

C-SMART COMMUNITY PROFILES

MUIR BEACH

Community Profile: Muir Beach

Muir Beach, West Marin’s southernmost community, is located 2 miles northwest of Muir Woods National Monument, along the lower portions of Redwood Creek and on a ridge overlooking the Pacific Ocean. Muir Beach is home to just over 300 people. The following assets may be vulnerable:

- Bluff top homes could be impacted by erosion by the medium-term.
- Portions of Pacific Way could flood, limiting routine and emergency access for residents and visitors in the long-term.
- Intertidal rocky and beach habitats.
- Emergency access through the Green Gulch Zen Center to Muir Beach public area could flood in the long-term.

Recently, the National Park Service completed the Redwood Creek Restoration 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 California red legged frog.¹ The beach and tidal lagoon were given room to migrate inland with sea level rise. The parking lot was reconfigured away from direct wave action to minimize storm surge impacts.² Because this project occurred after the geographic baseline for the CoSMoS model was taken, the geographic extent of the sea levels may be overestimated. [Map 58](#) depicts the project.

Vulnerable Assets

In the near- to medium-term, several homes are vulnerable to bluff erosion. Portions of Pacific Way and emergency access through the Green Gulch Zen Center to the Muir Beach public area are vulnerable at the high end of the long-term scenario. Archaeological sites may also be present. [Table](#) lists the vulnerable assets here by timing and water depth. [Maps 59, 60, and 61](#), at the end of this profile, illustrate the developed and natural assets vulnerable to sea level rise and accelerated erosion.

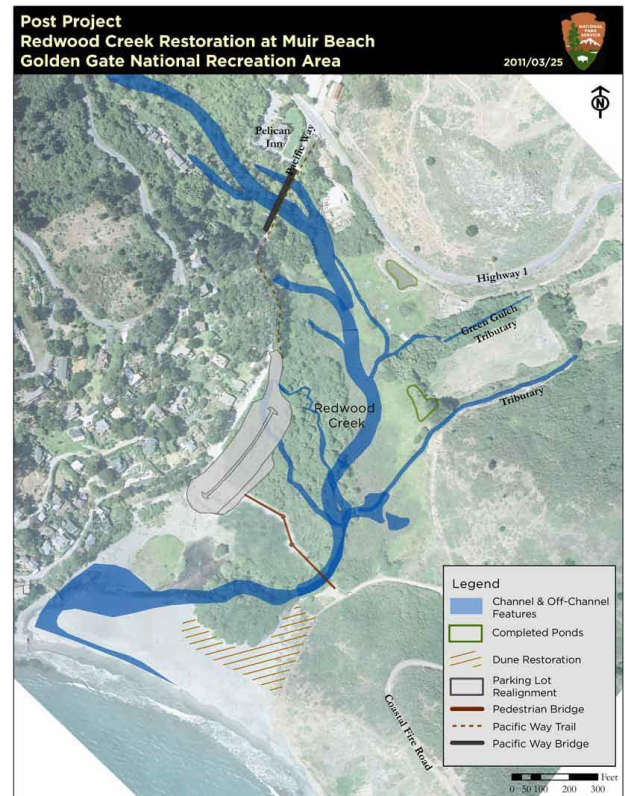
¹ Redwood Creek Restoration and Muir Beach. www.nps.gov/goga/learn/nature/muir-beach.htm

² Redwood Creek Restoration at Muir Beach, Frequently Asked Questions. Revised 2009.

IMPACTS AT-A-GLANCE

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

Map 60. Muir Beach Restoration Project



Source: NPS, 2011

Parcels & Buildings

The bluff wall beneath the oceanfront homes in Muir Beach could be susceptible to undercutting from wave activity, especially during storms. Such damage could accelerate bluff erosion, increasing the vulnerability of oceanfront homes. An analysis was conducted using sea levels from C-SMART scenarios, revealing that just over 50 homes in Muir Beach could be vulnerable to future erosion trends.

MUIR BEACH

Table 31. 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

Transportation

In the long-term, Pacific Way could be exposed from the coast to its intersection with Shoreline Highway, blocking access to the Muir Beach parking lot. This could result in fewer visitors to Muir Beach and cause complications for residents who depend on it for daily activities and emergency access.

Additionally, many Muir Beach residents and visitors use the Manzanita Interchange in Sausalito (outside the study area) for southerly access, which floods during current high tides and storms.

Utilities

Not vulnerable.

Working Lands

Not vulnerable.



View south toward Muir Beach. Credit: CDA

Table 32. Muir Beach Vulnerable Assets

Asset	Tidal & 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. Values not underlined represent extreme event flooding.)					Vulnerability TF: Temp. Flooding during extreme events; HS: Habitat Shifts
	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	
Bluff Top Buildings			X	X	X	E
Emergency Access (Green Gulch Center)					SLR + Creek Flooding	TF
Pacific Way					22"	TF
Green Gulch Creek	Water Resource					HS
Redwood Creek	Water Resource					HS

Source: Marin Mao, CoSMoS, Asset Manager Interviews

MUIR BEACH

Natural Resources

Beaches are among the most vulnerable local habitat types, susceptible to higher tide lines, flooding, erosion, and sand shift;³ however, the Redwood Creek restoration project created space for the beach and marsh to migrate landward. Despite this, ecosystem shifts could disturb habitats of shorebirds, wildflowers, and other species. While Redwood Creek may be able to tolerate higher water levels, some of the key species it provides habitat for, such as Coho salmon, steelhead trout, and California red-legged frog could be disturbed by increased salinity in the tidal areas and upstream.^{4,5} Rocky intertidal habitats are vulnerable to increased salinity, flooding, erosion, wave action, and more standing water and less tidal flux. This could significantly impact species living in the zone, including the California mussel.⁶

Recreation

Based on the CoSMoS model results, access to the beach parking lot could be compromised at Pelican Way in the long-term scenarios. However, it is possible that the restoration completed in 2013 could reduce the threats modeled by CoSMoS.

Emergency Services

Emergency access through the Green Gulch Zen Center to Muir Beach public area and along Pacific Way could be compromised in the long-term. Combined with creek flooding during storms, temporary disruption could occur at lower levels of sea level rise.

Historic & Archaeological Resources

Archaeological sites could be present in the exposure zones. The Sonoma State University's Anthropological Study Center is inventorying archaeological sites for much of California's coastline in anticipation of sea level rise and coastal erosion.⁷



Rugged coastline near Muir Beach. Credit: CDA

³ Hutto, S.V., K.D. Higgason, J.M. Kershner, W.A. Reynier, D.S. Gregg. 2015. Climate Change Vulnerability Assessment for the North-central California Coast and Ocean. Marine Sanctuaries Conservation Series ONMS-15-02. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Office of National Marine Sanctuaries, Silver Spring, MD.

⁴ Botsford, L. and C. Lawrence. 2002. Patterns of co-variability among California Current chinook salmon, coho salmon, Dungeness crab, and physical oceanographic conditions. *Progress in Oceanography* 53 (2):283-305.

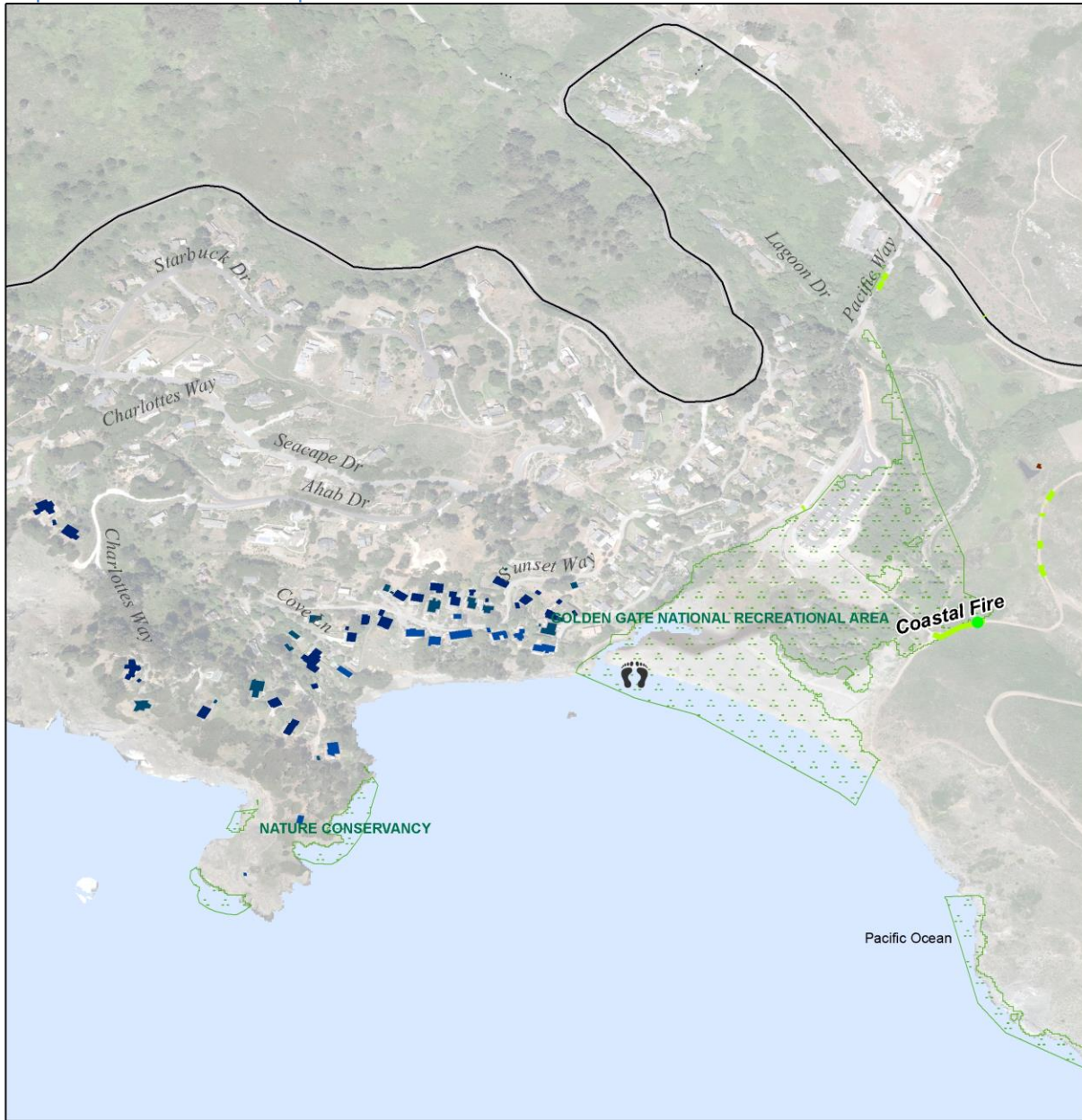
⁵ U.S. Fish and Wildlife Service. 2002. Recovery Plan for the California Red-legged Frog (*Rana aurora draytonii*). U.S. Fish and Wildlife Service, Portland, Oregon. viii + 173 pp.

⁶ Hutto, S.V., K.D. Higgason, J.M. Kershner, W.A. Reynier, D.S. Gregg. 2015. Climate Change Vulnerability Assessment for the North-central California Coast and Ocean. Marine Sanctuaries Conservation Series ONMS-15-02. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Office of National Marine Sanctuaries, Silver Spring, MD.

⁷ Newland, M. April 1, 2015. Sonoma State University, personal communication.

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Map 61. Muir Beach Developed Assets Vulnerable to Sea Level Rise and Accelerated Erosion



Roads

- @ 10' + Annual storm
- @ 10' + 20-year storm
- @ 20' + 20-year storm
- @ 40' + 100-year storm
- @ 80' + 100-year storm

* Roads may also have utility pipes underneath, are used for recreation, and serve as emergency access in some locations.

Other Assets

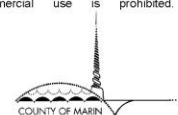
- Buildings Exposed to Flooding
- Buildings Vulnerable To Erosion
- Parcels
- Agricultural Parcels
- A Aquaculture
- Parkland
- Historic District

- ▲ Commercial
- ▲ Education
- Emergency
- ▲ Food
- Government Service
- Historic
- Institutional
- Recreation
- Residential
- Transportation
- ▲ Utilities

- Boat Launch
- Fishing Pier
- Access Point
- Port
- Marina

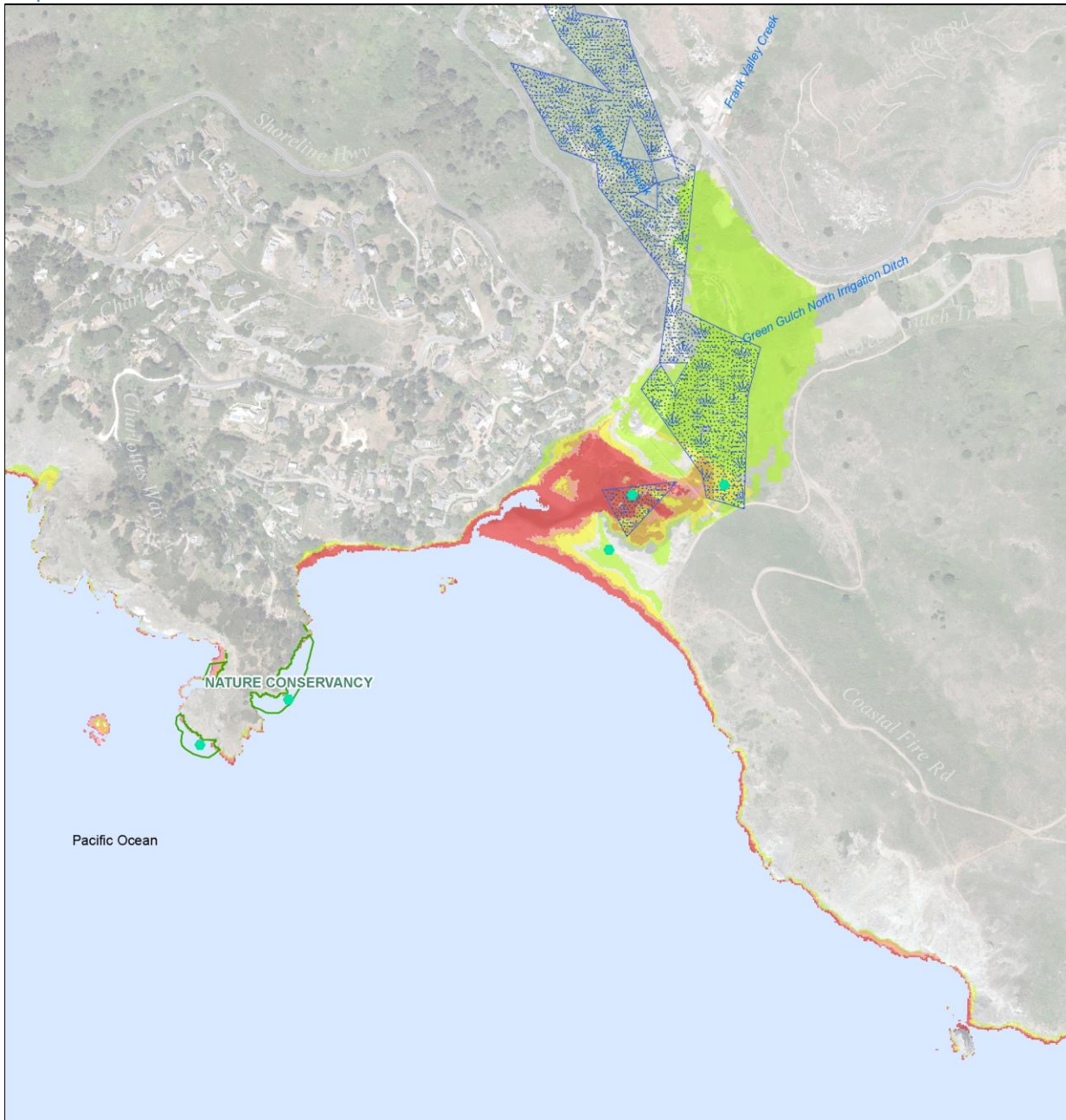
0 0.1 0.2 0.4 0.6 0.8 Miles

Source: Marin Map, Our Coast Our Future, CA Coastal Commission
 Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data providers here in, make no warranties of the accuracy or completeness of maps and data. Maps are representational and subject to future revision. Local site conditions must be examined. Commercial use is prohibited.
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Map 62. Muir Beach Natural Resource Assets Vulnerable to Sea Level Rise



Scenarios

- 1 10" SLR + Annual Storm
- 2 10" SLR + 20-year Storm
- 3 20" SLR + 20-year Storm
- 4 40" SLR + 20-year Storm
- 5 80" SLR + 100-year Storm

Assets

- Natural Resource Assets
- ▭ Parks
- 🐦 Seabird Colony
- 🐾 Mammal Haul Out

- ▨ Wetland
- ▨ Estuary
- ▨ Marsh



Source: Marin Map, Our Coast Our Future, Department of Fish & Wildlife
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Date: 4/4/2016



STINSON BEACH

Community Profile: Stinson Beach

Nestled between the Pacific Ocean, Bolinas Lagoon, and Federal and State Parkland, the low-lying areas of Stinson Beach may include some of the most impacted built assets in West Marin. Key issues in Stinson Beach are:

- All homes, buildings, and facilities west of Shoreline Highway are vulnerable to storm impacts, OWTs failure, water distribution pipe failure, and flooding.
- Calle del Arroyo, a principal access road to the Calles, Patios, and Seadrift neighborhoods, is vulnerable.
- Flooding from Bolinas Lagoon and Easkoot Creek already occur and will likely worsen.
- Beach loss is likely to occur by the long-term scenarios.

Stinson Beach is a nearly 400-acre village with about half of its land area within Seadrift, a large privately managed subdivision along the sand spit. The population of just over 630 residents, with hundreds to thousands of visitors, on any given day, throughout the year.

Vulnerable Assets

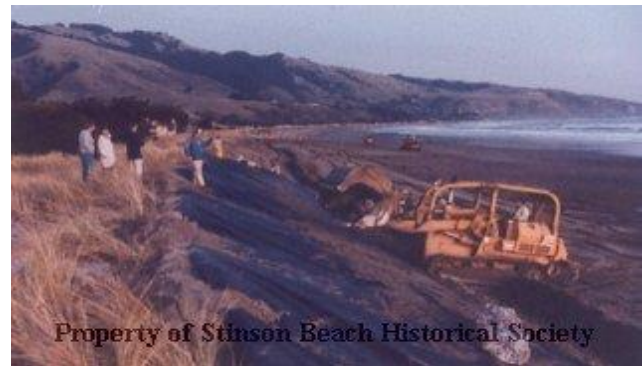
Stinson Beach's most vulnerable assets are buildings west of Shoreline Highway, Shoreline Highway, Calle del Arroyo and linked private roads, fire station no. 2, OWTs, water delivery systems, and the beach itself. All of these could be impacted in the near-term. All assets and their tidal and flood depths are presented in [Table 33](#) and described in the following sections. [Maps 65 and 66](#) at the end of this profile illustrate the developed and natural assets vulnerable to sea level rise and accelerated erosion.

