C-SMART ASSET PROFILES

PARCELS & BUILDINGS

Asset Profile: Parcels & Buildings

Properties and the buildings on them are significant assets along the Marin coast that provide for homes, goods and services providers, public facilities, worship, education and the ability to create equity and income in some cases. While a majority of the parcels feature buildings, many others are agricultural or natural in use and have unique vulnerabilities (see Working Lands and Natural Resources Profiles). The first threats to buildings will likely be the drinking water and disposal systems these buildings depend on (see Utilities Profile). In addition, road closures could prevent needed access to and from homes, schools, businesses, and public open spaces (see Transportation Profile). Ultimately, in low lying coastal locations, buildings will likely face severe storm damage, and, eventually, near daily flooding at high tides. The following are general key issues related to building vulnerability:

- Almost all buildings along Marin's open coast are vulnerable to storms, though some property owners are at higher risk due to construction materials, elevation, and location over or directly bordering waterways, and subject to forces of moving water.
- According to utility managers, the earliest threats of flood damage may be to non-structural building component, such as utility and mechanical systems at or below grade. Malfunctions could make a home unlivable.
- According to Stinson Beach and Bolinas asset managers, oceanfront and bluff properties are subject to erosion, and have seen erosion impacts and restructuring expenses in the past.
- Properties untouched by rising ocean water may still become isolated and cut off from essential services, and access routes could be compromised if roads become flooded, blocked with mudslides, or washed out.
- A few public facilities, including Stinson Beach Fire Station No. 2, are vulnerable in the near to medium-term. Most others in the study area, such as the post offices in Inverness and Bolinas, are vulnerable nearing the end of the century.

IMPACTS AT-A-GLANCE

1,100 homes, businesses, & institutions	3,000 people
Storm and tidal impacts already occur	Regional
Billions of dollars' worth of built assets exposed	Property Owners County CDA

Pier-based buildings on Wharf Road, Bolinas. Credit: Wong

Table 5. Exposed Parcels & Buildings by Scenario

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

Source: Marin Map, OCOF

PARCELS & BUILDINGS

All coastal communities have public and private properties that could be impacted by sea level rise, increased storm surges, higher water table, sub-surface saltwater intrusion, beach erosion, high winds, waves, and several others to bluff erosion. In the near term, hundreds of parcels and buildings could see tidal impacts. Figures amount to 16 percent of all parcels and 8 percent of all buildings in the study area. Of the parcels, 435 are residential and six are commercial parcels. The properties are concentrated in Stinson Beach Calles and Patios neighborhoods, and East Shore. Small portions of downtown Bolinas and the Tomales Bay Shoreline in Inverness could also see impacted parcels and buildings. Nearing the end of the century, about 1,300 parcels, or 25 percent of all parcels, and 1,100 buildings, or 20 percent of all buildings, could be exposed to average higher high tide flooding or storm flooding at 80 inches of sea level rise with a 100-year storm, the high end of the long-term scenarios. Across the scenarios impacted buildings nearly triple in number.

Table 6 breaks down the exposed residential and commercial parcels for scenarios 1 (near-term), 3 (medium-term), and 5 (long-term, high end) by number and percent of the total within that community. By far, a majority of the parcels are residential. However, ten to twenty percent of residential parcels, and twenty to just over thirty percent of commercial parcels on the Marin coast are exposed under these scenarios. In this regard, a twenty to thirty percent loss of existing parcels would be significant across both land uses.

At the community scale, Stinson Beach has the highest number of residential parcels exposed across all three scenarios. In fact, nearly half of the parcels west of Shoreline Highway exposed in the short-term and nearly all in the mid-term (scenario 3). East Shore and Inverness are next, with a majority of the exposed buildings located on or between Tomales Bay and the main road. By percentage, East Shore could see the greatest proportion of impacted residential and commercial parcels across all scenarios, with 90 percent exposed in the near-term. Inverness could see nearly 40 percent of commercial parcels in the same timeframe.

Residential parcels include multi-family and single-family housing. Overall, there are 28 multi-family parcels with 71 living units, and 706 single family parcels with 710 living units. Across both, there is likely a mix of owner-occupied and rental units, especially given the large portion of vacation rentals in West Marin. In the study area, approximately 241 residential and 5 commercial parcels do not have structures and are less vulnerable than those with structures and active uses.

Exposed government facilities include: Inverness and Bolinas Post Offices, Bolinas-Stinson school sites, Bolinas and Stinson Libraries, Bolinas Lift Station, and Stinson Fire Station No. 2. The Audubon Canyon Ranch facilities also have vulnerable farm buildings (offices, research, and education facilities). See Table 8 for timing and depth details.

Table 6. Exposed Parcels by Community and Land Use

	Scenario 1				Scenario 3				Scenario 5			
	Residential		Commercial		Residential		Commercial		Residential		Commercial	
	#	%	#	%	#	%	#	%	#	%	#	%
Stinson Beach	295	36%	6	21%	556	68%	6	21%	566	69%	6	21%
Bolinas	27	2%	1	7%	53	5%	4	27%	94	8%	13	87%
Inverness	38	3%	7	37%	72	6%	8	42%	108	9%	10	53%
Pt. Reyes Station	9	2%	3	8%	11	3%	3	8%	30	8%	4	11%
East Shore	66	49%	9	90%	105	78%	9	90%	114	84%	10	100%
Dillon Beach	0	0%	1	4%	1	0%	1	4%	6	1%	3	10%
TOTAL	**435**	**10%**	**27**	**20%**	**798**	**19%**	**31**	**23%**	**918**	**22%**	**46**	**33%**

Source: Marin Map Parcel Layer Land Use Description 2014

PARCELS & BUILDINGS

Most of the buildings in the coastal zone are wooden single-story or two-story buildings, and are susceptible to water damage from flooding and structural damage from wind and waves. Buildings built prior to 1970 typically have T-footing foundations that extend 18 inches deep. Such buildings are prone to scouring from water hitting above their foundations, and their wooden floors are more likely to slide off the foundation. Older buildings in downtown Bolinas feature these foundation types. Homes built after 1970, most common in Stinson Beach, are secured to drilled piles 20-30 feet deep with reinforced steel cages and concrete connecting the home to the foundation. These buildings are engineered to resist settling and earthquake impacts, and could withstand lateral forces from water and wind during storms. Many, though not all, cement foundation homes have an 18 inch crawl space containing electrical wires, pipes, mechanical ducts, and furnaces that could become flooded and trap debris that could weaken the structure. The majority of exposed buildings were built after 1980, with concentrations of older buildings in Downtown Bolinas and a few in Stinson Beach and Inverness. Many of the exposed buildings in Inverness and Marshall are wooden and on pier foundations or directly on the shoreline.

Commercial structures, except for those on piers, and a few other wooden structures, tend to be cinder block construction with stucco or paint sealing. Cinder block buildings built over twenty years ago are likely unreinforced and more vulnerable than newer reinforced buildings. Forty-two commercial parcels containing approximately 40 buildings with businesses and 29 living units; concentrated in downtown Bolinas (Bolinas Market, Smileys Schooner Saloon and Hotel), and the shores of Tomales Bay in Inverness (Brock Schreiber Boat House) and Marshall (East Shore; Hog Island Oyster, Tomales Bay Oyster, Marshall Boat Works, Tony's Restaurant) could be vulnerable, especially those close to the shoreline.

Table 8 lists some of the vulnerable buildings and the parcels they rest on. This list shows onset and tidal mean higher high water (MHHW) and any additional extreme event flood depths for groups of buildings, and in some cases specific buildings were assessed. This list is not exhaustive of all the buildings that could be exposed to sea level rise and storm impacts in the study area.

Table 7. Physical Vulnerabilities of Buildings

Factors	Influence
Elevation	▪ At or Below Grade – If the lowest floor is as high as or below the flood level, it is susceptible to water and salt. Mechanical or electrical equipment, pumps, utilities, heat, ventilation, power, openings (e.g. windows, entryways, or ventilation grates), etc. can be vulnerable if at or below grade.[1] ▪ Bluff top developments are highly vulnerable to erosion and scouring of the bluff toe.
Materials	▪ Wooden buildings tend to be lighter and low-rise, and can incur structural damage.[2, 3] ▪ Cinder block, brick, and reinforced concrete built buildings are heavier, taller, and less vulnerable to damage.[4] Brick foundations are able to withstand up to 3 feet of flooding (highly unlikely).[5] ▪ Mobile and manufactured homes are susceptible to flooding.
Building Codes	▪ Buildings built before modern building codes and FEMA requirements for flood prone areas may be more susceptible.[6]
Surrounding environment	▪ Buildings in areas without or failing coastal armoring are more vulnerable.

[1] The City of New York, *A Stronger, More Resilient New York* (2013), 75.
[2] Ibid.
[3] Bay Conservation and Development Commission, *Housing Indicators Table*. Unpublished document.
[4] The City of New York, *A Stronger, More Resilient New York* (2013), 75.
[5] Bay Conservation and Development Commission, *Housing Indicators Table*. Unpublished document.
[6] The City of New York, *A Stronger, More Resilient New York* (2013), 76.

PARCELS & BUILDINGS

Table 8. Building Assets Ranked by Onset and Flood Depth

Location	Asset	Tidal & Extreme Event Flooding Depth Estimates (Underlined values indicate daily tidal flooding at mean higher high water (MHHW) based on one geographic point placed at the landward limit of the first scenario where it overlaps the asset. Values not underlined represent temporary extreme event flooding. For groups of buildings, a maximum is provided.)					Vulnerability TF: Temp. Flooding during extreme events; I: Inundated at MHHW; E: Erosion; WS: Wave Surge; HW: High Wind
		Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	
Stinson Beach	Patios and Calles Buildings	10”+1”4”	10”+6”3”	1'6”+ 7’	4'9”+5’10”	6'5”+ 6’8”	I, WT, WS, TF, E
Inverness	Inverness Yacht Club	3’2”	4’1”	4’11”	6’10”	10’1”	I, WS, HW
Inverness	Brock Schreiber Boathouse	2’7”	3’6”	4’	5’10”	9’2”	I, E
East Shore	Hog Island Oyster	2'1"	2'1"	2'10"	4'10"	8'1"	I
Inverness	Shoreline Buildings	2’+1’2”	2’+2’	2’10”+2	4’8”+2'	8'+8‘8”	I, WT, WS, TF
East Shore	Shoreline Buildings	1'9”+1’	1'9”+1’11”’	2'6”+2’	4’3”+2’2”	7’8”+2’2”'	I, WT, WS, TF
Stinson Beach	Seadrift Buildings	2’5”	4’11”	4’10”	3'4”+8’3”	6’1+ 5’9”	I, WT, WS, TF, E
Bolinas	Downtown Buildings	1’8”+1’5”	1’8”+2’2”	2'7”+2’	4’5”+2’1’	7’9”+1’7”	I, WT, WS, TF
East Shore	Tony's Restaurant	8”	1’8”	2’6”	4’5”	7’9”	I
East Shore	Tomales Bay Oyster Company	8"	1'5"	2'3"	4'1"	7'5"	I, TF
Stinson Beach	Water District Office	7”	3’3”	4’8”	6’6”	8’8”	TF, I
Dillon Beach	Lawson’s Landing Facilities	2”	1’1”	2’11”	3’10”	7’3”	I, E, WS, HW
Bolinas	Historic District		3’10”	4’8”	6’4”	10’	I, E
Dillon Beach	Bluff-top buildings	X	X	X	X	X	E
Bolinas	Bluff-top buildings	X	X	X	X	X	E
Muir Beach	Bluff-top buildings	X	X	X	X	X	E
Stinson Beach	Fire Station #2		3’6’’	5’3”	6’10”	9’1”	I, TF, WT
Bolinas	Sewage Lift Station			3’3”	5’	8’7”	TF, I
Inverness	Inverness Store			2’5	4’4”	7’6”	TF, I, WT
Bolinas	Bolinas Super Market			8”	2’6”	6’1”	I, E, SI
Inverness	Motel Inverness				2’9”	5’10”	I, WS, HW
East Shore	Nick's Cove				2’6”	5’10”	
East Shore	Historic District				2’5”	4’5”	I
Inverness	Historic District				2’1”	5’1”	TF
Bolinas	Bolinas Library				1’8”	5’3”	I, TF
Bolinas	Bo-Gas Station				1’7”	5’3”	I
Bolinas	Gospel Flats				1’7”	5’3”	I, WT, SI, TF
Bolinas	Community Center Emergency Shelter				1’7”	5’2”	I, E
Bolinas	Community Land Trust Housing				1’2”	4’10”	I
Bolinas	Church: Calvary					5’10”	I, TF

PARCELS & BUILDINGS

Location	Asset	Tidal & Extreme Event Flooding Depth Estimates (Underlined values indicate daily tidal flooding at mean higher high water (MHHW) based on one geographic point placed at the landward limit of the first scenario where it overlaps the asset. Values not underlined represent temporary extreme event flooding. For groups of buildings, a maximum is provided.)					Vulnerability TF: Temp. Flooding during extreme events; I: Inundated at MHHW; E: Erosion; WS: Wave Surge; HW: High Wind
		Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	
	Presbyterian						
Inverness	Tomales Bay Resort					4’	TF
Inverness	Inverness Post Office Building					3’7”	TF, I, WS, E
Bolinas	Bolinas People's Store					3’	I, TF
Bolinas	Bolinas Post Office					2’9	TF, I
Bolinas	Bolinas Stinson School					2’2”	I, TF, E, WS
Pt. Reyes Station	Buildings along Lagunitas Creek					1’8”-3’2”	TF, I

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

If a structure is purchased using a federally-backed loan, the owner may be required to maintain flood insurance through FEMA depending on their flood vulnerability to provide financial relief to recover from damages caused during storm events. To attain lower insurance premiums or to avoid the insurance need altogether, homes in FEMA mapped flood zones (Flood Insurance Rate Maps or FIRMs) are required to meet construction standards, to reduce flood risks and impacts. FEMA designates two flood zones that define the building requirements that one needs to meet for new or substantially rebuilt structures. The v-zone is characterized by high velocity waves over 3 feet. The a-zone has smaller waves and less flooding under the 1% annual exceedance probability (AEP)[7] flow. Homes that do not meet these requirements pay more for their annual flood insurance premiums. Over the years, requirements have changed; therefore homes on the coast are built to the varying standards. Nevertheless, with storms combined with sea level rise, homes that meet current standards could become vulnerable because FEMA standards are based on historic trends and do not incorporate future sea levels.

Several buildings along the coast and Tomales Bay shoreline have federal flood insurance and only a portion of buildings are raised and constructed to attain low insurance rates or avoid insurance requirements all together by meeting FEMA v- and a-zone structural integrity standards. Based on data provided by FEMA, approximately 26 repetitive loss properties exist on the outer coast.[8] The overall unincorporated Marin County total is 78 repetitive loss properties.[9] Major storms may result in unaffordable claims for flood damages, as has already happened during recent storms on the East Coast. FEMA will likely continue to raise flood insurance premiums, may start limiting payouts, and strengthen their construction standards in response.

Table 9 provides estimates for the cost of damages to buildings and their contents according to the FEMA scale used in post-disaster assessments (assuming every building exposed in scenario 5 suffers the same amount of damage).[10] According to

[7] Since hurricane Katrina, agencies changed to Annual Exceedance Probability from the year based flood description, for example “100-year flood.” The latter has misled people to interpret that such a storm only should happen once every 100 years when, in fact, it is a flood that has a 1% probability of happening in any given year and a 30% chance of happening over the course of a 30-year mortgage. (See Methods for more details).

[8] Defined by FEMA as “a property for which two or more flood insurance claims of more than $1,000 have been paid within any 10-year period since 1978”

[9] Flood insurance is required for all federally backed home mortgages.

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

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the *Structure Debris Estimates: Hazus Level 1 Flood and Wind Losses*,[11] building damage is assigned as:

- Yellow Tag
  - Affected: Full Verified Loss (FVL) is $0 to $5,000, or water depth greater than 0 to 2 feet (2.05 tons of debris per 1,000 square feet)
  - Minor: FVL is $5,001 to $17,000, or water depth greater than 2 to 5 feet (4.1 tons of debris per 1,000 square feet)
- Orange Tag: FVL greater than $17,000 or water depth greater than 5 feet (8 tons of debris per 1,000 square feet).
- Red Tag: Destroyed.

To determine how many buildings could face storm hazards strong enough to destroy the building, FEMA v-zone criteria for flood depth and wave velocity was assessed for each building under the sea level rise and storm scenarios. Table 10 shows how many buildings could see destructive forces.

Table 11 provides monetary figures for buildings that would be exposed to hazardous conditions, meaning that they could be destroyed in a severe storm. Over $250 million in assessed building (improvement) value could occur at the scenario 5 sea level of 80 inches and a 100-year storm. And once a home cannot be safely rebuilt, the land assessment value will also decline. Market values would be impacted in similar ways, though at much higher losses.

In addition to damage from flooding and storms, several homes in Muir Beach, Stinson Beach, Bolinas, and Dillon Beach could be vulnerable to accelerated erosion, or erosion rates that take in to account higher tides. Nearly 450 bluff top buildings could be impacted, in addition to 300 or so homes that are already subject to flooding at the high end of the long-term scenarios, scenario 5, as seen in Table 12. Note that this analysis only uses the sea level component, and not the storms, of each scenario.

Seadrift neighborhood, Stinson Beach. Credit: CDA

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

PARCELS & BUILDINGS

Table 9. FEMA Damage Levels Applied to Buildings in SLR Scenario 5

	Buildings	Yellow Tag-Minor ($5,000-17,000)	Orange Tag $17,001+	Red Tag (County assessed improvement value)
Stinson Beach	660	$3,070,000-10,438,000	$10,438,001+	$220,778,456
Bolinas	98	$490,000-1,666,000	$1,666,001+	$23,114,950
Inverness	75	$375,000-1,275,000	$1,275,001+	$10,155,532
East Shore	163	$840,000-2,856,000	$2,856,001+	$18,035,996
Pt. Reyes Station	36	$180,000-612,000	$612,001+	$5,480,520
Dillon Beach	5	$50,000-85,000	$85,001+	$282,597
TOTAL	**1,037**	**$5,105,000-17,357,000**	**$17,357,001+**	**$293,856,687**

Source: FEMA Hazuz applied to Marin Map and OCOF

Table 10. Buildings Potentially Facing Hazardous Conditions

	Scenario 1		Scenario 2		Scenario 3		Scenario 4		Scenario 5	
	#	%	#	%	#	%	#	%	#	%
East Shore	43	13%	59	18%	61	18%	56	17%	125	38%
Stinson	27	2%	48	4%	89	8%	239	21%	582	51%
Bolinas	3	<1%	6	<1%	15	1%	25	1%	98	5%
Inverness	4	<1%	4	<1%	4	<1%	14	1%	36	2%
Pt. Reyes Station									36	4%

Source: Marin Map, OCOF

Table 11. Assessed Value for Land and Improvements Exposed to Hazardous Conditions in Scenario 5

	Parcels	Land Assessment Value[a]	Improvement Assessment Value[a]	Total
Bolinas	61	$13,074,598	$14,781,273	$27,855,871
East Shore	87	$18,261,732	$15,209,504	$33,471,236
Inverness	45	$14,437,134	$10,884,967	$25,322,101
Muir Beach	1	$34,300	$0	$34,300
Pt. Reyes Station	14	$2,370,960	$2,229,076	$4,600,036
Stinson Beach	492	$403,489,417	$217,439,909	$620,929,326
Total	**700**	**$451,668,141**	**$260,544,729**	$712,212,870

Source: Assessor Data 2014/2015 Tax Year

Table 12. Buildings Vulnerable to Accelerated Erosion at MHHW

	Bluff top Erosion (Muir Beach, Bolinas, Dillon Beach)	Shoreline Erosion (Stinson Beach)	Total
Scenarios 1&2*	60	0	60
Scenario 3*	143	5	148
Scenario 4*	332	51	383
Scenario 5*	435	284	719

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

PARCELS & BUILDINGS

Around 72% of California's beaches are known to be facing active erosion. Of this 72% (1267 km), about 1028 km of California's coast is characterized by the erosion of uplifted marine terraces of relatively low relief (Runyan 2003). Bolinas Mesa is among this vast coastline of eroding, low relief bluffs. Bolinas Mesa is known to have historical erosion rates of about 0.75 m/yr along the west facing cliffs and 0.5 m/yr along the south-east facing shore. These rates were reported in 1977 by the California Division of Mines and Geology, and even then were reported to be widely variable. Now, the 1977 rates are relatively unreliable based on new methods and technologies for measuring coastal erosion. With impending sea level rise, which is also widely variable, these erosion rates are bound to continue accelerating in the coming decades.

Much of the threat to development from bluff erosion stems from bad timing between the development of the California coast and natural climate processes. The first half of the 20th century was marked by prolonged drought, so development was based on drought-like conditions, where there wasn't a lot of storm based erosion, so it wasn't seen as a distinctive hazard. In the 1970s there was a shift in California's climate pattern, ushering in a period of cyclical, severe El Niño events. The aftermath of many of these storms proved that the coastal infrastructure is insufficient for handling these types of storms, which are likely to become more common and more severe in the long term.

The nature of uplifted marine terraces has created a precarious scenario for much of California. Because of their proximity to the Pacific and flat formation, they're highly desirable for development. However, these terraces are desirably flat because of their erodible nature, and have been put in a precarious position because of their heavy development, which contributes further to the inherent instability of these platforms.

