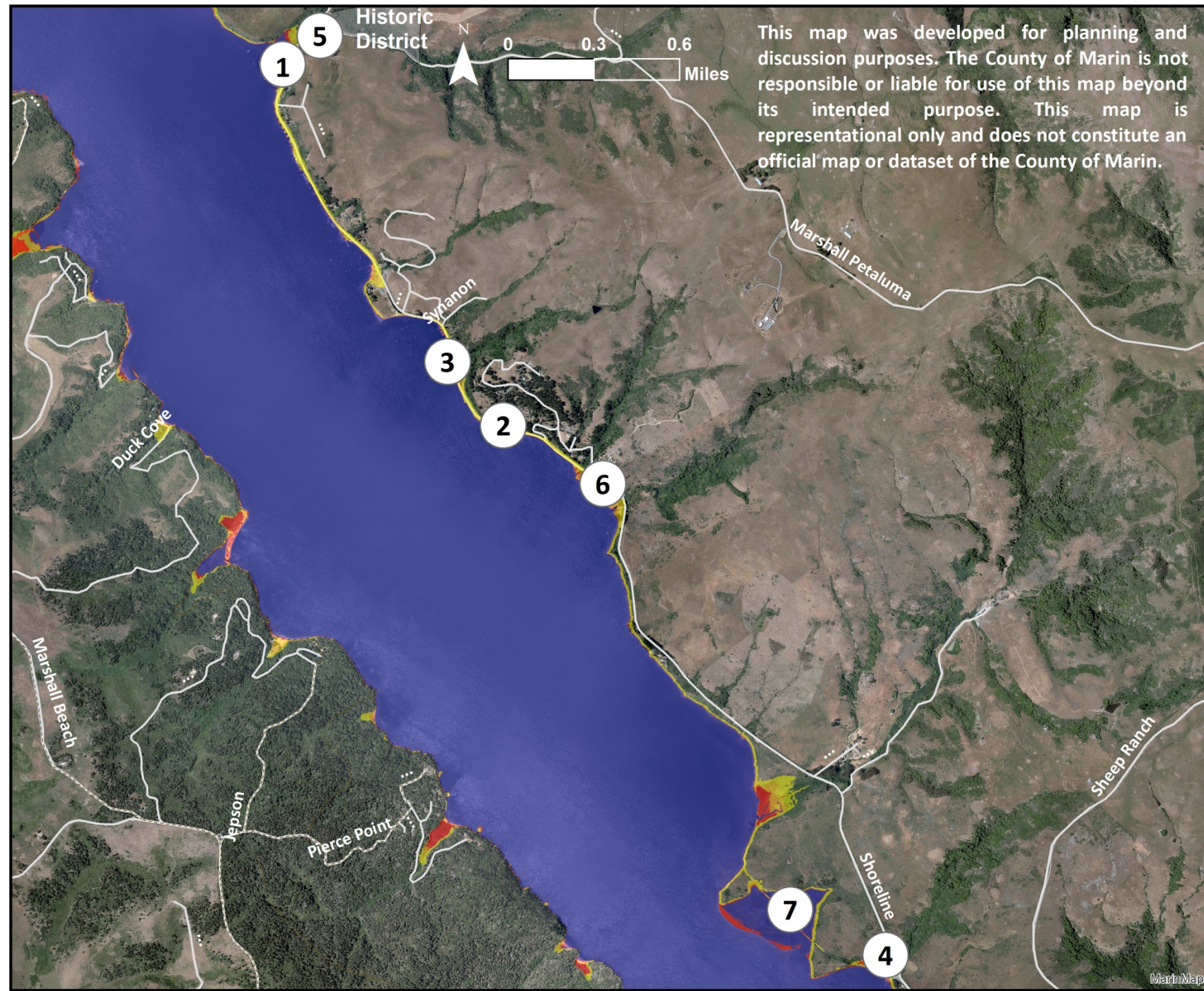


## Sea Level Rise (SLR) Scenarios

- Baseline No SLR / No Storm
- 25 cm (≈1 foot) SLR w/annual storm
- 25 cm (≈1 foot) SLR w/20 year storm
- 50 cm (≈2 feet) SLR w/20 year storm
- SLR100Wave100\_fldhazd\_Erase1
- 200 cm (≈6.5 feet) SLR w/100 year storm

Map 52. East Shore Exposure Map. Does not include geomorphic change.

# East Shore (S)



## Vulnerable Assets

Site Specific Assets Identified on Map

- 1 Hog Island Oyster
- 2 Marconi Boat Launch
- 3 Tony's Restaurant
- 4 Tomales Bay Oyster Company
- 5 Historic District
- 6 Shoreline Highway
- 7 Marshes

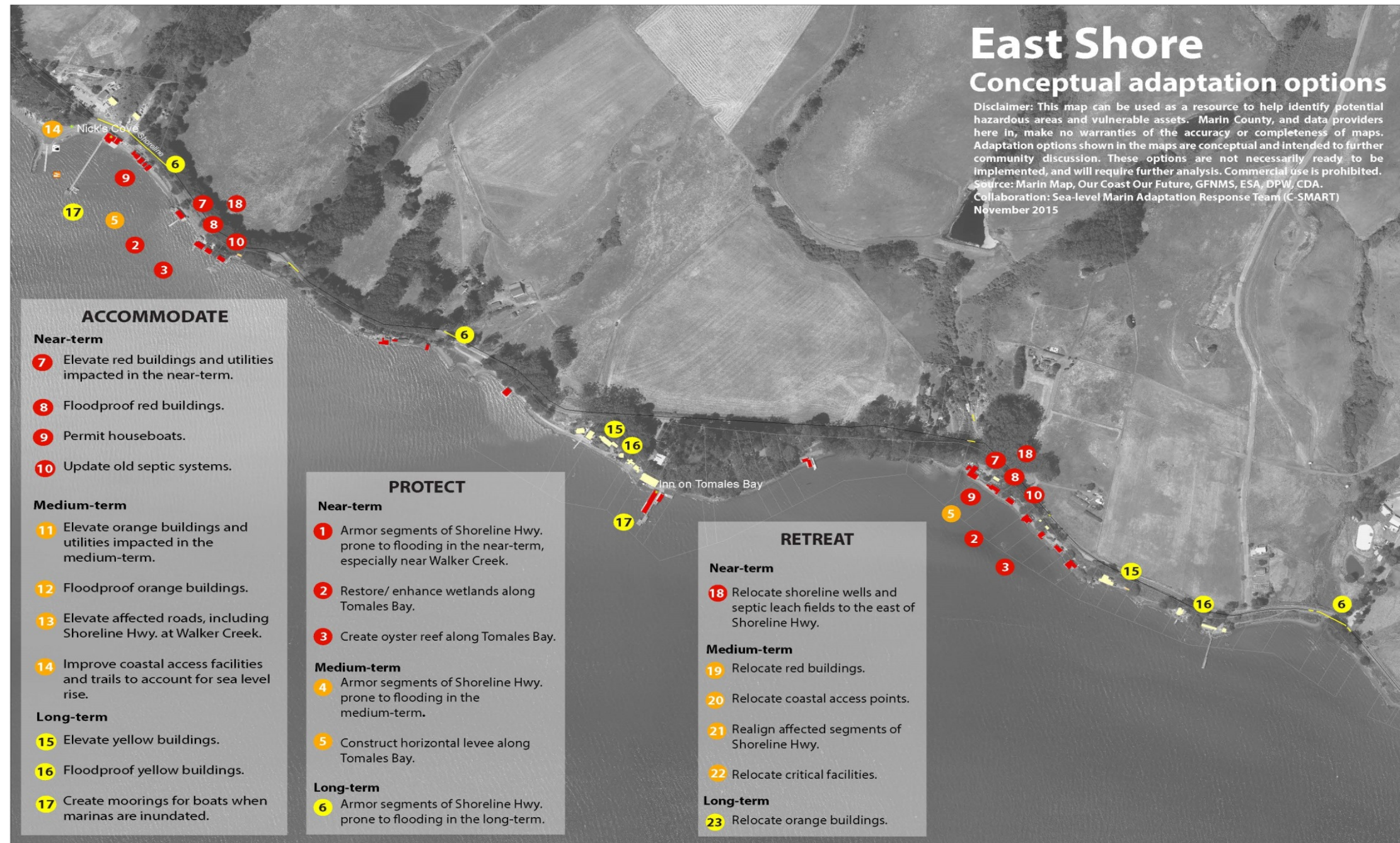
## Eastshore Buildings Potentially Facing Hazardous Conditions