IMPACTS AT-A-GLANCE

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



Stinson Beach. Credit: CDA



Property of Stinson Beach Historical Society
Building the Seadrift seawall. Credit: Stinson Beach Historical Society

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Table 33. Stinson Beach Vulnerable Assets

Asset	Tidal & 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. Values not underlined represent extreme event flooding. Groups of buildings are ranked by the maximum flood level. Roads received a high and low value along the line segment.)					Vulnerability TF: Temp. Flooding during extreme events; I: Inundated at MHHW; E: Erosion; WT: Water Table; SI: Saltwater Intrusion; WS: Wave Surge; HW: High Wind, HS: Habitat Shift
	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	
OWTS west of Shoreline Hwy.	<u>4.5'</u>	<u>4.5'</u>	<u>6'</u>	<u>7.5'</u>	<u>10.5'</u>	I, WT, WS, TF
	underground resource					
Water Lines west of Shoreline Hwy	<u>4.5'</u>	<u>4.5'</u>	<u>6'</u>	<u>7.5'</u>	<u>10.5'</u>	E, WS, TF, I, SI, ES
	underground resource					
Calle del Arroyo	<u>7" - 6'11"</u>	<u>3" - 6'8"</u>	<u>8" - 9'6"</u>	<u>2'5" - 12'2"</u>	<u>5'11" - 13'9"</u>	I, TF
Stinson/ Upton Beach	<u>4'7"</u>	<u>6'2"</u>	<u>7'5"</u>	<u>9'8"</u>	<u>14'9"</u>	I, E
Patios & Calles Buildings	<u>10"+1'4"</u>	<u>10"+6'3"</u>	<u>1'6"+ 7'</u>	<u>4'9"+5'10"</u>	<u>6'5"+ 6'8"</u>	I, WT, WS, TF, E
Seadrift Buildings	<u>2'5"</u>	<u>4'11"</u>	<u>4'10"</u>	<u>3'4"+8'3"</u>	<u>6'1+ 5'9"</u>	I, WT, WS, TF, E
Shoreline Hwy	<u>0" - 1'8"</u>	<u>0" - 2'3"</u>	<u>0" - 3'1"</u>	<u>0.4" - 4'10"</u>	<u>0.4" - 8'6"</u>	I, TF
Water District Office	<u>7"</u>	<u>3'3"</u>	<u>4'8"</u>	<u>6'6"</u>	<u>8'8"</u>	TF, I
Walla Vista Walkway	<u>3"</u>	<u>1'8"</u>	<u>2'</u>	<u>4'4"</u>	<u>10'4"</u>	I, E
Stinson Fire Department #2		<u>3'6"</u>	<u>5'3"</u>	<u>6'10"</u>	<u>9'1"</u>	I, TF, WT
Coastal Trail				<u>0.4"</u>	<u>1'3"</u>	TF, E
Bolinas Lagoon	water resource					HS
Easkoot Creek	water resource					HS

Source: Marin Map, CoSMoS Exposure and Flood Depth data, Asset Manager Interviews

Parcels & Buildings

Relative to other West Marin communities, Stinson Beach has a high number of buildings exposed to sea level rise and storms. The percent of exposed buildings range from 15 percent in the near-term, to 60 percent in the high end of the long-term scenario at 80 inches of sea level rise and a 100-year storm. In the near-term, the most vulnerable buildings are in the Calles and Patios neighborhoods. Seadrift properties are at slightly higher elevations and protected by a rock revetment, and therefore not anticipated to be exposed to permanent inundation until the long-term scenarios. However, some properties could be exposed to storm flooding in the near- and medium-term, as storm waves combined with higher sea levels could overtop Seadrift armoring.⁸ Table 34, Table 35, and Table 36 summarize parcel and building exposure, buildings

by type and depth of flooding, and exposed residential and commercial parcels, respectively.

Table 34. Stinson Beach Exposed Parcels & Buildings By SLR Scenario

	Parcels	Buildings
Scenario 1	379	223
Scenario 2	590	429
Scenario 3	600	468
Scenario 4	608	589
Scenario 5	614	660

Source: CoSMoS, Marin Map

⁸ Erickson, L. 2015. USGS. Personal Communication.

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Most of Stinson Beach's buildings are wood-framed. While it is unclear how many buildings are older than 30 years, newer buildings typically have drilled piles 20-30 feet deep with reinforced steel cages and concrete to connect the homes to the foundation. This feature can help homes withstand lateral forces from wind and water. However, even if buildings remain structurally intact, utility related equipment could be vulnerable. Moreover, material and content damage from water and salt could occur.

Nearly 68 percent of all residential parcels in Stinson Beach could be vulnerable to 40 inches of sea level rise and a 20-year storm (medium-term). This amounts to the near entirety of buildings west of Shoreline Highway, and the majority of buildings in the community overall. While most commercial properties are east of Shoreline Highway, the 20 percent of commercial parcels west of Shoreline Highway are all vulnerable in the near-term. [Map 63](#)

shows near term flood depths across lower Stinson Beach ranging from 0 to 12.6 feet.

[Table 37](#) estimates damage costs for buildings and their contents using FEMA tagging designations under scenario 5, assuming every exposed building experiences the same level of damage. Over \$3 million of damage could occur in the near-term and over \$220 million at the high end of the long-term.

To determine how many buildings could be re-tagged under each scenario, buildings were evaluated for exposure to a combined wave velocity and flood depth significant enough to destroy them. This analysis shows that up to 582 buildings could be damaged beyond repair, destroying over \$220 million in assessed building value.

Table 35. Stinson Beach Building Flood Depths

	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
Flood Depth (feet)	223	430	466	591	660
Storm Inundation	207 (93%)	414 (96%)	401 (86%)	427 (73%)	110 (17%)
0 - 1.5	106	184	186	114	32
1.5 - 3	61	119	120	87	35
3 - 4.5	35	57	61	72	22
4.5 - 6	5	46	27	59	14
6 - 7.5		8	7	61	4
7.5 - 9				25	2
9 - 10.5				8	
10.5 - 12				1	
Tidal Inundation	16 (7%)	16 (4%)	65 (14%)	164 (27%)	549 (83%)
0 - 1.5	3	1	1	8	8
1.5 - 3	5	3	12	9	27
3 - 4.5	8	2	7	20	23
4.5 - 6		3	5	25	105
6 - 7.5		7	32	38	71
7.5 - 9			8	35	105
9 - 10.5				29	117
10.5 - 12					80
12 - 13.5					14

Source: Marin Map, CoSMoS

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Table 36. Stinson Beach Exposed Residential and Commercial Parcels by Scenario

Scenario 1				Scenario 3				Scenario 5			
Residential		Commercial		Residential		Commercial		Residential		Commercial	
#	%	#	%	#	%	#	%	#	%	#	%
295	36%	6	21%	556	68%	6	21%	566	69%	6	21%

Source: Parcel Layer Land Use Description 2014

Map 63. Stinson Beach at 20 inches Sea Level Rise & 20-Year Storm



Source: CoSMoS Flood Depth Layer. Marin Map

Table 37. Stinson Beach FEMA Damage Levels Applied to Buildings in Exposed in Scenario 5

Buildings	Yellow Tag-Minor (\$5,000-17,000)	Orange Tag (\$17,001+)	Red Tag-Destroyed (County assessed improvement value)
660	\$3,070,000-10,438,000	\$10,438,001+	\$220,778,456

Source: Marin Map, Assessor Data

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Table 38. Stinson Beach Buidings Potentially Facing Hazardous Conditions (feet, inches)

Scenario 1		Scenario 2		Scenario 3		Scenario 4		Scenario 5		
#	%	#	%	#	%	#	%	#	%	Value*
27	2%	48	4%	89	8%	239	21%	582	51%	\$217,439,909

*Improvement Assessed Value Marin County Assessor 2014. Source: Marin Map

The deterioration and destruction of Stinson Beach’s buildings would have devastating impacts on the local economy and sense of place. Having to rebuild or repair buildings after flood events could be traumatic and costly for local residents. Foreclosure and vacancy rates could increase, and the community’s population could decline. Moreover, sales appeal to potential buyers could decline.

Table 39. Buildings Vulnerable to Accelerated Erosion

	Buildings
Scenarios 1&2*	0
Scenario 3*	5
Scenario 4*	51
Scenario 5*	284

* This analysis does not include storms. Source: Marin Map, CoSMoS, ESA

Transportation

Shoreline Highway is the only access road to Stinson Beach, and temporary or permanent flooding of this road, Calle del Arroyo, and other private Calles and Patios streets could have significant impacts on the residents and visitor-serving facilities. Without Shoreline Highway, residents who work out of the town will find it difficult to commute. Leisure travelers may be dissuaded from visiting, resulting in less economic activity. Finally, emergency services would be compromised west of Shoreline Highway.



Beachgoers flock to Stinson Beach. Credit: CDA

Table 40. Stinson Beach Exposed Road Segments (Scenarios 2-5 include roads in previous scenarios)

Scenarios 1 & 2	Scenarios 3-5
Alameda Patio ^P	McKennas Gulch Fire Rd.
Calle del Arroyo ^M	
Calle del Embarcadero ^P	
Calle del Occidente ^P	
Calle del Onda ^P	
Calle del Pinos ^P	
Calle del Pradero ^P	
Calle del Resaca ^P	
Calle del Ribera ^P	
Calle del Sierra ^M	
Dipsea Rd. ^P	
Francisco Patio ^P	
Joaquin Patio ^P	
Jose Patio ^P	
Rafael Patio ^P	
Sacramento Patio ^P	
Seadrift Rd. ^P	
Shoreline Hwy. ^C	
Sonoma Patio ^P	

P- Private Road, M- Marin County, C- Caltrans. Source: Marin Map, CoSMoS

STINSON BEACH

Utilities

The underground water distribution pipes west of Shoreline Highway are vulnerable to pressure caused by higher groundwater levels. Salt in the groundwater could also increase the rate of pipe corrosion. Residents' livability, visitor services, and health and safety systems could all be negatively impacted if potable water service is disrupted for extended periods of time.

Several Stinson Beach homes use gravity-fed underground OWTS that could be significantly compromised when inundated. Older systems are prone to malfunction during high waters, and could release contaminants into the ocean. According to the water district, about 20 older systems are replaced every year with systems that stop releasing effluent when water levels are high. However, all underground systems are vulnerable during power outages.

The Stinson Beach County Water District (SBCWD) provides water service to 718 metered water connections, monitors 700 privately owned OWTSs, and provides garbage disposal services for the community, all of which could be vulnerable before flooding is over the vulnerable roads discussed in the transportation section.

Natural Resources

Stinson's beach habitat is vulnerable to higher tide lines, inundation, flooding, erosion, and sand shifts. Erosion could force beach and dune areas inland. However, where development abuts the beach in the

Calles, Patios, and Seadrift neighborhoods, the beach could shrink offering less room for human and wildlife activity.

Average beach widths and levels of beach loss risk are tabulated in [Table 41](#) for current and future sea levels. Seadrift's beach is currently narrow along this rock revetment and during seasonal fluctuations and coastal storm events the dry beach can completely disappear. This stretch of beach is vulnerable because it is armored and unable to migrate inland.

The rest of Stinson Beach is backed by a mix of individually armored homes, other beachfront structures, and dunes. This area is typically wider than Seadrift and has a lower vulnerability in the near-term, though the risk of beach loss increases at higher sea levels.

Table 41. Stinson Beach Beach Width and Vulnerability

	Width (meters) & Vulnerability				
	Base line	Scen 1 & 2	Scen 3	Scen 4	Scen 5
Stinson Beach	53	48	32	9	2
	Low	Low	Low	Med	High
Seadrift Beach	38	29	14	0	0
	Low	Low	Med	High	High

Source: ESA 2015, CoSMoS

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Map 64. Stinson Beach Beach Loss by Sea Level Rise Amount (no storms)



- 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

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STINSON BEACH

Map 65. Easkoot Creek Flood Extent Under Storm and Downstream Sea level Rise in Bolinas Lagoon (no direct coastal flooding)



1A. Maximum inundation depths, Dec. 2005 (lower)



1B. Maximum inundation depths, Dec. 2005 (upper)



2A. Maximum inundation depths, 200-yr event (lower)



2B. Maximum inundation depths, 100-yr event (upper)

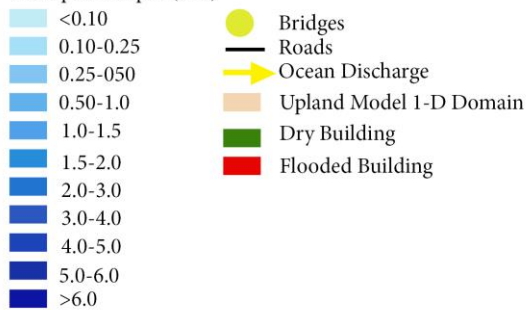


3A. Maximum inundation depths 100-yr event (lower)



3B. Maximum inundation depths, 200-yr event (upper)

Floodplain Depth (feet)



STINSON BEACH

According to the *Stinson Beach Watershed Program Flood Study and Alternative Assessment*, Easkoot Creek once flowed southerly into the ocean, and was altered northerly through NPS parkland to Bolinas Lagoon.⁹ The creek is prone to overflowing its banks; for example, in February 2014 a storm eroded the northwest stream bank. [Table 42](#) and [Map 65](#) show the results of the study’s assessment.

Table 42. Easkoot Creek Storm and Sea Level Rise Impacts

Event	# of Flooded Buildings
2-year storm	2
10-year storm	34
100-year storm	59
January 2008	16
December 2005	45
December 2005 MHHW	24
December 2005 MHHW + 2050 Sea Level Rise	27

Source: Stinson Beach Watershed Program *Flood Study and Alternative Assessment*. O’Connor Environmental Inc.

Recreation

Stinson Beach is a popular recreational destination, and visitors can easily exceed 10,000 persons on a summer weekend. As discussed in the Natural Resources section, most of the beach area could be lost. This loss could have negative effects on the sense of place and local economy. The portion of Stinson Beach that falls within the Golden Gate National Recreation Area is federal land outside of the County (and C-SMART) jurisdiction. The National Park Service’s [Adapting to Climate Change in Coastal Parks: Estimating the Exposure of Park Assets to 1 m of Sea-Level Rise](#),¹⁰ estimated over \$3 million in current replacement value for Stinson Beach’s sand area, bridge, and north parking lot. Additionally, the portion of the California Coastal Trail that runs through the GGNRA property is vulnerable in its current path in the long-term.

Emergency Services

Stinson Beach Fire Station No. 2 could face nuisance and structurally damaging flooding in the near- to medium-term. Emergency access to residents in the Calles, Patios, and Seadrift neighborhoods could be compromised. The loss or compromised function of tsunami evacuation routes along Shoreline Highway and Calle del Arroyo would be detrimental to community safety.

Historic & Archaeological Resources

Archaeological sites could be vulnerable to sea level rise, storms, and erosion.¹¹



Homes in the Stinson Beach Calles Neighborhood. Credit: CDA

⁹ Marin County Department of Public Works. 2014. Stinson Beach Watershed Program Flood Study and Alternatives Assessment

¹⁰ McDowell Peek, Katie, R. S. Young, R. L. Beavers, C. Hawkins Hoffman, B. T. Diethorn, S. Norton. *Adapting To Climate Change in Coastal Parks: Estimating the Exposure of Park Assets to 1 m of Sea-Level Rise*. Natural Resource Technical Report NPS/NRSS/GRD/NRR—2015/916. http://www.nature.nps.gov/geology/coastal/coastal_assets_rep_ort.cfm.

¹¹ Newland, M. April 1, 2015. Sonoma State University, personal communication.

STINSON BEACH

Map 66. Stinson Beach Developed Assets Vulnerable to Sea Level Rise



Exposed Roads

- @ 10" + Annual storm
- @ 10" + 20-year storm
- @ 20" + 20-year storm
- @ 40" + 100-year storm
- @ 80" + 100-year storm

* Roads may also have utility pipes underneath, are used for recreation, and serve as emergency access in some locations.

Other Exposed Assets

- Buildings Exposed to Flooding
- Buildings Vulnerable to Erosion
- Parcels
- Agricultural Parcels
- Aquaculture
- Parkland
- Historic District
- ▲ Commercial
- Education
- Emergency
- ▲ Food
- Government Service
- Historic
- Institutional
- Recreation
- Residential
- Transportation
- ▲ Utilities

- Boat Launch
- Fishing Pier
- Access Point
- Port
- Marina

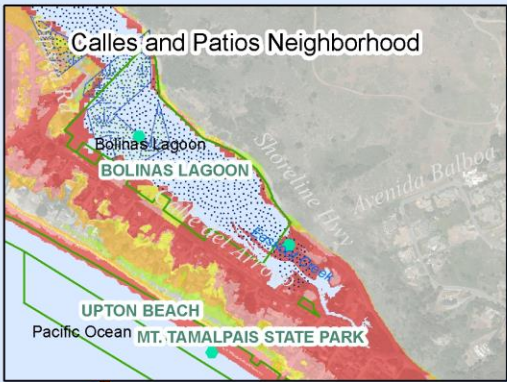
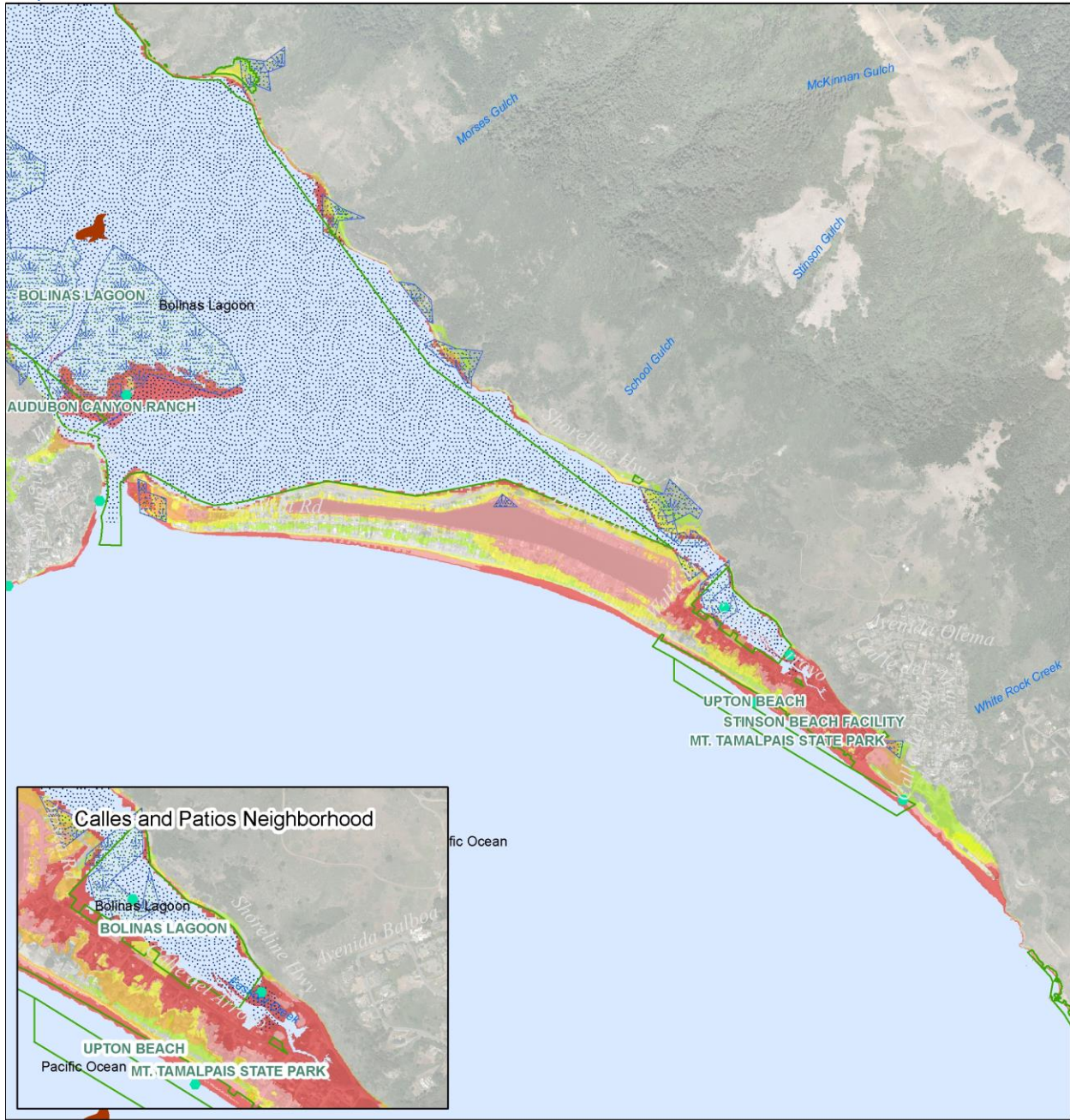


Source: Marin Map, Our Coast Our Future, CA Coastal Commission
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STINSON BEACH

Map 67. Stinson Beach Natural Resource Assets Vulnerable to Sea Level Rise



Scenarios

- 1 10" SLR + Annual Storm
- 2 10" SLR + 20-year Storm
- 3 20" SLR + 20-year Storm
- 4 40" SLR + 20-year Storm
- 5 80" SLR + 100-year Storm

Assets

- Natural Resource Assets
- Parks
- Seabird Colony
- Mammal Haul Out
- Wetland
- Estuary
- Marsh



Source: Marin Map, Our Coast Our Future, Department of Fish & Wildlife
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Community Profile: Bolinas

Bolinas is a unique coastal community, known for its mesas, lagoon, beaches, and historic area. Bolinas is west of the San Andreas Fault, and is a relatively self-contained community with respect to public services. Bolinas covers approximately 3,800 acres with development in four neighborhoods: the historic downtown, Little Mesa, Big Mesa, Horseshoe Hill Road, Paradise Valley, and Gospel Flats. In 2010, the community was home to 1,620 people. Key sea level rise vulnerabilities include:

- Downtown buildings and roads could be vulnerable during high tide and storm combinations in the near-term.
- Increased bluff erosion potential as more intense storms and wave action reach new heights.
- The narrow beaches could disappear by the mid-term because they are backed by bluffs, armoring, and development.
- Sea level rise and erosion could significantly impact sewage collection and water distribution systems in downtown and on the Little Mesa.
- Only one access road to the community exists. If the Olema-Bolinas Road or its bridges are compromised for extended periods of time, Bolinas residents will be isolated.