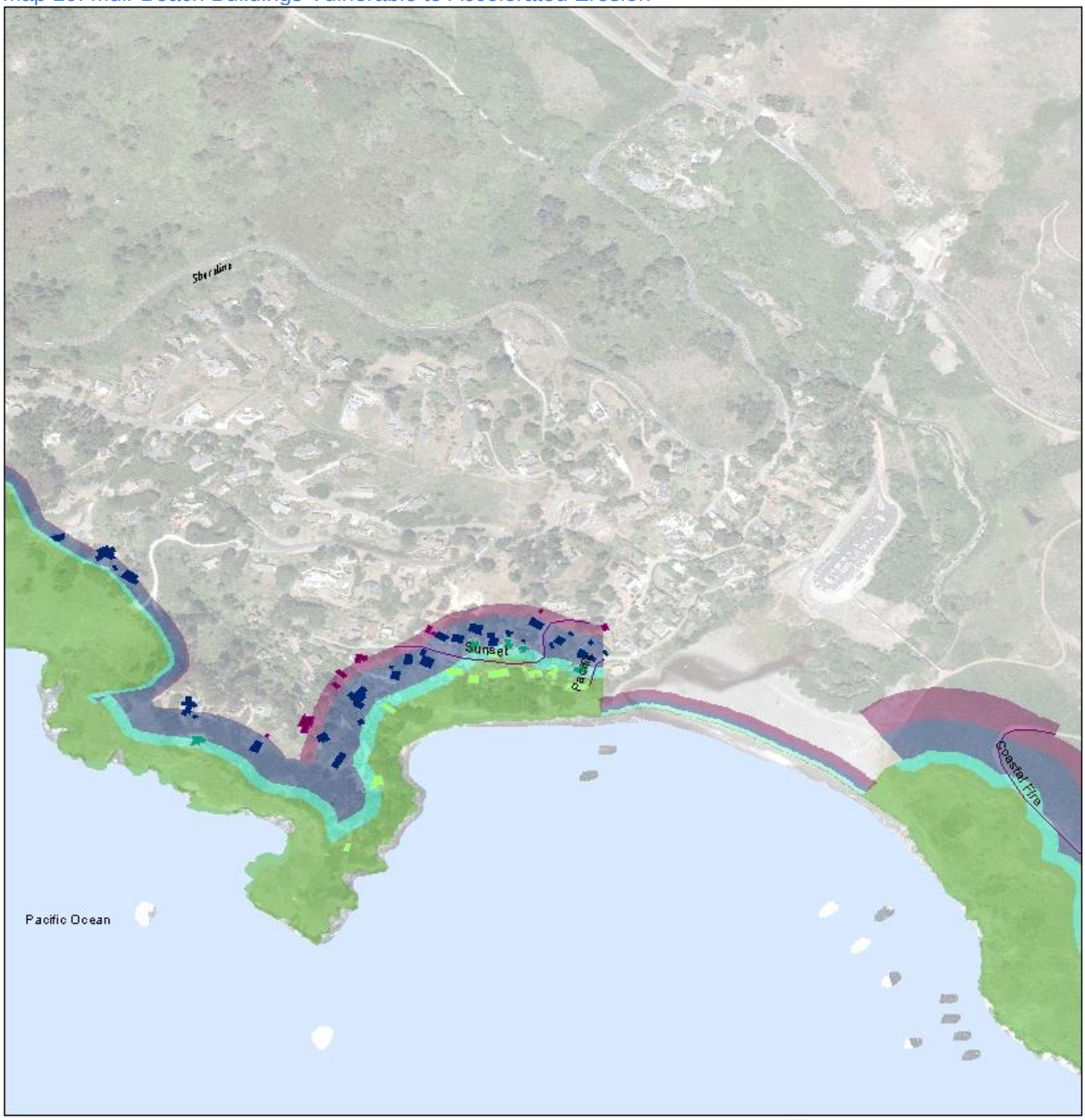
Erosion rates are directly related to intrinsic cliff factors, or the geologic makeup of the cliff, rather than to variation in wave energy (Runyan 2003). While the previously measured averages were somewhat useful in long term planning in terms of proposed setbacks, the nature of the cliffs' erosion is more likely to be characterized by lower, relatively non-perceivable levels of steady erosion interspersed with a few large erosion events during 10, 20, or 100 year storms that may occur in combination with high tides. This adds a level of uncertainty to any long-term plan, because there are possibilities of large portions of presently available setback space to fail.

While wave action certainly is a contributor the erosion of these cliffs, there has been debate as to how much wave action actually contributes to overall erosion. There are many factors that contribute to cliff-side erosion besides wave action, including seismic shaking, vegetation, climate, groundwater seepage, and overland flow. A 4.5 year study of the erosion along 1.6 km of cliff in Pacifica, CA between 2002 and 2007 showed that it can be fairly easy to determine whether or not cliff failure events were the result of wave action or of groundwater seepage. When there were larger, fragmented rock falls along the bluff face, it was determined that these were likely due to groundwater seepage, and these types of failures were more common in the areas studied that were more moderately cemented. Likewise, when failures observed had a more uniform, smoother consistency, they were likely the result of wave action-related failures, when the total water level was able to reach the toe elevation.

The following maps highlight the parcels and buildings that could be exposed to average higher high tide and storm activity across the 5 scenarios. Maps also illustrate the additional buildings (typically residences) vulnerable to accelerated bluff erosion. The maps focus on the areas with the highest number of impacted properties including: Stinson Beach, Bolinas, Inverness, Pt. Reyes Station, and East Shore/Marshall (not Muir Beach or Dillon Beach).

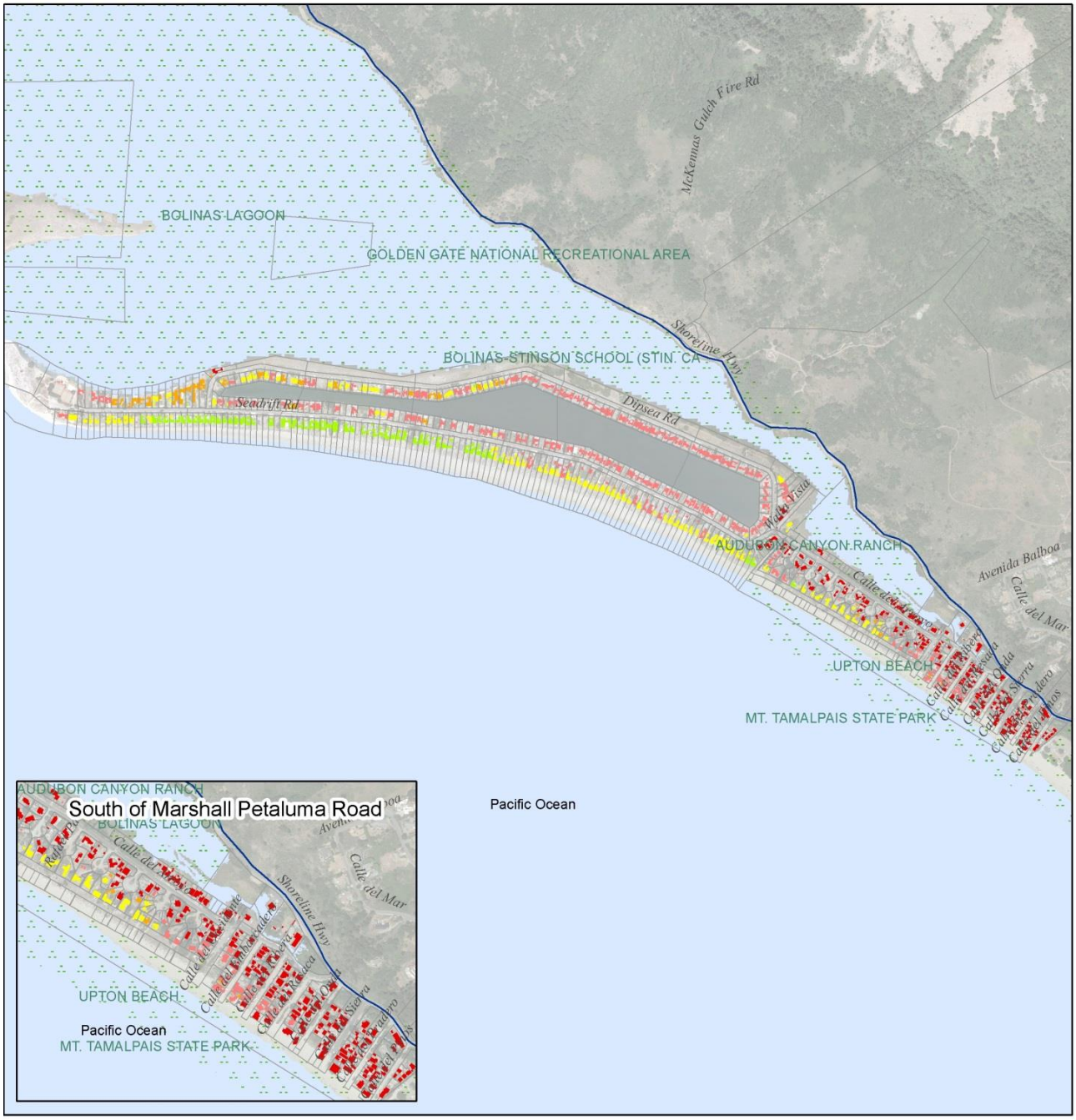
PARCELS & BUILDINGS

Map 10. Muir Beach Buildings Vulnerable to Accelerated Erosion



PARCELS & BUILDINGS

Map 11. Stinson Beach Parcels & Buildings Vulnerable to Sea Level Rise



Building Footprints

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

- Parcels
- Park Parcels

0 0.05 0.1 0.2 0.3 0.4 Miles

N

Source: Marin Map, Our Coast Our Future

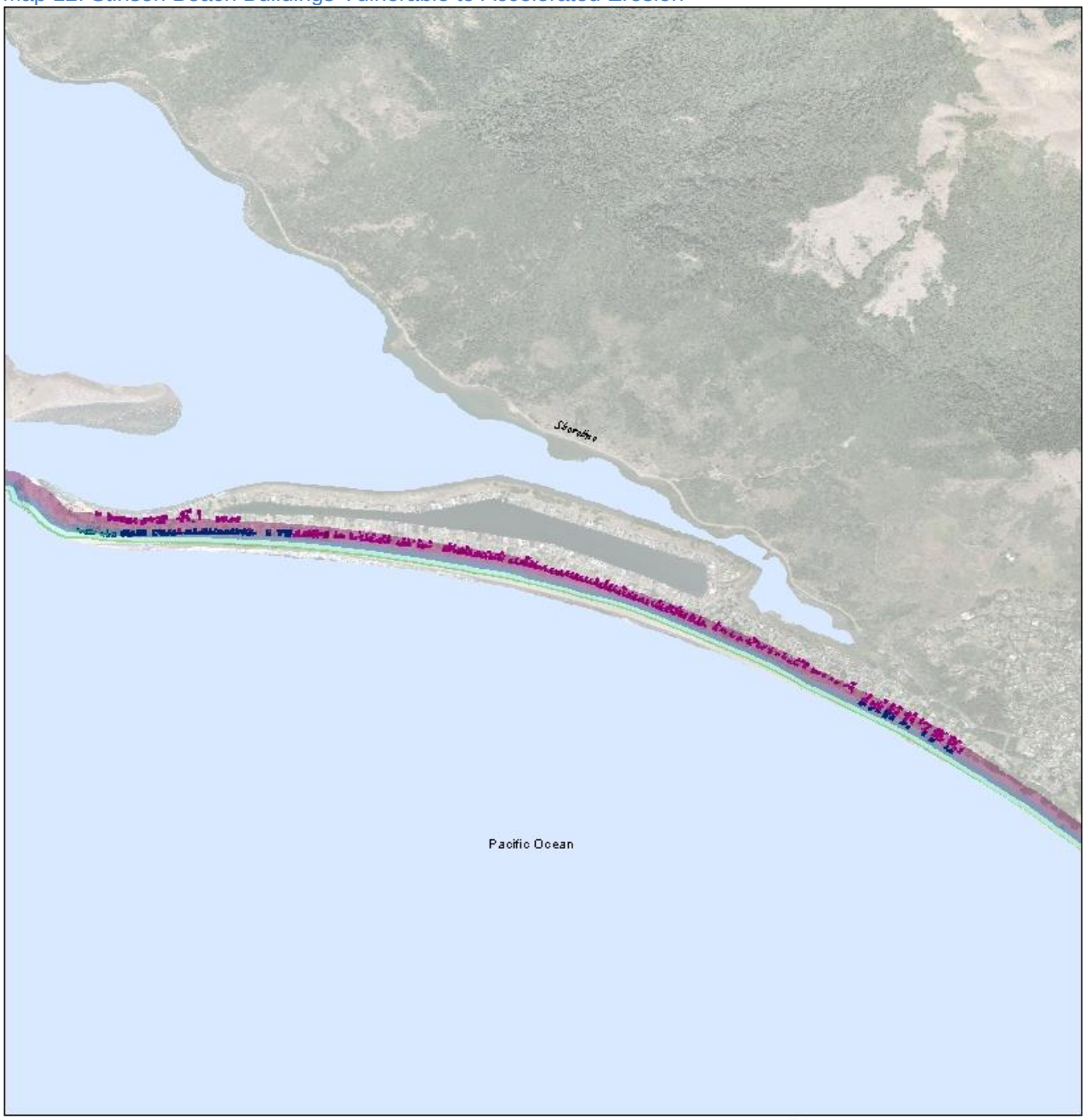
Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data providers here in, make no warranties of the accuracy or completeness of maps and data. Maps are representational and subject to future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

Date: 4/8/2016

COUNTY OF MARIN

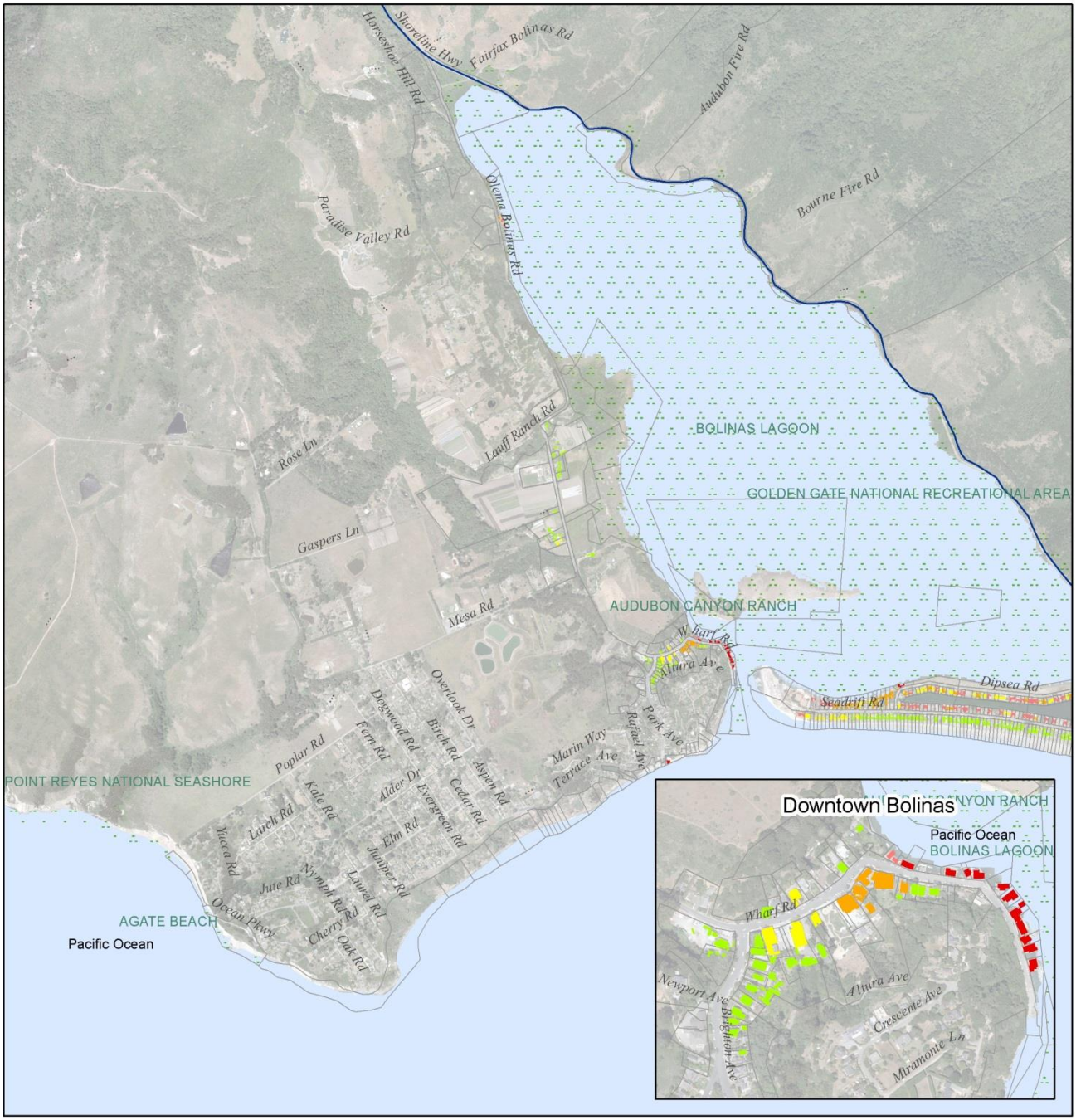
PARCELS & BUILDINGS

Map 12. Stinson Beach Buildings Vulnerable to Accelerated Erosion



PARCELS & BUILDINGS

Map 13. Bolinas Buildings Vulnerable to Sea Level Rise



Building Footprints

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

Parcels

Park Parcels

0 0.075 0.15 0.3 0.45 0.6 Miles

N

Source: Marin Map, Our Coast Our Future

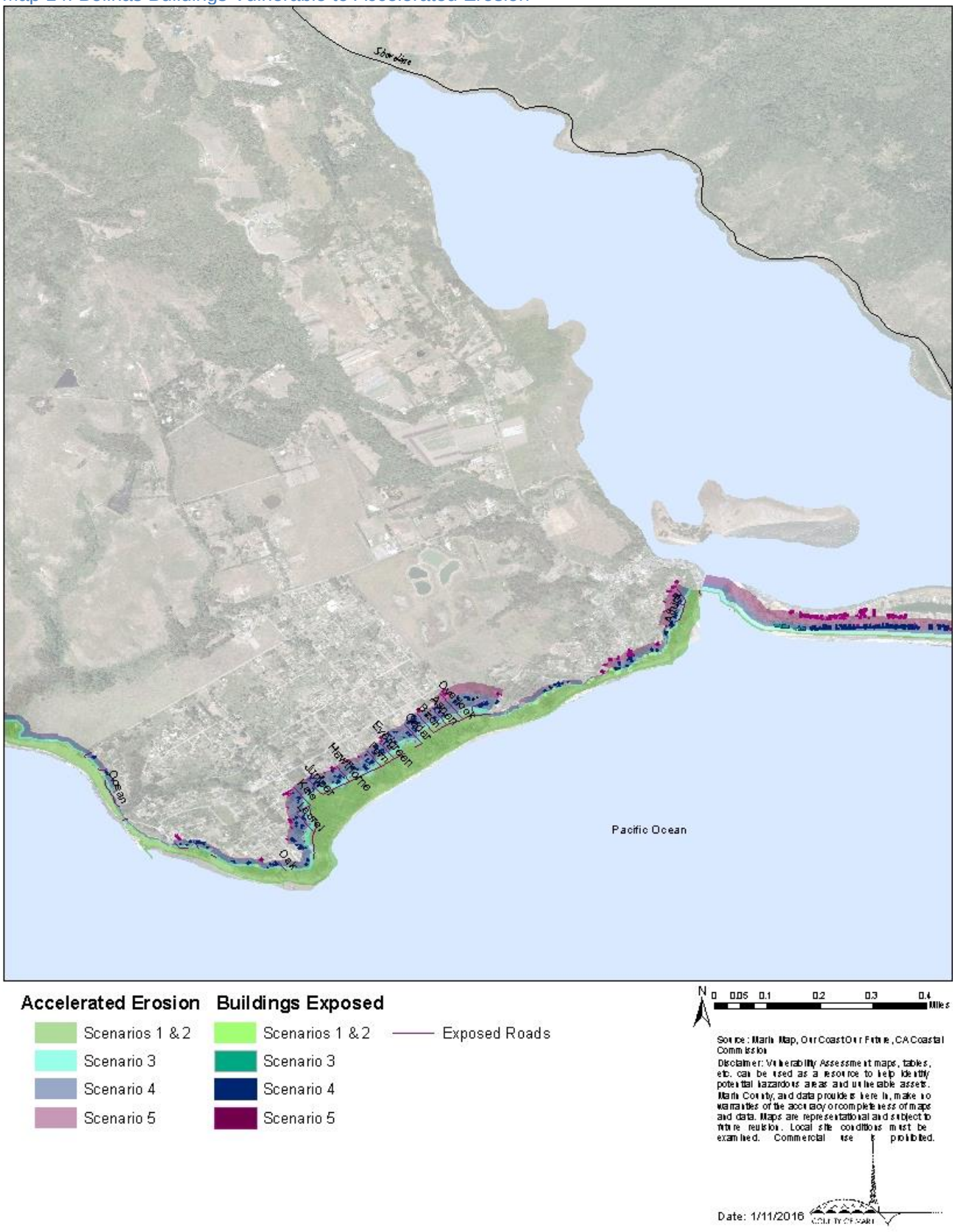
Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data providers here in, make no warranties of the accuracy or completeness of maps and data. Maps are representational and subject to future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