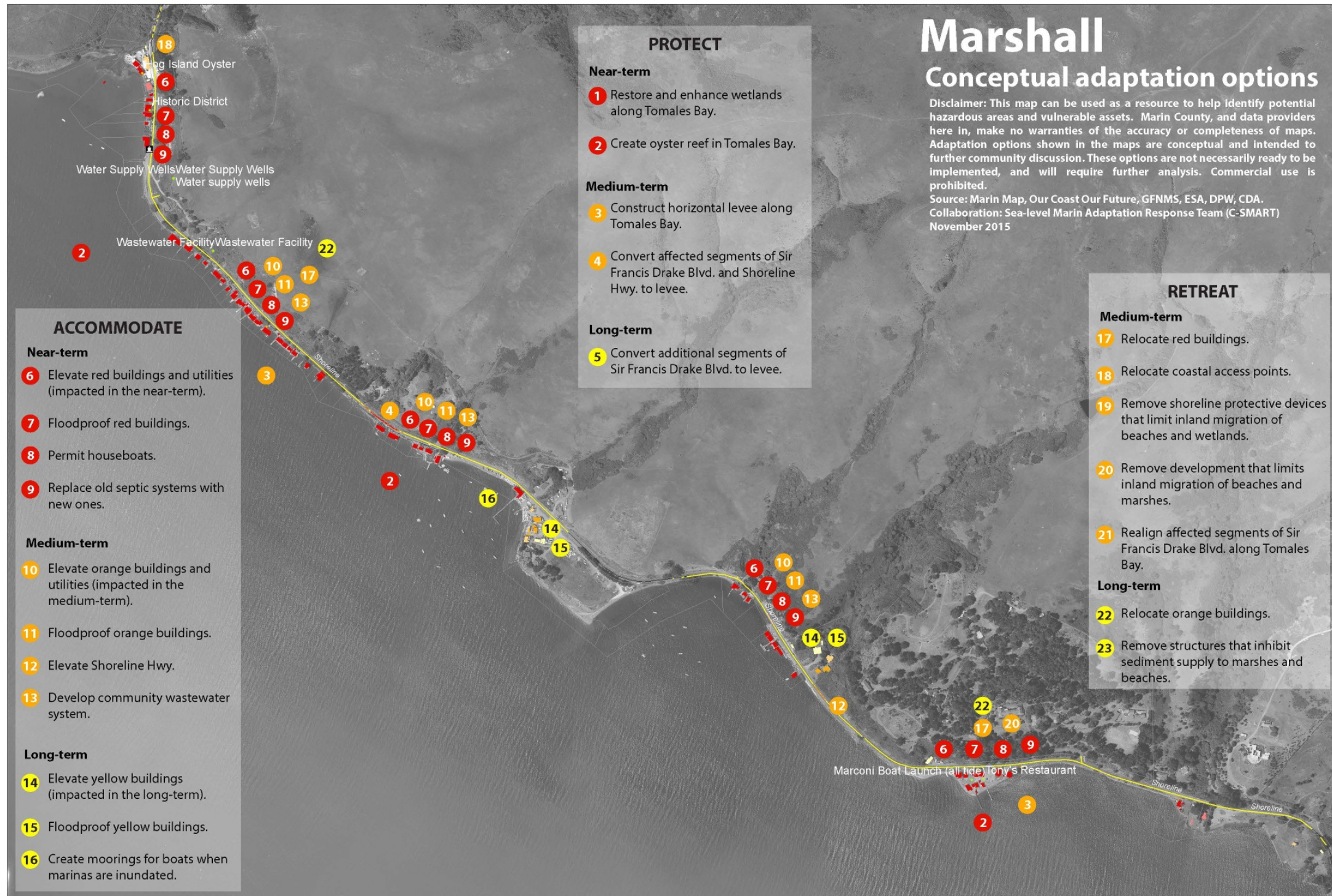
## Sea Level Rise (SLR) Scenarios

- Baseline No SLR / No Storm
- 25 cm (≈1 foot) SLR w/annual storm
- 25 cm (≈1 foot) SLR w/20 year storm
- 50 cm (≈2 feet) SLR w/20 year storm
- SLR100Wave100\_fldhazd\_Erase1
- 200 cm (≈6.5 feet) SLR w/100 year storm

Map 53. Inverness Exposure Map. Does not include geomorphic change.



Map 54. East Shore Adaptation Map (North)



Map 55. East Shore Adaptation Map (South)

**No action**

Access to, from and along Shoreline Highway could be compromised by temporary flooding in the near- to medium-term and permanently in the long-term. The area near Walker Creek often floods during storms and high tides. Waterfront housing, which acts as a first line of defense for Shoreline Highway, will face increasing challenges from rising waters. Homes on piers may see reduced ability to perform maintenance or repair, as low tides also become higher and in some cases do not expose mudflats along the shore. Utilities such as septic, water, and electrical systems may see increasing damage from flooding and saltwater intrusion. Tidal marshes may convert to mudflats or open water, and beaches may disappear where development or topography prevents inland migration.

**Marshall's community wastewater system**

Developed in 2014, the Marshall Community Wastewater System is an example of an effective community-level strategy to protect water quality and adapt vulnerable individual onsite wastewater treatment systems. Community members in Marshall petitioned Marin County to create an Onsite Wastewater Treatment Zone, which was then approved through a local election. Because Marshall is located near an impaired body of water, Tomales Bay, a Tier 3 system<sup>88</sup> was developed and installed. The system serves over 90% of the properties in central Marshall (a 3+-mile stretch) and over 50% of all the 90 homes and businesses in Marshall.

Marin County owns the septic system from the point of connection at each property up to and including the treatment equipment and the 15-acre upland leach field which it purchased specifically for that purpose. Marin County administers the program and outsources operations and maintenance to a service provider. Property owners pay the annual maintenance fee with their property taxes.

**EAST SHORE: LONG-TERM SLR IMPACTS**

163 buildings		10 businesses
Storm and tidal impacts already occur		
14 million worth of assets exposed	Residential Tourism Aquaculture	Caltrans Property Owners

<sup>88</sup> Tier 3 refers to “Advanced Protection Management Programs for Impaired Areas”. State Water Resources Control Board. *Onsite Wastewater Treatment Systems Policy*. 2012. [www.waterboards.ca.gov/water\\_issues/programs/owts/docs/owts\\_policy.pdf](http://www.waterboards.ca.gov/water_issues/programs/owts/docs/owts_policy.pdf).



*East Shore homes on pilings over Tomales Bay.  
Credit: Marin County CDA*

## Priority Actions

The recommended adaptation approach is to accommodate development with elevation and retrofits, and protect assets with nature-based strategies in the near- to-medium term, while considering additional options in the long-term. Homes and other structures currently over water could be raised higher, and portions of Shoreline Highway could also be raised to maintain access at higher water levels. Wetland restoration and oyster reefs in the near-term and potentially horizontal levee in the medium-term are potential nature-based solutions.

## Protect

### ***Restore/ enhance wetlands along Tomales Bay***

Restoring and enhancing living shorelines along Tomales Bay offers near- to medium-term protection against temporary flooding, storm surge, and wave impacts. Habitat restoration techniques can be used to manage the shoreline, reduce coastal erosion, and maintain coastal processes. Such techniques enhance habitat values and increase connectivity of wetlands and deeper intertidal and subtidal

lands, while providing some amount of shoreline protection. While design and permitting could be complex, wetland creation could be effective in limiting erosion of otherwise exposed road embankments (ESA 2015).

This strategy may involve a moderate to high cost, and will not prevent inundation of low-lying areas unless it is backed by a flood protection levee (CDA, DPW 2015). The effectiveness of wetland solutions will diminish with higher levels of SLR unless grades are raised as the wave dampening ability of tidal wetlands diminishes with increased water depth (DPW 2015). This measure could be funded by a local assessment district or government grant, and received strong support from poll respondents (100%).

### ***Create oyster reef in Tomales Bay***

Oyster reefs may be feasible in limited areas of Tomales Bay, and are not likely to be effective at reducing wave impacts right off the town of Marshall since water is relatively deep just offshore. However, residents expressed support for adaptation approaches that look holistically at all of Tomales Bay and the Marin coast. This measure could be funded by a local assessment district or government grant, and received moderate support from poll respondents (60%). GFNMS could also strongly support native oyster reef demonstration projects and provide information to help inform the most ideal locations.

### ***Construct horizontal levee along Tomales Bay***

In the medium-term, horizontal levees may serve as protection against SLR where land use, space and habitat allow. To the extent that other natural habitats in the bay can be protected, restored, or enhanced, Marin County can bolster the benefits provided by a

horizontal levee project and mitigate some of the technical and financial risks associated with the project.<sup>89</sup>

Fluvial inputs associated with two watersheds, Walker Creek and Lagunitas Creek, are large enough to create local estuarine gradients within the Bay. The largest tidal marshes are associated with the alluvial deltas of these creeks.<sup>90</sup> These areas are also vulnerable to SLR and may be good candidate areas to investigate the feasibility of horizontal levees. As sea level rises the high marshes are able to transgress inland along the valley profile. While these are areas with gently sloping migrating transition zones, some realignment of infrastructure such as roads and culverts may have to occur if they are to be realized.

This strategy could be funded by a local assessment district or government grant, and received moderate support from poll respondents (40%). A public meeting participant suggested that Marconi State Park might be an appropriate location for a horizontal levee.

#### ***Armor segments of Shoreline Highway***

Erosion and flooding currently threaten segments of Shoreline Highway, particularly where no structures are present. Armoring exposed segments could be implemented by the State and/or local service providers, and received strong support from poll respondents (100%). For discussion of constraints to armoring segments of Shoreline Highway, see “Transportation” in the Governance section.

#### **Accommodate**

##### ***Improve coastal access facility or trail to account for sea level rise***

The Walker Creek Access Point could be relocated or redesigned to be resilient to SLR. This strategy could be implemented by the County and State, and received strong support from poll respondents (100%).

##### ***Elevate Shoreline Highway***

General approaches for adapting roads to SLR include identifying water level triggers for management actions, and coordinating with the DPW and Caltrans. They are further described in the “Transportation” section of this report.

The Walker Creek area in particular experiences temporary flooding which will only worsen with SLR. This strategy would be implemented by Caltrans, and received strong support from poll respondents (100%). See “Transportation” in Governance section for discussion of road elevation considerations.

Road elevation is preferred along Tomales Bay by GFNMS to allow for wetland migration. GFNMS would need to be involved in new road design and construction review including avoiding risks of materials entering the sanctuary.

##### ***Elevate buildings and utilities***

Structures fronting Tomales Bay may be impacted by rising waters to varying degrees based on building construction and existing elevation above the water. One solution is to allow/encourage houses to be raised and seawalls maintained to protect houses, septic tanks and Shoreline Highway. Maintaining bulkheads under Marshall homes is a high priority to protect the homes, as well as possibly protecting Shoreline Highway from flooding.

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<sup>89</sup> Natural Capital Project, Center for Ocean Solutions. *Coastal Adaptation Policy Assessment*. 2016.

<sup>90</sup> Environmental Science Associates (ESA). *Geomorphic Response of Beaches and Marshes*. August 2015.