Vulnerable Assets

The assets most vulnerable to sea level rise and storms in Bolinas are Shoreline Highway, Bolinas-Olema Rd., Gospel Flats homes, downtown Bolinas, and eroding cliffs on the Big and Little Mesas. The following sections detail these vulnerabilities and others presented in [Table 43](#). [Maps 69 and 70](#) at the end of this profile illustrate developed assets vulnerable to sea level rise, natural assets vulnerable to sea level rise, and buildings and roads vulnerable to accelerated erosion, respectively.

IMPACTS AT-A-GLANCE

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



Bolinas Lagoon. Credit: CDA



Bolinas Library. Credit: B. White

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Table 43. Bolinas Vulnerable Assets

Asset	Tidal & Extreme Event Flooding Depth Estimates					Vulnerability TF: Temp. Flooding during extreme events; I: Inundated at MHHW; E: Erosion; WT: Water Table; SI: Saltwater Intrusion; WS: Wave Surge; HW: High Wind, HS: Habitat Shift
	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	
Tsunami Evacuation Route	<u>2'4"</u>	<u>1'8"</u>	<u>2'5"</u>	<u>4'2"</u>	<u>7'9"</u>	TF, I, WS, E
Downtown Buildings	<u>1'8"+1'5"</u>	<u>1'8"+2'2"</u>	<u>2'7"+2'</u>	<u>4'5"+2'1'</u>	<u>7'9"+1'7"</u>	I, WT, WS, TF
Wharf Road	6" - 2'1"	3" - 2'4"	2" - 2'9"	1" - 5'4"	<u>10" - 7'4"</u>	I, TF
Agate Beach	<u>2'1"</u>	<u>1'11"</u>	<u>2'8"</u>	<u>4'8"</u>	<u>9'3"</u>	I
Shoreline Hwy	0" - 1'8"	0" - 2'3"	0" - <u>3'1"</u>	<u>0.4" - 4'10"</u>	0.4" - <u>8'6"</u>	I, TF
Historic District		<u>3'10"</u>	<u>4'8"</u>	<u>6'4"</u>	<u>10'</u>	I, E
Bluff Top Buildings	X	X	X	X	X	E
Sewage Lift Station			<u>3'3"</u>	<u>5'</u>	<u>8'7"</u>	TF, I
Olema-Bolinas Road			<u>2'8"</u>	<u>4" - 4'4"</u>	<u>2" - 7'11"</u>	I, TF
Bolinas Super Market			<u>8"</u>	<u>2'6"</u>	<u>6'1"</u>	I, E, SI
Bolinas Library				<u>1'8"</u>	<u>5'3"</u>	I, TF
Bo-Gas Station				<u>1'7"</u>	<u>5'3"</u>	I
Gospel Flats				<u>1'7"</u>	<u>5'3"</u>	I, WT, SI, TF
Community Center Emergency Shelter				<u>1'7"</u>	<u>5'2"</u>	I, E
Community Land Trust Housing				<u>1'2"</u>	<u>4'10"</u>	I
Church: Calvary Presbyterian					<u>5'10"</u>	I, TF
Bob Stewart Trail					<u>4'8"</u>	I, TF
Bolinas People's Store					<u>3'</u>	I, TF
Bolinas Post Office Buildings					<u>2'9"</u>	TF, I
Bolinas Stinson School					<u>2'2"</u>	I, TF, E, WS
Bolinas Lagoon	water resource					HS
Pine Gulch Creek	water resource					HS

Source: Marin Map, CoSMoS Exposure and Flood Depth data, Asset Manager Interviews

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Parcels & Buildings

Compared to other West Marin communities, Bolinas has a relatively high number of threatened properties. In the near-term, the most vulnerable buildings are those directly above the tidal marshlands on piers along Wharf Road. Current high tides reach the top of the bulkheads reinforcing the shoreline and Wharf Road. This area includes 16 buildings and 69 parcels that could see sea level rise and storm impacts. In the long-term, 57 parcels and 110 buildings could be exposed, including the lift station that serves over a 100 homes and businesses. Without armoring, eroding cliffs could undermine several homes on the mesas over the coming decades.

Several historic properties are vulnerable, including the Bolinas Stinson School District Office and

Smiley's Schooner Saloon & Hotel. Other vulnerable properties include Gospel Flats homes and farms, the Bolinas Community Center and Library, Bo-Gas Station, Community Land Trust Housing, the People's Store, and the post office. [Table 45](#) organizes exposed buildings by flood type and depth for each scenario.

Table 44. Bolinas Exposed Parcels & Buildings

	Parcels	Buildings
Scenario 1	69	13
Scenario 2	73	16
Scenario 3	81	24
Scenario 4	91	30
Scenario 5	127	98

Source: Marin Map, CoSMoS

Table 45. Bolinas Building's Flooding Depth Estimates

	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
Flood Depth (feet)	13	16	24	30	98
Storm Flooding	5 (38%)	8 (50%)	24 (100%)	6 (20%)	17 (17%)
0 - 1.5	3	2	16	6	4
1.5 - 3	1	4	2	1	12
3 - 4.5	1	2	5		1
4.5 - 6			1		
Tidal Inundation	8 (62%)	8 (50%)		24 (80%)	81 (83%)
0 - 1.5	6	6		6	5
1.5 - 3	1			7	9
3 - 4.5	1	2		4	34
4.5 - 6				5	16
6 - 7.5				1	9
7.5 - 9					7

Source: Marin Map, CoSMoS

Table 46. Bolinas Exposed Residential and Commercial Parcels

Scenario 1				Scenario 3				Scenario 5			
Residential		Commercial		Residential		Commercial		Residential		Commercial	
#	%	#	%	#	%	#	%	#	%	#	%
27	2%	1	7%	53	5%	4	27%	94	8%	13	87%

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Table 46 shows that up to 90 percent of commercial parcels in Bolinas could be vulnerable. Because most of the town’s housing is located on the Big and Little Mesas, less than 10 percent of the residential buildings are vulnerable to temporary and permanent flooding. In addition, in the near-term, 30 buildings could see increased erosion risk, and in the medium-term that number increases to 84. In the long-term, over two hundred buildings could see heightened erosion threats in the Big and Little Mesa neighborhoods in the long-term. See Table 47.

Applying the FEMA damage tagging levels described in the Parcels & Buildings Profile reveals that minor damage could add to \$490,000-1,660,000, assuming every building exposed in scenario 5 experiences the same amount of damage.¹² If total destruction were to occur for each exposed building, over \$23 million in assessed building value¹³ could be lost. These figures are summarized in Table 48.

Buildings were also assessed for their potential to see storm forces strong enough to destroy them and lead to a red-tag. In the near-term the figures are low, however, by the medium-term, 15 buildings could see hazardous conditions. By the long-term time horizon, all 98 buildings exposed to sea level rise and storms could face destructive forces. See Table 49.

Hydrological processes within the cliff face at Bolinas play a significant role in erosion. Seepage is visible during the rainy season at the base of the bluffs, and that the cliff face becomes gullied from heavy rainfall. Bolinas Mesa faces erosion rates among the highest within a developed community in California. Along the west facing shore of the Mesa, a combination of subsurface flow and septic effluent, as well as wave action from the ocean, contribute on average up to 2 feet of erosion per year, with episodic larger erosion events. Several homes have already been removed on the southeast facing

shore, where significant erosion can occur during powerful southern-sourced winter storms.¹⁴

Table 47. Bolinas Buildings Vulnerable to Accelerated Erosion*

	Buildings
Scenarios 1&2	30
Scenario 3	84
Scenario 4	227
Scenario 5	275

* This analysis does not include storms
Source: Marin Map, CoSMoS

¹² ArcGIS. FEMA Modeling Task Force (MOTF)-Superstorm Sandy Impact Analysis. Last update June 22, 2015. <http://www.arcgis.com/home/item.html?id=307dd522499d4a44a33d7296a5da5ea0>

¹³ Market value is likely significantly higher than assessed value.

¹⁴ Griggs et al. *Living With the Changing California Coast* “Bolinas – Case Study of an Unplanned Development”.

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Table 48. FEMA Damage Levels Applied to Buildings in Bolinas Exposed in Scenario 5

Buildings	Yellow Tag-Minor (\$5,000-17,000)	Orange Tag \$17,001+	Red Tag (Assessed improvement value)
98	\$490,000-1,666,000	\$1,666,001+	\$23,114,950

Source: Marin Map, CoSMoS

Table 49. Bolinas Buildings Potentially Facing Hazardous Conditions

Scenario 1		Scenario 2		Scenario 3		Scenario 4		Scenario 5		
#	%	#	%	#	%	#	%	#	%	Value*
3	<1%	6	<1%	15	1%	25	1%	98	5%	\$23,114,950

*Improvement Assessed Value Marin County Assessor 2014. Source: Marin Map

Table 50. Bolinas Exposed Road Segments (Scenarios 2-5 include roads in previous scenarios)

Scenarios 1 & 2	Scenario 3	Scenario 4	Scenario 5
Shoreline Hwy. ^C Wharf Rd. ^M	Bolinas Wye ^C	Olema Bolinas Rd. ^M Fairfax Bolinas Rd. ^M	Brighton Ave. ^M Newport Ave. ^P Park Ave. ^M

P- Private Road, M- Marin County, C- Caltrans. Source: Marin Map, CoSMoS

Transportation

Several roadways already experience winter and tidal flooding, especially during storms. As sea level rises and storm severity increases, these occurrences may become more severe. Major vulnerable roadways include Shoreline Highway (State Route 1) at the Bolinas Wye to the south, Fairfax-Bolinas Road, and Olema-Bolinas Road.

The Pine Gulch Creek bridge on Bolinas-Olema Road is the first vulnerable spot along the access road. Bridge failure would reduce southerly access. If the bridge and road are out for extended periods of time, the community would have limited access to propane, food, and gasoline. Wharf Road, the main road in the small commercial downtown, could be impacted in the near-term. Brighton and Park Avenues could see impacts in the medium- and long-terms. Several bluff top roads near the edge could erode more quickly than historic rates predict.

Water transportation for pleasure, fishing, and crabbing is a major use of the Bolinas Wharf area. As tides rise, boating opportunities may improve. However, crabbing and fishing habitat may shift.



Olema-Bolinas Road, December 2014. Credit BPUD

Utilities

Some of the biggest threats to utilities are to the water and waste systems. These utilities are typically under the road or property. Electricity and telephone communications, both above and underground, are vulnerable during storms.

Changes in water elevation and pressure in the ground could greatly impact the strength and function of potable water system distribution lines. With respect to wastewater removal, the most vulnerable asset in the long-term is the lift station that serves downtown and the Little Mesa. The

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collection system serves 141 residential, 20 commercial, and 2 institutional properties. This service could be severely disrupted at 6 feet of sea level rise (scenario 5). This gravity fed system leads into a lift station that reaches 25 feet underground with access points a few feet above sea level. The above ground mechanical components are elevated about one foot. If this system were to fail or be disrupted, as many as 162 properties in Downtown and Little Mesa would become unuseable.

Erosion is of particular concern and several improvements to the pipe system have helped to increase the longevity of the system. In 2004, in anticipation of bluff collapse, BCPUD relocated the water pipes along Terrace Avenue at Overlook Drive behind homes landward of the new road. The County funded the \$1.5 million bluff stabilization project. Additionally, in 2013, anticipating catastrophic bluff collapse at another point beneath Terrace Avenue at “Surfer’s Overlook”, BCPUD relocated the water main, costing approximately \$485,000. The BCPUD evaluated the relocating the sewer main in the same location, and engineers estimate the cost at approximately \$250,000. In the 1990’s, when the BCPUD relocated a sewer main on the Little Mesa due to bluff erosion, homeowners were required to buy and install costly pump stations at their own expense to convey wastewater to the newly relocated main. The BCPUD anticipates a similar expense would be needed from other homeowners served by the Terrace Avenue sewer main should it be relocated.

Bolinas Mesa erosion is combination of both wave action and groundwater flow processes. Bolinas Mesa uses onsite wastewater treatment (OWTS), the common mode of treating waste in rural/semi-rural communities across the country. It has been shown that it only takes 1 OWTS every 16 acres to begin infiltrating the groundwater supply because these systems are sensitive to crowding. OWTS become particularly sensitive in areas where the groundwater system is shallow, like in Bolinas. Because the groundwater system is so close to the surface (2-6 ft below ground), a single storm system can cause groundwater levels to rise precariously close to the surface, which lead to near full saturation of the soil. These conditions cause the septic tanks to infiltrate the groundwater supply.

Some Bolinas residents use propane services for heating and cooking. If roadways are comprised, the supply line between the residents and purveyors is

cut off. If significant flooding occurs, ground level tanks may be dislodged and potentially hazardous. Finally, the Bo-Gas Station, the only source of gasoline along the coast, is exposed overland in the long-term; however, underground tanks could see impacts sooner from moisture and salinity in the soil.



BCPUD lift station and backup generators. The building extends 25 feet underground. Credit: CDA

Table 51. Brighton, Agate, and Wharf Rd. Beaches Future Average Widths and Vulnerability

	Baseline	Scen 1 & 2	Scen 3	Scen 4 & 5
Width (meters)	22	9	3	0
Vulnerability	Low	High	High	High

Source: ESA, 2015, CoSMoS

Natural Resources

Brighton and Agate beaches are highly vulnerable to sea level rise and storm impacts in the near-term (see [Table 51](#)). Agate and Brighton beaches are currently, and will continue to be, subjected to tidal and storm flooding. Both beaches are against the bluff and could disappear in the medium-term. Portions of Brighton Beach feature low walls protecting beachfront homes and groins to maintain sand on the beach. Sea level rise would likely increase the rate of erosion and increase the sediment supply. Wharf Road Beach is slightly wider and could disappear by the end of the century.

If intensifying wave action erodes the base of cliffs and protective beachfronts, existing vegetation regimes could shift and impact the greater food web. Finally, major landslides onto beaches could eliminate bird, mammal, and invertebrate habitat.

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The Bolinas Lagoon could also see changing conditions. Bolinas Lagoon is a tidal embayment sheltered by the Stinson Beach sand spit. The lagoon is approximately 1,000 acres of shallow water, 600 acres of extensive mud, and additional acreages of sand tidal flats, ebb tide shoals, small alluvial fans, deltas, and tidal salt marsh. The water is primarily saline and connects via a tidal inlet that has remained open for 1,600 years.¹⁵ Ten small seasonal drainages, and the perennial Pine Gulch Creek, contribute freshwater and 25 percent of the coarse alluvial sediment in the lagoon. The *Memorandum: Bolinas Lagoon Restoration Project Design Review Group*¹⁶ provides a summary of the implications of higher sea levels:

- Accelerated sea level rise replaces the risk of excessive lagoon sedimentation and tidal prism loss as an overriding ecosystem concern. Long-term lagoon submergence is a major challenge to the lagoon's ecosystem health and resilience.
- Sediment values can be neutral, beneficial, or adverse, depending on the location, timing, magnitude, and context. Sedimentation is an asset to evolution of the lagoon.
- The lack of space for the lagoon to migrate into lowlands and fault valleys as sea level rises is a concern for long-term health and stability.
- The barrier sand spit and tidal inlet are essential components of the lagoon's evolution in response to sea level rise. Future changes in the lagoon's barrier beach and tidal inlet will occur in response to accelerated sea level rise.

In addition, changes in salinity will affect vegetation. Lower salinities, common in winter and early spring, positively affect plant recruitment. Increases in salinity, especially during the summer, can negatively affect vegetation diversity and shift salt tolerant vegetation inland, soil conditions permitting.

Map 69 and Table 52 show the existing and shifting habitats in Bolinas Lagoon for each sea level associated with the C-SMART scenarios. The analysis assumes the best case of 6.8 mm/year of sediment. As sea level rises, the marshes could be restricted to the Pine Gulch Creek delta, Kent Island,

Easkoot Creek and the Lewis and Wilkins Gulches at the head of the lagoon. Marshes close to Pine Gulch Creek are likely to survive longer due to sediment collection in the delta. All other marsh areas are likely to be inundated. Approximately 50 percent of high marsh is expected to be lost by mid-century; converting to low marsh, mud and sand flats.¹⁷ This figure increase to 80 percent, leaving only 20 percent of existing marsh lands by 2100.¹⁸

¹⁵ Byrne, R., L. Reidy, D. Schmidt, D. Sengupta, A. Arthur, 2005. Recent (1850-2005) and late Holocene (400-1850) sedimentation rates at Bolinas Lagoon. Report prepared for Marin County Open Space District.

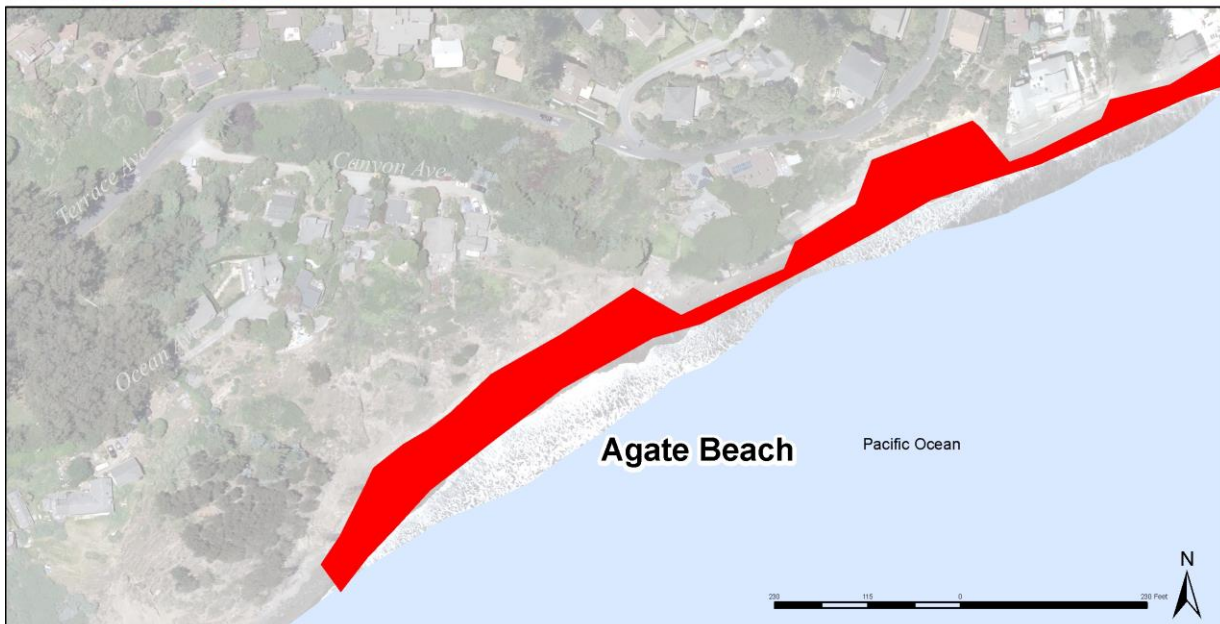
¹⁶ Baye, P. R., 2014. Memorandum: Bolinas Lagoon Restoration Project Design Review Group (DRG) Meeting San Francisco Bay Joint Venture (SFBJV) Meeting Summary and Synthesis Draft.

¹⁷ This is a conservative estimate as there may be increases in accretion rates and changes from sand bodies in the lagoon such as Kent Island, which increases protection from wave action and enhance sedimentation rates.

¹⁸ This is a conservative estimate as there may be increases in accretion rates and changes from sand bodies in the lagoon such as Kent Island, which increases protection from wave action and enhance sedimentation rates.