Date: 4/6/2016

COUNTY OF MARIN

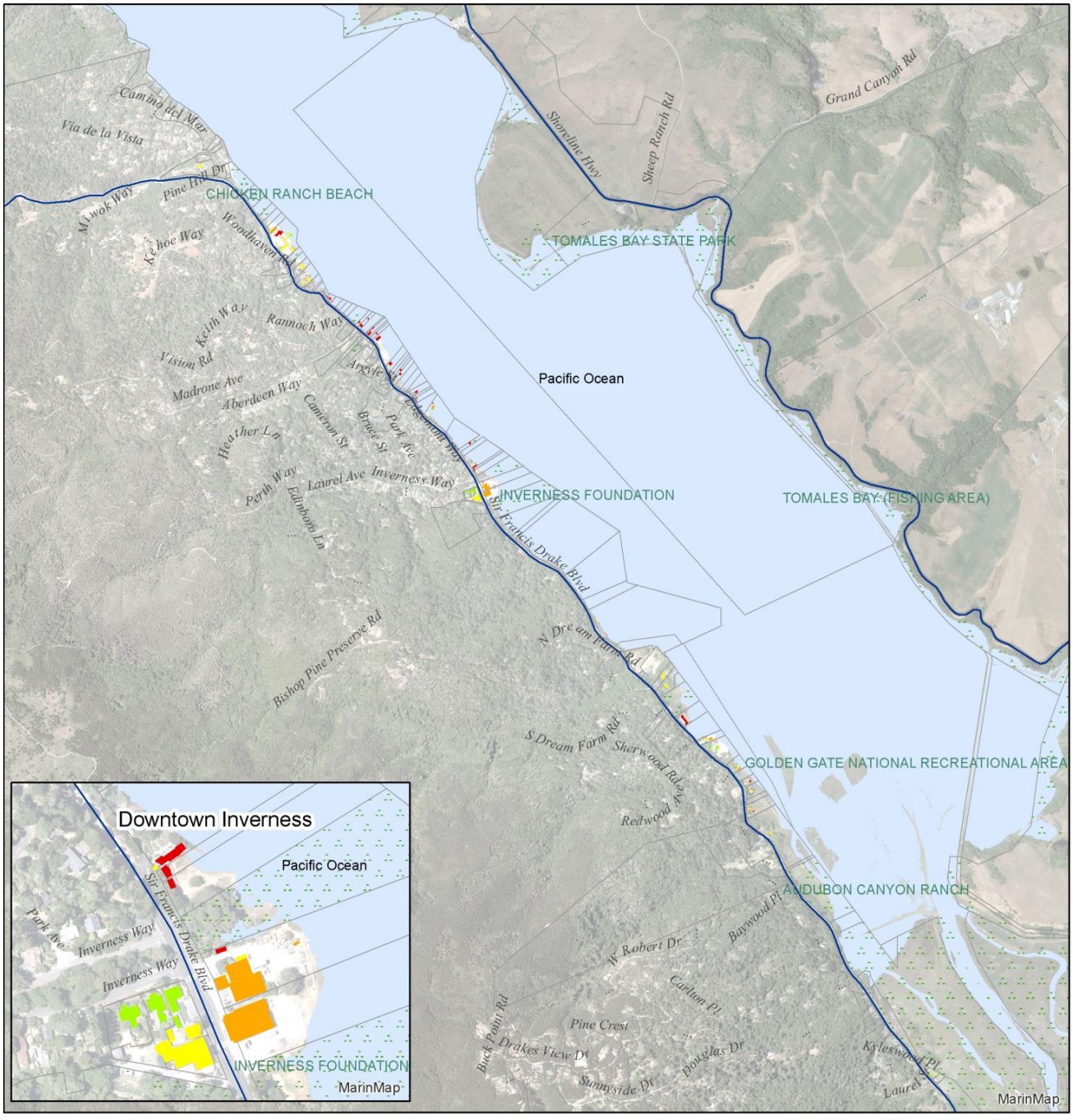
PARCELS & BUILDINGS

Map 14. Bolinas Buildings Vulnerable to Accelerated Erosion



PARCELS & BUILDINGS

Map 15. Inverness Parcels & Buildings Vulnerable to Sea Level Rise



Building Footprints

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

Parcels

Park Parcels

0 0.075 0.15 0.3 0.45 0.6 Miles

N

Source: Marin Map, Our Coast Our Future

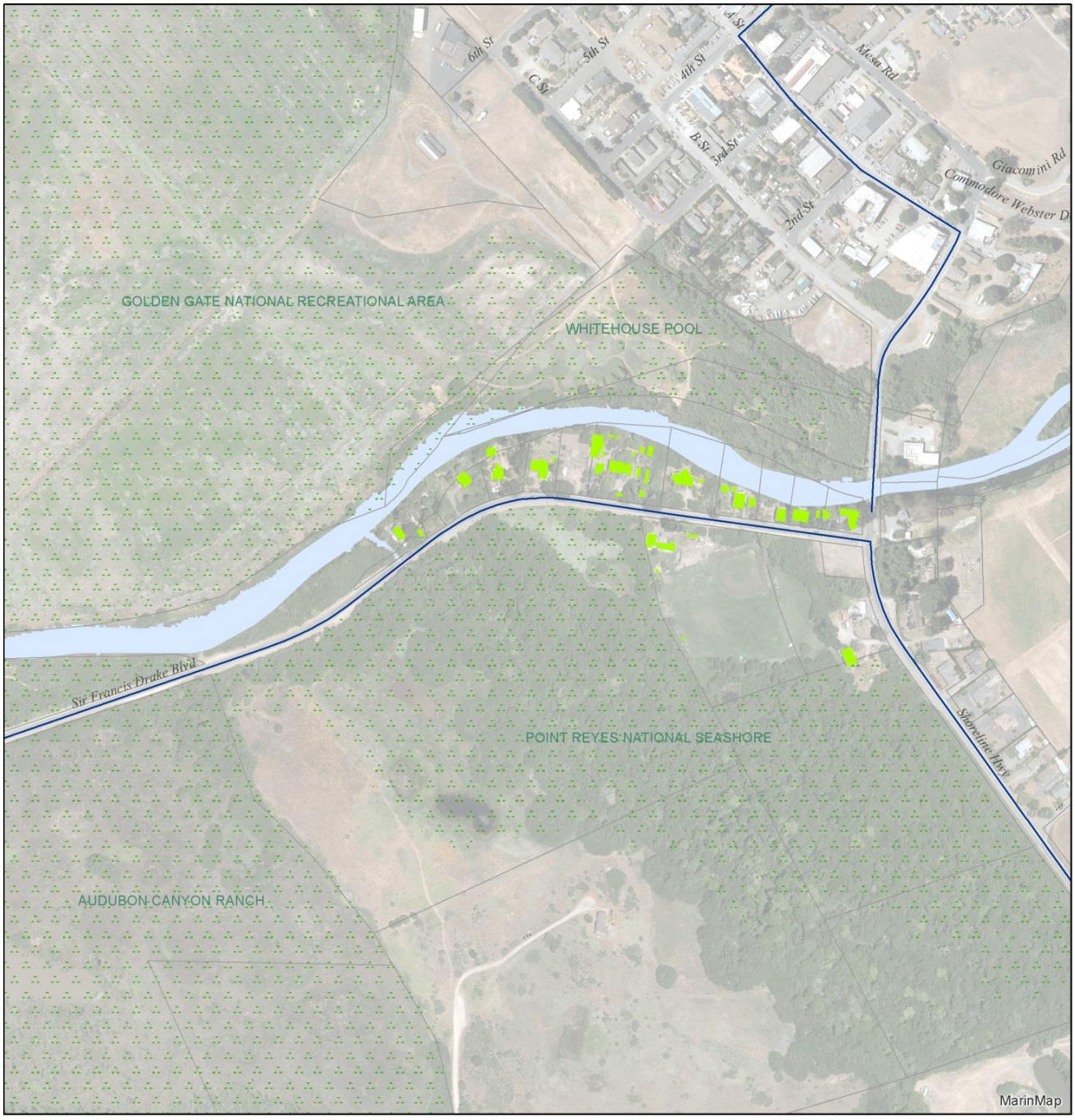
Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data providers here in, make no warranties of the accuracy or completeness of maps and data. Maps are representational and subject to future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

Date: 4/6/2016

COUNTY OF MARIN

PARCELS & BUILDINGS

Map 16. Point Reyes Station Parcels & Buildings Vulnerable to Sea Level Rise



Building Footprints

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

Parcels

Park Parcels

0 0.0175 0.035 0.07 0.105 0.14 Miles

N

Source: Marin Map, Our Coast Our Future

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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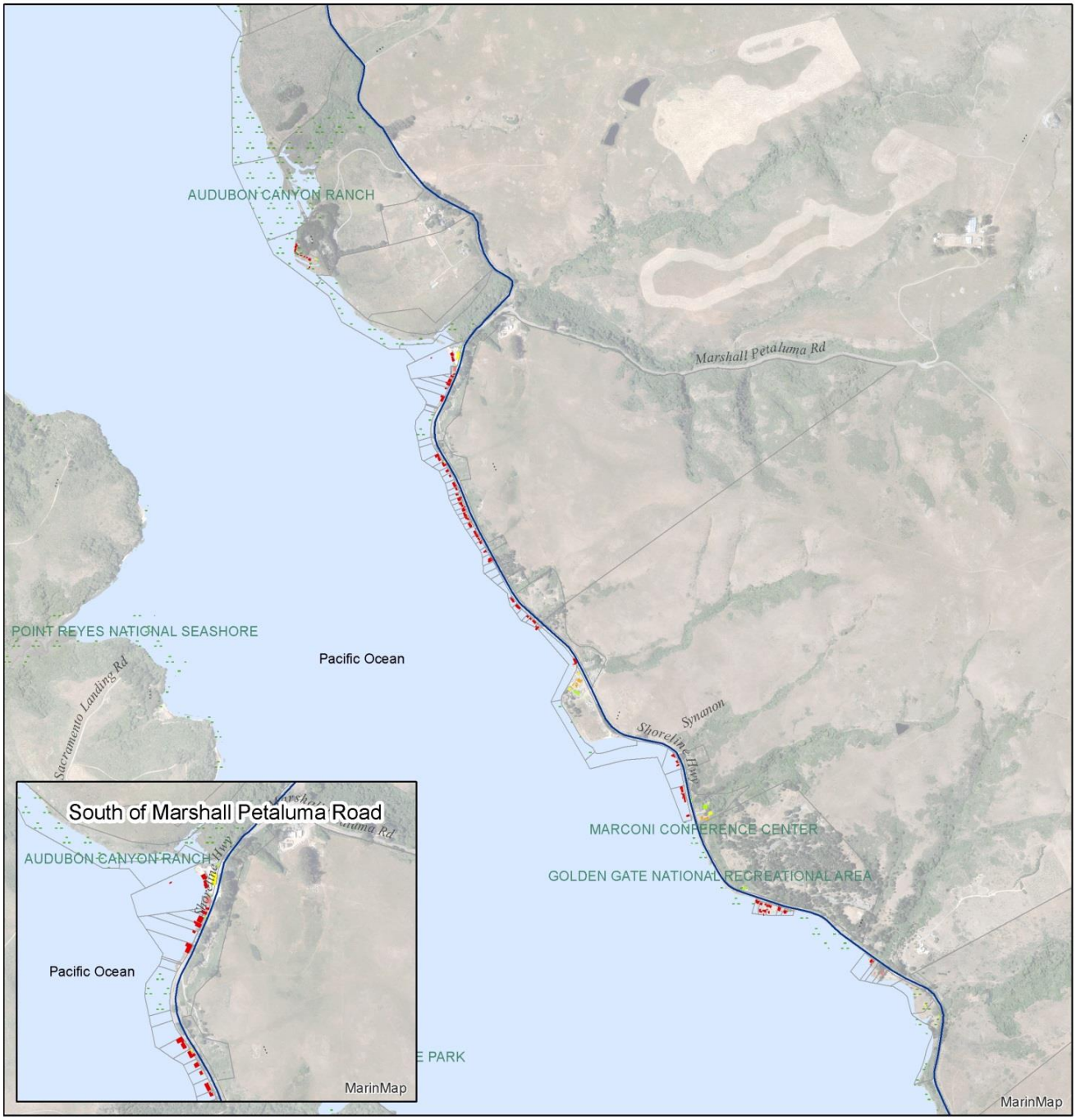
PARCELS & BUILDINGS

Map 17. East Shore Parcels & Buildings Vulnerable to Sea Level Rise



Building Footprints

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

- Parcels
- Park Parcels

0 0.075 0.15 0.3 0.45 0.6 Miles

Source: Marin Map, Our Coast Our Future

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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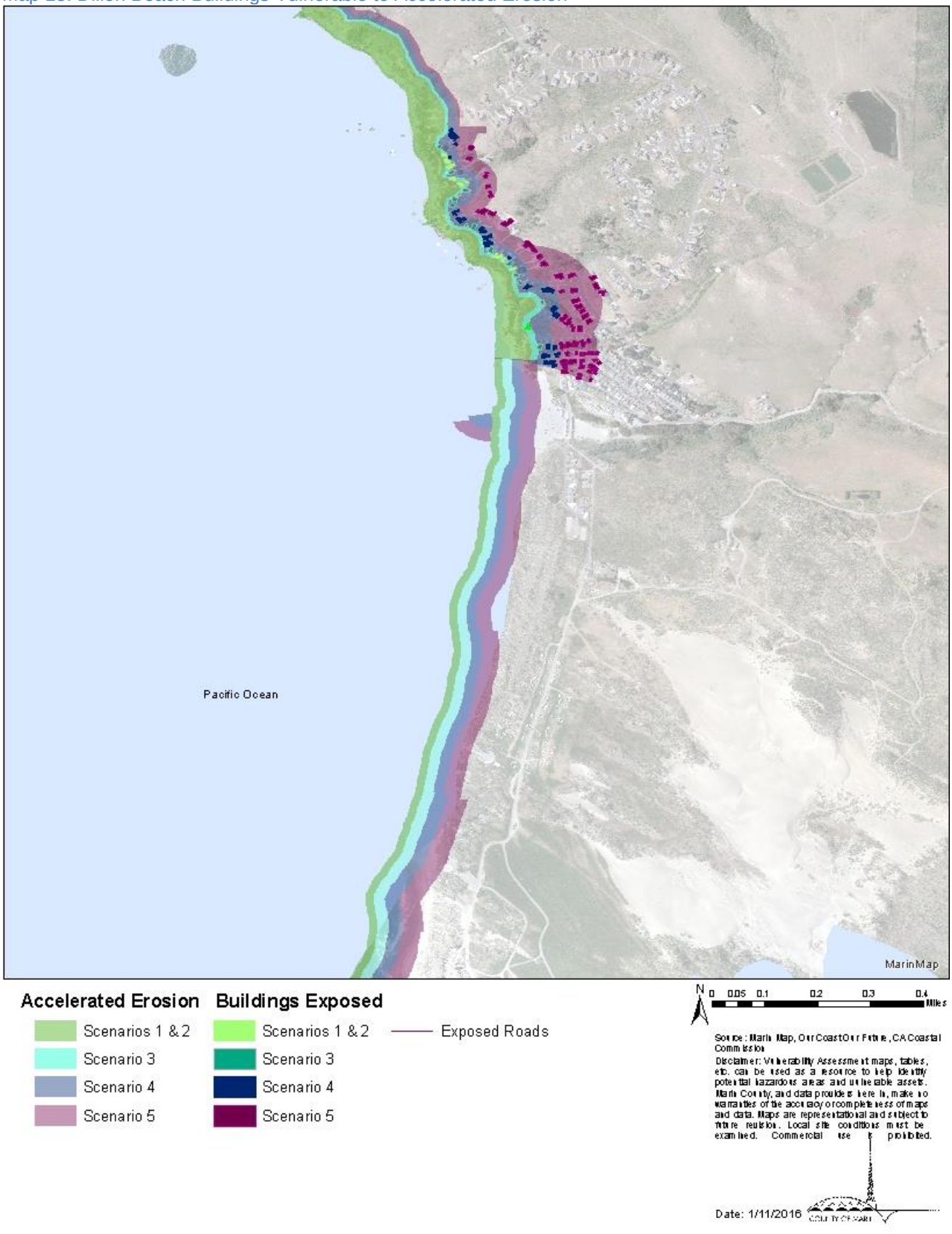
COUNTY OF MARIN

PARCELS & BUILDINGS

Map 18. Dillon Beach Buildings Vulnerable to Accelerated Erosion



PARCELS & BUILDINGS

Existing Policies

Coastal Act policies Sections 30210, 30240, and 30251 dictate that new development shall be safe from hazards and recognize that shoreline protective devices, such as seawalls may be appropriate in certain instances, to serve coastal-dependent uses or to protect existing structures or public beaches in danger from erosion. However, shoreline protective devices must be designed to eliminate or mitigate adverse impacts on the sand supply of surrounding natural shorelines. Other relevant Coastal Act policies include:

- Section 30210: Development shall not interfere with the public's right of access to the sea including the use of beaches.
- Section 30240: Environmentally Sensitive Habitat Areas (ESHA) shall be protected.
- Section 30251: The scenic and visual qualities of coastal areas shall be considered and protected as a resource of public importance.

The Board adopted Marin County Local Coastal Program (LCP) also contains policies to regulate development, particularly in areas vulnerable to environmental hazards. The Draft LCP Environmental Hazards policies are intended to "enhance the safety of residents and visitors in potentially hazardous areas, while allowing carefully designed and sited development to proceed" (Marin County DLCP C-EH-22.a.2, p. 40). The Environmental Hazards policies proposed by the County through its DLCP Amendment process have yet to be certified by the Coastal Commission and local stakeholders.

The County of Marin recently adopted higher regulatory standards than those established by both FEMA and Marin County Code (MCC) §23.09 for construction in the FEMA special flood hazard areas (SFHA). The Marin County Code refers to the California Residential Code (CRC), which requires construction in the FEMA special flood hazard areas to be 1 foot above the base flood elevations (BFE) with utilities above the lowest floor elevations, including freeboard. Marin County adopted the 2013 California Building Standards Code in 2013, and it became effective and enforceable in 2014.

Other Considerations

Economic

The more than 1,000 exposed properties, many with homes and businesses, account for $7.2 million in annual tax revenue (Marin County total levy is about $500 million) that could be impacted. As a portion of this, West Marin tourism generates nearly $800,000 in transient occupancy taxes, which is 80 percent of the transient occupancy tax countywide. If vacation rentals sustain damages, this area could see a significant decline in tourism, impacting whole communities and economies, not just the owners or users of individual assets. The West Marin region accounts for millions of dollars in economic activity. Additionally, the study area's jobs and employment opportunities could diminish and compromise the viability of Marin's coastal communities as they exist today.

Table 13. Economic Impacts on Exposed Buildings Sea Level Rise Scenario 5

	Assessment Value[a] (Land+Improvements)	Property Tax Generation[b]	Tourism Tax Generation[b]	Median Market Household Value[c]
Muir Beach	$121,461,219			No homes exposed
Stinson Beach	$807,643,088			$1,821,553,200
Bolinas	$336,878,134			No data
Pt. Reyes Station	$187,847,319			$39,713,700
Inverness	$477,136,109			$82,467,300
East Shore	$63,184,727			No data
Dillon Beach	$187,659,869			No homes exposed
TOTAL	**$2,181,810,465**	**$7,226,058**	**$762,871**	**$1,943,734,200+**

Sources: [a]Assessor Data 2014/2015 Tax Year, [b] Marin County Department of Finance (2014/2015 tax year), Zillow

PARCELS & BUILDINGS

Several existing buildings are protected with coastal armoring, such as seawalls, revetment, bulkheads, bluff walls, and other hard engineering structures, to impede flooding and erosion. These protective structures may become compromised and require increased maintenance or replacement, or relocation. Some may already be in need of repair. For example, while the seawall in front of the Seadrift neighborhood in Stinson Beach is inspected by a qualified engineer every two years and maintained at no cost to the County, it is rated as low quality by FEMA. Maintaining this structure could come at increasing cost to homeowners in the future.

Additionally, regulations could diminish an individuals' capacity to maintain and retain their properties in the most cost effective ways. The equity held in these properties could be lost; negatively impacting a major contributor to wealth.

Environmental

Storm damage could result in debris that could pollute the ocean. When homes are repaired or rebuilt, resource consumption will occur. As homes are demolished and relocated, additional consumption could occur and degradation of the relocation site is likely to occur. Additionally, using seawalls and other shoreline protective devices to protect buildings could result in the loss of beaches, wetlands, and other habitats and recreational areas by impeding the ability of these areas to migrate inland.

Social Equity

If residents are unable to maintain their homes, deterioration could have negative impacts on community pride and sense of place. Temporarily or permanently relocating residents can sever neighborhood relationships, reducing neighborhood cohesion and breaking down emergency preparedness networks. Neighborhoods without these social networks are especially vulnerable to sea level rise and storm threats.

People living with scarce financial resources, with health or mobility constraints, who do not own a home or car, or are not proficient in the English language may be disproportionally burdened by sea level rise and storms. Vulnerable groups may lack access to information and resources to stay safe during storm events, and may not have the ability to take proactive steps to prepare for sea level rise impacts. With long-term sea level rise, displaced residents may not have access to equivalent or affordable housing near the jobs, schools, and facilities they rely on. Equity questions may arise regarding who should pay for adaptation or recovery related to sea level rise impacts. Coastal access may also be diminished as public spaces become inundated, impacting recreational opportunities for everyone.

The vulnerable libraries and community centers in Bolinas and Stinson serve a critical role in their communities. The Bolinas library is extremely busy, offering several services, the most popular, aside from book borrowing, is internet use and DVD borrowing. These serve as cultural centers and are the main source of information dissemination for these small communities. Losing these centers or access to them could negatively impact the social fabric of West Marin communities.

Management

Potential state boundary changes could occur as waters rise. This could significantly impact private property rights when flooded land becomes lands of the State. As necessary, road alterations, or other public infrastructure relocations, are planned and implemented, and acquisition of private property may be required. Moreover, as housing opportunities on the coast diminish, so could political representation. Additionally, as public service facilities become threatened, they will need to relocate using public funds. Some examples are Stinson Beach Fire Station No. 2, roads, and utilities in Stinson Beach and Bolinas. In addition, several assets are part of national and state systems, such as Shoreline Highway, that will be competing for political attention and funding, with several other regional roadways threatened by sea level rise. As the planning process moves forward it is likely laws and regulations will need to be modified to permit individuals to implement protective and restorative measures without incurring significant expenditures for permits and regulatory compliance.