Although properties look the same on the map, the reality on the ground varies significantly and would require different adaptation approaches. Homes are at varying elevations and construction methods have changed over time. Around six houses are below high water. Some places, for example the fisherman's village on the peninsula, may need armoring, not elevation.

Raising houses along the Marshall waterfront is very difficult and expensive, requiring creative solutions. As water levels rise, the area under houses becomes less accessible for foundation work. Home elevation is estimated to cost approximately \$100,000 per 1,000 square feet in this area.<sup>91</sup>

There was a great deal of interest from residents in developing a community-wide solution to raise all homes through a coordinated effort. This could help provide a better economy of scale for permitting, design work and construction. Such a pilot project could potentially acquire funding through a government grant and homeowners could pay off their share over time through property taxes. The community set a precedent for taking a collaborative approach through the Marshall Community Wastewater System, where a State grant covered 50% of costs, and residents covered 50%. I-Bank offered reasonable loan rates, and everyone was assessed the same amount of \$20,000 over 20 years, despite differences in the scale of work that needed to be done on each system.

Depending on community desires, the timing of elevating structures could be determined by a

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<sup>91</sup> Marshall homeowner. Personal communication. March 2016.

chosen acceptable level of protection against monthly high water (EMHW) or greater (1-year or 10-year flood), as explained in the "Governance: Triggers for Adaptive Management" section of this report. The strategy of structural elevation would be implemented by property owners in partnership with government agencies, and received strong support from poll respondents (80%).

Community members noted that policies requiring mitigation for loss of sand supply by preventing erosion and other matters could make both coastal armoring and elevation of homes prohibitively expensive, even if permitting requirements could be eased and streamlined.

#### ***Flood proof buildings***

FEMA provides guidelines for wet and dry floodproofing. This strategy would be implemented by property owners, and received moderate support from poll respondents (60%).

#### ***Boat moorings***

Apart from Lawson's Landing at Dillon Beach (which provides seasonal moorings), there are no active marinas on the east shore of Tomales Bay. There are pontoons in the Marshall Boat Works that seasonally host a couple of boats. The demand and number of moorings has dwindled over the years. In 2014, GFNMS and State Lands Commission commenced the [Tomales Bay Mooring Program](#) to permit and lease moorings in Tomales Bay. By November 2016 all abandoned moorings were removed by GFNMS, which contributed to the decrease in the total number of moorings. Although this decrease could be due to the program's costs and requirements, this action freed up space for more moorings on the Bay.

### **Houseboats**

Houseboats are not recommended as an adaptation strategy due to harsh wind and wave conditions, increased threat of discharges and marine debris, and the lack of houseboat marinas and services. This strategy received low support from poll respondents (20%). There are no County, State or Federal laws that prevent someone from living aboard a boat in Tomales Bay, except within a quarter mile of the Point Reyes National Seashore shore on the west side of the Bay, north of Duck Cove. The NPS formerly restricted overnighters through camping regulations, but they have since changed their maps and enforcement activities to reflect revised jurisdictional boundaries<sup>92</sup>.

### **Relocate/ Managed Retreat**

Marin County could research potential costs and community interest in a long-term buyout or property acquisition strategy if rising sea levels or storm impacts become imminent threats to homeowners. The County could also consider having a plan and specific proposals in place in case of a major storm/flood event that makes homeowners more likely to be interested in the buyout.<sup>93</sup> Easements and other land use policies could be used to limit further construction and investment in the most hazardous areas.

Relocation of buildings could eventually be implemented by property owners, and received moderate support from poll respondents (40%). Relocation of any remaining shorefront septic leachfields to the east of Shoreline Highway

could be implemented by a local assessment district and/or the County, and received strong support from poll respondents (100%).

Relocation of coastal access points at Walker Creek and Livermore Marsh Cypress Grove could be implemented by the County and State, and received moderate support from poll respondents (60%).

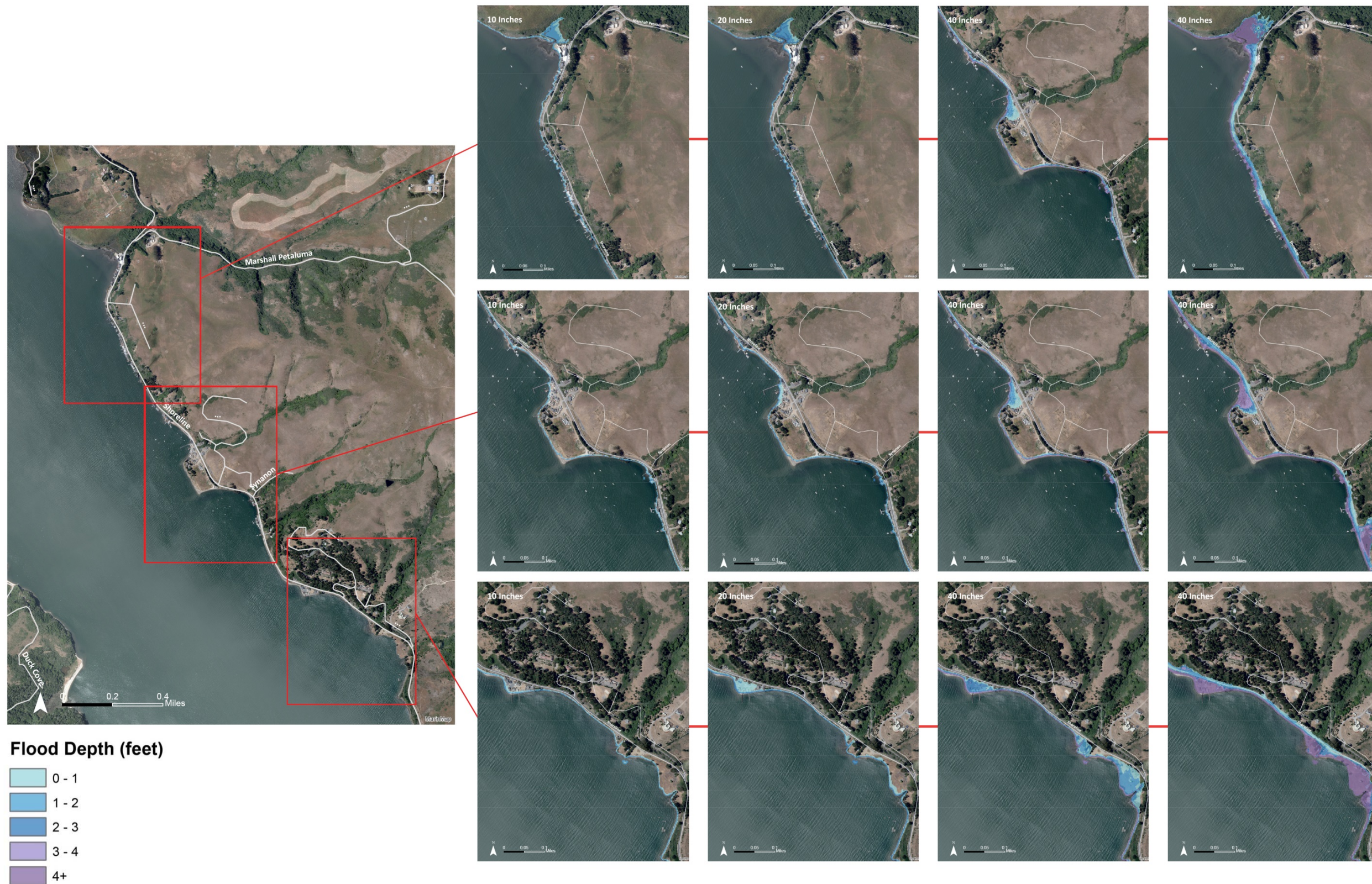
Realignment of affected segments of Shoreline Highway could be implemented by Caltrans in collaboration with affected landowners and stakeholders, and received moderate support from poll respondents (60%). See “Transportation” in Governance section for discussion of considerations for road realignment.

Potential locations of adaptation strategies are shown in **Error! Reference source not found.** (North) and **Error! Reference source not found.** (South).

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<sup>92</sup> Clyde, George. West Marin Review. *How Rep. Phillip Burton and a Magic Marker Hijacked Tomales Bay into the Golden Gate National Recreation Area*. 2012.