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Map 68. Bolinas Beach Loss By Scenario

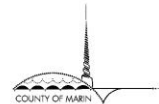


- Beach Loss @ 10 inches SLR
- Beach Loss @ 20 inches SLR
- Beach Loss @ 40 inches SLR
- Beach Loss @ 80 inches SLR
- Beach around end of century)

Source: Marin Map, Our Coast Our Future, ESA

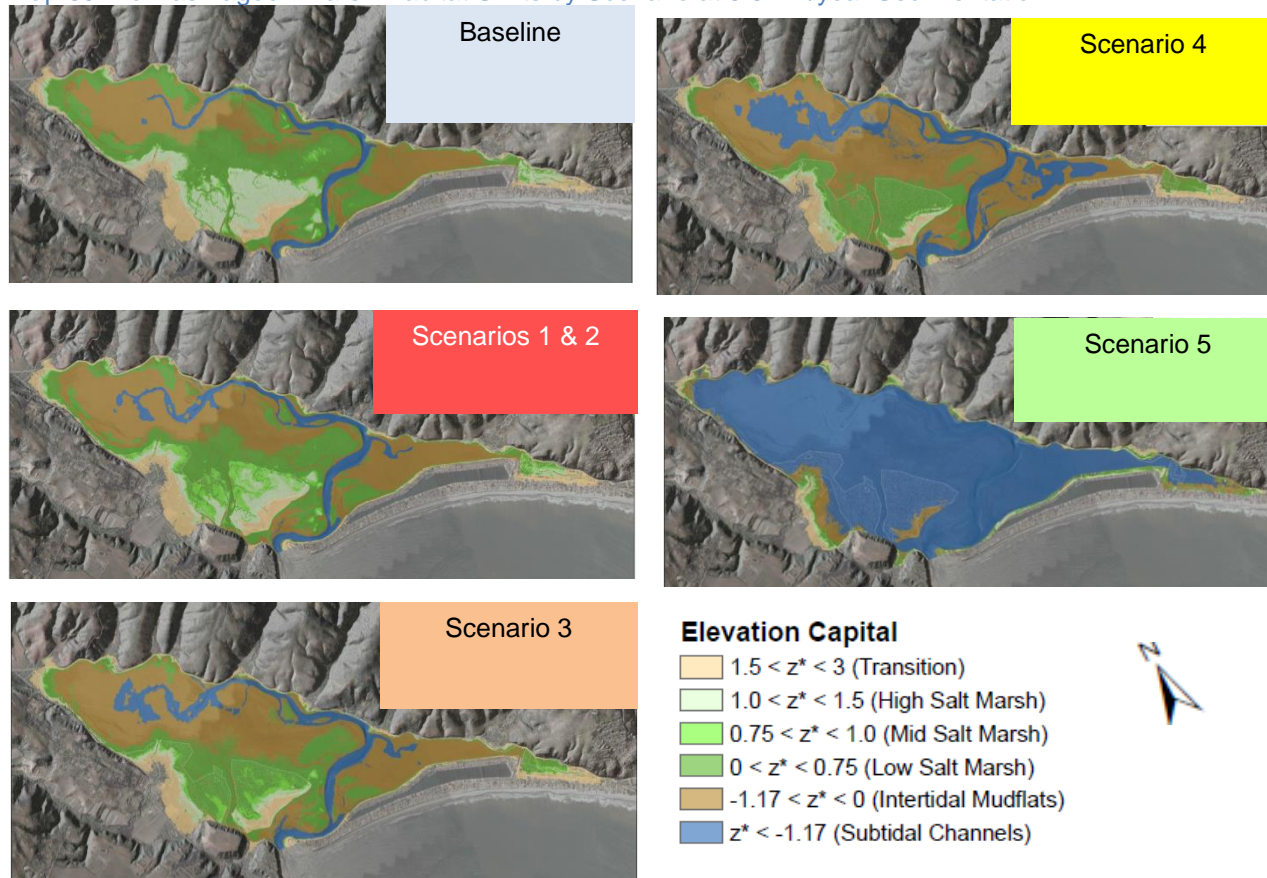
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Map 69. Bolinas Lagoon Marsh Habitat Shifts by Scenario at 6.8mm/year Sedimentation



Dark and light brown color in the lagoon is an artifact of the aerial imagery and not a distinction in Intertidal habitat. Source: ESA, 2015

Table 52. Bolinas Lagoon Spatial Distribution of Marsh Habitat & Vulnerability at 6.8 mm/year Sedimentation

Habitat Type	Area (acres)					Elevation Capital z^* Range
	Baseline	Scenarios 1 & 2	Scenario 3	Scenario 4	Scenario 5	
Transition zone	129	123	118	107	66	1.5 – 3
High salt marsh	164	95	478	42	27	1 - 1.5
Mid salt marsh	35	76	42	14	9	0.84 – 1
Low salt marsh	430	328	305	236	67	0 - 0.84
Intertidal Mudflats	387	497	581	600	126	-1.04 – 0
Subtidal Channels & Shallows	68	106	142	253	1026	< -1.04
Vulnerability Level						
Low	255	184	140	115	49	1 - 2.5
Medium	257	234	221	78	77	0.3 – 1
High	662	772	849	1,048	1,180	below 0.3

Source: ESA, 2015

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Working Lands

Permanent flooding and erosion threaten small agricultural operations in the lowlands of Gospel Flats, as protective earthen berms could give out. In the lagoon and off the coast, crabbing and other fishing activities may see a shift; or if changes are significant enough, the habitat may be lost. These areas also provide food for the local community, including a community farm stand that is in the potential flood hazard area.

Recreation

If beaches are diminished and waters shift inland, beach and water recreation, such as surfing, could be severely diminished at Brighton Beach. The Bolinas County Park provides trails along the marsh that could be permanently inundated. Blocked by Olema-Bolinas Road, the marsh area is prevented from migrating and could transition to unnavigable mudflat, reducing aesthetics and access. Residents and visitors use the roadway for bicycling and fishing access that could see increased water barriers. Visitors and residents use the Bob Stewart Trail that is sensitive with low adaptive capacity. Finally, the Bolinas People's Store, Bolinas Super Market, museum, art galleries, and other entertainment venues could be inundated, greatly impacting residents and inconveniencing recreationists and tourists who seek water, food, and other supplies to support their experiences.

Historic & Archeological Resources

Vulnerable buildings in Bolinas's historic district include the Bolinas Market, the two-story Smiley's, and the Calvary Presbyterian Church. Destruction and deterioration could impact the historic district's character; with potential negative impacts on sense of place and economy.

Archaeological sites could be present in the exposure zones. The Sonoma State University's Anthropological Study Center is inventorying archaeological sites for much of California's coastline in anticipation of sea level rise and coastal erosion.¹⁹

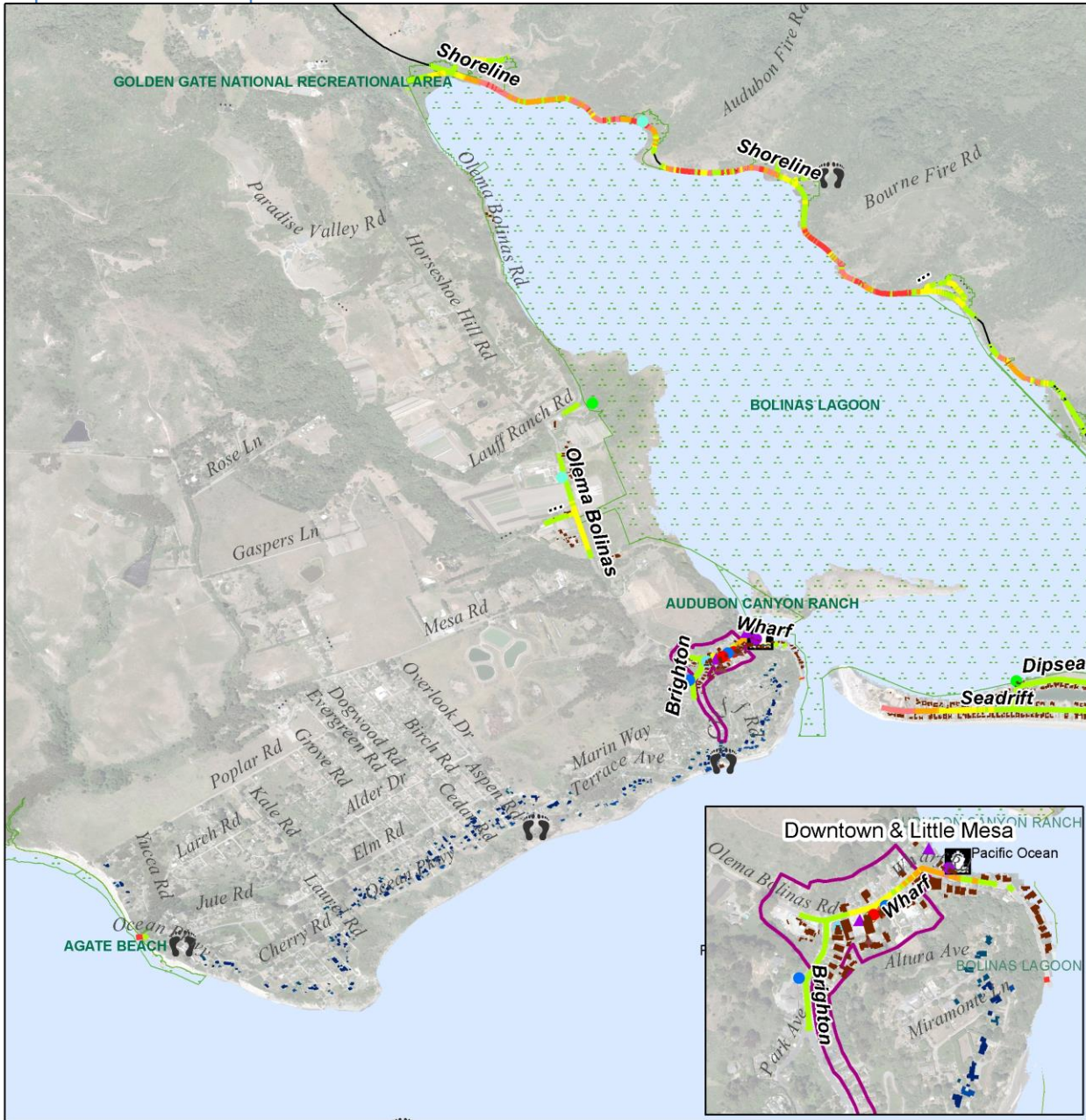
Emergency Services

The greatest threat to emergency services is loss of access to downtown. The tsunami evacuation route out of downtown could also be vulnerable.

¹⁹ Newland, M. April 1, 2015. Sonoma State University, personal communication.

BOLINAS

Map 70. Bolinas Developed Assets Vulnerable to Sea Level Rise and Accelerated Erosion



Roads

- @ 10" + Annual storm
- @ 10" + 20-year storm
- @ 20" + 20-year storm
- @ 40" + 100-year storm
- @ 80" + 100-year storm

* Roads may also have utility pipes underneath, are used for recreation, and serve as emergency access in some locations.

Other Assets

- Buildings Exposed to Flooding
- Buildings Vulnerable to Erosion
- Parcels
- Agricultural Parcels
- Aquaculture
- Parkland
- Historic District
- ▲ Commercial
- Education
- Emergency
- ▲ Food
- Government Service
- Historic
- Institutional
- Recreation
- Residential
- Transportation
- ▲ Utilities

- Boat Launch
- Fishing Pier
- Access Point
- Port
- Marina

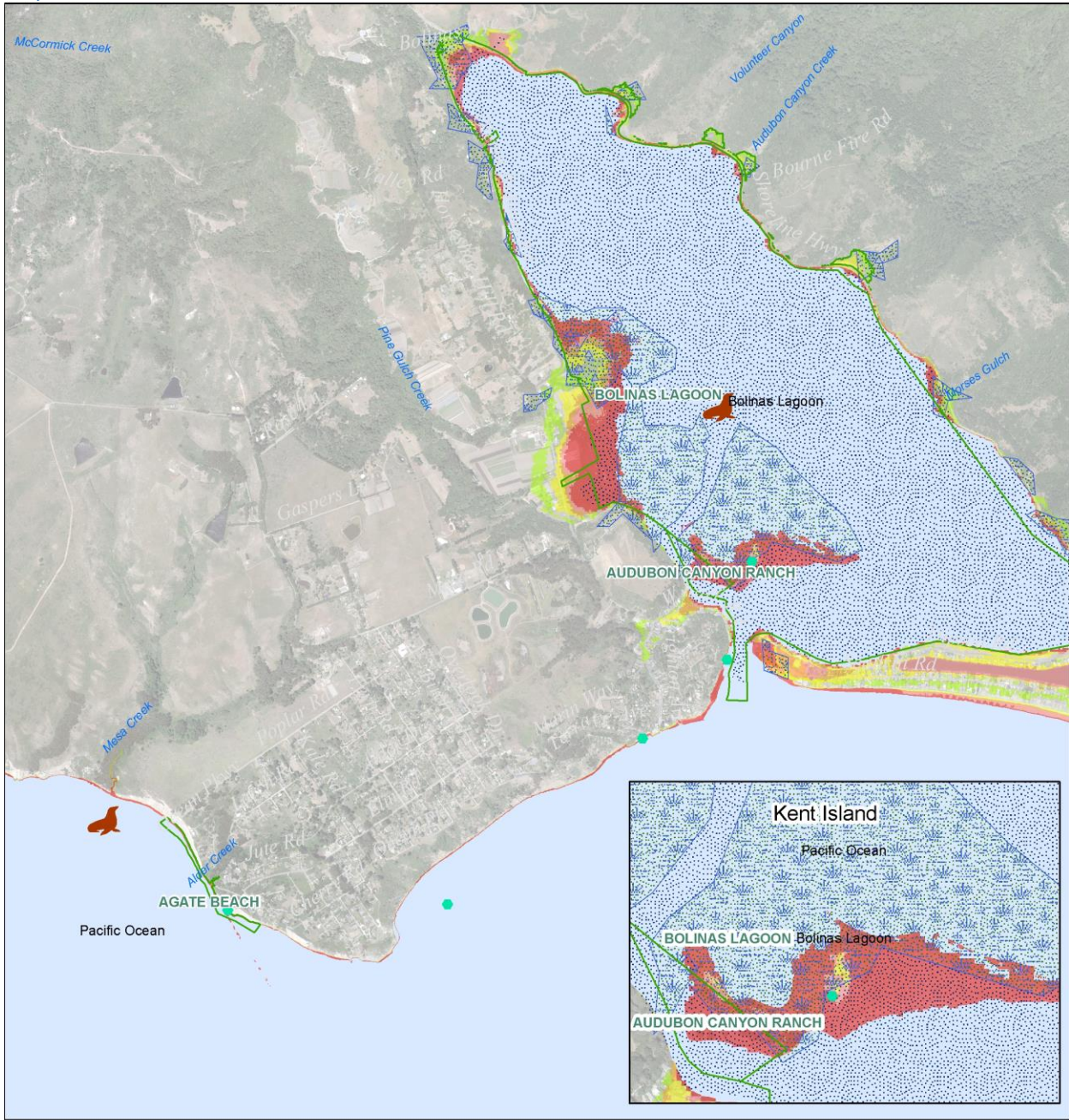


Source: Marin Map, Our Coast Our Future, CA Coastal Commission
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Map 71. Bolinas Natural Resource Assets Vulnerable to Sea Level Rise



Scenarios

- 1 10" SLR + Annual Storm
- 2 10" SLR + 20-year Storm
- 3 20" SLR + 20-year Storm
- 4 40" SLR + 20-year Storm
- 5 80" SLR + 100-year Storm

Assets

- Natural Resource Assets
- Parks
- Seabird Colony
- Mammal Haul Out
- Wetland
- Estuary
- Marsh

0 0.1 0.2 0.4 0.6 0.8 Miles



Source: Marin Map, Our Coast Our Future, Department of Fish & Wildlife
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INVERNESS

Community Profile: Inverness

Inverness is located on the southwest shore of Tomales Bay. The community is primarily residential, with just over 1,300 people. Recreational and small commercial boating facilities exist along Tomales Bay. A handful of hotels, inns, and visitor-serving facilities are spread throughout town. Increased sea level rise and storm surges could significantly compromise this coastal community in the following ways:

- 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 beneath it.
- Several shoreline and pier developments are vulnerable to rising waters and storm impacts in the near-term.

Vulnerable Assets

Inverness’s most vulnerable assets include Sir Francis Drake Blvd., the water distribution pipeline beneath Sir Francis Drake Blvd., and a number of shoreline developments of economic, civic, recreational, and/or historical value. Surrounding wetlands, Tomales Bay, and public lands to access the bay are also vulnerable. Archaeological sites may be present. The following sections provide greater detail on these vulnerabilities. [Table 53](#) lists the vulnerable assets in Inverness by onset and flood depth.

IMPACTS AT-A-GLANCE

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



Inverness commercial area on Sir Francis Drake Boulevard. Credit: CDA



Historic Brock Schreiber Boat House. Tomales Bay from Inverness. Credit: CDA

INVERNESS

Table 53. Inverness Vulnerable Assets

Asset	Tidal & Extreme Event Flooding Depth Estimates					Vulnerability
	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. Values not underlined represent extreme event flooding. Maximum values are provided for groups of buildings. Roads received a high, used for ranking, and low value along the line segment.					
	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	
NMWD Pipeline	underground resource (see Shoreline Hwy., Pt. Reyes Station to Inverness)					WT, SI, E
Inverness Yacht Club	<u>3'2"</u>	<u>4'1"</u>	<u>4'11"</u>	<u>6'10"</u>	<u>10'1"</u>	I, WS, HW
Brock Schreiber Boathouse	<u>2'7"</u>	<u>3'6"</u>	<u>4'</u>	<u>5'10"</u>	<u>9'2"</u>	I, E
Shoreline Buildings	<u>2'+1'2"</u>	<u>2'+2'</u>	<u>2'10"+2</u>	<u>4'8"+2'</u>	<u>8'+8'8"</u>	I, WT, WS, TF
Martinelli Park	<u>1'1"</u>	<u>2'</u>	<u>2'2"</u>	<u>4'1"</u>	<u>7'3"</u>	I, E
Tomales Bay State Park	10"	1'10"	<u>2'8"</u>	<u>4'7"</u>	<u>7'10"</u>	I, HS
Chicken Ranch Beach	Tidal Zone					HS
Sir Francis Drake Blvd.			<u>1" - 3'6"</u>	<u>1" - 4'6"</u>	<u>1" - 7'10"</u>	I, TF, WS
Inverness Store			2'5	<u>4'4"</u>	<u>7'6"</u>	TF, I, WT
Shoreline Hwy			6"	3" - 1'5"	1'9" - <u>9'7"</u>	I, TF
Dana Marsh & Beach Access				<u>3'</u>	<u>6'2"</u>	I, E, SI, HS
Motel Inverness				<u>2'9"</u>	<u>5'10"</u>	I, WS, HW
Historic District				<u>2'1"</u>	<u>5'1"</u>	TF
Shell Beach Tomales Bay SP				5"	<u>3'4"</u>	TF, I, WT
Tomales Bay Resort					<u>4'</u>	TF
Tomales Bay	water resource					HS

Source: Marin Map, CoSMoS Exposure and Flood Depth data, Asset Manager Interviews

Parcels & Buildings

Compared to neighboring coastal communities, Inverness has fewer buildings that could be exposed to sea level rise. Several homes and businesses between Sir Francis Drake Blvd. and Tomales Bay are on piers and can tolerate tidal flooding and moderate storms. However, inundation and severe storms could impact these and lower-lying properties, such as the Inverness Yacht Club and the Brock Schreiber boathouse, which sustained severe wave damage in the December 2014 storm. Several OWTSS and the water distribution system are also vulnerable and could impact homes and businesses along the shoreline, as well as properties on the other side of Sir Francis Drake Blvd. up into the ridge lands.

Table 54 shows how many parcels and buildings are directly impacted, with 20 to 34 buildings in the near- and medium-terms, respectively, and upwards to 60

and 75 buildings in the long-term scenarios. Up to 130 parcels, many containing these buildings could be vulnerable. Several of the parcels without buildings are state lands and other parklands.