TRANSPORTATION

Asset Profile: Roads & Waterways

Low lying roads and other ground transportation infrastructure in Marin's coastal communities are already susceptible to flooding at high tides, especially king tides and storms. Storms can damage roads, even those at higher elevations, enough to close them for days. At worst, some roadways will become completely inundated most hours of the day or eroded beyond repair. If the road network becomes compromised, coastal communities will be extremely vulnerable due to reduced access to supplies essential for daily living (gas, food, etc.). Postal service could be interrupted, schools closed down, and tourism capacity significantly reduced. Water travel will likely be able to adapt, however during storms boats and boat lauches, marinas, and piers could see significant damage and may not function as emergency rescue. The following are key issues related to transportation vulnerability:

- If the road network is disrupted or destroyed, several other assets, or their usefulness, will also be disrupted. While temporary shut downs during high tides and storms could be tolerated, chronic flooding could render road segments permanently impassable.
- In most West Marin communities, few alternate routes are available.
- A few vulnerable roadways and boating facilities are critical for emergency access and evacuation.
- Vulnerable roadways can also cover, protect, and support critical utility lines.
- Loss of road and parking use could reduce the carrying capacity for visitors that contribute to the regional economy.
- Not all residents have cars and travel by bike, depend on others, or use transit, and may not be able to evacuate in emergencies.
- Erosion susceptible roadways and parking areas exposed to frequent flooding could see recurring damage and lighting systems in parking lots could be impacted creating an electrical hazard.
- Roadways are also compromised by creek flooding during storms.
- Transit services could be interrupted in Inverness and along Shoreline Highway impacting residents and visitors.

IMPACTS AT-A-GLANCE

18 miles of road exposed	3,000+ people
Everyday living, tourism	Regional
Several hundred million dollars needed	Caltrans Department of Public Works Private Road Owners HOAs

Flooded roads block access Est. date, 1990's. Credit: CDA

TRANSPORTATION

Table 14. Miles of Exposed Road Segments

	Shoreline Hwy.	Sir Francis Drake Blvd.	Local & Private
Scenario 1	0.7 (2%)		1.6 (1%)
Scenario 2	1.2 (4%)		2.9 (2%)
Scenario 3	1.8 (5%)	0.2 (1%)	3.1 (2%)
Scenario 4	2.3 (7%)	0.5 (4%)	4.5 (2%)
Scenario 5	6.7 (19%)	2.4 (17%)	8.9 (3%)

Source: Marin Map

Washed out parking lot, Stinson Beach. Credit: Marin County DPW

The most vulnerable roads are Shoreline Highway (several locations), Sir Francis Drake Blvd. (Inverness), Calle del Arroyo (Stinson Beach) and Olema-Bolinas Road (Bolinas). Shoreline Highway (State Route or Highway 1), the main road connecting every coastal community to the rest of the state, country, and world, has seen several closures in the past years during high tides and storms. Bolinas-Olema Road is the primary access route to Bolinas from Shoreline Highway and is especially critical between Mesa Road and Horseshoe Hill. Sir Francis Drake Blvd., vulnerable in the medium-term provides access to low lying areas in Inverness from Shoreline Highway. And while Bear Valley Road provides an alternative route, this road is compromised in scenarios 4 and 5, and is susceptible to river and marsh flooding.

Table 14 summarizes how many miles of these arterial roadways are exposed in each sea level rise scenarios. The table also enumerates how many of the many miles of local and private roads are exposed to flooding. The majority of the private roads impacted are in Stinson Beach, these amount to 1.35 of the 1.6 miles in scenario 1, 2.5 of the roughly 3 miles in scenarios 2 and 3, 3.2 miles of the 4.5 miles in scenario 4, and 4.2 of the 8.9 miles in scenario 5. Of the remaining mileage, 2 of the 8.9 miles are under county jurisdiction, with less than a half mile impacted for earlier scenarios. Table 15 names each road that could be vulnerable by community and shows the cumulative lengths of roads and trails exposed for each scenario.

TRANSPORTATION

Table 16 lists some of the potentially vulnerable transportation related assets in the study area. This list measures onset and tidal mean higher high water (MHHW) and extreme event flood depths for a high and low value along a vulnerable road segment. In these scenarios a roadway may be impacted for just short periods of high tide, be submerged on a daily basis at mean higher high water, or somewhere in between. This list is not exhaustive of all the transportation assets that could be exposed to sea level rise and storm impacts in the study area.

TRANSPORTATION

Table 15. Exposed Roads by Community (Scenarios 2-5 include roads in previous scenarios)

	Scenario 1 ~2.5 miles (0.2%)	Scenario 2 ~4.3 miles (1%)	Scenario 3 ~5.2 miles (3%)	Scenario 4 ~7.4 miles (3%)	Scenario 5 ~18 miles (7%)
Muir Beach					Coastal Fire Rd. Pacific Wy.[M]
Stinson Beach	Alameda Patio[P] 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]		McKennas Gulch Fire Rd.		
Bolinas	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]
Inverness	Sir Francis Drake Blvd.[M]			Vision Rd.[M] Rannoch Wy.[P] Argyle St.[M] Duck Cove Rd.[P]	Bear Valley Rd.[M] Inverness Wy.[P] Woodhaven Rd.[P]
Pt. Reyes Station	Shoreline Hwy.[C]				
East Shore	Shoreline Hwy.[C] Willow Wy.[P]				Grand Canyon Rd.[P]
Dillon Beach	Bay Dr.[P] Estero Trl. Valley Ford Frank Sch Rd.[M] Middle Rd.[M]				

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

TRANSPORTATION

Table 16. Transportation Assets Ranked by Onset and Flood Depth (feet and inches)

Location	Asset	Tidal & Extreme Event Flooding Depth Estimates (Underlined values indicate tidal flooding at mean higher high water (MHHW) based on a geographic point at the landward limit of the scenarios overlapping the asset. Values not underlined represent temporary event flooding. Roads received a high, used for ranking, and low value along the line segment.)					Vulnerability TF: Temp. Flooding during extreme events; I: Inundated at MHHW; E: Erosion; WS: Wave Surge; HW: High Wind,
		Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	
Stinson Beach	Calle del Arroyo	7"-6'11"	3"-6'8"	8"-9'6"	2'5"-12'2"	5'11"-13'9"	I, TF
East Shore	Walker Creek Access Point	2'4"	3'3"	4'2"	6'1"	9'3"	I
Bolinas	Wharf Road	6"-2'1"	3"-2'4"	2"-2'9"	1"-5'4"	10"-7'4"	I, TF
East Shore	Shoreline Hwy	3"-1'7"	3"-2'4"	3"-3'	2'-4'6"	6"-8'1"	I, TF
Stinson Beach	Shoreline Hwy	0"- 1'8"	0"-2'3"	0"-3'1"	0.4"-4'10"	0.4"-8'6"	I, TF
East Shore	Marconi Boat Launch	1'1"	2'	2'11"	4'10"	8'2"	I
Stinson Beach	Walla Vista Wkwy	3"	1'8"	2'	4'4"	10'4"	I, E
Dillon Beach	Lawson's Landing	2"	1'1"	2'11"	3'10"	7'3"	I, E, WS, HW
Pt. Reyes Station	Green Bridge	No depth data	No depth data	2"	2'	9'10"	I, TF
Inverness	Sir Francis Drake Blvd.			1"-3'6"	1"-4'6"	1"-7'10"	I, TF, WS
Bolinas	Olema-Bolinas Rd			2'8"	4"-4'4"	2"-7'11"	I, TF
Pt. Reyes Station	White House Pool/Trail			2'5"	2'3"	5'11"	I
Pt. Reyes Station	Shoreline Hwy			6"	3"-1'5"	1'9"-9'7"	I, TF
Inverness	Dana Marsh Beach Access				3'	6'2"	I, E, SI
Bolinas	Bo-Gas Station				1'7"	5'3"	I
Stinson Beach	Coastal Trl				0.4"	1'3	TF, E
Bolinas	B. Stewart Trl					4'8"	I, TF
East Shore	Shoreline Hwy					3'5"	I, E
Point Reyes Station	Olema Marsh Trl					2'9"	I
Dillon Beach	Dillon Beach Resort Parking					1'6"	I

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

TRANSPORTATION

Table 17. Transportation Asset Vulnerabilities

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

As seen in the maps at the end of this profile, the majority of the roads exposed in scenario 1 are in Stinson Beach and Shoreline Highway between Stinson Beach and Bolinas. All of the exposed households and businesses in the Calles, Patios, and Seadrift neighborhoods in Stinson Beach could be isolated if Calle del Arroyo and its intersection with Shoreline Highway flood in the near-term. Green Bridge in Point Reyes, Pine Gulch Creek Crossings in Bolinas, and bridge crossings on Valley Ford Franklin School Road and Middle Road north of Dillon Beach are also vulnerable in the near-term.

In the medium-term, if Olema-Bolinas Road floods between Mesa Road and Lauff Ranch Road, nearly 1,600 Bolinas households could be isolated at home or prevented from returning home. In Inverness, if Sir Francis Drake Blvd. is compromised near Shoreline Highway, over 1,600 households could be without ingress and egress options. In scenario 5, East Shore could also see nearly all 100 buildings isolated by the high end of the long-term scenarios, plus tens of others dependent on Shoreline Highway to head inland or along the coast. In the long-term, Muir Beach residents along Lagoon Road could be isolated by flooding on Pacific Way.

Participants at community workshops cited existing high tide and storm flooding at (south to north):

- Pacific Way, Muir Beach,
- Shoreline Highway between Stinson Beach and Bolinas,
- Bolinas-Olema Road, Bolinas,
- Shoreline Highway at and up Sir Francis Drake, Inverness,
- Green Bridge, Point Reyes Station, and
- Shoreline Highway at Walker Creek, Marshall.

In addition to roads vulnerable to flooding, several are also vulnerable to shoreline erosion and subsidence.

Caltrans is the asset manager for Shoreline Highway, and the Marin County Department of Public Works manages the remaining public roads. Several private roads, especially in the Seadrift, Calles, and Patios neighborhoods in Stinson Beach, are also vulnerable to flooding. The maintenance and repair of private rights-of-way (ROW) is the responsibility of each landowner owning the easement.

Caltrans is in the early stages of developing sea level rise analysis for the state, with varying degrees across the different districts. Marin County is in Caltrans District 4 with Sonoma, Solano, Napa, Contra Costa, Alameda, San Mateo, and San Francisco Counties (see Map 19). Retrofitting and adapting the District 4 systems for near-term exposure levels could coast billions of dollars. According to the *Caltrans Guidance on Incorporating Sea Level Rise*, the State Highway System is limited in adaptive capacity because of the numerous services it facilitates, its permanent location, longitudinal nature, long lifespan, and uncertain resources.[12]

Caltrans asks three questions in assessing sea level rise planning:

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

Other factors include anticipated travel delays, goods movement, emergency evacuation, travel safety, burden on public funds, impacts on connecting streets, and environmental constraints.

Caltrans is working with Marin County Public Works, the Greater Farallones National Marin Sanctuary, the Golden Gate National Recreation Area, and other property owners to resolve several challenges

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

TRANSPORTATION

facing Shoreline Highway and Bolinas-Olema Road. Preliminary conversations with Caltrans confirm that this four-mile stretch of State Route 1 as susceptible to tidal flooding and has submerged in past extreme storms.[13] Elevating this portion of the road to a causeway platform designed to allow drainage of the surrounding hillsides and tidelands could exceed several hundred million dollars and is very environmentally sensitive.

Several other roads fall under Marin County jurisdiction including major arterials such as Sir Francis Drake Blvd., Olema-Bolinas Rd., and Olema-Fairfax Rd. Another critical road that is vulnerable in the near-term is Calle del Arroyo in Stinson Beach. This road provides access to the majority of homes in the Calles, Patios, and Seadrift neighborhoods. Further north, though far from the coast line, Valley Ford Franklin School and Middle Roads already suffer from Estero Americano Creek over-topping bridges at high tide. This occurrence is expected to continue and become more frequent.

Marin County Public Works stressed that roadway impacts from water will severely degrade the base and surface materials from the weight of vehicles breaking up the roadway. The goal to limit water intrusion and avoid damaging the roadway, including the drainage facilities, is not easily met. Raising a road, pumping water, adding a barrier system, or developing an alternate route are possible solutions usually involving land acquisition and or work outside of existing road right of way. In addition, measures to ensure that adjacent properties are not impacted by the proposed improvements must also be identified. Additional environmental review and permits from federal wildlife and state fish and game agencies would also likely be required to implement any of the above alternatives.

Identifying cost effective and environmentally feasible solutions requires engineering studies with partnerships from local stakeholders and permitting agencies. Without detailed engineering studies, preparation of cost estimates is not possible, although it is anticipated that the cost to implement these alternatives will be very high. County Public Works estimates the cost for a feasibility study for each roadway asset is between $50,000 to $100,000 to identify an appropriate response to sea level raise impacts and to prepare a cost estimate. Developing solutions will involve public dialogue and funding that is yet to be determined.

Marin Transit runs two transit routes to the coast from the Manzanita Park-and-Ride in Sausalito to West Marin. Route 61, the West Marin Stage Coach, to Stinson Beach and Bolinas travels the most vulnerable route in West Marin. The northern Route could be vulnerable at its destination points of Point Reyes and Inverness in the medium- and long-terms. Transit here depends on accessible and safe road conditions on the coast and bayside at the junction of Shoreline Highway and Highway 101.

The maps on the following pages present vulnerable transportation assets in the most impacted communities. The C-SMART scenarios are not shown to improve visibility of the exposed roadways.

Olema-Bolinas Rd. King Tide Dec. 2014. Credit: BCPUD

13 Sea Level Rise Vulnerability Assessment Interview. Caltrans. April 30, 2015. J. Peterson. D. Fahey. Marin County Development Agency. B. Van Belleghem

TRANSPORTATION

Map 19. Caltrans District 4

TRANSPORTATION

Map 20. Stinson Beach Transportation 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

Other Assets

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

0 0.125 0.25 0.5 Miles

N

Sources: Our Coast Our Future, Marin Map
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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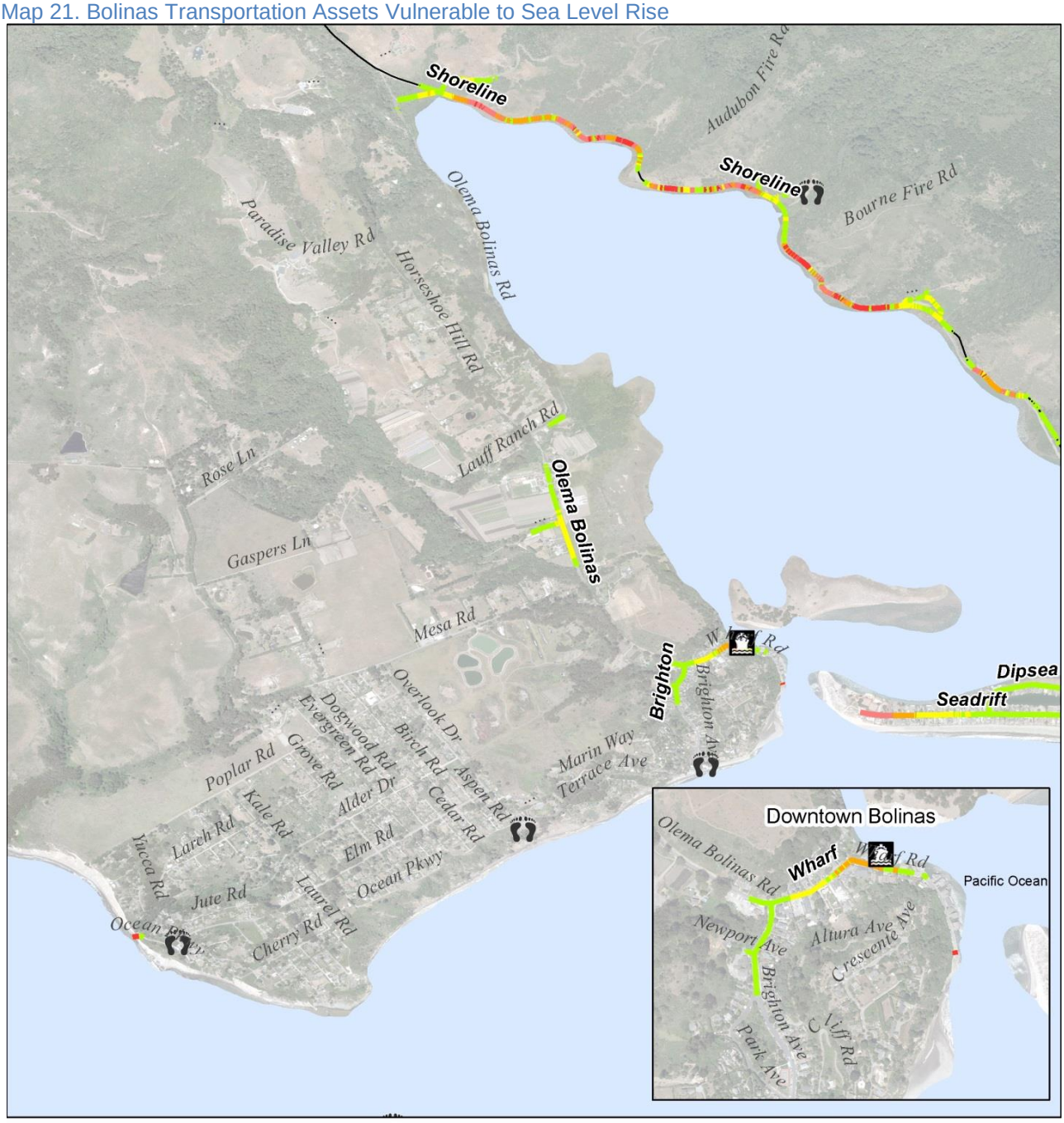
TRANSPORTATION

Map 21. Bolinas Transportation 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

Other Assets

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

0 0.15 0.3 0.6 Miles N

Sources: Our Coast Our Future, Marin Map

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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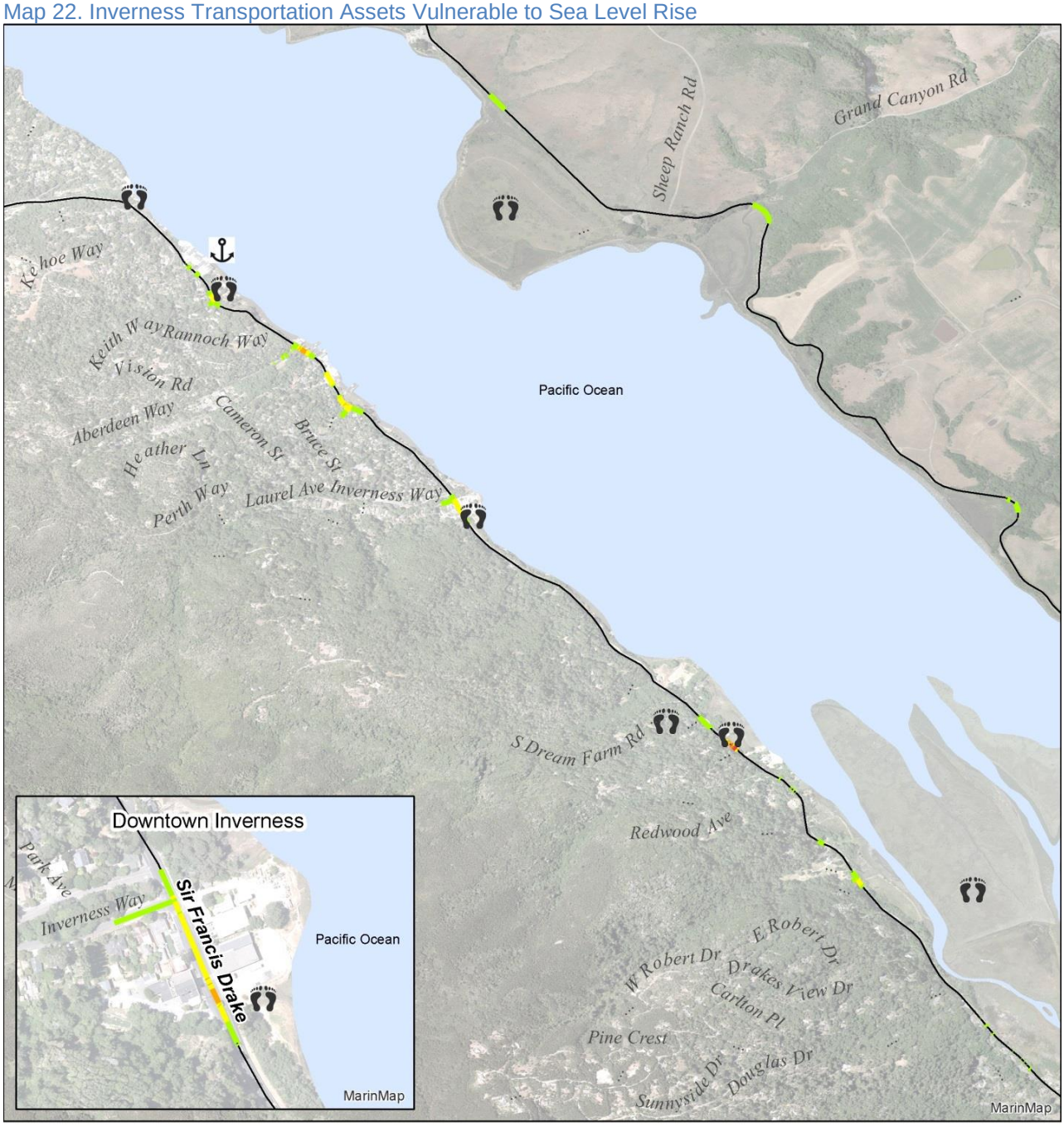
TRANSPORTATION

Map 22. Inverness Transportation 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

Other Assets

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

0 0.125 0.25 0.5 Miles

N

Sources: Our Coast Our Future, Marin Map

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: 4/5/2016

COUNTY OF MARIN

TRANSPORTATION

Map 23. Point Reyes Station Transportation 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