<sup>93</sup> *ibid*



**Maps 56-68 East Shore Exposure** Source: Coastal Storm Modeling System (CoSMos)

## 6.7) Point Reyes Station

### PRIMARY VULNERABILITIES

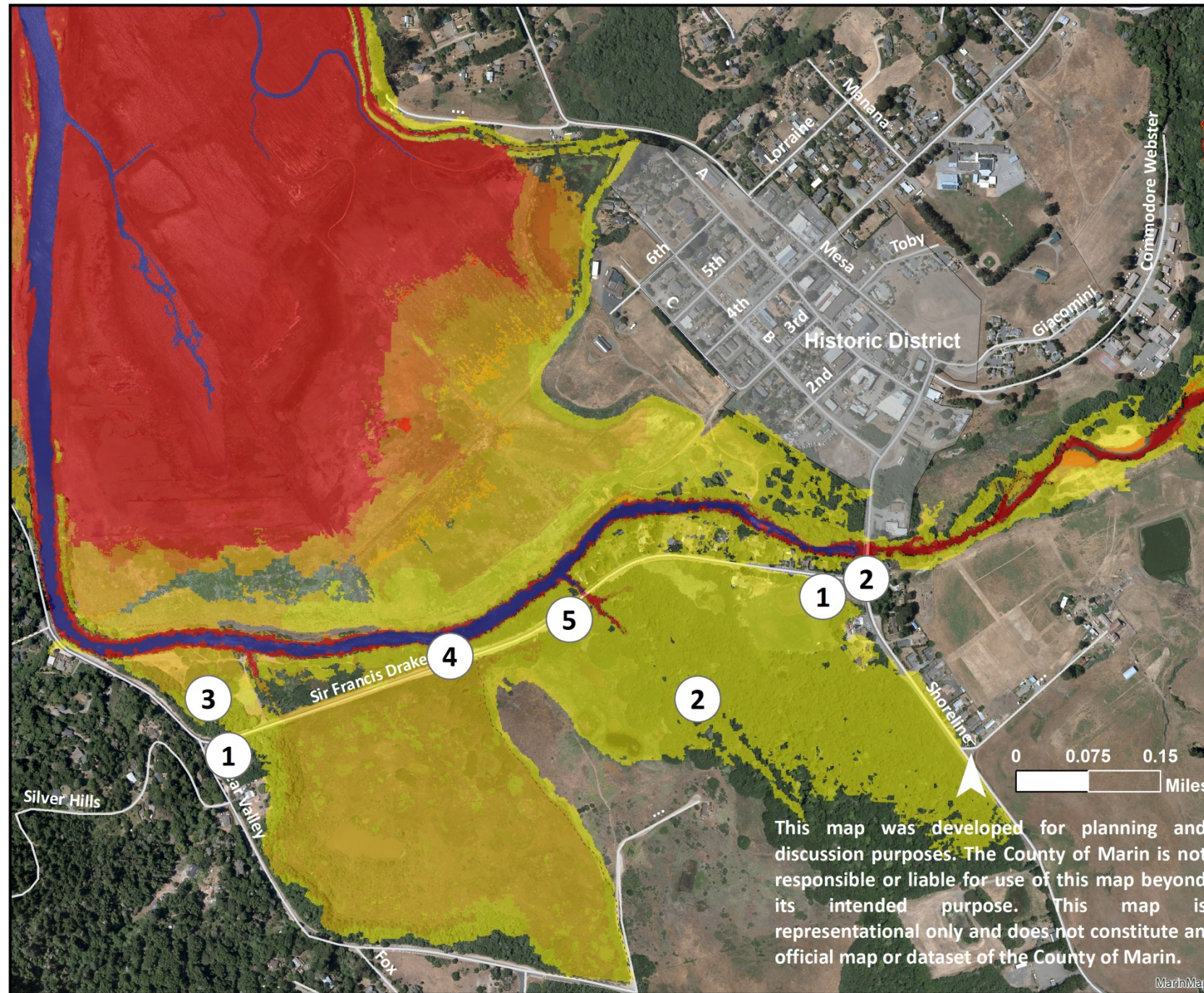
- Storm and tidal impacts already occur
- Long-term flooding will impact 36 buildings, 4 businesses, and 700 people
- The cost of impacts to exposed assets will be \$2 million
- Others impacted will include the residential tourism industry, Caltrans, and NMWD

### PRIORITY ACTIONS

- Accommodate existing development with elevation and retrofits
- 
- Protect assets with nature-based strategies

Strategy	Timeframe/Term NT=Near MT=Medium LT=Long	L=Low 0-40% M=Moderate 41-70% S=Strong 71%+ NA=Not available
<b>PROTECT</b>		
• Restore/enhance wetlands along Tomales Bay	• NT	• S
• Armor segments of Shoreline Hwy	• LT	• M
• Construct a horizontal levee along Tomales Bay	• MT	• L
<b>ACCOMMODATE</b>		
• Elevate Green Bridge	• NT	• S
• Elevate Shoreline Hwy	• MT	• M
• Elevate Sir Francis Drake Blvd	• MT	• M
• Elevate existing buildings	• MT	• M
• Flood proof existing buildings	• NT-MT	• L
<b>RELOCATE/MANAGED RETREAT</b>		
• Research costs and interest of long-term buyout or acquisition strategy	• LT	• NA
• Relocation of buildings	• LT	• L
• Relocation of Gallegher well upstream	• LT	• M
• Removal of development and shoreline protection that limit inland migration of habitats	• LT	• M

# Point Reyes Station



## Vulnerable Assets

Site Specific Assets Identified on Map

- 1 NMWD Pipeline
- 2 Green Bridge
- 3 White House Pool/Trail
- 4 Sir Francis Drake Blvd
- 5 Olema Marsh Trail

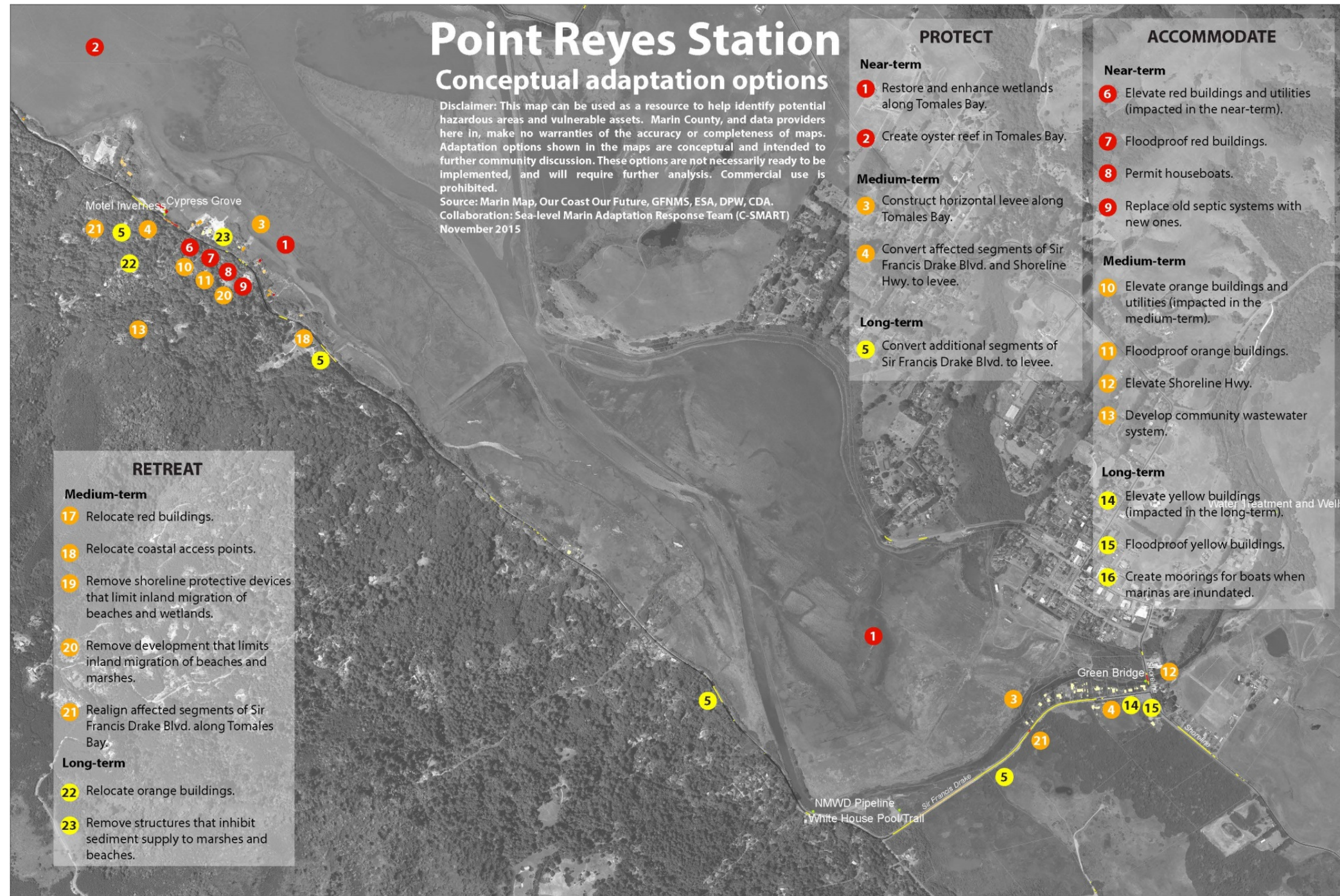
Buildings Potentially Facing Hazardous Conditions plus some septic systems and water distribution lines



## Sea Level Rise (SLR) Scenarios

- Baseline No SLR / No Storm
- 25 cm (≈1 foot) SLR w/annual storm
- 25 cm (≈1 foot) SLR w/20 year storm
- 50 cm (≈2 feet) SLR w/20 year storm
- 100 cm (≈3 feet) SLR w/100 year storm
- 200 cm (≈6.5 feet) SLR w/100 year storm

Map 69. Point Reyes Station Exposure Map. Does not include geomorphic change.



# Point Reyes Station Conceptual adaptation options

Disclaimer: This map 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. Adaptation options shown in the maps are conceptual and intended to further community discussion. These options are not necessarily ready to be implemented, and will require further analysis. Commercial use is prohibited.  
Source: Marin Map, Our Coast Our Future, GFNMS, ESA, DPW, CDA.  
Collaboration: Sea-level Marin Adaptation Response Team (C-SMART)  
November 2015

- ### PROTECT
- Near-term**
- 1 Restore and enhance wetlands along Tomales Bay.
  - 2 Create oyster reef in Tomales Bay.
- Medium-term**
- 3 Construct horizontal levee along Tomales Bay.
  - 4 Convert affected segments of Sir Francis Drake Blvd. and Shoreline Hwy. to levee.
- Long-term**
- 5 Convert additional segments of Sir Francis Drake Blvd. to levee.

- ### ACCOMMODATE
- Near-term**
- 6 Elevate red buildings and utilities (impacted in the near-term).
  - 7 Floodproof red buildings.
  - 8 Permit houseboats.
  - 9 Replace old septic systems with new ones.
- Medium-term**
- 10 Elevate orange buildings and utilities (impacted in the medium-term).
  - 11 Floodproof orange buildings.
  - 12 Elevate Shoreline Hwy.
  - 13 Develop community wastewater system.
- Long-term**
- 14 Elevate yellow buildings (impacted in the long-term).
  - 15 Floodproof yellow buildings.
  - 16 Create moorings for boats when marinas are inundated.