Table 54. Inverness Exposed Parcels & Buildings by Scenario

	Parcels	Buildings
Scenario 1	100	23
Scenario 2	101	23
Scenario 3	107	34
Scenario 4	120	61
Scenario 5	127	75

Source: Marin Map, CoSMoS

Table 55 delineates the exposed buildings by flood depth range, showing how many and what portions of the exposed buildings are flooded within each.

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Table 55. Inverness Building's Flooding Depth Estimates

	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
Flood Depth (feet)	23	23	37	61	75
Storm Inundation	6 (26%)	6 (26%)	10 (27%)	3 (5%)	
0 - 1.5	5			1	
1.5 - 3	1	6	6	3	
Tidal Inundation	17 (74%)	17 (74%)	27 (73%)	58 (95%)	75 (100%)
0 - 1.5	4		1		
1.5 - 3	11	11	21	23	5
3 - 4.5	2	6	7	28	16
4.5 - 6			2	4	23
6 - 7.5				2	23
7.5 - 9					6
9 - 10.5					2

Source: Marin Map, CoSMoS Exposure and Flood Depth data, Asset Manager Interviews

Table 56. Inverness Exposed Residential and Commercial Parcels

Scenario 1				Scenario 3				Scenario 5			
Residential		Commercial		Residential		Commercial		Residential		Commercial	
#	%	#	%	#	%	#	%	#	%	#	%
38	3%	7	37%	72	6%	8	42%	108	9%	10	53%

Table 57. FEMA Damage Levels Applied to Buildings in Inverness Exposed in Scenario 5

Buildings	Yellow Tag-Minor (\$5,000-17,000)	Orange Tag \$17,001+	Red Tag (assessed improvement value)
75	\$375,000-1,275,000	\$1,275,001+	\$10,155,532

Source: Marin Map, CoSMoS

Table 58. Inverness Buildings Potentially Facing Hazardous Conditions

Scenario 1		Scenario 2		Scenario 3		Scenario 4		Scenario 5		
#	%	#	%	#	%	#	%	#	%	Value*
4	<1%	4	<1%	4	<1%	14	1%	36	2%	\$4,874,655

*Improvement Assessed Value Marin County Assessor 2014. Source: Marin Map

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Table 56 shows how many of the exposed parcels are residential or commercial in use, and the portion those parcels represent for the community. In the near-term 38 residential and 7 commercial parcels could be vulnerable to sea level rise and storms. In the long-term, 53 percent of all commercial properties in Inverness could be exposed to bay waters. Table 57 outlines damage cost estimates for buildings and their contents under scenario 5, using FEMA damage levels and assuming every building would face the same level of damage. Over \$10 million of damage could occur with sea level and storm combinations in the long-term.

Additionally, buildings were assessed for exposure to wave velocity and flood depths under each scenario to determine the buildings most likely to experience destructive conditions that would result in the buildings being red-tagged. This reveals that in the near- and medium-terms 4 buildings and up to 36 of the 75 buildings exposed to sea level rise and storms. If all 75 buildings were red tagged, losses exceeding \$10 million in assessed building value could be experienced. See Table 58.

Transportation

Sir Francis Drake Blvd. is the main access road to the Point Reyes National Seashore and Tomales Bay State Park. Temporary and permanent flooding could negatively impact recreational opportunities, complicate residents' daily routines, and cut off access for emergency vehicles. Bear Valley Rd., outside Inverness and Point Reyes Station, is an alternative access route; however, this road is vulnerable to sea level rise and storms in the long-term and is susceptible to stormwater flooding.

Table 59. Inverness Exposed Road Segments
(Scenarios 2-5 include roads in previous scenarios)

Scenarios 1 & 2	Scen 3	Scenario 4	Scenario 5
Sir Francis Drake Blvd. ^M		Vision Rd. ^M Rannoch Wy. ^P Argyle St. ^M Duck Cove Rd. ^P	Inverness Wy. ^M Woodhaven Rd. ^P

P- Private Road, M- Marin County, C- Caltrans. Source: Marin Map, CoSMoS

Utilities

Water distribution pipes beneath marshland south of Tomales Bay and adjacent to Sir Francis Drake Boulevard are considered vulnerable. In addition, exposed buildings could also have vulnerable underground septic systems, as many are sited just off the shoreline. Like other communities, the loss of potable water and sanitary service would have significant negative impacts on public safety, quality of life, and the local economy. Additionally, Inverness depends on private propane services and could be cut off from suppliers if Sir Francis Drake Blvd. and Bear Valley Rd. are compromised for an extended period.

Water service is provided by two different water companies, and several residents operate private wells. Inverness Park and Paradise Ranch estates are served by the North Marin Water District-West Marin with groundwater pumped from two wells adjacent to Lagunitas Creek through its Point Reyes Water System. Of these two wells, the Gallagher Well is vulnerable in the long-term to salt water intrusion. The Inverness Public Utility District (IPUD) provides water service to around 1,600 acres, including the entire publicly owned portions of the watershed.²⁰ IPUD and the North Marin Water District (NMWD) have an emergency water agreement that allows transfer of up to 40 gallons per minute of water between the two district's water systems in an emergency. The agreement expires in 2024. Both systems manage under road distribution pipelines that could be vulnerable in the near-term.

Working Lands

Not Applicable.

Natural Resources

Tomales Bay, a Ramsar wetland of international importance, is highly vulnerable to increased salinity, inundation, and waves. Tomales Bay supports numerous species, including the Ridgway's rail (formerly known as California clapper rail) and black rail, salmon and steelhead trout, whose populations could be impacted if the Bay's ecological functions shift dramatically.

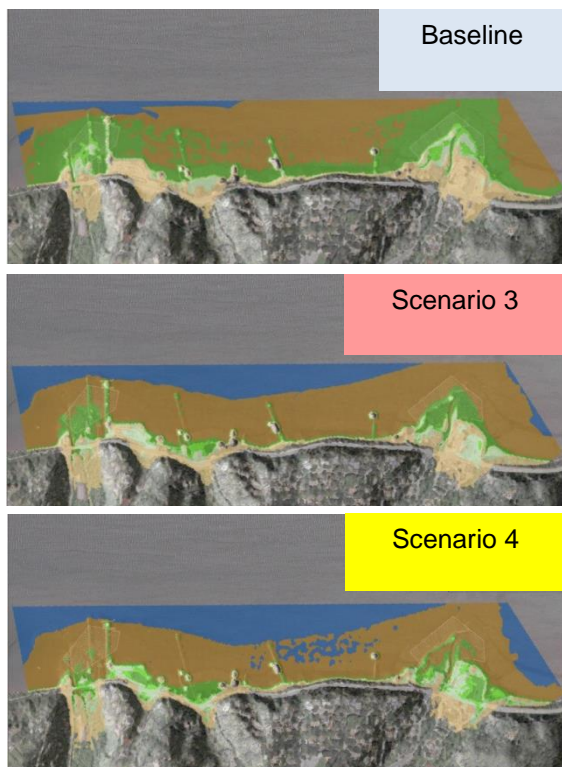
All the marshes in Inverness are vulnerable because they are confined by the roadway. As sea levels rise, much of the low salt marsh will be converted to mud

²⁰ Inverness Area Sphere of Influence Update, May 2007, p. 3

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and sand flats. Because the Inverness shore is steep, marsh transition areas shrink with elevating sea levels. [Map 72](#) shows how the marsh habitats in Inverness could shift for each sea level rise scenario (not including storms) using a sedimentation rate of 1.5mm/year. [Table 60](#) shows the corresponding area for each marsh habitat type. Approximately 50 percent of the high marsh is expected to be lost in the long-term (low end); converting to low marsh, mud, and sand flats. Existing low marsh is expected to lose 80 percent of area in the same period.

Map 72. Inverness Area Marsh Habitat Transitions by Scenario at 1.5mm/ year Sedimentation



Elevation Capital

- 1.5 < z* < 3 (Transition)
- 1.0 < z* < 1.5 (High Salt Marsh)
- 0.75 < z* < 1.0 (Mid Salt Marsh)
- 0 < z* < 0.75 (Low Salt Marsh)
- 1.17 < z* < 0 (Intertidal Mudflats)
- z* < -1.17 (Subtidal Channels)



Recreation

Inverness borders the Point Reyes National Seashore and Tomales Bay State Park. A variety of vulnerable recreation areas provide access to Tomales Bay including Martinelli Park, Dana Marsh, and Chicken Ranch Beach. These areas may shrink with rising waters, compromising public access, and leading to negative economic and quality of life impacts. The marinas and boat storage areas are vulnerable, and the loss of such businesses, and others that support them, could have dramatic impacts on the economy. Visitor serving uses like Tomales Bay Resort and Motel Inverness are vulnerable in the near-term, and others such as Perry's Deli, on the west side of Sir Francis Drake Blvd. are vulnerable in the long-term.

Emergency Services

The helicopter launch pad is vulnerable; however, it can be easily relocated.²¹ The tsunami evacuation route on Vision Road could be vulnerable by the medium-term scenario. The loss or compromised function of this route would be detrimental to public safety. The Inverness Public Utility District (IPUD) provides fire protection to Inverness and is susceptible to creek flooding. Access to those in need could be compromised when waters are high. In addition, if water pipes break with road erosion and flooding, emergency water supplies may also be compromised.

Historic & Archaeological Resources

The historic building the post office is in and the Brock Schreiber Boathouse are considered vulnerable, and their destruction or deterioration could impact the historic district's character. Archaeological sites could be present in the exposure zones.²²

²¹ Hanks, Ursula. March, 9 2015 Marin Office of Emergency Services, personal communication.

²² Newland, M. April 1, 2015. Sonoma State University, personal communication.

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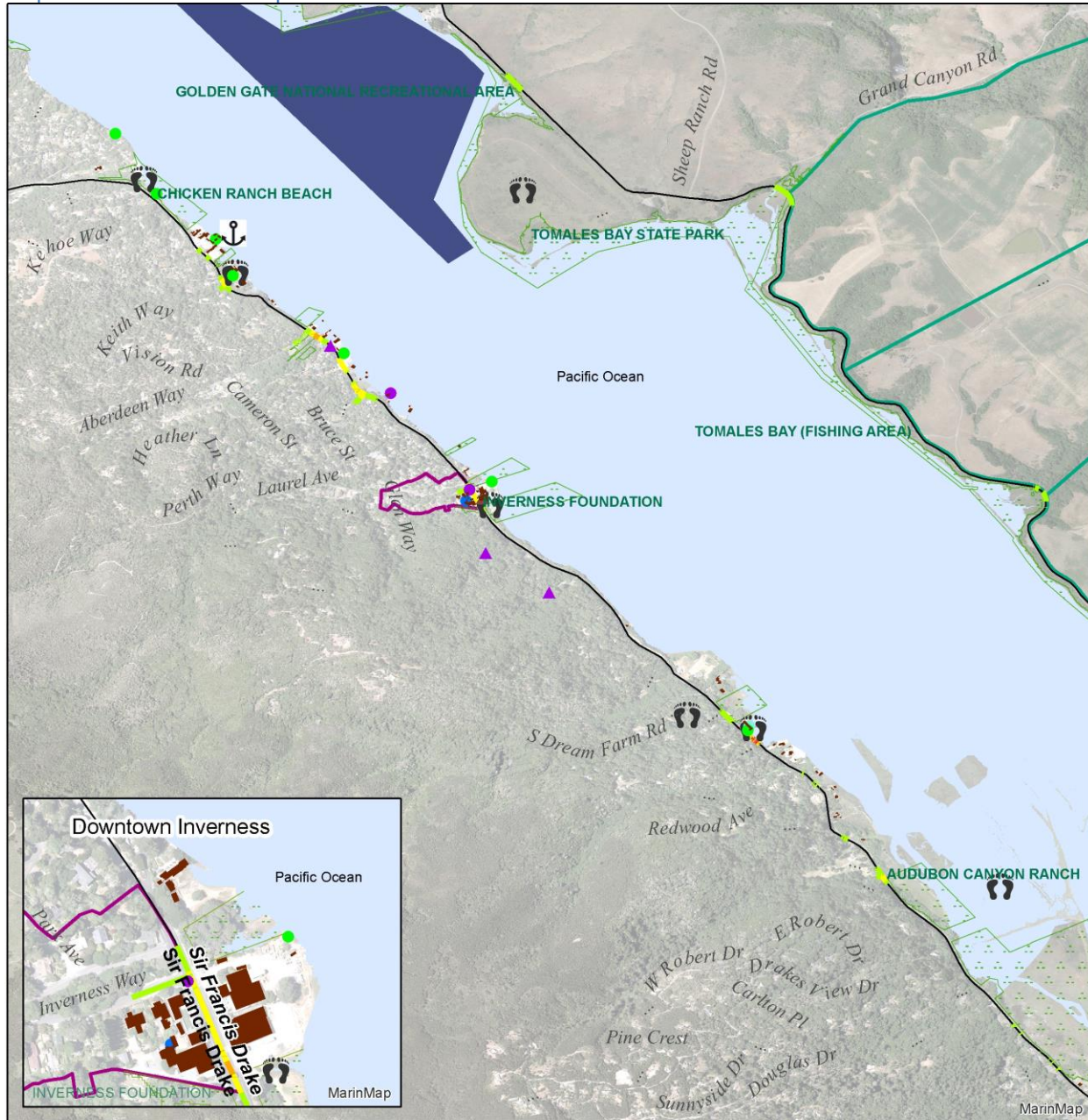
Table 60. Inverness Distribution of Marsh Vulnerability

Habitat Type	Area (acres)			Elevation Capital z* Range
	Baseline	Scenario 3	Scenario 4	
Transition zone	10	9	7	1.5 - 3
High salt marsh	3	4	4	1 - 1.5
Mid salt marsh	2	1	2	0.75 - 1
Low salt marsh	20	6	4	0 - 0.75
Intertidal Mudflats	24	35	32	-1.17 - 0
Subtidal Channels & Shallows	3	13	20	< -1.17

Source: ESA, 2015, CoSMoS

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Map 73. Inverness Developed Assets Vulnerable to Sea Level Rise



Roads

- @ 10" + Annual storm
- @ 10" + 20-year storm
- @ 20" + 20-year storm
- @ 40" + 100-year storm
- @ 80" + 100-year storm

* Roads may also have utility pipes underneath, are used for recreation, and serve as emergency access in some locations.

Other Assets

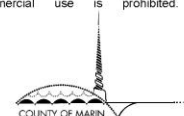
- Buildings Exposed to Flooding
- Buildings Vulnerable To Erosion
- Parcels
- Agricultural Parcels
- Aquaculture
- Parkland
- Historic District

- ▲ Commercial
- Education
- Emergency
- ▲ Food
- Government Service
- Historic
- Institutional
- Recreation
- Residential
- Transportation
- ▲ Utilities

- Boat Launch
- Fishing Pier
- Access Point
- Port
- Marina

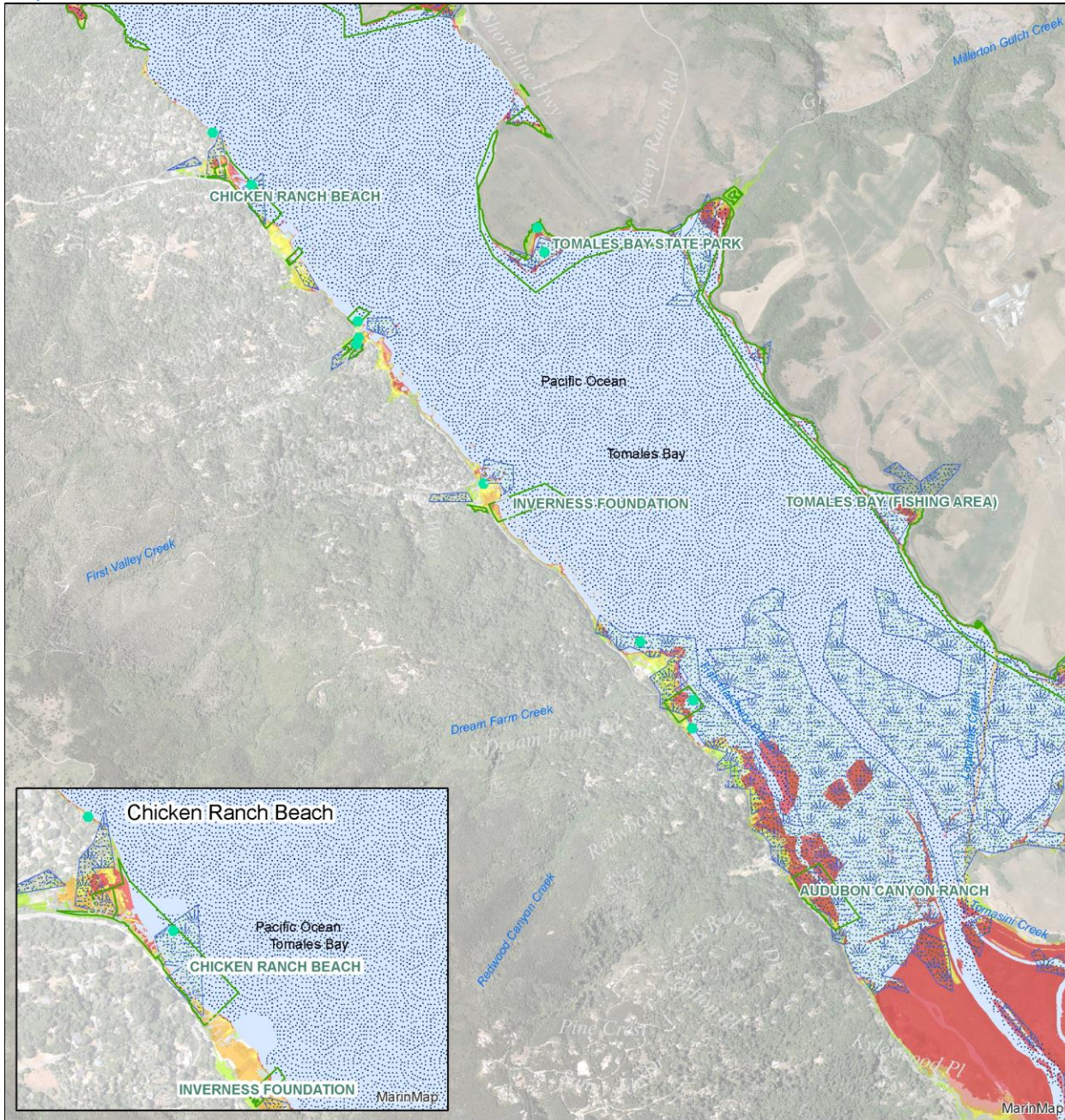


Source: Marin Map, Our Coast Our Future, CA Coastal Commission
 Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data providers here in, make no warranties of the accuracy or completeness 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



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Map 74. Inverness Vulnerable Natural Resource Assets

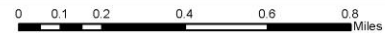


Scenarios

- 1 10" SLR + Annual Storm
- 2 10" SLR + 20-year Storm
- 3 20" SLR + 20-year Storm
- 4 40" SLR + 20-year Storm
- 5 80" SLR + 100-year Storm

Assets

- Natural Resource Assets
- Parks
- Seabird Colony
- Mammal Haul Out
- Wetland
- Estuary
- Marsh



Source: Marin Map, Our Coast Our Future, Department of Fish & Wildlife
 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



POINT REYES STATION

Community Profile: Point Reyes Station

At the southeast tip of Tomales Bay, Point Reyes Station is the gateway to the Point Reyes National Seashore. Point Reyes Station is one of Marin County's oldest coastal communities. The 1,500 acre town was home to 848 people in 2010.²³ While most of the community is outside of sea level rise exposure zones, some of Point Reyes Station's assets could be impacted. Key issues in Pt. Reyes Station include:

- 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; however Lagunitas (Green) bridge could be vulnerable sooner.

Vulnerable Assets

Point Reyes Station's most vulnerable assets include NMWD pipelines that lead to Inverness, Green Bridge on Shoreline Highway, and the surrounding wetlands. In the long-term, roughly 30 homes along Lagunitas Creek could also see flooding and more severe storm surge flooding. [Table 61](#) lists assessed vulnerable assets in Point Reyes Station and the following sections provide further detail for each asset category.