Other Assets

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

0 0.05 0.1 0.2 Miles

N

Sources: Our Coast Our Future, Marin Map

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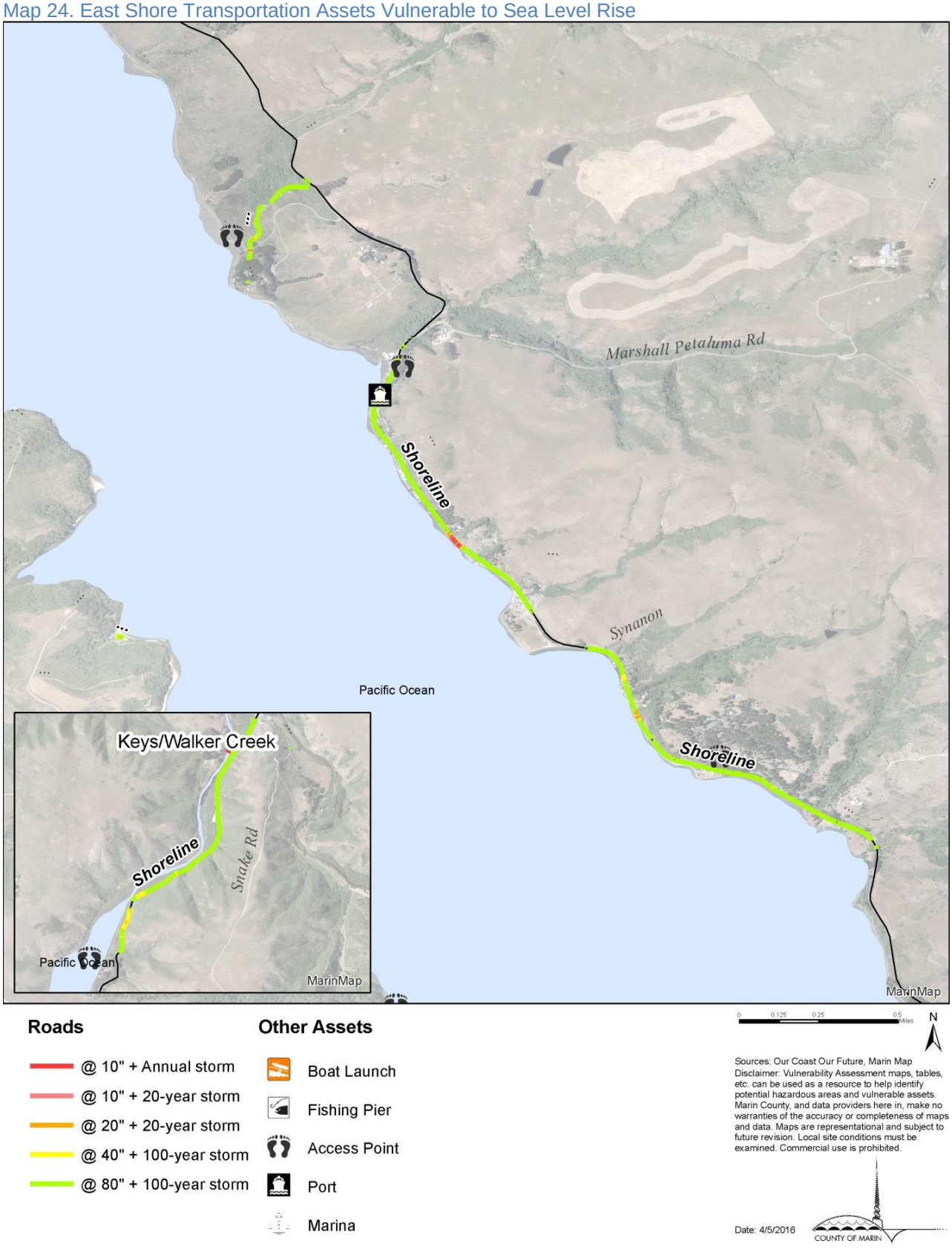
Date: 4/5/2016

COUNTY OF MARIN

TRANSPORTATION

Map 24. East Shore Transportation Assets Vulnerable to Sea Level Rise



TRANSPORTATION

Existing Policies

The Draft Local Coastal Program (DLCP) policies prohibit the construction of additional highway lanes and ensure road improvements are limited and undertaken in a way that respects their environment. Instead of providing for an increase in vehicular traffic, the DLCP encourages reduction of congestion through alternative means, such as limiting local parking and providing shuttle service to popular destinations. As a condition of new development, the DLCP also encourages the designation of new trails, roadways or paths. The DLCP policies recognize and seek to minimize the impacts of sea level rise on Shoreline Highway using the least environmentally damaging means. Figure 3 shows select transportation policies from the Draft LCP.

Figure 3. Draft Marin County LCP Transportation Policies (abridged)

C-TR-1 Roads in the Coastal Zone. Limit roads to two lanes. Work with state and federal agencies and local communities to enhance road safety, improve pedestrian, bicycle, and transit access, and stabilize or reduce congestion...projects will not be undertaken to increase the motorized vehicular capacity of these roads.

C-TR-3 Impacts to Highway One from Sea Level Rise. Consult with the California Department of Transportation to protect access to the coast and to minimize impacts of sea level rise on Highway 1.

C-TR-6 New Bicycle and Pedestrian Facilities. Encourage, and where appropriate, require new development to provide trails or roadways and paths for use by bicycles and/or on-street bicycle and pedestrian facilities. Consider facilities that…Connect to the existing bikeway or trail system, including linkages to and between communities and recreation areas…Provide diverse recreational and aesthetic experiences.

C-TR-8 Expansion of the Countywide Trail System. Acquire additional trails to complete the proposed countywide trail system, providing access to or between public lands and enhancing public trail use opportunities for all user groups, including multi-use trails.

Reflects California Coastal Commission Suggested Modifications to Marin County DLCP Amendment (May 2014). ***Subject to change.***

Other Considerations

Economic

Road access to the Marin Coast is critical for all economic activity, whether it is supply transport for daily needs, commuting to work, getting to school, or access for the several million tourists that visit the Marin Coast annually.

Funding for elevating roads will likely be difficult, straining limited county funding sources, at the same time other counties will be competing for state and federal resources. Moreover, state funding reductions have drastically impacted the County's overall road maintenance work program.

Several road segments are protected by coastal armoring, such as seawalls, revetments, bulkheads, bluff walls, and other hard engineering solutions to prevent flooding and erosion. These structures may become compromised and require increasingly costly maintenance or replacement. In some cases where retreat is selected, the roads and protecting structures may be closed and abandoned in place, or relocated. If seawalls and bulkheads in Bolinas fail, repairs to the road and utilities underneath will be very costly to the community. New alternative routes may require acquiring private property. If access to these local communities becomes compromised, tourist oriented businesses could lose potential revenues.

Environmental

Road repair and reconstruction can have significant environmental impacts. When roads completely fail, sediment and asphalt can enter into the surrounding properties and habitat. Constructing new roadways as alternative routes can have even greater impacts and could alter habitats significantly.

Social Equity

According to the Healthy Marin Partnership, 2013 Community Health Needs Assessment, nearly 25 percent of Marin's coastal residents pay more than 15 percent of their income towards transportation

costs.[14] This is considered a major cost burden. For those of lesser means, for example the nearly 30 percent of residents who have an annual household income under $35,000,[15] increases in these costs could be significant. Combined with housing cost burden, the needs assessment reveals that between 50 and 70 percent of Marin Coast residents pay more than 45 percent of their incomes on housing and transportation combined. The affordability standard is 30 percent of income on housing, 15 percent on transportation. This indicates that a large portion of residents are already overburdened by these basic expenses, leaving less income available for other necessities such as emergency preparedness, medical care, healthy food, child care, or education.

Moreover, the costs of owning a personal vehicle could increase if damaged in storm events. And if the Bo-Gas Station in Bolinas halts operation due to frequent flooding, the gas station in Pt. Reyes Station would be the last remaining gas station in Marin's Coastal Zone.

Residents dependent on bus routes 61 or 68 for travel along the coast or to other transit lines at the Manzanita Park-and-Ride to access Marin's bay side could face disruptions in service. Youth and other residents from Mill Valley often use the weekend service to access the beach communities. Those without personal vehicles may not be able to reach higher ground or leave the area to replenish needed supplies.

Management

Efforts to proactively reengineer existing routes will require collaboration amongst several land owners, private and public. Emergency services should be considered to ensure roadways are wide enough as responders depend on accessibility to any affected areas. Coordination is critical to ensure consistent access and wise use of financial resources. Environmental and land condemnation processes can be extremely political, lengthy, and expensive. Planning and implementing adaptation measures for the extent of the roadways in the study area for higher water levels could span several electoral cycles and will require continuous leadership and action across them with respect to sea level rise preparation.

14 Healthy Marin Partnership. Community Health Needs Assessment Sub-county Health Indicators. 2013.
15 2010 US Census.

UTILITIES

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

Most habitable buildings depend on several utility services including: water supply, onsite wells, septic systems (regulated as onsite wastewater treatment systems (OWTSs)), community waste systems, electricity, propane, communications, and stormwater infrastructure. These systems are significant assets and can be disrupted or destroyed before a building's structural components—reducing the building's functionality and livability. Stormwater drainage failures could also impact roadways. West Marin residents have weathered temporary disruptions before; however, at some point in the coming decades, these occurrences could become unbearable and costly. A few additional utilities are threatened by bluff and road erosion. The following are key vulnerabilities for exposed utilities:

- Electricity, propane, water supply, and wastewater management systems are lynch pin assets. If severely compromised, even dry properties and buildings could become unusable.
- Wells are vulnerable to saltwater intrusion, elevating freshwater table, erosion, and salt water corrosion of distribution lines (East Shore, Dillon Beach).
- Most aging OWTS were installed deeper than current systems and are vulnerable to flooding and ground water intrusion. All systems are vulnerable to inundation and erosion. Flood waters could come in contact with waste water from saturated disposal fields and pollute surrounding ocean and fresh water resources (Stinson Beach, Inverness, Point Reyes Station, East Shore).
- Temporary threats to overland power and communication lines include high winds that fell trees.
- Many homes depend on propane tanks that could dislodge and become hazardous.

Several utility providers supply drinking water, wastewater management, electricity, propane, and communication technology to residents in Marin's coastal communities including:

IMPACTS-AT-A-GLANCE

~1,100 buildings	Public Utilities Districts Property Owners PG&E AT&T
3,000 people affected	
$477 million in assessed value	Local & regional impacts

Inverness Yacht Club septic system covers. Credit: S. Callow

UTILITIES

- North Marin Water District (Point Reyes Station and Inverness Park),Inverness Public Utilities District (Inverness Ridge),
- Bolinas Community Public Utilities District,
- Stinson Beach Water District,
- Muir Beach Community Services District,
- Estero Mutual (Dillon Beach),
- CalWater (Dillon Beach),
- AT&T,
- PG&E,
- Private propane providers (McPhails, ProFlame, DiCarli's, Blue Rhino, etc.).

These agencies are aware of, and where necessary, prepared for sea level rise.

Table 18 lists some of the potentially vulnerable utility assets in the study area. This list measures onset, tidal mean higher high water (MHHW), and extreme event flood depths; however many utilities assets are underground. This list is not exhaustive of all the utility assets that could be vulnerable.

Potable Water

According to asset manager interviews, water distribution lines are the most vulnerable in the lower areas of Stinson Beach, Bolinas, and Inverness in the near-term because they are vulnerable to subsurface flooding. In these communities, the water lines are underneath every road, and nearly every road could be exposed with ten inches of sea level rise and an annual storm (scenario 1). If the road washes out, these utilities will also be impacted. California law dictates that water pipes and other system components can be safely buried 24 inches above the underground water table. The pipes also have to be a certain distance below the road to avoid damage from driving pressure.

The mainline to Inverness was installed underneath Sir Francis Drake Blvd. in 1974. During the 1982 storms, the road eroded and damaged the pipeline interconnection enough to disrupt water service for one week until a temporary overland pipe was installed. Two weeks lapsed before the underground pipe was fully repaired. If storms of the magnitude of the 1982 storm become more likely, as studies predict, the threat to these pipes could increase. In Bolinas, waterlines are vulnerable on eroding cliff sides and in downtown. The Bolinas Community Public Utilities District has worked with property owners and Public Works to relocate water lines on the eroding bluffs; however, the issue remains in some locations.

Table 18. Utility Assets Ranked by Onset and Flood Depth (feet and inches)

Location	Asset (not exhaustive)	Tidal & Extreme Event Flooding Depth Estimates (Underlined values indicate tidal flooding at mean higher high water (MHHW) based on one geographic point placed at the landward limit of the first scenario where it overlaps the asset. values not underlined represent temporary extreme event flooding.)					Vulnerability TF: Temp. Flooding; I: Inundated at MHHW; E: Erosion; WT: Water Table; SI: Saltwater Intrusion; WS: Wave Surge
		Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	
Stinson Beach	Septic systems west of Shoreline Hwy.	4.5'	4.5'	6'	7.5'	10.5'	I, WT, WS, TF
		underground resource					
Stinson Beach	Water Lines	4.5'	4.5'	6'	7.5'	10.5'	E, WS, TF, I, SI
		underground resource					
Inverness-Pt. Reyes Station	NMWD Pipeline	underground resource (see Shoreline Highway Point Reyes Station to Inverness for depths)					WT, SI, E
Stinson Beach	Water District Office	7"	3'3"	4'8"	6'6"	8'8"	TF, I
Bolinas	Lift Station			Under and over ground resource			I
Pt. Reyes Station	Gallagher Well					underground resource	SI
Dillon Beach	Sewage Pump Station	bluff top asset					E

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

UTILITIES

Table 19. Potable Water Vulnerabilities

Depth	▪ Wells: Saltwater intrusion into groundwater will contaminate freshwater. ▪ Water distribution: Pipes must maintain 24" of space from the groundwater table, and 32" below ground. As the water table rises, pipes will be exposed to saltwater and shift underground.
System Upgrades	▪ Wells: Adjustments to well withdrawal when groundwater shifts from fresh to salt water. ▪ Water Distribution: Pipes will need to be upgraded.

A few wells are also vulnerable. In East Shore private wells can pull water from areas as large as the parcel and at great depths. As the water rises closer to the surface further inland, this useable underground space becomes increasingly limited. Two wells next to Tomales Bay serving Hog Island Oysters and another property are experiencing salt water intrusion already. East Shore property owners recently obtained approval to draw from a well on a neighboring property at a higher elevation. Marshall Boat Works' wells are at low elevation and the main well is adjacent to a creek. Private springs serving homes near the Marconi Center are near sea level elevation. In addition, vulnerable wells can be found at Audubon's Bolinas Lagoon Preserve wells in canyon floors adjacent to creeks.

With respect to community scale wells, according to NMWD managers, the Gallagher well in Pt. Reyes Station may be threatened at scenario 5 water levels. Dillon Beach has two water systems, Estero Mutual owned mutually by Oceana Marin homeowners and Coast Springs owned by CalWater. Estero Mutual seasonally pumps water up hill to an open reservoir. The pumping station and pond that collects water are close to the estuary and vulnerable to saltwater intrusion.[16] The main well for Coast Springs, though not exposed on the surface, is vulnerable to storm surges and extreme high water along Dillon Creek.[17]

[16] S. Callow. Marin County Public Works. Email correspondence. April 8, 2015.
[17] Ibid.

Bolinas Lift Station extends 25 feet below ground. Credit: CDA

According to the National Park Service and Muir Beach CSD, Muir Beach water supplies are far enough inland to avoid sea level rise impacts. This is also the case for Bolinas and Stinson Beach.

Wastewater

Coastal residences and businesses dispose of their wastewater through privately owned OWTS; small wastewater systems with Waste Discharge Permits from the State Regional Water Quality Control Board, or public wastewater systems. An OWTS leach field for a typical three-bedroom home is 500-5,000 square feet either beneath or above the ground surface, depending on the system, soil, ground water levels, and site constraints.[18] Some OWTS require pumps and electrical components that could be affected during power outages.

Public wastewater systems exist in Bolinas and Oceana Marin (next to Dillon Beach). In Oceana Marin, the lift station is on an eroding terrace and could be susceptible if erosion rates increase with storm severity in the long-term. In downtown Bolinas, the collection system serves 141 residential, 20 commercial, and 2 institutional properties. Low lying downtown Bolinas depends on a gravity fed lift station at sea level that is highly vulnerable in the medium-term to chronic flooding. Uplands in Bolinas underground distribution lines and mains are also vulnerable to continuing erosion. In several locations, sewage pipes were relocated

[18] Alegria, A. Asset Manager Interview. May 2015. Environmental Health Services. Marin County CDA.

UTILITIES

landward, and on the Little Mesa, homeowners were required to buy, install, and run pumps and lines to get their effluent to the relocated main.

With respect to OWTSs, the most common wastewater management systems on the Marin Coast, projected sea level rise could raise the level of subsurface ground water causing flooding of disposal fields and contamination of groundwater. Even newly installed shallow, or above ground systems, could be impacted by flood waters and power outages in the near-term. Erosion could also reduce the land area for percolation. If ground water rises under septic tanks it could have enough pressure to cause tanks to pop out of the ground. These systems are privately managed by the land owner and regulated by the Marin County Department of Environmental Health Services, Stinson Beach Water District, or Regional Water Quality Control Board.

According to district managers and Marin County Environmental Health Services, OWTSs vary in age, size, and type of system. Additionally, through existing programs and private investment, upgrades on individual properties are made as needed. In the Calles, Patios, and Seadrift neighborhoods in Stinson Beach, approximately 20 of the 700 systems per year are upgraded to turn off when flood waters are too high. Some systems have manual diverter switches, and all but 12 of the septic systems have holding tanks that leach underground and are vulnerable to rising groundwater and flood waters.

In downtown Bolinas there are 163 connections to the public wastewater system. In Inverness and Marshall, several pier based or shoreline buildings could also be vulnerable to septic system malfunction. A community wastewater system was recently installed in Marshall to relocate several independent leach fields to a shared leach field east of Shoreline Highway due to water quality violations. However, individual septic tanks and the pipes connecting these homes to the community system would still be vulnerable to corrosion.

Septic systems in Marin's coastal zone are regulated by the Marin County Draft Local Coastal Program (DLCP), the Marin County Development Code, and the State Water Control Board. Figure 4 lists relevant Local Coastal Program policies. More information on regulations can be found at http://www.marincounty.org/depts/cd/divisions/environmental-health-services/septic-systems.

Figure 4. Draft Marin County LCP Public Facilities & Services (PFS) Policies (abridged)

C-PFS-6 Sewage Disposal and Water Quality Protection.

C-PFS-7 Adequately Sized Disposal Systems.

C-PFS-8 Disposal Systems Requirements for New Lots.

C-PFS-9 Preference for On-Site Sewage Disposal Systems.

C-PFS-10 Adequate On-Site Sewage Disposal Systems.

C-PFS-11 Alternative On-Site Disposal Systems.

Reflects CCC Suggested Modifications to Marin County DLCP Amendment. ***Subject to change.***

Table 20. Wastewater System Vulnerabilities

Depth	OWTS: Erosion can reduce the land area available to percolate waste. Saltwater intrusion into the leach field could impact percolation rates and reduce useable area. Shared Wastewater: Lift stations below grade are vulnerable (Bolinas).
Materials/ Models	Septic: Older single field gravity septic systems are more susceptible to storm flooding than newer (year) systems, as newer systems are equipped with "flip" switches that turn off percolation when groundwater levels are too high to prevent contamination. Drip dispersal tubing is also being used in newer systems. Newer systems are sensitive to power outages during storm events.
Codes	Septic: OWTS State regulations Public Wastewater: State Water Resources Control Board adopted statewide Order No. 2006-0003-DWQ requires a Sewer System Management Plan (Bolinas PUD Plan).
System Upgrades	Septic: Upgrades are conducted on an ongoing basis (about 20 annually) to include automatic flip switches and close contaminant boxes. Shared Wastewater: Erosion risk, may need to move pipes inland.

UTILITIES

Fuels (Home and Automotive)
Residents in West Marin use individual propane tanks for heat, hot water, and cooking. According to asset managers, propane tanks are highly vulnerable to sea level rise and storm impacts. Propane tanks are stored outside typically at or slightly above grade. While tanks are typically stored on the landward side of a building, this may not be feasible on every property, and in severe flooding, this precaution may not be sufficient. If a property floods, and waves and water dislodge the propane tank, the tank could pose a serious hazard.

Propane is transported to the area through private contractors. Route blockages could prevent residents from refilling tanks in a timely manner as early as 2030, when tides are high and storms are passing through. With the most severe storms and high tides in the winter, these disruptions could occur when residents need the propane most.

With respect to liquid fuels, one automotive gas station is located in the flood area in downtown Bolinas and has experienced storm flooding in the past. More frequent flooding here may make continued operations challenging. The next nearest gas station is in Pt. Reyes Station and is not exposed to sea level rise.

Electricity
According to Pacific Gas and Electric (PG&E), few electrical system components are vulnerable to sea level rise and storms on the Marin Coast. The features exposed are poles, transmission wires, and the individual wires dropping down to each home. The tall large wooden poles are vulnerable, currently and into the future, to falling tree branches; however they can withstand some degree of flooding. Excessive or permanent flooding could weaken the poles over time, warranting replacement. Poles are also vulnerable to erosion and roadway collapse because the poles are often located in the right-of-way alongside roads. The Bolinas and Olema sub-stations are well outside the area exposed to sea level rise and storms.

Several buildings, especially government facilities (i.e., Bolinas lift station, Inverness Fire Department) use back-up generators. If not elevated on an adequate cement pedestal, these expensive generators could be powerless.