- ### RETREAT
- Medium-term**
- 17 Relocate red buildings.
  - 18 Relocate coastal access points.
  - 19 Remove shoreline protective devices that limit inland migration of beaches and wetlands.
  - 20 Remove development that limits inland migration of beaches and marshes.
  - 21 Realign affected segments of Sir Francis Drake Blvd. along Tomales Bay.
- Long-term**
- 22 Relocate orange buildings.
  - 23 Remove structures that inhibit sediment supply to marshes and beaches.

0 500 1,000 2,000 Feet

**LEGEND**

<b>Exposed Buildings</b>	<b>Exposed Roads</b>
<p><b>Near-term</b></p> <ul style="list-style-type: none"> <li>Red square: @ 10 in. &amp; annual storm</li> <li>Light red square: @ 10 in. &amp; 20-year storm</li> </ul>	<p><b>Near-term</b></p> <ul style="list-style-type: none"> <li>Red line: @ 10 in. &amp; annual storm</li> <li>Light red line: @ 10 in. &amp; 20-year storm</li> </ul>
<p><b>Medium-term</b></p> <ul style="list-style-type: none"> <li>Orange square: @ 20 in. &amp; 20-year storm</li> </ul>	<p><b>Medium-term</b></p> <ul style="list-style-type: none"> <li>Orange line: @ 20 in. &amp; 20-year storm</li> </ul>
<p><b>Long-term</b></p> <ul style="list-style-type: none"> <li>Light orange square: @ 40 in. &amp; 100-year storm</li> <li>Yellow square: @ 80 in. &amp; 100-year storm</li> </ul>	<p><b>Long-term</b></p> <ul style="list-style-type: none"> <li>Light orange line: @ 40 in. &amp; 100-year storm</li> <li>Yellow line: @ 80 in. &amp; 100-year storm</li> </ul>

Map 70. Point Reyes Station Adaptation Map

## Point Reyes Station

### No action

Surrounding wetlands and marshes, including Giacomini Wetlands and Olema Marsh could be degraded by flooding, erosion, and increased salinity. Water district pipes traversing under the marsh and road could be damaged by higher groundwater. Flooding is probable on portions of Shoreline Highway in the long-term scenarios, however Green Bridge is vulnerable in the near-term.

#### POINT REYES STATION: LONG-TERM IMPACTS

36 buildings		700 people
Storm and tidal impacts already occur		4 businesses
2 million worth of assets exposed	Residential Tourism	Caltrans NMWD

### Priority Actions

The recommended adaptation approach is to accommodate development with elevation and retrofits, and protect assets with nature-based strategies in the near- to-medium term, while considering additional options in the long-term.

#### Protect

##### **Restore/ enhance wetlands along Tomales Bay**

This strategy could be funded by government grants, and received strong support from poll respondents (100%).

##### **Armor segments of Shoreline Highway**

General approaches for adapting roads to SLR include identifying water level triggers for management actions, and coordinating with the DPW and Caltrans. They are further described in the “Transportation” section of this report.

This strategy would be implemented by Caltrans, and received moderate support from poll respondents (54%). See “Transportation” in Governance section for discussion of considerations for armoring Shoreline Highway.

##### **Horizontal levee along Tomales Bay**

This strategy would be implemented by a local assessment district or government grant, and received low support from poll respondents (15%).

For more information about horizontal levees, see section 2.7 of Appendix A.

### Accommodate

Elevating Green Bridge received strong support from poll respondents (85%). Improving coordination among government agencies is a key aspect of adaptation planning. Elevating affected segments of Shoreline Highway would also be implemented by Caltrans, and received moderate support from poll respondents (69%). Elevating Sir Francis Drake Boulevard received moderate support from poll respondents (62%). Elevating buildings would be implemented by property owners, and received moderate support from poll respondents (54%). Floodproofing buildings would be implemented by property owners, and received low support from poll respondents (15%).

### Relocate/ Managed Retreat

Marin County could research potential costs and community interest in a long-term buyout or property acquisition strategy if rising sea levels or storm impacts become imminent threats to homeowners. The County could also consider having a plan and specific proposals in place in case of a major storm/flood event that makes homeowners more likely to be

interested in the buyout.<sup>94</sup> Easements and other land use policies could be used to limit further construction and investment in the most hazardous areas. These easements would move (or “roll”) with bluff and shore erosion.

Relocation of buildings would be implemented by property owners, and received low support from poll respondents (23%). Relocation of Gallagher well upstream would be implemented by North Marin Water District, and received moderate support from poll respondents (62%). Removal of development and/or shoreline protective devices that limit inland migration of beaches and marshes would be implemented by property owners, and received moderate support from poll respondents (62%).

Relocation of coastal access points would be implemented by the County and State, and received moderate support from poll respondents (46%).

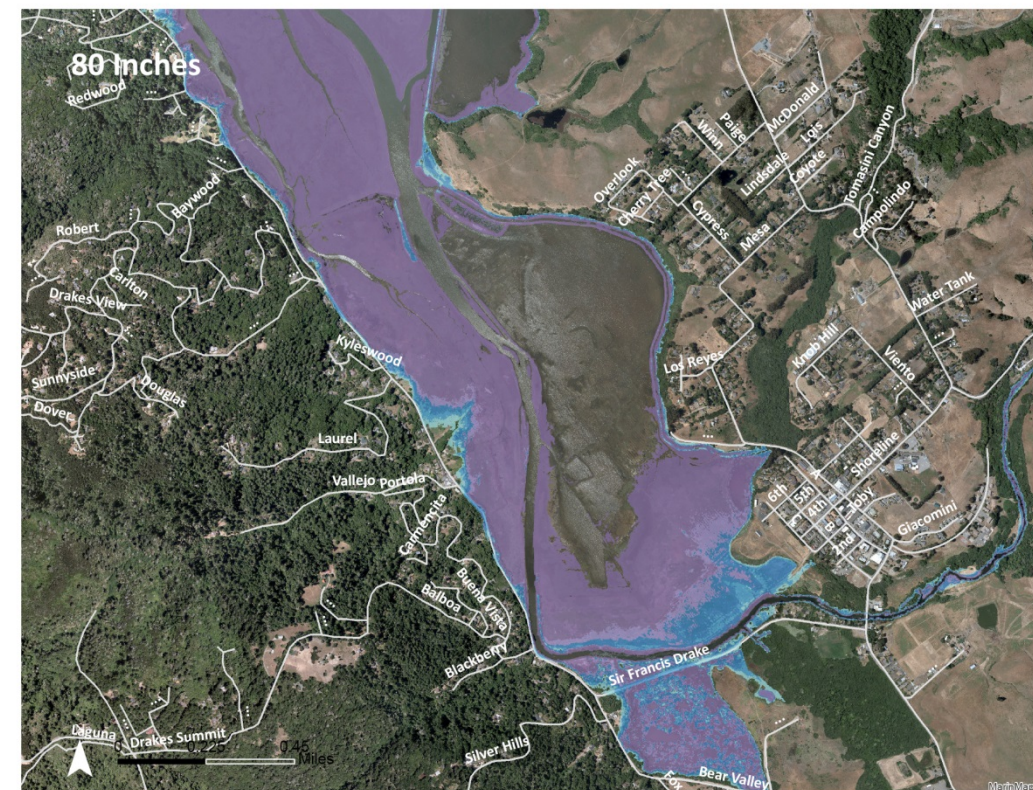
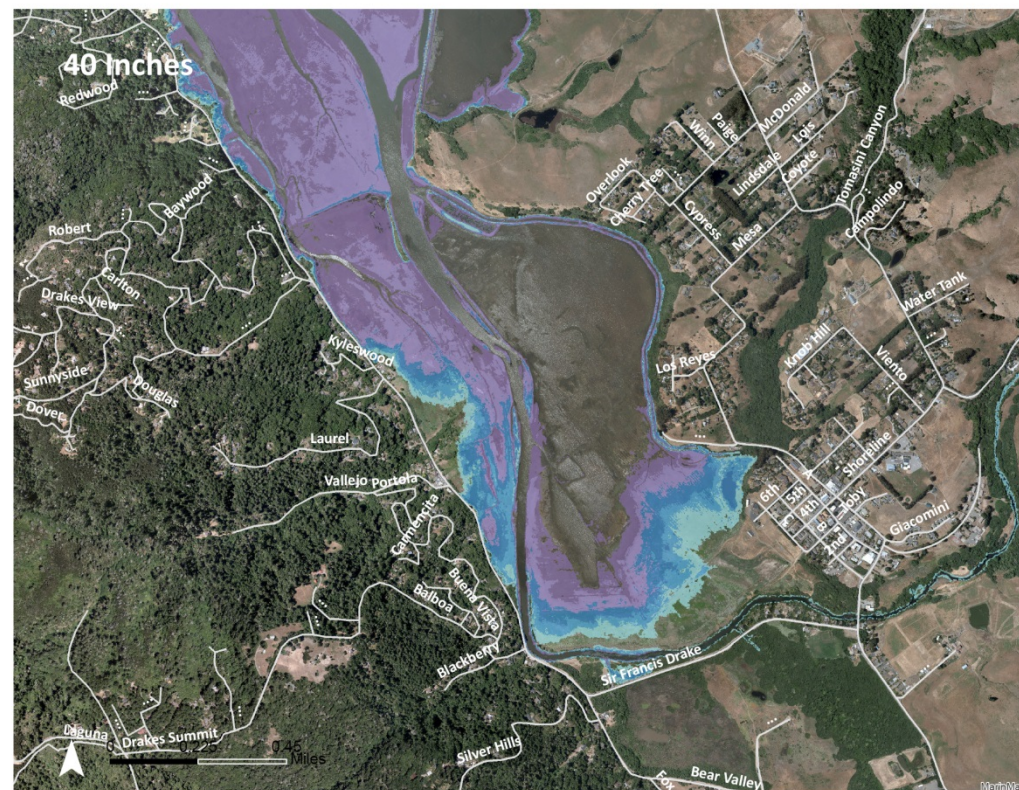
Realignment of affected segments of Shoreline Highway would be implemented by Caltrans, and received moderate support from poll respondents (38%). See “Transportation” in Governance Section for discussion of considerations for realigning Shoreline Highway.