IMPACTS AT-A-GLANCE

36 buildings	700 people
Storm and tidal impacts already occur	4 businesses
2 million worth of assets exposed	Residential Tourism
	Caltrans NMWD



Point Reyes Station. Credit: CDA

²³ U.S. Census Bureau Profile of General Population and Housing Characteristics: 2010

POINT REYES STATION

Table 61. Pt. Reyes Vulnerable Assets

Asset	Tidal & 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. Values not underlined represent extreme event flooding. Maximum flood values are provided for groups of buildings. Roads received a high and low value along the line segment.)					Vulnerability TF: Temp. Flooding during extreme events; I: Inundated at MHHW; E: Erosion; WT: Water Table; SI: Saltwater Intrusion; WS: Wave Surge; HW: High Wind, HS: Habitat Shift
	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	
NMWD Pipeline	underground (see Shoreline Hwy Pt. Reyes Station to Inverness)					I, SI
Green Bridge	No depth data	No depth data	<u>2"</u>	<u>2'</u>	<u>9'10"</u>	I, TF
White House Pool/Trail			<u>2'5"</u>	<u>2'3"</u>	<u>5'11"</u>	I
Shoreline Hwy			6"	3" - 1'5"	1'9" - 9'7"	I, TF
Olema Marsh Trail					<u>2'9"</u>	I
Buildings along Lagunitas Creek					<u>1'8"-3'2"</u>	TF, I
Gallagher Well					underground	SI
Lagunitas Creek	water resource					HS

Source: Marin Map, CoSMoS Exposure and Flood Depth data, Asset Manager Interviews

Parcels & Buildings

Only a small percentage of the parcels and buildings fall within the exposure zone, and only at higher scenarios. Loss or degradation of these properties could have significant impacts for the residents who reside within them. Primarily undeveloped parcels are exposed in the near- and medium-terms. In the long-term twice as many parcels are exposed and 36 buildings along Lagunitas Creek are exposed, see [Table 62](#).

Table 62. Pt. Reyes Station Exposed Parcels & Buildings by Scenario

	Parcels	Buildings
Scenario 1	31	0
Scenario 2	31	0
Scenario 3	30	0
Scenario 4	38	0
Scenario 5	60	36

Source: CoSMoS. Marin Map 2014

[Table 63](#) provides how many of these buildings are vulnerable to temporary and or permanent flooding and at what depth. Of the 36 exposed buildings, eight are exposed to tidal flooding. Several of the remaining homes are elevated and could tolerate temporary flooding.

[Table 65](#) estimates damage costs for buildings and their contents under scenario 5, assuming every building would face the same level of damage, using FEMA post-disaster rankings. Over \$5 million of damage could occur.

To determine how many buildings could experience red-tag level destruction, buildings were analyzed for exposure to wave velocity and flood depths strong enough to destroy a building for each scenario. This reveals up to 36 buildings could be destroyed, resulting in losses over \$5 million in assessed value.

Table 63. Pt. Reyes Station Flood Depths for Building Footprints

	Scenarios 1-4	Scenario 5
Flood Depth (feet)		36
Storm Inundation		28 (78%)
0 - 1.5		22
1.5 - 3		3
3 - 4.5		1
4.5 - 6		1
Tidal Inundation		8 (22%)
0 - 1.5		2
1.5 - 3		6
3 - 4.5		2

Source: Marin Map, CoSMoS

POINT REYES STATION

Table 64. FEMA Damage Levels Applied to Buildings Exposed in Pt. Reyes Station in Scenario 5

Buildings	Yellow Tag-Minor (\$5,000-17,000)	Orange Tag \$17,001+	Red Tag (County assessed improvement value)
36	\$180,000-612,000	\$612,001+	\$5,480,520

Source: Marin Map, CoSMoS, Marin County Assessor

Table 65. Pt. Reyes Station Buildings Potentially Facing Hazardous Conditions

Scenario 1		Scenario 2		Scenario 3		Scenario 4		Scenario 5		
#	%	#	%	#	%	#	%	#	%	Value*
								36	4%	\$5,480,520

*Improvement Assessed Value Marin County Assessor 2014. Source: Marin Map

Transportation

Shoreline Highway is vulnerable at Green Bridge in the near-term and along other segments south of the bridge in the long-term. This segment's loss would cut off south west access to Point Reyes Station, and could lead to negative economic impacts for local businesses that depend on the tourist economy, emergency accessibility impacts, and negative sense of place impacts.

Table 66. Pt. Reyes Station Exposed Roads (Scenarios 2-5 include roads in previous scenarios)

Scenarios 1 & 2	Scenario 3	Scenario 4	Scenario 5
Shoreline Hwy. (@ Green Bridge) ^C			Bear Valley Rd. ^M

P- Private Road, M- Marin County, C- Caltrans. Source: Marin Map, CoSMoS

Utilities

NMWD's water distribution lines beneath the marshes south of Tomales Bay and adjacent to Sir Francis Drake Boulevard are of concern, as pipe damage in Point Reyes Station or Inverness could disrupt flow and pressure throughout the system. The NMWD Gallagher Well could be threatened by saltwater intrusion at the high end of the long-term scenario. During times of low creek flow and/or high tides, seawater can be drawn into the wells and water supply, such as during the 1976-77 drought,

and the winters of 1980-81 and 1986-87. A salinity intrusion-avoidance plan aims to lessen impacts.²⁴

NMWD also serves the Point Reyes National Seashore Headquarters at Bear Valley, Silver Hills, and the U.S. Coast Guard Housing Facility. Preliminary review of Marin County's database of private drinking and irrigation wells indicates that 14 wells are in Point Reyes.²⁵ The NMWD West Marin service area and the neighboring Inverness Public Utility District (IPUD) have an emergency water agreement (ends 2024) that allows for water transfer between the two district's water systems.²⁶

Point Reyes Station relies on OWTS, cesspools, mound systems, and other sewage disposal methods that discharge into the ground. This is an issue for the handful of homes exposed to sea level rise along Lagunitas Creek.

Working Lands

Not Vulnerable.

²⁴ Nichols Berman Environmental Planning. Nov. 2007. 2007 *Marin County Wide Plan Final Environmental Impact Report*. p. 4.9-14. State Clearinghouse No. 2004022076. http://www.marincounty.org/~media/files/departments/cd/planning/currentplanning/publications/county-wide-plan/cwp_eir/cwpupdatefeir1107.pdf

²⁵ Marin County Local Coastal Program Amendment Land Use Analysis draft, June 2012, p. 44

²⁶ Nichols Berman Environmental Planning. Nov. 2007. 2007 *Marin County Wide Plan Final Environmental Impact Report*. p. 4.9-16. State Clearinghouse No. 2004022076. http://www.marincounty.org/~media/files/departments/cd/planning/currentplanning/publications/county-wide-plan/cwp_eir/cwpupdatefeir1107.pdf

POINT REYES STATION

Natural Resources

Olema Marsh (Point Reyes National Seashore, Audubon Canyon Ranch) and Giacomini Wetlands (State Parks) are large marshes that support habitat for a variety of bird, plant, and other species. Map 75 shows how marsh habitats will shift by 2050 and 2100 using the average historic sedimentation rate of 1.6mm/year.²⁷ Downshifting from mid-marsh to tidal flats is anticipated, particularly in low-lying areas adjacent to Point Reyes Station. The area has relatively significant freshwater inputs and salinity changes could have significant impacts. The high marshes could transgress inland along the valley profile with some realignment of infrastructure such as roads and culverts.

Areas most vulnerable are those without gradually sloping transitional uplands. Table 67 shows the increasing vulnerability of marsh functions as sea level rises and marshes are squeezed against steeper upland slopes.

Table 67. Pt. Reyes Station of Marsh Habitat

Habitat Type	Area (acres)		
	Baseline	Scenario 3	Scenario 4
Transition zone	233	229	194
High salt marsh	255	73	81
Mid salt marsh	125	45	37
Low salt marsh	298	401	247
Intertidal Mudflats	233	464	521
Subtidal Channels	13	35	211

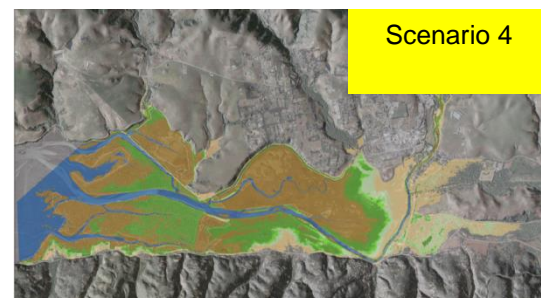
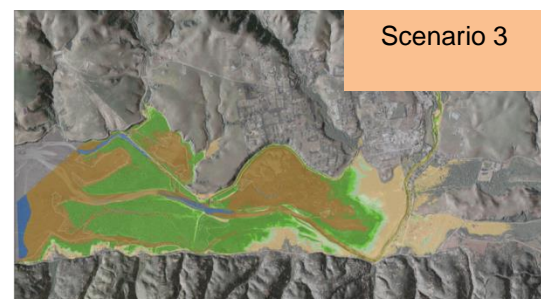
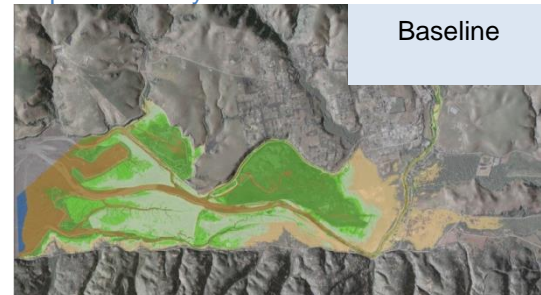
Source: ESA, 2015, CoSMoS

Recreation

Olema Marsh, Giacomini Wetlands, and the Whitehouse Pool provide access to trails and waterways. If altered by inundation, saltwater intrusion, erosion, habitat shifts, or other impacts, these areas may no longer support the diversity of wildlife or recreational functions, and may thus; lose some of their recreational appeal. The privately held Love's baseball field already floods and sea level rise would increase the amount and duration of flood waters.

²⁷ Smith, S. V. and J. T. Hollibaugh (1998). The Tomales Environment, University of Hawaii, School of Ocean and Earth Science and Technology and San Francisco State University, Tiburon Center. <http://lmer.marsci.uga.edu/tomales/tomenv.html>

Map 75. Pt. Reyes Station Marsh Habitat Transition



Elevation Capital

- 1.5 < z* < 3 (Transition)
- 1.0 < z* < 1.5 (High Salt Marsh)
- 0.75 < z* < 1.0 (Mid Salt Marsh)
- 0 < z* < 0.75 (Low Salt Marsh)
- 1.17 < z* < 0 (Intertidal Mudflats)
- z* < -1.17 (Subtidal Channels)



Historic & Archaeological Resources

No historic sites are exposed. Archaeological sites could be present in the exposure zones.²⁸

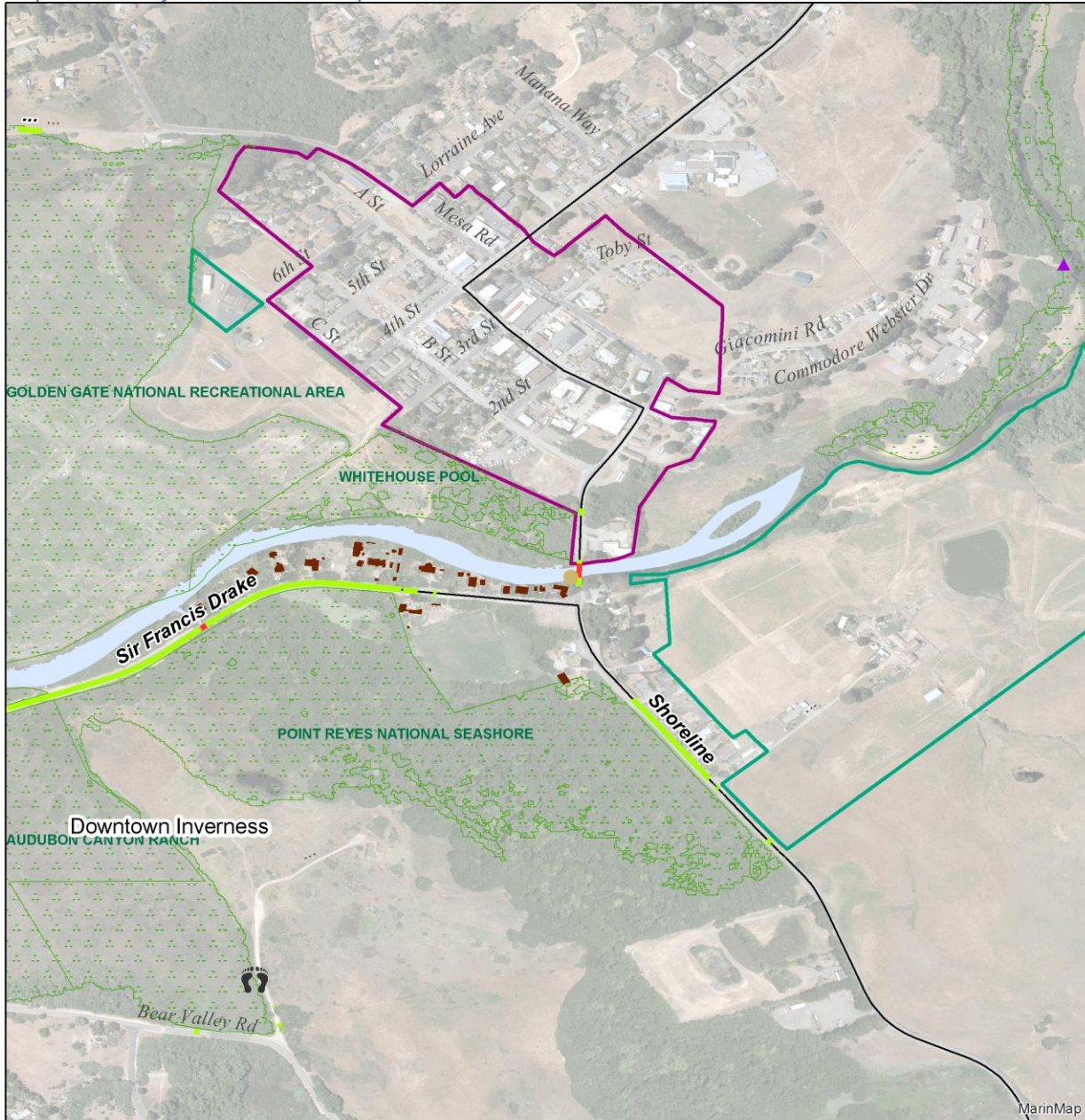
Emergency Services

Emergency service is not directly impacted in Pt. Reyes Station. However, sheriff and fire access to impacted areas of the community may be compromised in the long-term scenarios.

²⁸ Newland, M. April 1, 2015. Sonoma State University, personal communication.

POINT REYES STATION

Map 76. Pt. Reyes Station Developed Assets Vulnerable to Sea Level Rise



Roads

- @ 10" + Annual storm
- @ 10" + 20-year storm
- @ 20" + 20-year storm
- @ 40" + 100-year storm
- @ 80" + 100-year storm

* Roads may also have utility pipes underneath, are used for recreation, and serve as emergency access in some locations.

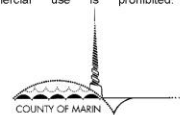
Other Assets

- Buildings Exposed to Flooding
- Buildings Vulnerable To Erosion
- Parcels
- Agricultural Parcels
- Aquaculture
- Parkland
- Historic District
- ▲ Commercial
- ▲ Education
- Emergency
- ▲ Food
- Government Service
- Historic
- Institutional
- Recreation
- Residential
- Transportation
- ▲ Utilities

- Boat Launch
- Fishing Pier
- Access Point
- Port
- Marina

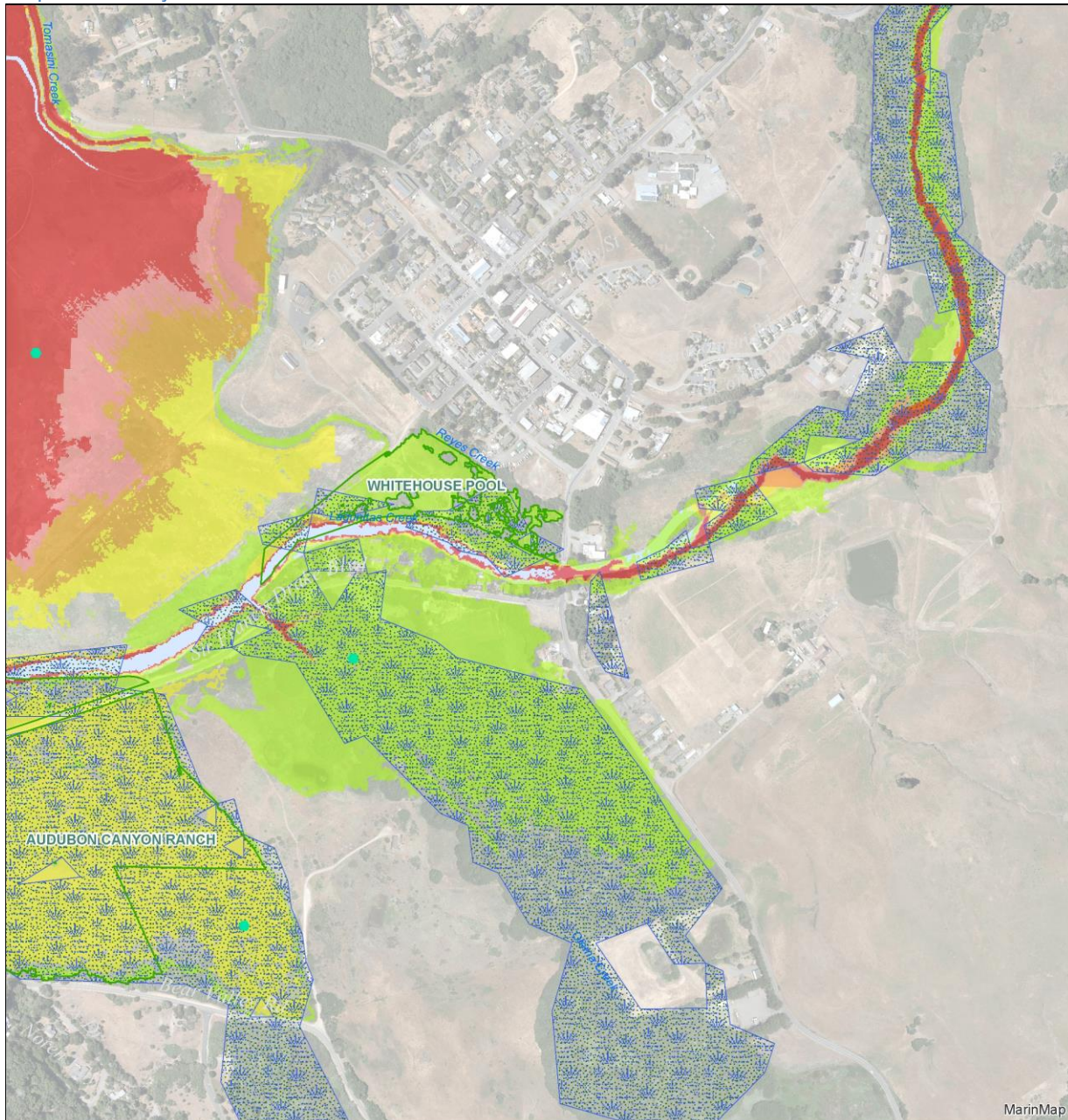
0 0.015 0.03 0.06 0.09 0.12 Miles

Source: Marin Map, Our Coast Our Future, CA Coastal Commission
 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



POINT REYES STATION

Map 77. Pt. Reyes Station Natural Resource Assets Vulnerable to Sea Level Rise



Scenarios

- 1 10" SLR + Annual Storm
- 2 10" SLR + 20-year Storm
- 3 20" SLR + 20-year Storm
- 4 40" SLR + 20-year Storm
- 5 80" SLR + 100-year Storm

Assets

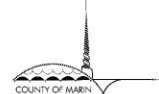
- Natural Resource Assets
- Parks
- Seabird Colony
- Mammal Haul Out
- Wetland
- Estuary
- Marsh

0 0.0375 0.075 0.15 0.225 0.3 Miles



Source: Marin Map, Our Coast Our Future, Department of Fish & Wildlife
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Date: 4/4/2016



EAST SHORE

Community Profile: East Shore

East Shore of Tomales Bay and the town of Marshall are vulnerable to sea level rise and storm surges. Key issues include:

- Access to, from and along Shoreline Highway, especially at Walker Creek.
- Pier based and shoreline housing, which act as a first line of defense for Shoreline Highway, are highly vulnerable.
- Public beaches could become inundated.