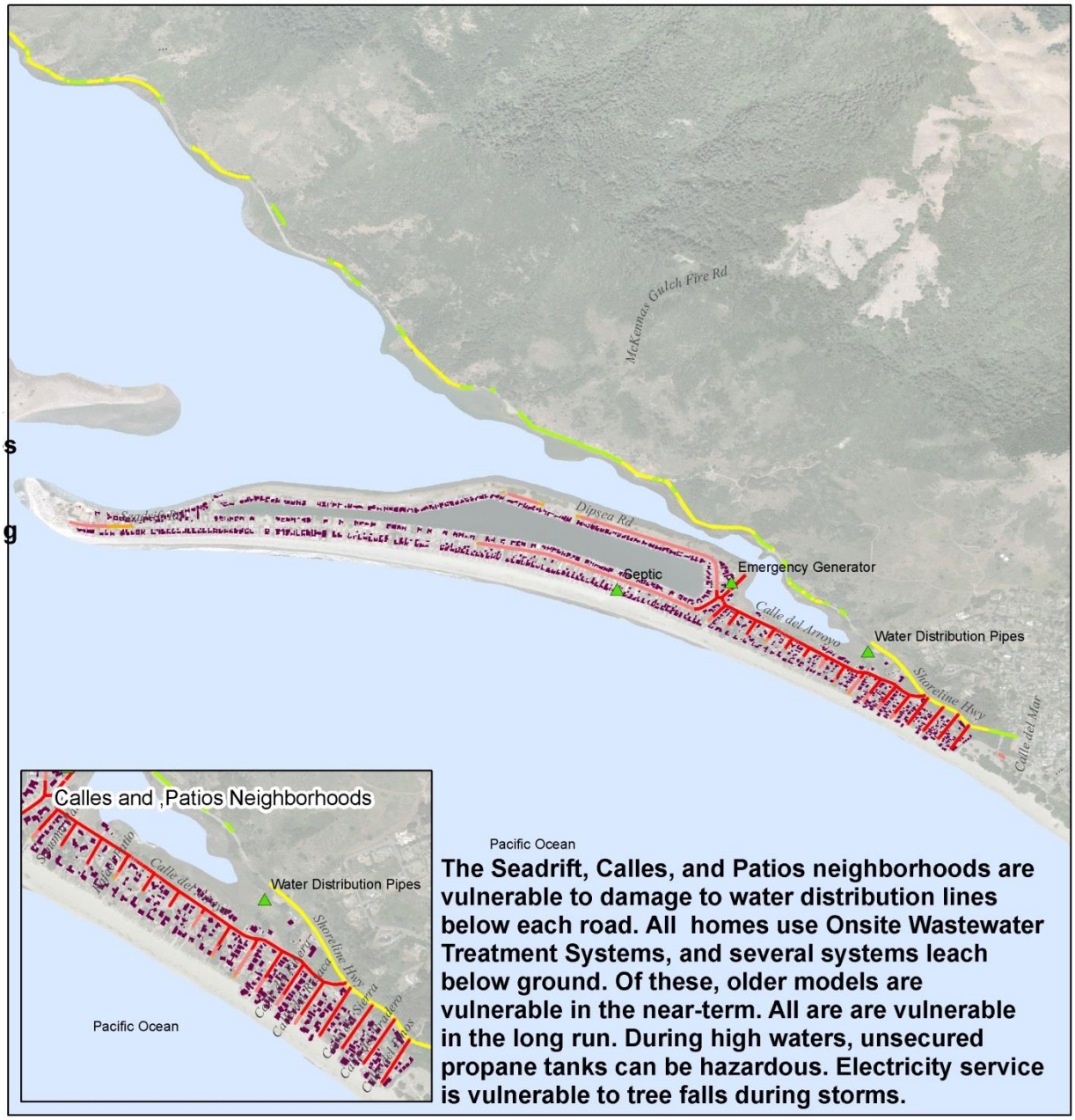
Telecommunications
The asset manager of all shared telecommunications assets is AT&T. In general, according to AT&T asset managers, telecommunication assets are not vulnerable on their own as they are designed to withstand wet weather and tidal impacts. In addition, consistent level of service is a primary goal of the company; therefore, the company would anticipate and prepare for potential impacts. The most vulnerable assets are the communication cables under vulnerable roads. In addition, poles, as discussed above, are vulnerable during storms to tree fells.

Storm Drains
Storm drains, such as culverts and outfalls, are also a critical utility aligned with or under the road. Sediment build-up and sea level rise can block gravity flow through stormwater drainage paths that travel under the roads, for example around Bolinas Lagoon. If the storm drains are unable to function, upstream flooding could occur and potentially weaken and erode the road. Stormwater infrastructure along private properties is typically managed by the property owner. Some public drainage facilities are maintained by Marin County along Bolinas-Olema Rd. and Sir Francis Drake Blvd., while those along Shoreline Highway are managed by Caltrans.

The maps on the following pages highlight vulnerable utility based assets. Since several utility assets are underground and could be exposed to sea level rise and storm threats before surface flooding shown in the maps occurs, supplemental information is provided with each map to describe these vulnerabilities. In addition, specific well and septic system locations are not available in the County GIS database, Marin Map. Building footprints are shown on the maps as a proxy for where these systems exist and may be vulnerable.

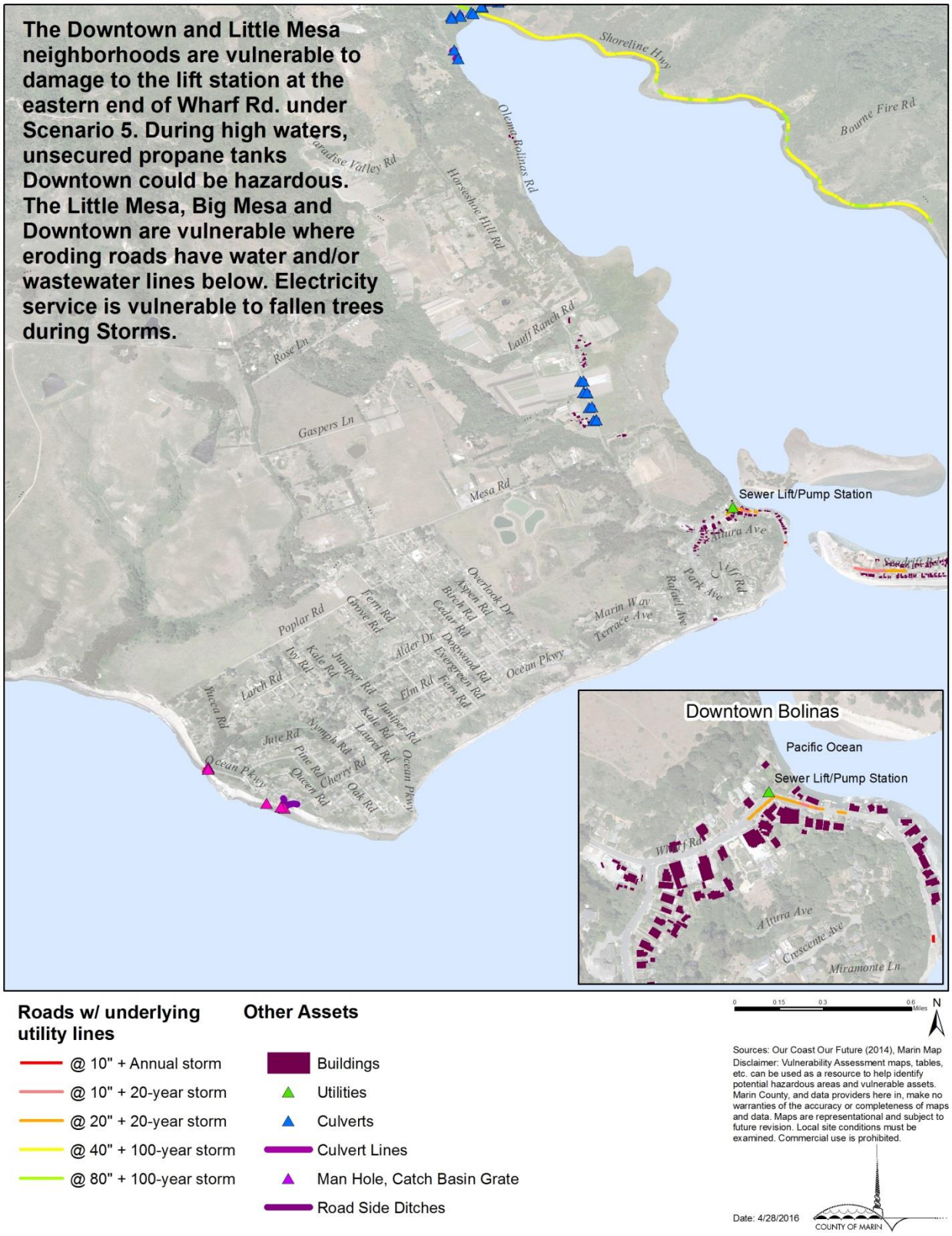
UTILITIES

Map 25: Stinson Beach Utilities Vulnerable to Sea Level Rise



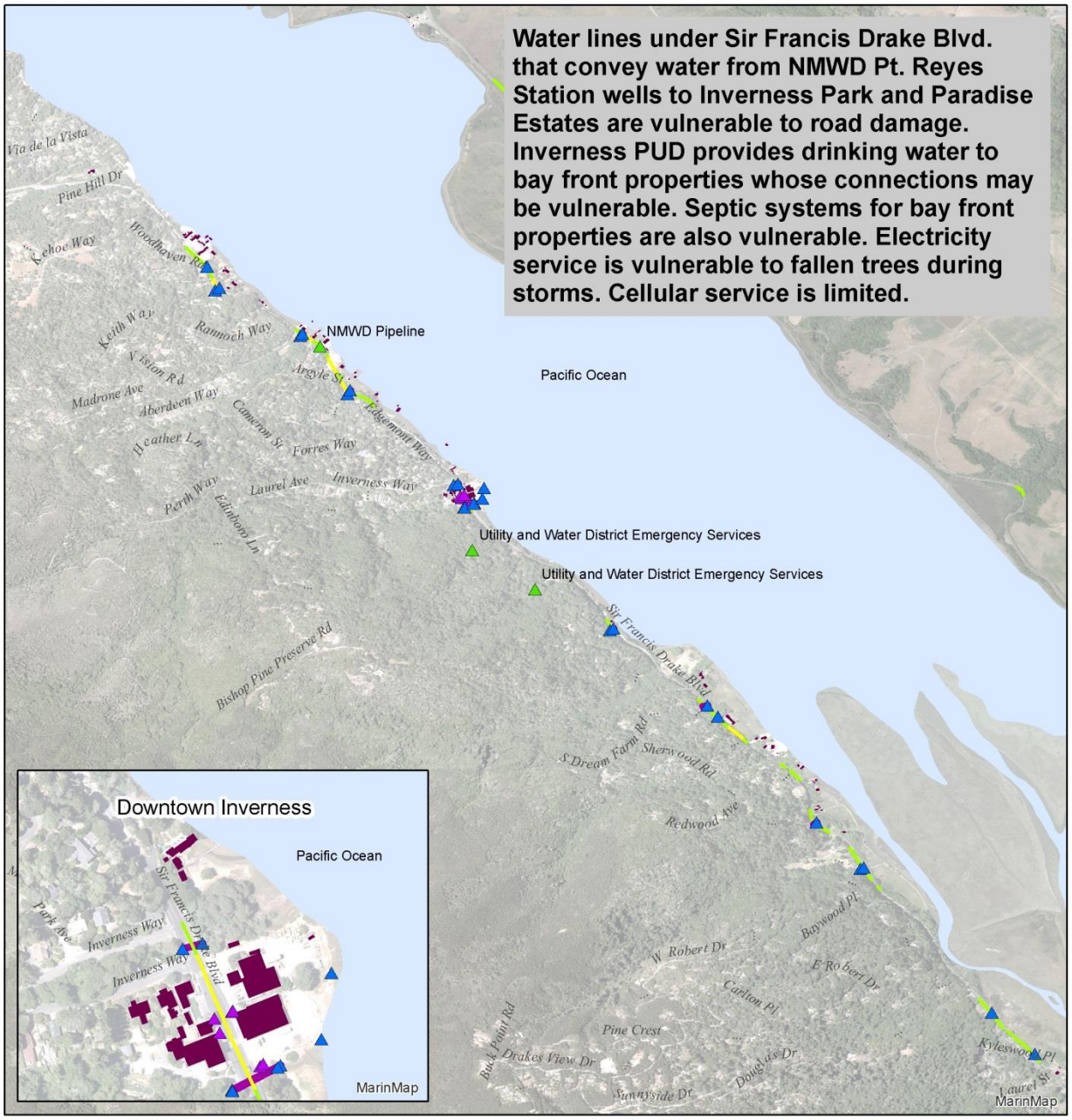
UTILITIES

Map 26: Bolinas Utilities Vulnerable to Sea Level Rise



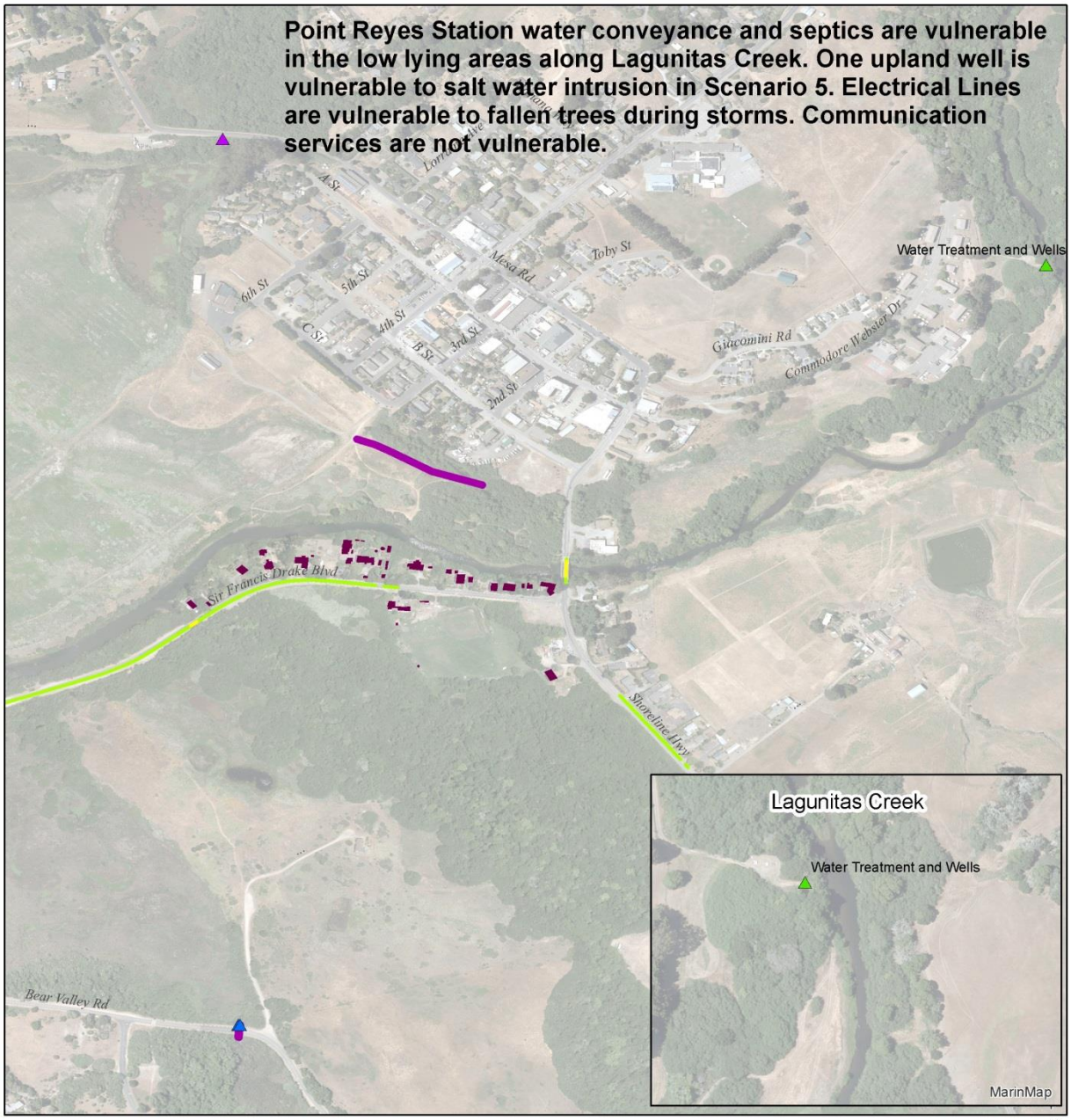
UTILITIES

Map 27: Inverness Utilities Vulnerable to Sea Level rise



UTILITIES

Map 28: Pt. Reyes Station Utilities Vulnerable to Sea Level Rise



Roads w/ underlying utility lines

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

Other Assets

- Buildings
- Utilities
- Culverts
- Culvert Lines
- Man Hole, Catch Basin Grate
- Road Side Ditches

0 0.05 0.1 0.2 Miles N

Sources: Our Coast Our Future (2014), Marin Map

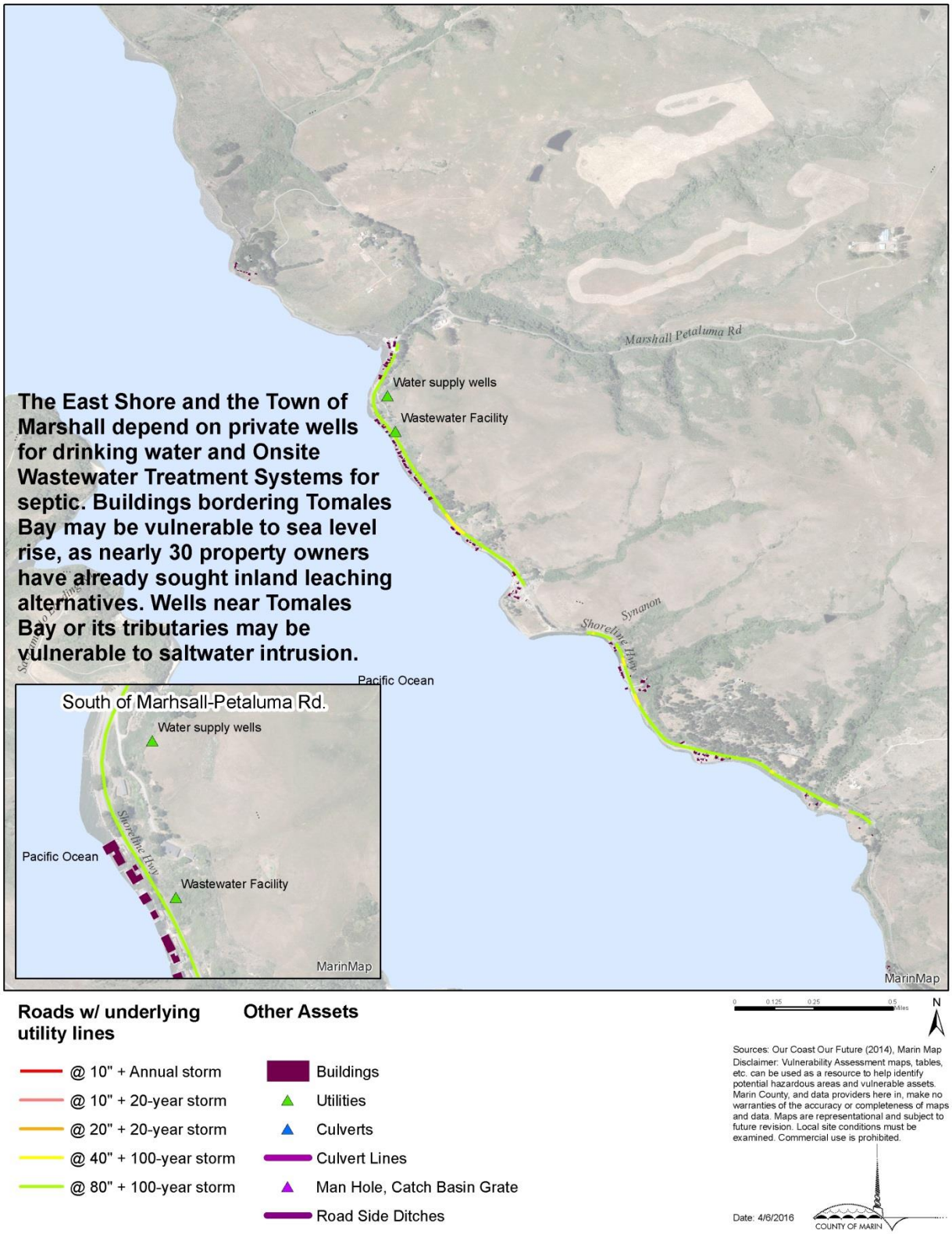
Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data providers here in, make no warranties of the accuracy or completeness of maps and data. Maps are representational and subject to future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

Date: 4/6/2016

COUNTY OF MARIN

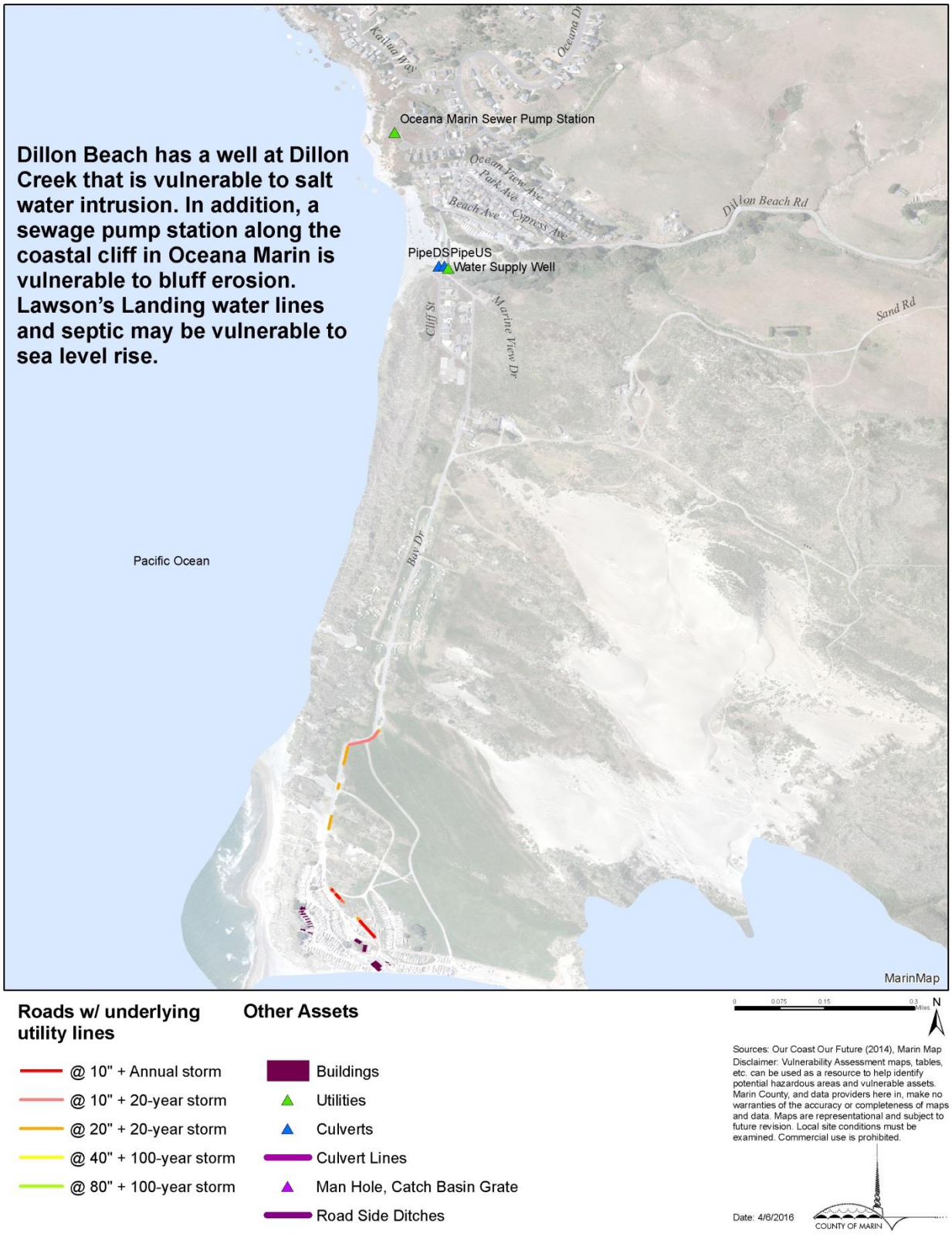
UTILITIES

Map 29: East Shore Utilities Vulnerable to Sea Level Rise



UTILITIES

Map 30: Dillon Beach Utilities Vulnerable to Sea Level Rise



UTILITIES

Other Considerations

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

Repairs and relocations can be very costly, and in recent years a few multi-million dollars projects were implemented in Bolinas and East Shore.