Potential locations of adaptation strategies are shown in [Map 70](#).

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<sup>94</sup> *ibid*





**Flood Depth (feet)**

- 0 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- 4+

**Maps 71-74 Point Reyes Station Exposure** Source: Coastal Storm Modeling System (CoSMos)

## 6.8) Dillon Beach

### PRIMARY VULNERABILITIES

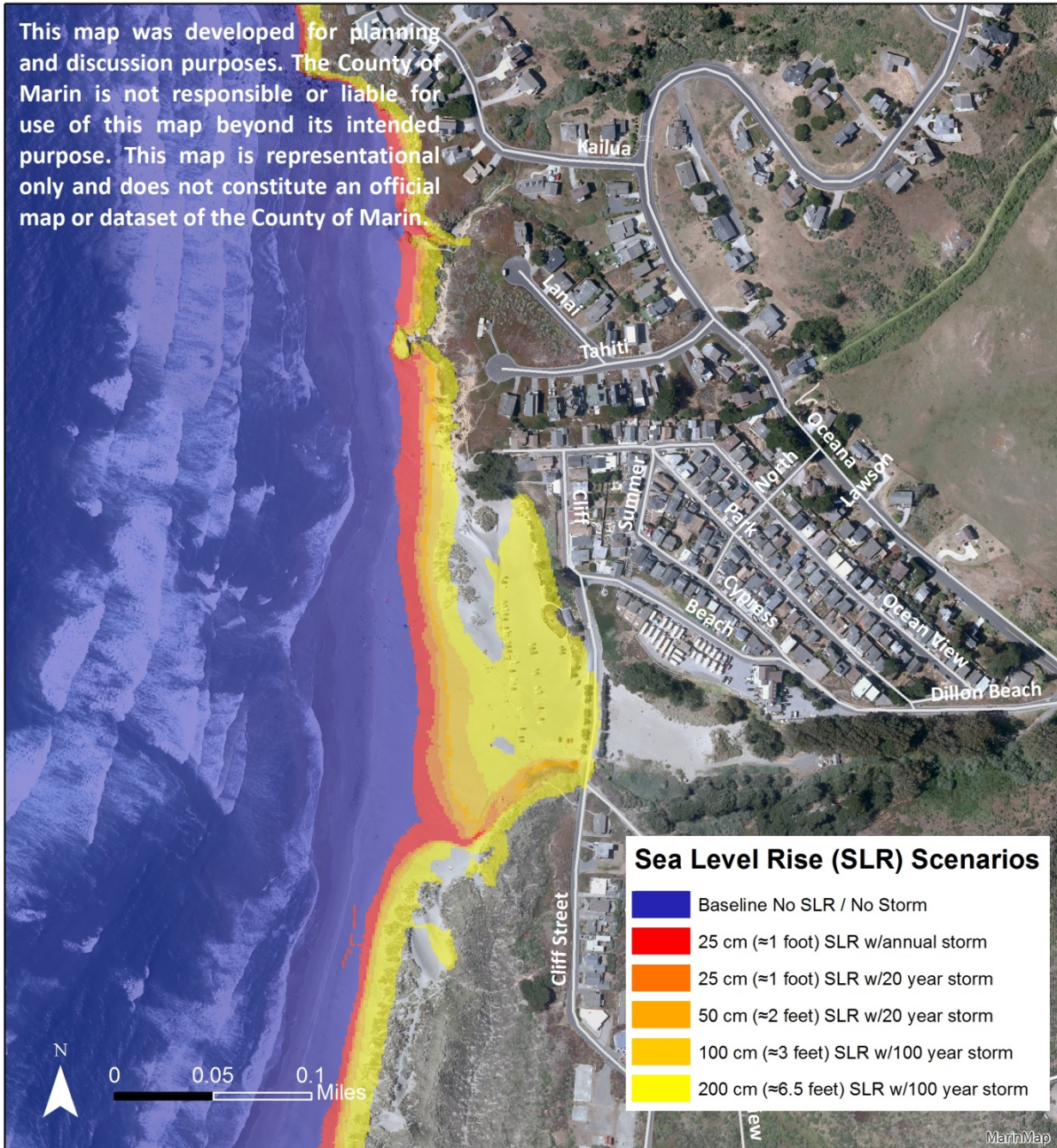
- Storm and tidal impacts already occur
- Long-term SLR will impact two businesses, the residential tourism and agriculture industries, as well as private tourism assets
- Others impacted will include Ocean Marin HOA, Lawson’s Landing, Dillon Beach Resort, and property owners

### PRIORITY ACTIONS

- Support dune restoration efforts as a protective measure
- Research alternatives for managing flooding on Bay Drive
- Implement policies to ensure bluff top homes are safe from erosion

Strategy	Timeframe/Term NT=Near MT=Medium LT=Long	L=Low 0-40% M=Moderate 41-70% S=Strong 71%+ NA=Not available
<b>PROTECT</b>		
• Dune restoration near Lawson’s Landing	• NT	• NA
• Support dune restoration pilot programs	• NT	• NA
<b>ACCOMMODATE</b>		
• ID water level triggers for management actions	• NT	• NA
• Elevate and floodproof existing structures at Lawson’s Landing	• NT	• M
<b>RELOCATE/MANAGED RETREAT</b>		
• Research costs and interest of long-term buyout or acquisition strategy	• LT	• NA
• Relocate the well on Dillon Creek at Bay Drive	• NT	• M

# Dillon Beach



Map 75. Dillon Beach Exposure Map. Does not include geomorphic change.

### No Action

Flooding could affect Bay Drive leading to Lawson’s Landing. The centralized Oceana Marin Sewer System could be degraded by erosion and waves. Bluff top homes could experience heightened erosion risks as sea levels rise. Camping capacity at Lawson’s Landing could be reduced due to inundation and erosion. North of Dillon Beach, agriculture could face vehicular access constraints and decreases in land area due to erosion and higher water levels.

#### DILLON BEACH: LONG-TERM SLR IMPACTS

Storm and tidal impacts already occur		2 businesses
Private tourism assets exposed	Residential Tourism Agriculture	Ocean Marin HOA Lawson’s Landing Dillon Beach Resort Property Owners

### Priority Actions

Support dune restoration efforts as a protective measure, research alternatives for managing flooding on Bay Drive, and implement policies to ensure that bluff top homes are safe from erosion. Plans for dune restoration and enhancement are being developed for Lawson’s Landing. Planting native vegetation to augment existing beach grass may help encourage natural augmentation of the dunes. This is considered a cost-effective and environmental approach, compared to importing sand. A monitoring plan will be developed to contribute to the body of research on the efficacy of this measure at reducing coastal erosion and

protecting Lawson’s Landing recreational facilities from wave run up.

### Protect

Dunes aid in protecting Bay Drive and the small community at Lawson’s Landing while also providing key recreational beach going and camping opportunities. The surfgrass along Kailua Way leading north towards the agricultural areas bordering Estero de San Antonio play a lower relative role in reducing exposure to coastal impacts.<sup>95</sup>

In the near-term, managers of Lawson’s Landing may pursue a dune restoration project on the south end of the beach with experimental design areas and monitoring to help test the protective services dunes provide. Dune restoration would help to protect exposed parcels zoned “Residential” (including residential structures) as well as the areas zoned “Resort and Commercial Recreation” including Bay Drive. Marin County could be at the forefront of helping to develop data to determine dune restoration design metrics and elements of success as well as how hydrological and geomorphological conditions in different areas contribute to the success or failure of restored dunes as a natural infrastructure alternative to armoring. This project would add to the body of evidence from similar demonstration sites recently funded by the SCC in Humboldt and Monterey Counties. Coastal dune restoration on the west coast of North America was pioneered in the Lanphere Dunes in Humboldt County in the 1980s and many case studies published from the dune restoration projects can provide valuable

<sup>95</sup> Center for Ocean Solutions, Natural Capital Project. *Coastal Adaptation Policy Assessment*. 2016.

support.<sup>96</sup> Prioritizing dune habitat protection and restoration can ensure the protective service for the community of Dillon Beach while also continuing to provide recreational opportunities so important to the region.

Due to relative exposure risks and relative undeveloped nature of this area, this may be a lower priority project for the County, especially since such a monitoring and restoration project would require significant funding. However, SCC and other sources of funding are available for these types of projects, and as mentioned above, would help reduce uncertainties associated with the extent of flood protection and habitat benefits dune restoration provides compared to traditional armoring. In addition, a reduction in exposure to flooding for Bay Drive ultimately leads to a reduction in exposure for Lawson's Landing as that is the main transportation corridor for the small community.

### Accommodate

General approaches for adapting roads to SLR include identifying water level triggers for management actions, and coordinating with the DPW and Caltrans. They are further described in the "Transportation" section of this report.

Continue to elevate and/or floodproof affected structures, primarily at Lawson's Landing. The existing cottages are designed to be moveable. This strategy received moderate support from poll respondents (50%).

### Relocate/ Managed Retreat

Marin County could research potential costs and community interest in a long-term buyout or property acquisition strategy if bluff erosion become imminent threats to homeowners. Easements and other land use policies could be used to limit further construction and investment in the most hazardous areas. These easements would move (or "roll") with bluff and shore erosion.

Relocating the well along Dillon Creek at Bay Drive inland would prevent saltwater intrusion that could occur in the near-term. The community could also consider relocating sewage pump (50%) and parking lot (100%) inland in the medium- to long-term. Bay Drive, which provides access to Lawson's Landing, could be realigned inland.