East Shore covers approximately 4,250 acres on a narrow strip of land along the eastern shoreline of Tomales Bay. Existing development is generally clustered west of Shoreline Highway. Between these developed clusters are stretches of undeveloped land.

Vulnerable Assets

East Shore’s most vulnerable assets include Shoreline Highway, private wells, septic systems, the Livermore Cypress Preserve, and a number of recreation and shoreline developments including visitor serving assets such as the Marconi Boat Launch, several restaurants, and Nick’s Cove. Vulnerable archaeological sites may be present.

Parcel & Buildings

East Shore contains a high number of potentially vulnerable properties along the shoreline. Over 15 parcels and 100 buildings could be impacted in the near-term by sea levels and storms. In the long-term, 45 percent of the buildings were identified as exposed. [Table 68](#) shows that 154 to 168 parcels and 103 to 163 buildings could be exposed across the five scenarios. [Table 70](#) organizes buildings by the type and flooding depth.

Table 68. East Shore Exposed Parcels & Buildings by SLR Scenario

	Parcels	Buildings
Scenario 1	154	103
Scenario 2	155	109
Scenario 3	157	121
Scenario 4	159	135
Scenario 5	168	163

Source: Marin Map, CoSMoS

IMPACTS AT-A-GLANCE

163 buildings	10 businesses
Storm and tidal impacts already occur	
14 million worth of assets exposed	Residential Tourism Aquaculture
	Caltrans Property Owners



East Shore. May 30, 2008. Credit: CDA



Marshall Store Boat Launch, East Shore. July 19, 2009. Credit: CDA

EAST SHORE

Table 69. East Shore Vulnerable Assets

Asset	Tidal & Extreme Event Flooding Depth Estimates					Vulnerability
	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	
OWTS and wells	Underground Resource					TF, I, SI
Walker Creek Access Point	<u>2'4"</u>	<u>3'3"</u>	<u>4'2"</u>	<u>6'1"</u>	<u>9'3"</u>	I
Brighton Beach	<u>2'2"</u>	<u>3'5"</u>	<u>4'11"</u>	<u>6'</u>	<u>9'11"</u>	E, WS
Livermore Marsh Cypress Grove	<u>2'1"</u>	<u>3'1"</u>	<u>3'11"</u>	<u>5'10"</u>	<u>9'2"</u>	I, HS
Hog Island Oyster	<u>2'1"</u>	<u>2'1"</u>	<u>2'10"</u>	<u>4'10"</u>	<u>8'1"</u>	I, TF
Shoreline Hwy	3" - 1'7"	3" - 2'4"	3" - 3'	<u>2' - 4'6"</u>	<u>6" - 8'1"</u>	I, TF
Buildings west of Shoreline Hwy.	<u>1'9"+1'</u>	<u>1'9"+1'11"</u>	<u>2'6"+2'</u>	<u>4'3"+2'2"</u>	<u>7'8"+2'2"</u>	I, WT, WS, TF
Marconi Boat Launch	1'1"	2'	<u>2'11"</u>	<u>4'10"</u>	<u>8'2"</u>	I
Tony's Restaurant	8"	1'8"	<u>2'6"</u>	<u>4'5"</u>	<u>7'9"</u>	I
Tomales Bay Oyster Company	8"	1'5"	<u>2'3"</u>	<u>4'1"</u>	<u>7'5"</u>	I, TF
Nick's Cove				<u>2'6"</u>	<u>5'10"</u>	I, TF, E, WS
Millerton Point				<u>2'5"</u>	<u>5'8"</u>	I, E
Historic District				<u>2'5"</u>	<u>4'5"</u>	I
Shoreline Hwy					<u>3'5"</u>	I, E
Tomales Bay	water resource					HS
Keys Creek (Fishing Area)	water resource					HS

Source: Marin Map, CoSMoS Exposure and Flood Depth data, Asset Manager Interviews

Table 70. East Shore Building's Flood Depth Estimates

	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
Flood Depth (feet)	105	122	122	136	163
Storm Inundation	20 (19%)	37 (30%)	16 (13%)	11 (8%)	2 (1%)
0 - 1.5	16	24	7	6	2
1.5 - 3		11	7	1	
3 - 4.5				2	
Tidal Inundation	85 (81%)	85 (70%)	106 (87%)	125 (92%)	161 (99%)
0 - 1.5	34	14	9	8	6
1.5 - 3	55	62	61	19	17
3 - 4.5		11	36	64	18
4.5 - 6			2	32	25
6 - 7.5				4	53
7.5 - 9					37
9 - 10.5 feet					5

Source: Marin Map, CoSMoS

EAST SHORE

Table 71. FEMA Damage Levels Applied to Buildings Exposed in East Shore in Scenario 5

Buildings	Yellow Tag-Minor (\$5,000-17,000)	Orange Tag \$17,001+	Red Tag (County assessed improvement value)
163	\$840,000-2,856,000	\$2,856,001+	\$18,035,996

Source: Marin Map, CoSMoS

Table 72. East Shore Station Buildings Potentially Facing Hazardous Conditions

Scenario 1		Scenario 2		Scenario 3		Scenario 4		Scenario 5		
#	%	#	%	#	%	#	%	#	%	Value*
43	13%	59	18%	61	18%	56	17%	125	38%	\$15,209,504

*Improvement Assessed Value Marin County Assessor 2014. Source: Marin Map

Table 71 outlines damage cost estimates for buildings and their contents under scenario 5, assuming that every building would face the same level of damage. Over \$18 million of damage would occur at the high end. Damage levels and associated costs are derived from FEMA. See the Parcels & Buildings Profile for more information).

Table 72 shows how many buildings could experience destructive enough storms to be destroyed, or red-tagged. This analysis applies velocity and flood depth to each building for each scenario. This analysis reveals that up to 43 of the 163 buildings could be exposed to sea level rise and storms in the near-term and 125 of the 193 buildings could be exposed. In the long-term, flooding could result in over \$15 million in assessed building value losses.

Transportation

Shoreline Highway is vulnerable in East Shore in the near-term near creek crossings, such as Walker Creek. Flooding in this location, and others, could worsen in the long-term scenarios. This would limit north to southern travel along East Shore, leading to potential economic, quality of life, sense of place, and emergency access impacts for locals and visitors alike.

East Shore faces unique challenges because the bayside houses inadvertently serve to armor Shoreline Highway from flooding impacts. The loss or compromise of shoreline houses would impact the highway as well.

Table 73. East Shore Exposed Road Segments (Scenarios 2-5 include roads in previous scenarios)

Scenarios 1 & 2	Scenario 3	Scenario 4	Scenario 5
Shoreline Hwy ^C Willow Way ^M			Grand Canyon Rd ^M

P- Private Road, M- Marin County, C- Caltrans Source: Marin Map, CoSMoS

Utilities

East Shore properties with private OWTS systems adjacent to Tomales Bay are vulnerable to high tides and storms in the near-term. Properties south of Nick's Cove to just beyond Marconi Center have on-site septic systems that connect to the Marshall Community Wastewater System. The tank lids and metal straps on plumbing under existing buildings could be corroded by increased exposure to saltwater. The underground tanks, laterals, and main lines are designed to withstand marine conditions. The community pretreatment unit and leach field are located east of State Route 1 and are not vulnerable. The remaining East Shore properties adjacent to Tomales Bay with on-site leach fields could be vulnerable to sea level rise.

EAST SHORE

Working Lands

Aquaculture, particularly oyster production, is integral to the East Shore economy and sense of place. Mariculture buildings and facilities to process and vend their harvest are vulnerable to flooding, failed OWTs, and wave impacts. Losses in this sector could have economic impacts locally and for importers across the globe. Land based operations, such as dairies, could see saline conditions reaching higher along creeks and greater extents of flooding. This may warrant revisions to the operation's conservation management plan. However, the primary near-term concern is transportation access along Shoreline Highway. Finally, agritourism along this route could be compromised if the roads are closed due to flooding or erosion.

Natural Resources

Beaches in the Marshall area are limited to a few small pockets either near creek mouths, or tucked behind docks and armoring structures. Since most are narrow and backed by armor, they are vulnerable to higher tides and inundation associated with sea level rise.



Aquaculture in East Shore. Credit: CDA

Table 74. East Shore Average Beach Widths and Vulnerability Levels

	Base line	Scen 1 & 2	Scen 3	Scen 4	Scen 5
Width	Beaches along Tomales Bay are less than 10 meters wide				
Vulnerability	High	High	High	High	High

Source: CoSMoS, Marin Map, OPC, ESA

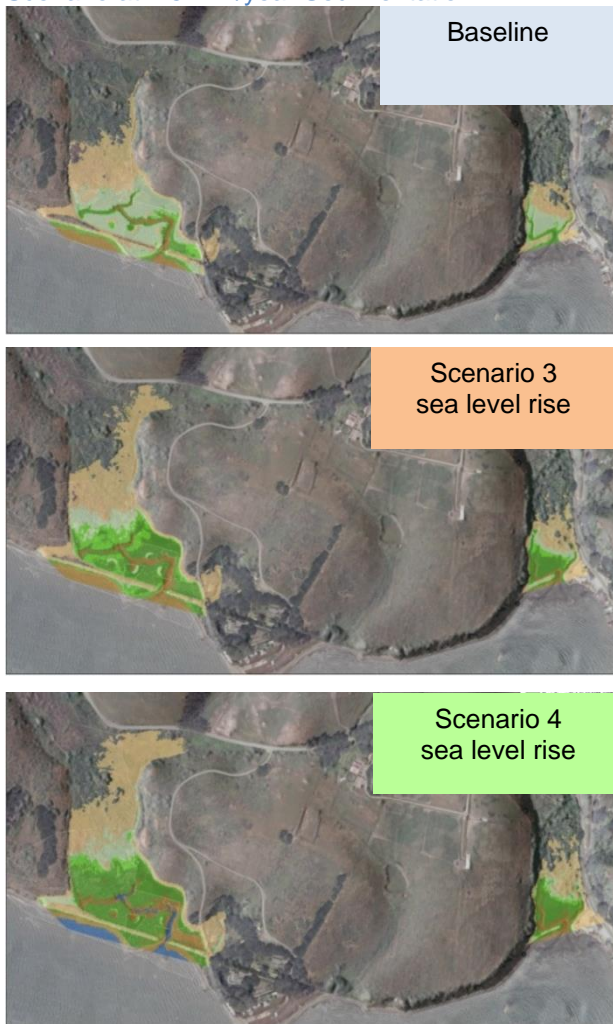
Just like the beaches, Tomales Bay marsh habitats along this stretch of shoreline are also vulnerable to drowning. One example is the Audubon Canyon Ranch's Livermore Marsh Cypress Grove Preserve just north of Marshall. In addition to habitat, its historic Victorian cabins serve as an important center for ornithological research, and their destruction could be a significant loss to the field of conservation science. [Map 80](#) shows how habitat types change from the baseline to the medium-term and long-term scenarios using an average historic sedimentation rate of 1.6mm/year²⁹ at the Cypress Grove Preserve on the right and near Hog Island Oyster on the left of the images.

[Table 75](#) shows the increasing vulnerability of marsh functions at Cypress Grove as sea level rises and marshes are squeezed against steep slopes. The high marsh in long-term scenario 4 is about the same acreage as in the medium-term scenario 3. The acreage of mudflat does increase as the former low lying marsh areas are drowned. For Walker Creek, as shown in [Table 76](#), the area of high and mid marsh diminishes considerably from current conditions to long-term conditions as the wetland migrates up the funnel shaped valley. Upstream in the Walker and Keys Creek valleys, river floodplains can be expected to expand onto adjacent flat terrain as sea levels rise.

²⁹ Smith, S. V. and J. T. Hollibaugh (1998). The Tomales Environment, University of Hawaii, School of Ocean and Earth Science and Technology and San Francisco State University, Tiburon Center. <http://lmer.marsci.uga.edu/tomales/tomenv.html>

EAST SHORE

Map 78. East Shore Marsh Habitat Shifts by Scenario at 1.5 mm/year Sedimentation



Elevation Capital

- $1.5 < z^* < 3$ (Transition)
- $1.0 < z^* < 1.5$ (High Salt Marsh)
- $0.75 < z^* < 1.0$ (Mid Salt Marsh)
- $0 < z^* < 0.75$ (Low Salt Marsh)
- $-1.17 < z^* < 0$ (Intertidal Mudflats)
- $z^* < -1.17$ (Subtidal Channels)



Source: ESA, 2015

EAST SHORE

Table 75. Cypress Grove Preserve Marsh Habitat Distribution at 1.6 mm/year of Sedimentation (acres)

Habitat Type	Area (acres)					z* Range
	Baseline	Scenarios 1 & 2	Scenario 3	Scenario 4	Scenario 5	
Transition zone	7	7	8	9	8	1.5 – 3
High salt marsh	5	4	2	2	4	1 - 1.5
Mid salt marsh	1	3	2	1	2	0.75 – 1
Low salt marshes	1	2	4	6	4	0 - 0.75
Intertidal Mudflats	1	2	2	3	8	-1.17 – 0
Subtidal Channels & Shallows	0	0	0	1	4	< -1.17

Source: ESA, 2015, CoSMoS

Table 76. Walker Creek Area Marsh Habitat Distribution at 1.6 mm/year of Sedimentation (acres)

Habitat Type	Area (acres)			z* Range
	Baseline	Scenario 3	Scenario 4	
Transition zone	52	69	77	1.5 - 3
High salt marsh	48	13	17	1 - 1.5
Mid salt marsh	26	13	7	0.75 - 1
Low salt marsh	43	70	47	0 - 0.75

Source: ESA, 2015, CoSMoS

Recreation

A number of Tomales Bay recreational assets, such as Miller Boat Launch and the only all-tide Marconi Boat Launch, may need to adjust to rising seas and have moderate adaptive capacity in the near- and medium-terms. In the long-term these assets are vulnerable to inundation. Several other visitor services are highly vulnerable in the near-term. The loss of these assets could have economic and quality of life impacts for residents.

Emergency Services

Temporary or permanent flooding of Shoreline Highway could compromise emergency access between Marshall and Point Reyes Station and between Marshall and Tomales; however service from Tomales may be available.

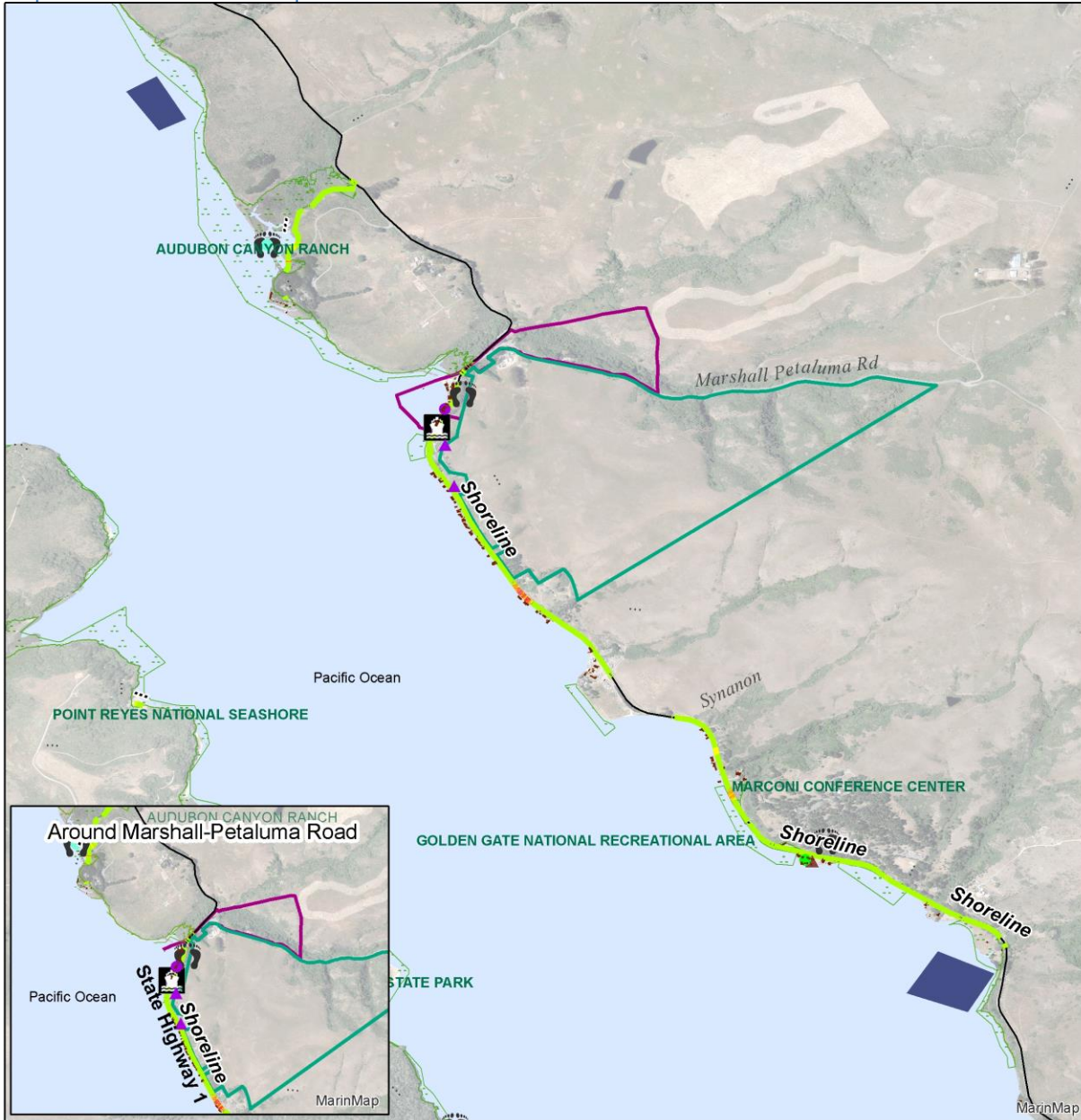
Historic & Archaeological Resources

Exposed historic buildings on the shoreline include the Marshall Tavern, Marshall Store, and J. Shields and Sons Coal and Feed. Because these buildings are adjacent to the water, near-term sea level rise could cause structural damage, and weaken the historic integrity and character. Archaeological Sites could be present in the exposure zones.³⁰

³⁰ Newland, M. April 1, 2015. Sonoma State University, personal communication.

EAST SHORE

Map 79. East Shore Developed Assets Vulnerable to Sea Level Rise



Roads

- @ 10' + Annual storm
- @ 10' + 20-year storm
- @ 20' + 20-year storm
- @ 40' + 100-year storm
- @ 80' + 100-year storm

* Roads may also have utility pipes underneath, are used for recreation, and serve as emergency access in some locations.