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

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

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

WORKING LANDS

Asset Profile: Agriculture & Aquaculture

Working lands host cultivation and livestock activities. The majority of land based operations exposed to sea level rise on the Marin Coast are ranches, dairies, and small produce farms. Ocean-based operations in Tomales Bay cultivate a variety of shellfish, while fishing and crabbing vessels leave from several boat launches in Bolinas, Inverness, and Marshall. All are major economic and cultural contributors to West Marin. The following are key issues related to working lands' vulnerability:

- Across all scenarios, the loss of vehicular access to and from working lands and processing facilities during storms and, eventually, on a daily basis threatens the viability of agricultural operations. Heavy vehicles may lose access as roadways become increasingly compromised by flooding. Bridges crossing Middle Road and Frank Valley School Road, north of Dillon Beach, already flood seasonally.
- Fishing vessels and aquaculture operations will face new challenges and may need to adjust practices and adapt their facilities.
- Aquaculture and land-based operations depend on access to local, regional, and worldwide markets.
- Lack of vehicular access for agri-tourism operations and bus tours could have negative tourism impacts on the region.

Agriculture

Other than grazing at Lawson's Landing, very little agricltural land is directly impacted in the near-term. Several properties along Stemple and Americano Creeks could see tidal and storm surge encroachment by the medium-term.

Under scenario 5, over 450 acres across forty-five parcels are exposed to sea level rise and storm conditions. Exposed agricultural parcels are concentrated north of Pt. Reyes Station with the exception of the Green Gulch Zen Center organic farm near Muir Beach and lagoon side fields in Bolinas. North of Pt. Reyes Station, a cluster of four grazing operations could be affected, including the Blake Family Farm and Giacomini Dairy. Exposed grazing parcels are also concentrated along Walker Creek in Marshall and extend a few miles inland (10 parcels, 8 property owners).

IMPACTS AT-A-GLANCE

457 agricultural acres (mostly ranch)	**30 land owners**
569 aquaculture acres	**Site specific**
Economic impact unknown	**Property Owners**

Oyster farm on Tomales Bay at low tide. Credit: CDA

Giacomini Dairy. Credit:, Marin Agricultural Land Trust

According to local community members, this area is impassable during storm and high tide events. Additional grazing parcels are located along Stemple Creek (14 parcels, 10 property owners) and along the Americano Creek (9 parcels, 7 property owners).

Most farm operation buildings are set back far enough from the coast and creeks and are not exposed to sea level rise. However, coastal land based farming operations could see increases in brackish water conditions in creeks and erosion along the creeks and shoreline. In the area north of Dillon Beach and in Pt. Reyes Station, bridges are vulnerable to flooding, leaving transport vehicles and the products they carry stuck on one side or the other of the creek. Many of the exposed agricultural parcels are large and the land area exposed on the property is a small portion of the total parcel acreage. Bolinas has a few parcels with small scale agriculture that are shielded from coastal flooding by earthern berms. Muir Beach's Green Gulch farm operation was not deemed vulnerable based on a site visit and property owner consultation. However, all agricultural operations in West Marin could be vulnerable to breakdowns in the transportation network, whether maritime or land based, local, regional, or statewide. Transportation disruptions would also impact the farm tour, or agri-tourism, based economy that depends on vehicular access to the areas wine, cheese, and other agricultural products.

Table 21. Exposed Agricultural Parcels and Acreage (ac.) by Community

	Scenario 1		Scenario 3		Scenario 5	
	#	Ac.	#	Ac.	#	Ac.
Muir Beach					4	13
Pt. Reyes Station					2	5
East Shore	6	8	8	11	15	34
Dillon Beach	18	100	21	159	25	405
Total	**32**	**110**	**32**	**172**	**46**	**457**

Source: Marin Map, Parcels. 2014

Aquaculture (Mariculture)

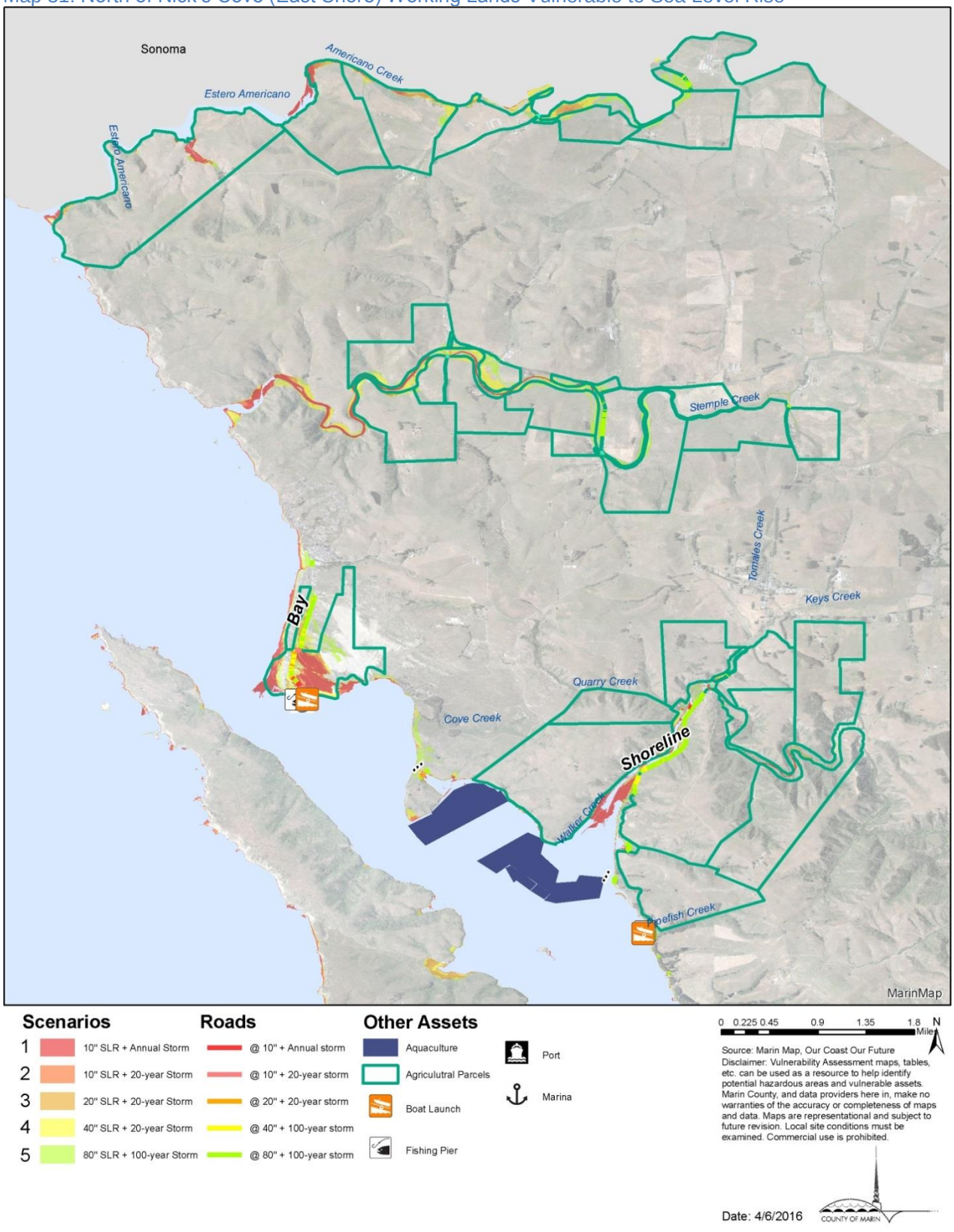
By their nature, aquaculture operations are exposed at existing water levels. Current practice depends on low tide for harvesting. As tides push landward, these operations could become inundated, prompting a shift in practices and permitting. The hard edge along the bay shore will prevent inland flow and create dramatic conditions during storms that could damage the oyster beds. Aquaculture buildings could see structural damage from storms and inundation because they are often directly on the shoreline. And much like with agri-tourism for land-based products, vehicular access could also be a hindrance on the thriving oyster restaurants and tours that depend on fully functioning roadways in the Coastal Zone.

Aquaculture, or mariculture, operations are located in East Shore on Tomales Bay. Twelve parcels, totalling nearly 600 acres, cultivate 10 oyster (Pacific, Kumamoto, Pacific Giant, Eastern flat, European, eastern, flat, native, Olympia, suminoe), 4 clam (manila, Northern Quahog, native littleneck, Japanese littleneck), 3 mussel (bay, California sea, blue), and 2 scallop (rock, Japanese) varieties, and red abalone. According to the 2014 Agriculture and Livestock Report, these parcels contributed $10.6 millon in economic activity that year (10 percent of the total Marin agricultural economy).[19] In addition, crabbing and fishing are popular commercial activities in Bolinas and Tomales Bay that could be impacted by habitat shifts and changes in boating practices and access to populated areas.

[19] Carlsen, Stacy. *2014 Marin County Agriculture and Livestock Report*, Marin County department of Agriculture, Weights and Measures. http://www.marincounty.org/~/media/files/departments/ag/crop-reports/2014.pdf?la=en

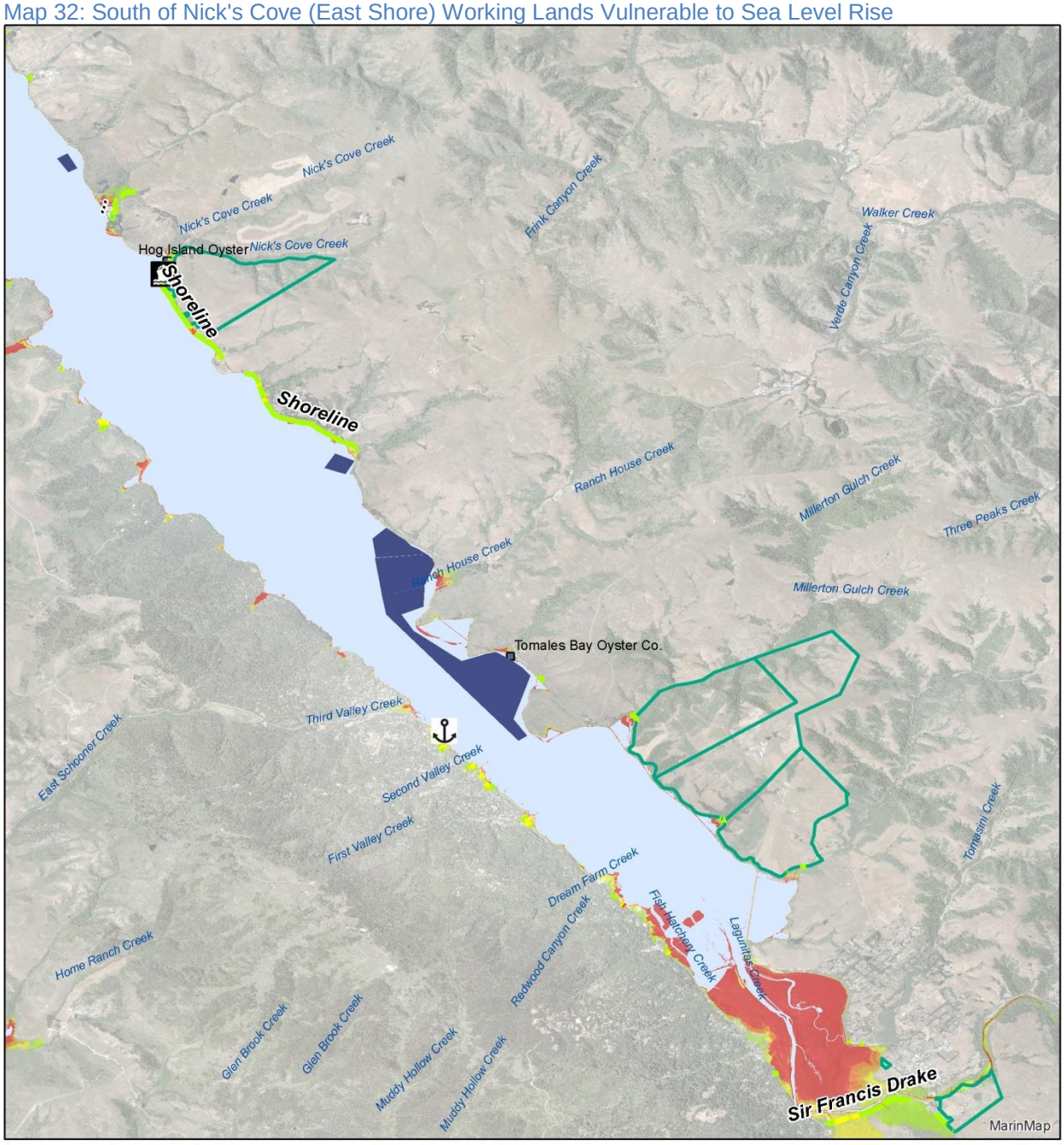
WORKING LANDS

Map 31. North of Nick's Cove (East Shore) Working Lands Vulnerable to Sea Level Rise



WORKING LANDS

Map 32: South of Nick's Cove (East Shore) Working Lands 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

Roads

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

Other Assets

- Aquaculture
- Agriculutral Parcels
- Boat Launch
- Fishing Pier
- Port
- Marina

0 0.2 0.4 0.8 1.2 1.6 Miles N

Source: Marin Map, Our Coast Our Future

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: 4/6/2016

COUNTY OF MARIN

WORKING LANDS

Existing Policies

The Draft Local Coastal Program (DLCP) strongly supports continued diversified agricultural and aquaculture uses. The Coastal Agricultural Production Zone (C-APZ) district comprises nearly two-thirds of the Coastal Zone, and contains the majority of Marin's agricultural lands. The Coastal Agriculture, Residential Planned (C-ARP) district is also present in the study area.

Because mariculture operations in Marin County are in submerged areas, they are under the permit jurisdiction of agencies such as the Coastal Commission and the Department of Fish and Wildlife. The DLCP gives general support for mariculture, while avoiding site specific policy provisions.

Other Considerations

Economic

Exposed land based operations account for $7,146,200 in assessed land value that could see losses as lands newly under water become waters of the State. Aquaculture operations may need to adjust their harvesting practices in the near- to medium-terms to adjust to higher water levels and higher low tides by switching from tidal harvest to over water harvesting. Contamination from vulnerable wastewater systems could prevent safe production and prevent export. Exports and agri-tourism are contributors to the coastal Marin economy. If exporting agriculture and aquaculture goods becomes an ever increasing challenge on flooded roads, economic impacts could be incurred, including the loss of jobs. Finally, if tour routes are flooded during times of operation, reductions in tours, tourists, and their economic contributions could occur.

Environment

Intrusion of brackish water could change the ecological conditions of the ranchlands and ranch management practices. Invasive species are already a growing concern in the agricultural community, and warming conditions, with a weakening in the native flora, could increase the extent of some heat loving invasive plant species.

Social Equity

Employees of these operations could be disproportionately impacted if operations need to reduce labor costs. Local restaurants and markets in East Shore that vend West Marin agricultural products provide places for social gathering and jobs for local youth. Losing businesses and jobs could have significant impacts on social outcomes.

Management

Agriculture is a highly regulated industry at nearly all levels of government. For example, at the federal level is the Clean Water Act (Sections 401 and 404)[20] and the resulting Tomales Bay Conditional Grazing Waiver and Tomales Bay/ Stemple Creek/ Estero de San Antonio total maximum daily [sediment] loads (TMDLs) that farmers must comply with to reduce erosion and sediment loads to creeks. In many cases, working with the Marin Resource Conservation District to comply and improve water quality, farmers have fenced off creeks from livestock wading, installed new stream crossings and restored riparian areas that could be compromised under these sea level rise scenarios. Habitat changes prompted by sea level rise could require new conservation management plans and improvements in the coming decades to ensure water quality standards are upheld. The Coastal Commission may also impose regulations for farmland use that Marin County would be required to administer through the Local Coastal Plan

Aquaculture operations, in addition to the Clean Water Act, are subject to the Public Lands Doctrine and lease land from the State to conduct their cultivation efforts. These leases are associated with tides and as the tides change, the permits will need to adjust.

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

NATURAL RESOURCES

Asset Profile: Habitats & Wildlife

Marin County is known and treasured for its beaches, estuaries, wetlands, marshes, creeks, national and state park lands, marine sanctuaries, wildlife preserves, and unique landscapes.

Over 50 natural resource assets on the Marin Coast could be exposed to sea level rise and storms. Several are managed by state and federal agencies for public use. Major examples include: Golden Gate National Recreation Area (includes Muir Beach Park), Stinson Beach Federal Park, Mt. Tamalpais State Park, Point Reyes National Seashore, Tomales Bay State Park, and Tomales Bay Wetland Reserve. The Greater Farallones National Marine Sanctuary is located in the coastal waters and islands off the Marin County Coastaline. Others are preserved as county parks, such as Bolinas Lagoon Park, Agate Beach, and Duxbury Reef. Finally, some are held by non-profit organizations such as the Nature Conservancy and Audubon Canyon Ranch. Audubon Canyon Ranch manages the Martin Griffin Preserve and Livermore Cyress Grove.

A majority of these habitats and their wildlife inhabitants are already exposed to sea water during times of high tide, or always. What will change is the extent and nature of the sea water moving landward, and, in some cases, into freshwater habitats. The following are key issues related to natural resources and wildlife habitat vulnerability:

- Where space exists, sea level rise may push coastal beaches and marshes inland, and shift existing tidal areas to standing water, and flood inland areas with saltwater.
- Roads, storm drains, and development greatly restrict the ability of beaches and marshes to migrate landward and could completely transform them. In fact, beaches and marshes in Bolinas, East Shore, and Inverness could disappear by 2050.
- Increases in salinity in freshwater and brackish water habitats can impact habitat suitability for existing species.
- Endangered species and special habitats are especially vulnerable.
- Ecosystem services, such as water filtration and flood protection, may be compromised.

IMPACTS AT-A-GLANCE

Several land and water species		**GFNMS DFW CCC CA Wildlife Conservation Board**
Site specific		
Beaches Estuaries Rocky Intertidal Areas	**Western snowy plover Black oystercatcher Black Rail California Mussel Red Abalone**	

Sea lion sunbathing. Credit: CDA

NATURAL RESOURCES

Table 22 lists some of the potentially vulnerable natural resource related assets in the study area. This list provides onset and tidal mean higher high water (MHHW) and extreme event flood depths; however many natural resource assets are shoreline based or water features. This list is not exhaustive of all the natural resource assets that could be exposed to sea level rise and storm impacts in the study area.