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<sup>96</sup> Pickart AJ. *Dune Restoration Over Two Decades at the Lanphere and Ma-le'l Dunes in Northern California*. 2013.

## Green Strategy: Lawsons Landing Dune Restoration



*Lawson's Landing dunes. Flynn, 2014.*

**Benefits:** Habitat, Recreation, Tourism

**Cost estimate:** \$200,000/acre (ESA 2015)

Sand dunes act as a buffer to wave run-up erosion and minimize coastal flooding, while providing critical habitat to many species and beautiful recreational areas. Lawson's Landing dune restoration project at Lawson's Landing with experimental design areas and monitoring would help test the protective services of dunes, and serve as a model to other coastal communities for a "green" SLR adaptation strategy.

Lawson's Landing has been used for fishing, boating and camping since 1957. The 960-acre site is situated at the northern side mouth of Tomales Bay, bordered by the Pacific Ocean and Dillon Beach. Lawson's Landing has been formed by dune sand that is first deposited on the beach and then windblown southeastward into Tomales Bay. Introduction of European beach grass by the Soil Conservation Service in Northern California in the 1930's has created elevated foredunes. Wind and waves occasionally blow out the dunes, which re-establish over time.

The Tomales Dunes are some of the last mobile dune systems on the California

coast, and Lawson's Landing manages responsible recreation and conservation for the dunes, coastal meadows and wetlands that are home to Western Snowy Plover, seals and other species. The approximately 450 acres of wetland-dune complex at Lawson's Landing is under a permanent conservation easement with the Natural NRCS.

Lawson's Landing is undergoing a major redevelopment under a Coastal Development Permit, updating key infrastructure, including a wastewater system, water lines, electrical services, communication lines, roads, and hazard response center. As part of the redevelopment, Lawson's Landing is transitioning from a facility that had many permanent trailers to one that provides more temporary campsites and lodging for broader public access.

Given the environmental and public resource benefits resulting from the transition at Lawson's Landing, it is prudent to seek protection of these resources in the face of anticipated SLR. Low and high dunes at Lawson's Landing currently protect built assets. These natural systems show potential to be improved upon to provide additional adaptation and resilience to SLR.

Potential dune improvements may include extending the existing foredunes toward the southeast to protect cottages and RV campsites from storm surges, and in the northeastern portion of the camping area. These areas have a high habitat protection value and good potential as pilot experimental design and monitoring areas.

**Draft goals** of the Lawson’s Landing pilot project for natural adaptation strategies to address SLR:

1. Re-establish certain native dune plant species while facilitating dune enhancement.
2. Protect environmental and recreational value using geomorphological processes to provide adaptation to SLR.
3. Assess effects of a biotechnical approach to SLR on nearby boathouse, pier, sea wall and other high value recreation assets. (*i.e.* how to best align with storm surges).
4. Determine appropriate interventions to improve resilience and adaptation.
5. Capture and stabilize sand moving through area rather than losing it.
6. Install interpretative signage to explain adaptation strategies and collaborative/ complementary efforts/ organizations.
7. Enhance public awareness of Lawson’s Landing efforts to mitigate and adapt to climate change and protect low-cost coastal access.

Accumulation of sand and dune plant colonization around high value recreation area at Lawson’s Landing provides a timely opportunity for natural adaptation strategies consistent with environmental and coastal access protection. Monitoring this project would add to the body of evidence from similar demonstration sites recently approved for funding by the SCC in Humboldt and Monterey.

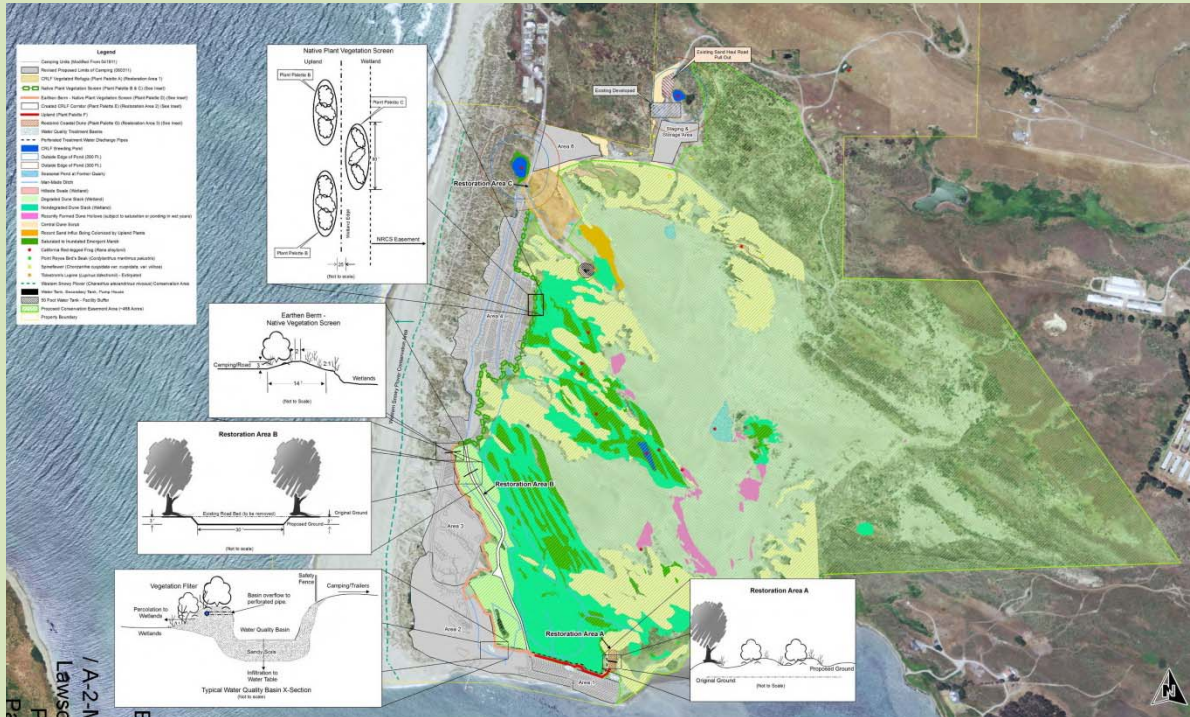
This project would add to the body of evidence from similar demonstration sites recently funded by the SCC in Humboldt and Monterey Counties. Coastal dune restoration on the west coast of North

America was pioneered in the Lanphere Dunes in Humboldt County in the 1980s and many case studies published from the dune restoration projects can provide valuable support.<sup>97</sup>

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<sup>97</sup> Pickart AJ. *Dune Restoration Over Two Decades at the Lanphere and Ma-le’l Dunes in Northern California*. 2013.

Figure 13. Lawson's Landing Proposed Resource Protection and Enhancement Area



Source: California Coastal Commission Staff Report Exhibit No. 3, 2011.  
documents.coastal.ca.gov/reports/2011/7/W10a-7-2011-a1.pdf





**Flood Depth (feet)**

- 0 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- 4+

**Maps 76-79 Dillon Beach Exposure** Source: Coastal Storm Modeling System (CoSMos)

## 7) CONCLUSION

### 7.1) Next Steps

This report summarizes adaptation options that have arisen through the C-SMART process to date. These options are not endorsed by the County of Marin or project partners, are not all necessarily feasible (economically, socially, environmentally, etc.), and in some cases may conflict with one another. However, the options presented in this report have been recognized as meriting further consideration. Option inclusion in this report does not imply financial commitment by Marin County, and completion of certain tasks is dependent on acquiring additional funding, which would require exploring various funding sources/types.

The fifth set of C-SMART public workshops included the *West Marin Sea Level Rise Adaptation Plan Passport* as a survey to solicit input from residents on next steps County staff could undertake. Additionally, the passport was posted online for further distribution via traditional and social media. Participants were asked to prioritize the possible next steps listed below with a high, medium, or low ranking. Space was also provided for comments on each ranking, as well as space to suggest entirely new options.

A total of 83 passports were completed. Indicated on each bullet below is the number of High votes, and the complete response summary can be found in Appendix G.

#### Site Scale Improvements

- Develop a “**Homeowner’s Guide to Preparing for Sea Level Rise**” to help property owners navigate regulatory system and funding opportunities to elevate or otherwise retrofit homes to

accommodate sea level rise and storms. Topics could cover:

- County permitting process
- Coastal Permit Development requirements
- Agency Compliance (FEMA, California Coastal Commission, etc.)
- Potential estimated building elevation increase

*This option received **58** high votes, tying it for number 1 of the 11 options.*

- Develop and distribute technical information and guidance on **home retrofitting options** which could include elevation, wet/dry floodproofing, flood gates, drainage improvements, amphibiation, etc.

*This option received **39** high votes, making it number 5 of the 11 options.*

#### Community Scale Planning

- Develop a **subcommittee** with Marin County BOS representation and community/local agency representatives to prioritize C-SMART next steps.

*This option received **31** high votes, making it number 9 of the 11 options.*

- Initiate **Community Plans for Adapting to Coastal Hazards** (Community PATCHs) in conjunction with community members and asset managers for smaller scale planning centered around vulnerable assets of community wide importance.
  - Identify subarea boundaries for prioritization, possibly based on timing, area of impact, costs, equity, environment, economy, etc.

- Develop planning timeframes around the point at which flooding creates recurring significant problems
- Evaluate adaptation alternatives with cost estimates in more detail, which may include armoring, elevation, realignment, etc.

*This option received **48** high votes, making it number 3 of the 11 options.*

- Consider sea level rise in capital improvement projects (roads, utilities, armoring, etc.) including both incremental repairs and maintenance, and new projects. Develop financing matrix for identifying possible funding sources including federal and state grants, local assessment districts, philanthropic resources, and public-private partnerships.

*This option received **58** high votes, tying it for number 1 of the 11 options.*

- Evaluate **land use planning, zoning and legal frameworks** for addressing sea level rise which could include height limits, construction standards, and post-storm prohibitions. Such options could be integrated in the Local Coastal Plan Implementation Program and Marin Countywide Plan update.