Other Assets

- Buildings Exposed to Flooding
- Buildings Vulnerable To Erosion
- Parcels
- Agricultural Parcels
- Aquaculture
- Parkland
- Historic District

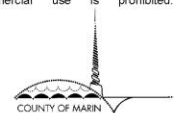
- ▲ Commercial
- Education
- Emergency
- ▲ Food
- Government Service
- Historic
- Institutional
- Recreation
- Residential
- Transportation
- ▲ Utilities

- Boat Launch
- Fishing Pier
- Access Point
- Port
- Marina

0 0.1 0.2 0.4 0.6 0.8 Miles

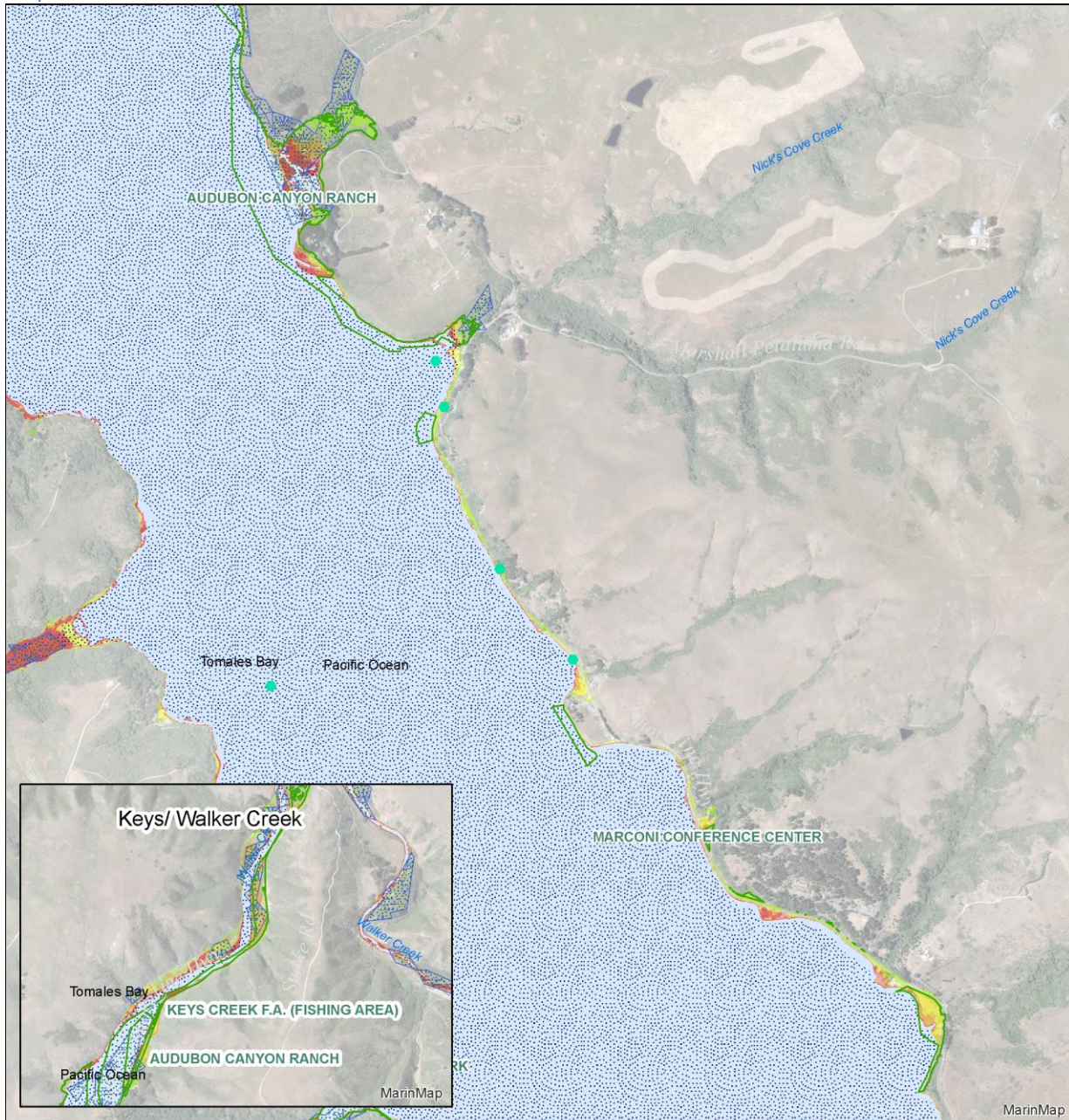
Source: Marin Map, Our Coast Our Future, CA Coastal Commission
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Date: 4/4/2016



EAST SHORE

Map 80. East Shore Natural Resource Assets Vulnerable to Sea Level Rise



Scenarios

- 1 10" SLR + Annual Storm
- 2 10" SLR + 20-year Storm
- 3 20" SLR + 20-year Storm
- 4 40" SLR + 20-year Storm
- 5 80" SLR + 100-year Storm

Assets

- Natural Resource Assets
- Parks
- Seabird Colony
- Mammal Haul Out

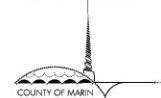
- Wetland
- Estuary
- Marsh

0 0.075 0.15 0.3 0.45 0.6 Miles



Source: Marin Map, Our Coast Our Future, Department of Fish & Wildlife
 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



DILLON BEACH

Community Profile: Dillon Beach

West Marin’s northernmost community, Dillon Beach, features a small bluff top residential community, and low-lying recreational beaches, dunes, camping, fishing, and boating facilities. Dillon Beach is a 200-acre community with 283 people³¹ and four subareas: Oceana Marin, the Village, Dillon Beach Resort, and Lawson’s Landing. North of Dillon Beach to the County line is the most rural section of the study area and could see impacts to ranching and wildlife habitats. Key issues include:

- Flooding on Bay Drive to Lawson’s Landing.
- The centralized Oceana Marin Sewer System could be degraded by erosion and waves.
- Cal Water wells along Dillon Creek.
- 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 tides.

Vulnerable Assets

Dillon Beach’s vulnerable assets include the Coast Spring Water system, Bay Drive, plus recreational, natural resource, and agricultural assets including Dillon Beach Resort and Lawson’s Landing facilities, grazing lands, and the Estero Americano. Archaeological sites may also be vulnerable.

In addition to sea level rise, accelerated erosion under these sea levels is a significant threat in Dillon Beach. Maps 80 and 81 at the end of this profile illustrate developed assets vulnerable to sea level rise, natural assets vulnerable to sea level rise, and accelerated erosion areas, respectively. The following sections provide greater detail for vulnerable assets in Dillon Beach.

IMPACTS AT-A-GLANCE

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



Dillon Beach. Credit: Wanderbat

³¹ U.S. Census Bureau Profile of General Population and Housing Characteristics: 2010

DILLON BEACH

Table 77. Dillon Beach Vulnerable Assets

Asset	Tidal & 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. Values not underlined represent extreme event flooding. Roads received a high and low value along the line segment.)					Vulnerability TF: Temp. Flooding during extreme events; I: Inundated at MHHW; E: Erosion; WS: Wave Surge; HW: High Wind, HS: Habitat Shift
	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	
Lawson's Landing Facilities	2"	1'1"	<u>2'11"</u>	<u>3'10"</u>	<u>7'3"</u>	I, E, WS, HW, HS
Bluff Top Homes	X	X	X	X	X	E
Dillon Beach Resort Parking Lot					<u>1'6"</u>	TF, I
Estero Americano	water resource					HS
Sewage Pump Station	bluff top asset					E

Source: Marin Map, CoSMoS Exposure and Flood Depth data, Asset Manager Interviews

Parcels & Buildings

The boathouse at Lawson's Landing is a fully equipped boathouse and outboard shop with boat and motor rentals and supplies (e.g., bait, tackle, food, beverages, etc.), and is exposed and vulnerable to sea level rise and storms in the medium-term. Without the boathouse, visitors and residents could face new barriers to fishing, boating, and other recreational activities. Staff residences at Lawson's Landing are also vulnerable to flooding and erosion.

Table 80 shows cost estimates of up to \$300,000 in damages for these buildings and their contents exposed in scenario 5, with the assumption that every building would face the same level of damage as designated by FEMA Hazus post-disaster tagging thresholds. Nearly all of the damage could occur at the high end of the long-term scenarios.

Buildings here are not vulnerable to hazardous conditions as described in the other community profiles. However, ten to over one hundred bluff top residences could be vulnerable under accelerated erosion across scenarios 1-5. See Table 79.

Table 78. Dillon Beach Exposed Parcels & Buildings by Scenario

	Parcels	Buildings
Scenario 1	3	0
Scenario 2	3	0
Scenario 3	6	1
Scenario 4	7	1
Scenario 5	7	5

Source: Marin Map, CoSMoS

Table 79. Dillon Beach Blufftop Buildings Vulnerable to Accelerated Erosion

	Buildings
Scenario 1&2*	8
Scenario 3*	22
Scenario 4*	43
Scenario 5*	101

* This analysis does not include storms.

Source: Marin Map, CoSMoS

Table 80. Dillon Beach FEMA Damage Levels Applied to Buildings Exposed in Scenario 5

Buildings	Yellow Tag-Minor (\$5,000-17,000)	Orange Tag \$17,001+	Red Tag (County assessed improvement value)
5	\$50,000-85,000	\$85,001+	\$282,597

Source: Marin Map, CoSMoS

DILLON BEACH

Transportation

Bay Drive connects Lawson’s Landing with the rest of Dillon Beach, and could be exposed by near-term scenarios, complicating local residents’ and employees’ daily routines, preventing recreational access, and cutting off emergency access. North of Dillon Beach, roads are primarily impacted at creek crossings, such as bridges along Middle Road and Valley Ford Franklin School Road and could impact agriculture.

Table 81. Dillon Beach Exposed Road Segments (Scenarios 2-5 include roads in previous scenarios)

Scenarios 1 & 2	Scenario 3	Scenario 4	Scenario 5
Bay Dr. ^P Valley Ford Frank Sch Rd. ^M Middle Rd. ^C			

P- Private Road, M- Marin County, C- Caltrans Source: Marin Map, CoSMoS

Utilities

Drinking water is supplied by Coast Springs Water Company and a community owned Estero Mutual Water Systems. Both are public water systems regulated by the State. A large portion of the Coast Spring water supply is pumped from a well adjacent to the channel of Dillon Creek. Estero Mutual serves approximately 130 connections in Oceana Marin, and 40 undeveloped lots in Ocean Beach. A catchment basin for this system could be impacted.

The centralized sewage treatment system for most of Oceana Marin’s 233 dwellings is vulnerable to erosion. Loss or dysfunction of system would cause homes to become unlivable, and potentially cause negative ecological and public health impacts if untreated sewage is released into the environment.

Working Lands

Coastal erosion and sea level rise may reduce the area of grazing land, ranging from 100 acres (scenario 1) to 405 acres (scenario 5), thus weakening the local agricultural economy. Rural ranchlands could see an increase in salinity in major creeks and creek tributaries that lead into the Pacific Ocean. Moreover, and of even greater concern, is access to and from the ranches along flooded roads throughout the region and county.

Natural Resources

Due to the amount of dune sand present at Dillon Beach, the beach width has a higher capacity to transgress with sea level rise compared to other beaches in the study area. Marsh habitat at Lawson’s Landing is currently undergoing restoration. North of Dillon Beach towards the county line, Stemple Creek, Americano Creek, and Esteros Americano and San Antonio are unique resources that will likely see habitat shifts from tidal habitats to wet habitats in the Estero, and from freshwater habitat to brackish habitat in the creeks.

Recreation

The private Dillon Beach Resort is a destination for vacationing, surfing, picnicking, bird watching, and more. The parking lot is subject to inundation at the long-term (high end scenario) which, if not addressed could have negative economic impacts from reduced visitor spending. North of Dillon Beach, the Estero Trail could be impacted.

As fishing, boating, and camping destination, the loss or deterioration of Lawson’s Landing could also have negative impacts on the community. Without Lawson’s Landing, visitor traffic to Dillon Beach could be significantly reduced, potentially leading to the closure of local businesses in Dillon Beach and Tomales.

Coastal armoring at Lawson’s Landing includes two seawalls and a berm to stabilize the area’s dunes. If the seawalls fail, the campsites could become too wet or muddy to use. The berm is not recognized on the CoSMoS model as it was installed after the LIDAR was flown, and therefore its vulnerability should be further assessed in future studies.

Emergency Services

Flooding on Bay Drive would cut off emergency access to Lawson’s Landing, thus leading to health and safety impacts for residents and visitors.

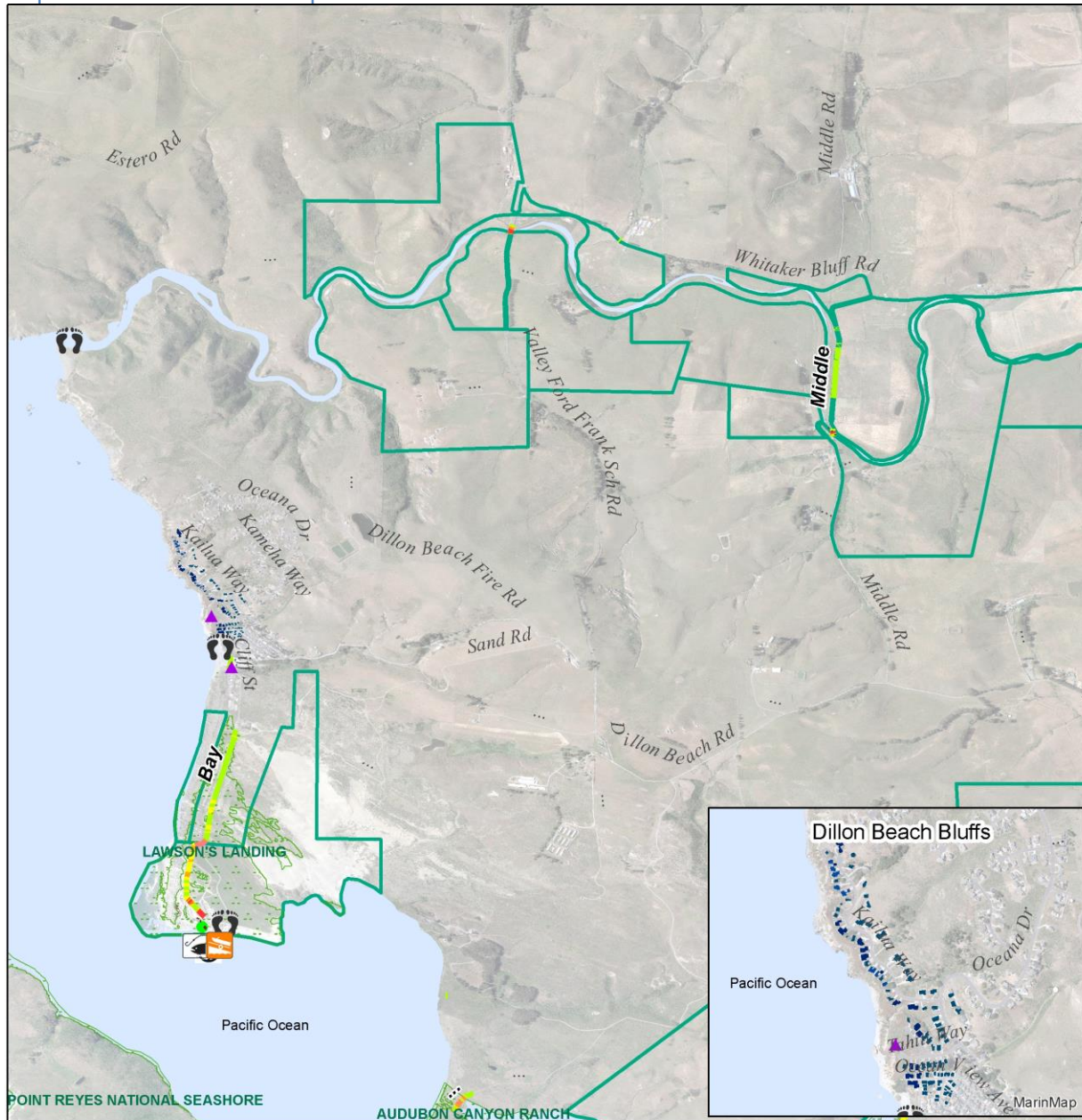
Historic & Archaeological Resources

Archaeological sites could be present in the exposure zones.³²

³² Newland, M. April 1, 2015. Sonoma State University, personal communication.

DILLON BEACH

Map 81. Dillon Beach Developed Assets Vulnerable to Sea Level Rise and Erosion



Roads

- @ 10' + Annual storm
- @ 10' + 20-year storm
- @ 20' + 20-year storm
- @ 40' + 100-year storm
- @ 80' + 100-year storm

* Roads may also have utility pipes underneath, are used for recreation, and serve as emergency access in some locations.

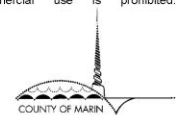
Other Assets

- Buildings Exposed to Flooding
- Buildings Vulnerable To Erosion
- Parcels
- Agricultural Parcels
- Aquaculture
- Parkland
- Historic District
- ▲ Commercial
- Education
- Emergency
- ▲ Food
- ▲ Government Service
- ▲ Historic
- Institutional
- Recreation
- Residential
- Transportation
- ▲ Utilities

- Boat Launch
- Fishing Pier
- Access Point
- Port
- Marina

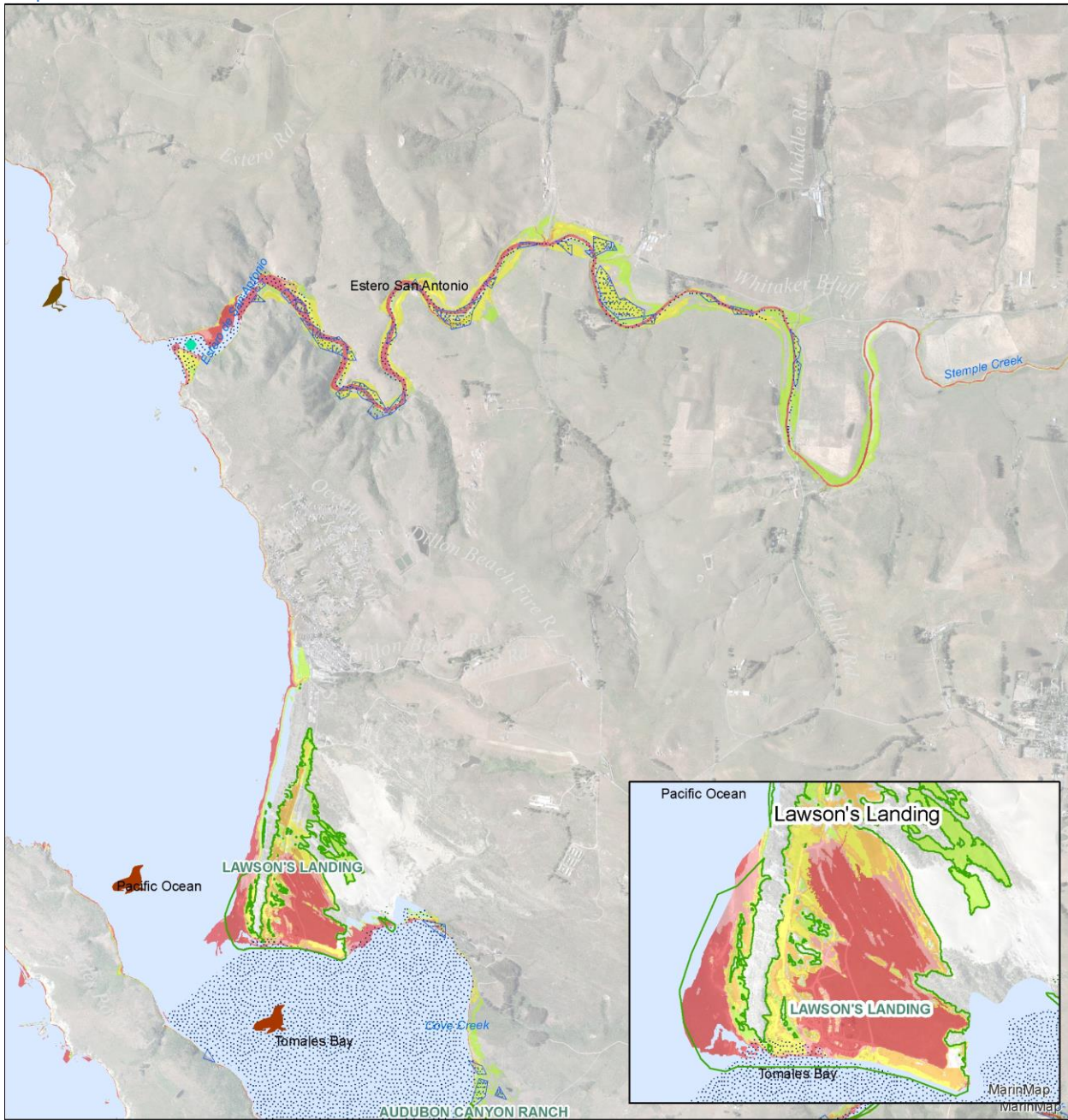


Source: Marin Map, Our Coast Our Future, CA Coastal Commission
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DILLON BEACH

Map 82. Dillon Beach Natural Resource Assets Vulnerable to Sea Level Rise

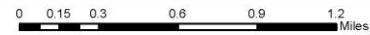


Scenarios

- 1 10" SLR + Annual Storm
- 2 10" SLR + 20-year Storm
- 3 20" SLR + 20-year Storm
- 4 40" SLR + 20-year Storm
- 5 80" SLR + 100-year Storm

Assets

- Natural Resource Assets
- Parks
- Seabird Colony
- Mammal Haul Out
- Wetland
- Estuary
- Marsh



Source: Marin Map, Our Coast Our Future, Department of Fish & Wildlife
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