*This option received **37** high votes, making it number 6 of the 11 options.*

- Consider sea level rise resiliency in the next update of the Marin Countywide Plan as a basis for developing countywide policies and programs.

*This option received **33** high votes, making it number 8 of the 11 options.*

### Continued Partnerships

- Develop an **interagency sea level rise task force** with membership including County Supervisor and agencies who oversee West Marin assets (transportation, utilities, public lands, natural resources, etc.). Participants could include:
  - Caltrans, MTC and TAM for transportation planning support
  - National Park Service/Golden Gate National Recreation Area/CA Department of Parks and Recreation/Marin County Parks
  - PG&E and local service providers to discuss utility adaptation

*This option received **43** high votes, making it number 4 of the 11 options.*

- Continue to work with the Sonoma/Marin County Sediment Management Working Group to assist with the development of a **Regional Sediment Management Plan** to
  - encourage beneficial reuse of available, non-polluted sediment resources;
  - restore and maintain coastal beaches;
  - reduce shoreline erosion and coastal storm damages; and
  - sustain recreation, tourism, public safety and access

*This option received **36** high votes, making it number 7 of the 11 options.*

### Public Education

- Establish a **citizen's science monitoring program** for community members to gather data on West Marin sea level rise impacts which could include measuring beach widths, documenting king tides and flooding, and monitoring wetlands.

*This option received **23** high votes, tying it for number 10 of the 11 options.*

- Continue to pursue funding and partnerships to formalize a sea level rise **public education** program for high school students.

*This option received **23** high votes, tying it for number 10 of the 11 options.*

DRAFT

## 7.2) Lessons learned

SLR Adaptation plans and proposals tend to be relatively new endeavors with few existing precedents to follow. Thus through this process C-SMART Staff have learned quite a bit of valuable information that can be applied to continued Marin County planning efforts and shared with other jurisdictions. Specific lessons learned include:

- *Adopt a process that is understandable.* Public participation is critical to successful planning and implementation efforts. Processes should make sense to local residents to gain their support. Avoid jargon and adopt consistent talking points for robust public outreach.
- *Gain a full understanding of available models.* Several flooding/SLR models are available for both the general public and professionals including FEMA, OCOF, and NOAA. As a professional it is critical to understand the specifics of each model, and the rationale for applying the chosen model. Discussions of models will likely come up in public processes and having answers to FAQs can be critical for public outreach.
- *Focus public outreach on existing groups.* Due to ‘meeting fatigue’ and busy schedules, it is often challenging for local residents to attend public meetings, especially for threats such as SLR which are perceived as distant and far away. Thus to augment public processes, existing community groups should be identified and reached out to see if staff can participate in upcoming meetings.
- *Collaborate early and often with other agencies.* As SLR sees no jurisdictional boundaries and can have widespread impacts on a variety of asset types regular collaboration with entities carrying out similar work can strengthen processes and products. Formalized working relationships can ensure regular communications and strengthen partnerships, setting the stage for increased adaptation planning efforts as SLR intensifies.

## BIBLIOGRAPHY

- Buoyant Foundation Project. <http://www.buoyantfoundation.org>. Accessed May 4, 2016.
- Buskey. 2009. 1 (appendices, 340); and Elizabeth English, “Amphibious Foundations and the Buoyant Foundation Project: Innovative Strategies for Flood-Resilient Housing,” (paper presented at the International Conference on Urban Flood Management, Paris, France, November 25-27, 2009), 7 (appendices, 412).
- California Coastal Commission. *Sea Level Rise Policy Guidance*. August 2015.
- California Department of Transportation (Caltrans). *District 1 Climate Change Vulnerability Assessment and Pilot Studies*. December 2014.
- California Department of Transportation (Caltrans). *Final Marin State Route 1 Repair Guidelines*. July 2015.
- California Department of Transportation (Caltrans). *Personal Communications*. July 2015.
- California Governor’s Executive Order #S-13-08. November 2008.
- California Natural Resources Agency. *Safeguarding California: Reducing Climate Risk*. July 2014.
- Center for Ocean Solutions, Natural Capital Project. *Coastal Adaptation Policy Assessment*. 2016.
- Climate Adaptation Knowledge Exchange. *Restoration and Management of Pacifica State Beach*. [www.cakex.org](http://www.cakex.org). December 2010.
- Clyde, George. West Marin Review. *How Rep. Phillip Burton and a Magic Marker Hijacked Tomales Bay into the Golden Gate National Recreation Area*. 2012.
- Columbia Center for Climate Change Law. *Managed Coastal Retreat: A Legal Handbook on Shifting Development Away from Vulnerable Areas*. October 2013.
- Delaware Coastal Programs. *Preparing for Tomorrow’s High Tide: Recommendations for Adapting to Sea Level Rise in Delaware*. September 2013.
- English, Elizabeth. December 9, 2015. The Buoyant Foundation Project, personal communication.
- Environmental Protection Agency (EPA) *National Estuary Program*. 2015.
- Environmental Science Associates (ESA). *Geomorphic Response of Beaches and Marshes*. August 2015.
- Environmental Science Associates (ESA). *Marin County Coastal Hazards and SLR Adaptation Strategies (Memo)*. April 2016.
- Environmental Science Associates (ESA). *Ocean Beach Master Plan*. 2012.
- Environmental Science Associates (ESA). *Sea Level Rise Adaptation Options for Marin County*. 2015.

- Environmental Science Associates (ESA) Phillip Williams and Associates (PWA) *Evaluation of Erosion Mitigation Alternatives for Southern Monterey Bay*. 2012.
- (FEMA). *Homeowner's Guide to Retrofitting*. 1998.
- (FEMA). *Selecting Appropriate Mitigation Measures for Floodprone Structures*. 2007.
- (FEMA). *Reducing Flood Risk to Residential Buildings that Cannot Be Elevated*. 2015.
- Global Environmental Change. *Maladaptation Editorial*. [www.elsevier.com/locate/gloenvcha](http://www.elsevier.com/locate/gloenvcha). 2010.
- Griggs, G, Árvai, J, Cayan, D, DeConto, R, Fox, J, Fricker, HA, Kopp, RE, Tebaldi, C, Whiteman, EA (California Ocean Protection Council Science Advisory Team Working Group). *Rising Seas in California: An Update on Sea-Level Rise Science*. California Ocean Science Trust, April 2017.
- ICLEI-Local Governments for Sustainability. *Sea Level Rise Adaptation Strategy for San Diego Bay*. January 2012.
- Johnson, Sam (USGS). Presentation at the 2015 CA Shore and Beach Preservation Association. *California Seafloor Mapping Program Update – Focus on Regional Sediment Thickness*.
- Linnean Solutions, The Built Environment Coalition and The Resilient Design Institute. *Building Resilience in Boston, Best Practices for Climate Change Adaptation and Resilience for Existing Buildings*. 2013.
- Lohman, Edith. (FEMA) Personal Communications. 2016.
- Marin County Community Development Agency. *Marin Ocean Coast Sea Level Rise Vulnerability Assessment Public Review Draft*. December 2015.
- Marin County Community Development Agency. *Planning Application Guide*. September 2015.
- Marin County Department of Public Works. *Memorandum on Completion of Asset Vulnerability Assessment Tool for Collaboration: Sea-Level Marin Adaptation Response Team (C-SMART)*. May 2015.
- Marin County Department of Public Works. *Stinson Beach Watershed Program Flood Study and Alternatives Assessment*. 2014.
- Marks v. Whitney, 6 Cal.3d 251 (Cal. 1971)
- National Park Service. *Redwood Creek Restoration and Muir Beach*. [www.nps.gov/goga/learn/nature/muir-beach.htm](http://www.nps.gov/goga/learn/nature/muir-beach.htm). Accessed January 2016.
- National Adaptation Forum. *Good Adaptation Pledge*. Accessed November 21, 2015. <https://www.nationaladaptationforum.org/about/adaptation-pledge>.
- National Trust for Historic Preservation. *The Greenest Building: Quantifying the Environmental Value of Building Reuse*. 2011.

- National Oceanic and Atmospheric Administration (NOAA). *Carbon Sequestration 101*.  
<http://www.habitat.noaa.gov/coastalcarbonsequestration.html>. Accessed April 27, 2016
- Pacific Institute. [\*The Impacts of Sea Level Rise on the California Coast\*](#). 2009.
- Pickart AJ. *Dune Restoration Over Two Decades at the Lanphere and Ma-le'l Dunes in Northern California*. 2013.
- PWA. [\*CA Coastal Erosion Response to Sea Level Rise – Analysis and Mapping\*](#). 2009
- Raives, James. *Conclusion and Recommendations of the Bolinas Lagoon Restoration Project Design Review Group (Memo)*. 2014.
- San Francisco Bay Living Shorelines Project.  
[http://www.sfbaylivingshorelines.org/sf\\_shorelines\\_about.html](http://www.sfbaylivingshorelines.org/sf_shorelines_about.html). Accessed July 2016.
- State Water Resources Control Board. *Onsite Wastewater Treatment Systems Policy*. 2012.  
[www.waterboards.ca.gov/water\\_issues/programs/owts/docs/owts\\_policy.pdf](http://www.waterboards.ca.gov/water_issues/programs/owts/docs/owts_policy.pdf).
- Stinson Beach County Water District. *Onsite Wastewater Management Program Report*. 2015.
- Sustainable Planning and Urban Research (SPUR). *Strategies for Managing Sea Level Rise*. 2009.
- Trulio, L., Callaway, J. and Crooks, S. *White Paper on Carbon Sequestration and Tidal Salt Marsh Restoration*. 2007.
- US Geological Survey (USGS). *Coastal Groundwater Systems*. Accessed August 2016.  
<http://wh.er.usgs.gov/slr/coastalgroundwater.html>