Table 22. Natural Resource Assets Ranked by Onset and Flood Depth (feet and inches)

Location	Asset (not exhaustive)	High Tide & Extreme Event Flooding Depth Estimates (Underlined values indicate tidal flooding at mean higher high water (MHHW) based on a geographic point at the landward limit of the scenarios overlapping the asset. Values not underlined indicate temporary event flooding.)					Vulnerability TF: Temp. Flooding; I: Inundated at MHHW; E: Erosion; WS: Wave Surge; HW:, HS: Habitat Shift
		Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	
Stinson Beach	Upton Beach	4'7"	6'2"	7'5"	9'8"	14'9"	I, E
East Shore	Walker Creek Access Point	2'4"	3'3"	4'2"	6'1"	9'3"	I
Bolinas	Brighton Beach	2'2"	3'5"	4'11"	6'	9'11"	E, WS
East Shore	Livermore Marsh Cypress Grove	2'1"	3'1"	3'11"	5'10"	9'2"	I, HS
Inverness	Chicken Ranch Beach	2'	3'1"	3'9"	5'5"	8'	I, E, HS
Inverness	Martinelli Park	1'1"	2'	2'2"	4'1"	7'3"	I, E
Bolinas	Agate Beach/ Duxberry Reef	2'1"	1'11"	2'8	4'8"	9'3"	I, HS
Inverness	Tomales Bay State Park (low lying areas)	10"	1'10"	2'8"	4'7"	7'10"	I, HS
Dillon Beach	Lawson's Landing	2"	1'1"	2'11"	3'10"	7'3"	I, E, WS, HW, HS
Pt. Reyes Station	White House Pool/Trail			2'5"	2'3"	5'11"	I, HS
Inverness	Dana Marsh & Beach Access				3'	6'2"	I, E, SI, HS
East Shore	Millerton Point				2'5"	5'8"	I, E
Inverness	Shell Beach Tomales Bay SP				5"	3'4"	TF, I, WT
Point Reyes Station	Olema Marsh Trail					2'9"	I
Dillon Beach (north)	Stemple Creek Recreation Area	X	X	X	X	X	HS
Stinson Beach / Bolinas	Bolinas Lagoon	water resource					HS
Inverness / East Shore	Tomales Bay	water resource					HS
North of Dillon Beach	Estero Americano	water resource					HS

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

NATURAL RESOURCES

The *Climate Change Vulnerability Assessment for the North-central California Coast and Ocean*, identifies how and why habitats and species across the North-central California coast and ocean region are likely to be affected by future climate conditions.[21] Consultation with the authors enabled isolating sea level rise findings from other climate change impacts.

As described in the Methods section, this interagency study used different methods to assess vulnerability than this Assessment to examine sensitivity, adaptive capacity, and exposure. The interagency study employed 80 scientists to provide overall vulnerability and confidence scores for each habitat and species. Scores for exposure were weighted less than scores for sensitivity and adaptive capacity by a factor of 0.5 due to uncertainty about the magnitude and rate of future change. Sensitivity, adaptive capacity, and exposure scores were combined into an overall vulnerability score calculated as follows:

Vulnerability=(Climate Exposure (0.5)+Sensitivity)/ Adaptive Capacity

The assessment concludes that the most vulnerable habitats are beaches (including dunes), estuaries, and rocky intertidal areas. These habitats are primarily vulnerable to sea level rise, storm surges, and erosion. Beach and dune habitat was scored as having the highest vulnerability to sea level rise, due to high exposure, high sensitivity, and moderate adaptive capacity. Cliff habitats were scored with the lowest vulnerability due to moderate sensitivity and low to moderate exposure.

Beaches

Sea level rise can inundate existing beach and dune systems and increase rates of shoreline erosion. This could potentially force beach and dune habitats inland.[22] However, in many cases along the Marin Coast, beachside development, roads, or steep slopes and bluffs, limit landward migration, causing beaches to shrink.[23] This habitat shift could affect many species, including pinnipeds (elephant seals, harbor seals, sea lions), shore birds, and smaller coastal species. In addition, shifts and losses in ecological zones within beach habitats could disrupt the food web[24] and ecosystem dynamics and quality.[25]

Stinson Beach from Shoreline Highway. Credit: CDA

[21] 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. 473 pp. http://sanctuaries.noaa.gov/science/conservation/pdfs/vulnerability-assessment-gfnms.pdf.

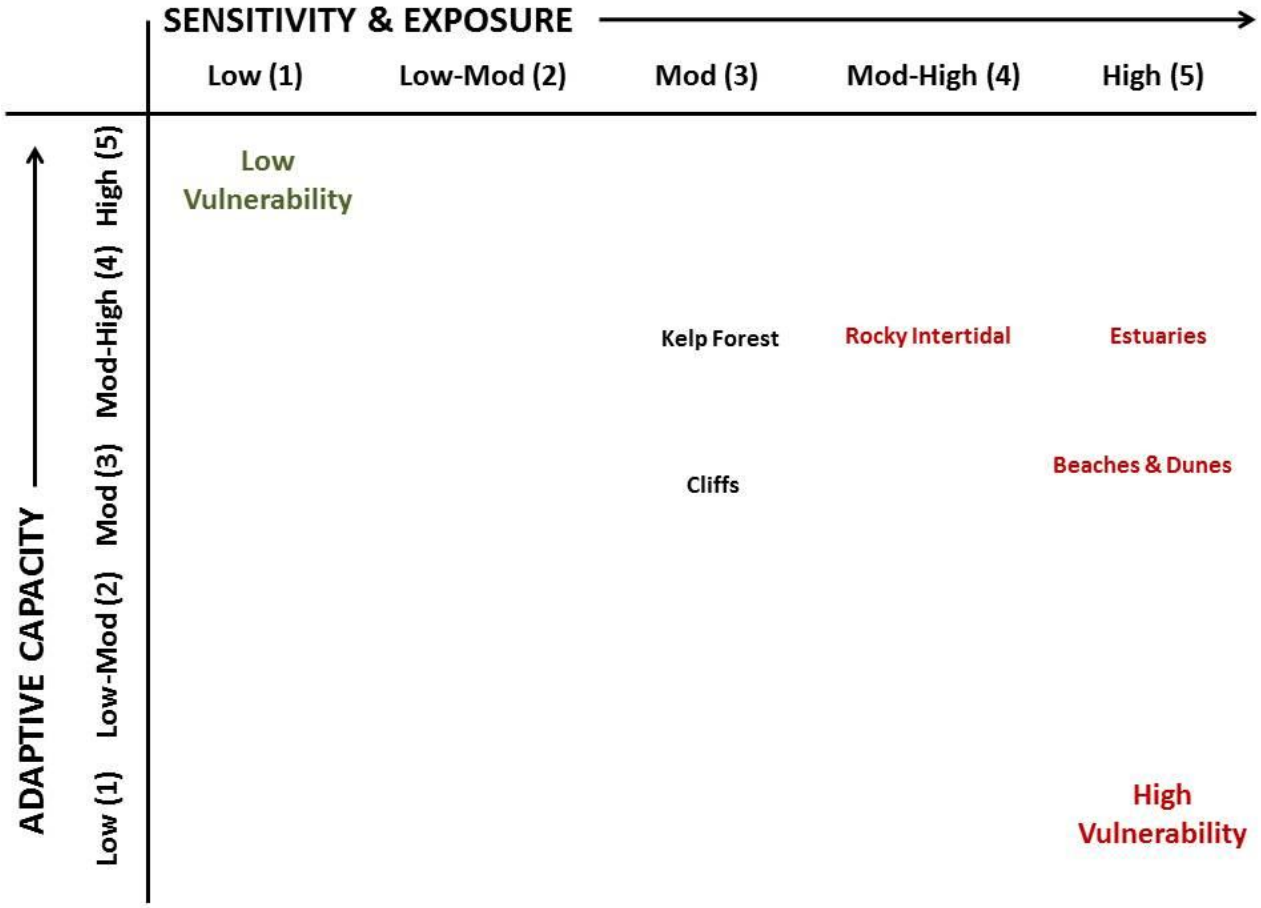
[22] Feagin, R.A., D.J. Sherman, and W.E. Grant. 2005. *Coastal erosion, global sea-level rise, and the loss of sand dune plant habitats.* Frontiers in Ecology and the Environment 7:359-364.

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

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

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

Figure 5. Sea Level Rise Vulnerability for the North-central California Coast and Ocean Habitats



Source: Hutto, S. Email Communication. 2015

Bluff erosion can have varying impacts on beach habitats. Eroding bluffs can be a major source of sediment allowing beaches to evolve.[26] Alternatively, beach loss due to bluff collapse can negatively impact sand crabs, wrack consumers, and species that depend on beach habitats for breeding and nesting.[27] Vulnerable beaches include:

- Muir Beach
- Stinson Beach
- Nude Beach
- Brighton Beach
- Agate Beach
- Upton Beach
- Dillon Beach
- Lawson's Landing
- Shell Beach
- Chicken Ranch Beach
- Heart's Desire Beach

Additional analysis for beaches in Stinson Beach, Bolinas, and East Shore, calculated the resulting beach areas for each sea level rise amount. The resulting beach widths and associated vulnerability levels are presented in Table 23.

[26] 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.

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

NATURAL RESOURCES

Table 23. Existing and Future Average Beach Widths and Corresponding Vulnerability Levels

	Width (meters) & Vulnerability					
	Base-line	Scen 1	Scen 2	Scen 3	Scen 4	Scen 5
Upton to Stinson Federal	53	48	48	32	9	2
	Low	Low	Low	Low	Med	High
Stinson (Seadrift)	38	29	29	14	0	0
	Low	Low	Low	Med	High	High
Bolinas	38	29	29	14	0	0
	Low	Low	Low	Med	High	High
Inverness/ East Shore	Beaches along are narrower than 10 meters.					
	High					

Source: ESA, 2015, OCOF

Stinson Beach (Upton to Stinson Federal)

Stinson is backed by a mix of armored homes, other beachfront structures, and unarmored dunes. The Federal area, is the widest and may allow the beach to migrate inland. However, the beach areas and associated vulnerability levels for future years in Stinson assume no transgression of the backshore, effectively treating the back of the beach as armored. Allowing the beach to migrate inland may help sustain the beach as an ecological and recreational resource into the future, though likely at the expense of parking and other beachfront facilities.

Stinson Beach (length in front of Seadrift neighborhood)

The Seadrift neighborhood backing this segment of beach was armored after homes sustained significant damage during the 1983 El Niño event.[28] This stretch of beach is more susceptible to loss because it is narrower than Stinson Federal and armored, preventing inland migration.

Bolinas

Bolinas is characterized by small patches of cliff-backed beaches with armored oceanfront homes. A slightly wider patch of beach off Wharf Road to the jetty; however, the beach width here fluctuates from year to year and has almost completely flooded out in years past. The west beach area is already narrow and increasingly vulnerable to loss with future sea level rise because the armored cliff and beachfront homes do not allow the beach to migrate landward. Agate Beach is backed by steep bluffs and already floods at high tide and could see increased flooding and reduced public access and use in the near-term.

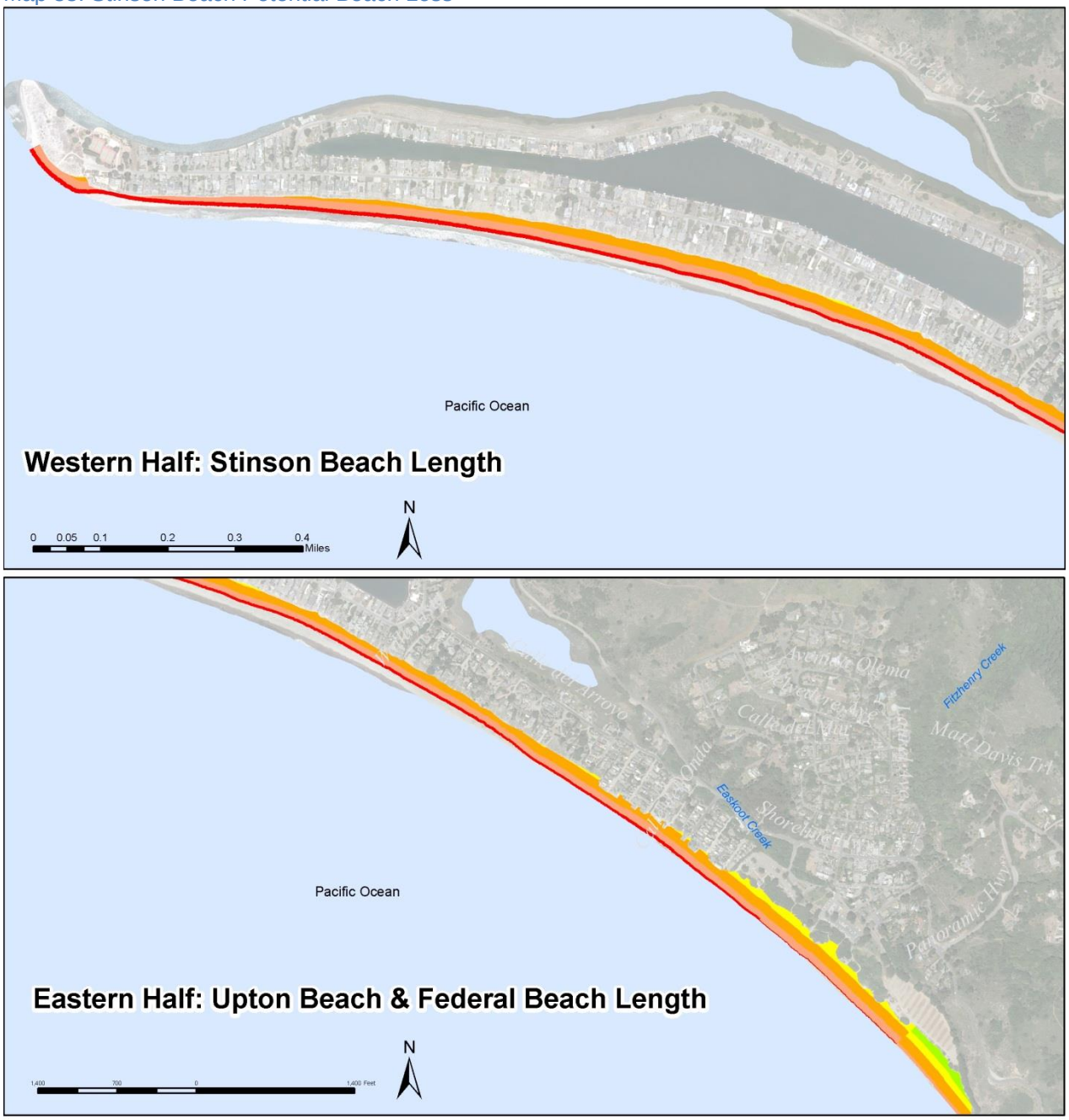
Inverness & East Shore

Beaches along Tomales Bay are limited to a few small pockets either near creek mouths or tucked behind docks and armoring structures. These beaches are less than 10 meters and highly vulnerable. Since most beaches here are backed by armor, buildings, or road, they could be highly vulnerable to sea level rise.

[28] Griggs, G., Patsch, K., Savoy, L. 2005. Living With The Changing California Coast. University of California Press. Berkeley, CA. 551pp.

NATURAL RESOURCES

Map 33. Stinson Beach Potential Beach Loss



Source: Marin Map, Our Coast Our Future, ESA

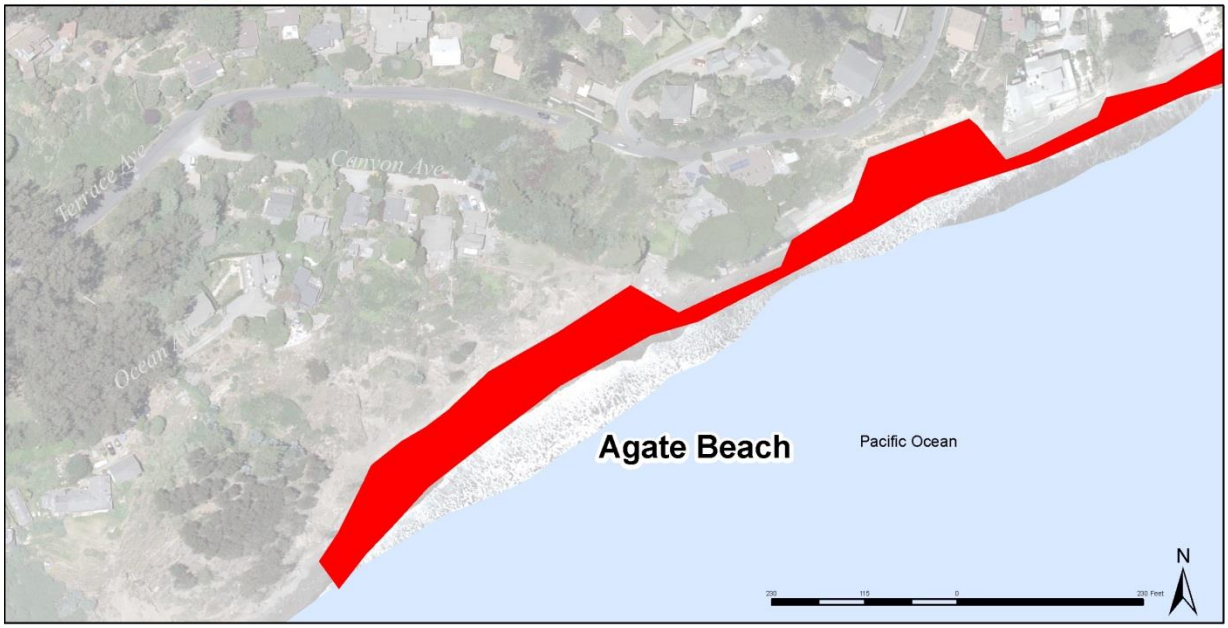
Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data providers here in, make no warranties of the accuracy or completeness of maps and data. Maps are representational and subject to future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

Date: 4/4/2016

COUNTY OF MARIN

NATURAL RESOURCES

Map 34. Bolinas Potential Beach Loss



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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COUNTY OF MARIN

NATURAL RESOURCES

Estuaries, Marine Wetlands, & Marshes

An estuary is a partially enclosed coastal body of brackish water, or a mixture of fresh and salt water, with one or more rivers or streams flowing into it that mix with and transition to open ocean. Many of these connect with marine wetlands and marshes, though wetlands and marshes also occur along the coast unassociated with estuaries. Overlaying the C-SMART scenarios on this habitat data reveals there are roughly 9,000 existing acres in the estuaries of Tomales Bay, Bolinas Lagoon, and Esteros Americano and San Antonio. Approximately, 1,600 acres of marshlands with established vegetation and an additional 200 acres of less vegetated wetland could be impacted to varying degrees across all of the scenarios.

Sea level rise will likely exacerbate shoreline erosion and potentially increase salinity.[29] Without a comparable increase in land elevation from sediment delivery, these coastal habitats will be unable to adjust, and thus, flood more frequently.[30,31] Much like beaches, these areas can be prevented from moving landward when backed by development, coastal armoring, or cliffs. Additionally, timing and extent of the rise and fall of the tide may be altered in estuaries and tidal rivers.[32] Increased storm activity could have significant implications for flooding of estuarine habitat and mouth.[33] Increased storm activity could also cause increased salinity of coastal wetlands and marshes.

The following are examples of the major estuarine, wetland, and marsh habitats that could be vulnerable to sea level rise and storms:

- Muir Beach Lagoon
- Bolinas Lagoon
- Giacomini Wetlands
- Olema Marsh
- Tomales Bay
- Shields Salt Marsh
- Estero San Antonio
- Estero Americano

In general vegetation occurs from just above mean sea level (MSL) to just above mean higher high water (MHHW). Cordgrass is found at lower elevations, and pickleweed is typically at the MHHW limit with a number of other species depending on local elevation, drainage, soils, site history and other factors.

Tomales Bay winter light. Credit: Silver

Bolinas Lagoon

Bolinas Lagoon is a tidal embayment sheltered by Stinson Beach Spit and consists of approximately 1,000 acres of open shallow water, extensive mud and sand tidal flats, approximately 600 acres, flood and ebb tide shoals and deltas, small alluvial fans and deltas, and fringing tidal salt marsh. Kent Island within the Lagoon is an emergent flood tidal delta island with a thin cap of beach and dune sands.[34] The water is primarily marine and connects via a tidal inlet that has primarily remained open for 1,600 years (as suggested by the absence of freshwater pollen from soil cores).[35]

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

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

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

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

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

[34] PWA, 2006. Projecting the future evolution of Bolinas Lagoon. Report prepared for Marin County Open Space District.

[35] 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.

Ten small seasonal drainages and Pine Gulch Creek contribute freshwater and coarse alluvial sediment, accounting for 25 percent of the sediment in the lagoon. Deltas at the mouth of these creeks are growing in response to increasing sediment load from channelization upstream. In the Pine Gulch Creek delta, this growth has converted intertidal estuarine habitats to upland riparian woodland. The Pine Gulch Creek delta and Kent Island shelter much of the western shoreline from wind and wave impacts and will facilitate mudflats converting to salt marsh.

Map 35 shows the existing and potential water elevations in Bolinas Lagoon for each sea level associated with each scenario. The analysis assumes the best case of 6.8 mm/year of sediment.

The most vulnerable areas in the Bolinas Lagoon are those without gradually sloping transitional uplands or are located away from the creek deltas. Table 24 shows the increasing vulnerability of loss of marsh functions as sea level rises and marshes are squeezed against slopes. Approximately 50 percent of the high marsh is expected to be lost by mid-century; converting to low marsh, mud and sand flats; this will increase to 80 percent loss nearing the end of the century.[36] As sea level rises, the marshes will 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 the Pine Gulch Creek are also likely to survive longer due to the higher rate of vertical accretion associated with deltaic processes.

The *Memorandum: Bolinas Lagoon Restoration Project Design Review Group*[37] provides a summary of the implications of higher sea level rise projections in Bolinas Lagoon:

- Accelerated sea level rise replaces the risk of excessive lagoon sedimentation and tidal prism loss as an overriding ecosystem concern. Long-term lagoon submergence due to accelerated sea level rise is a major challenge to the lagoon's ecosystem health and resilience.
- Sediment values can be neutral, beneficial, or adverse depending on location, timing, magnitude, and context. Sedimentation is an asset to evolution of the lagoon, not just an impact.
- Accommodation space is a primary concern for the long-term health and stability of Bolinas Lagoon.
- Future changes in the lagoon's barrier beach and tidal inlet will occur in response to accelerated sea level rise and coastal storms.

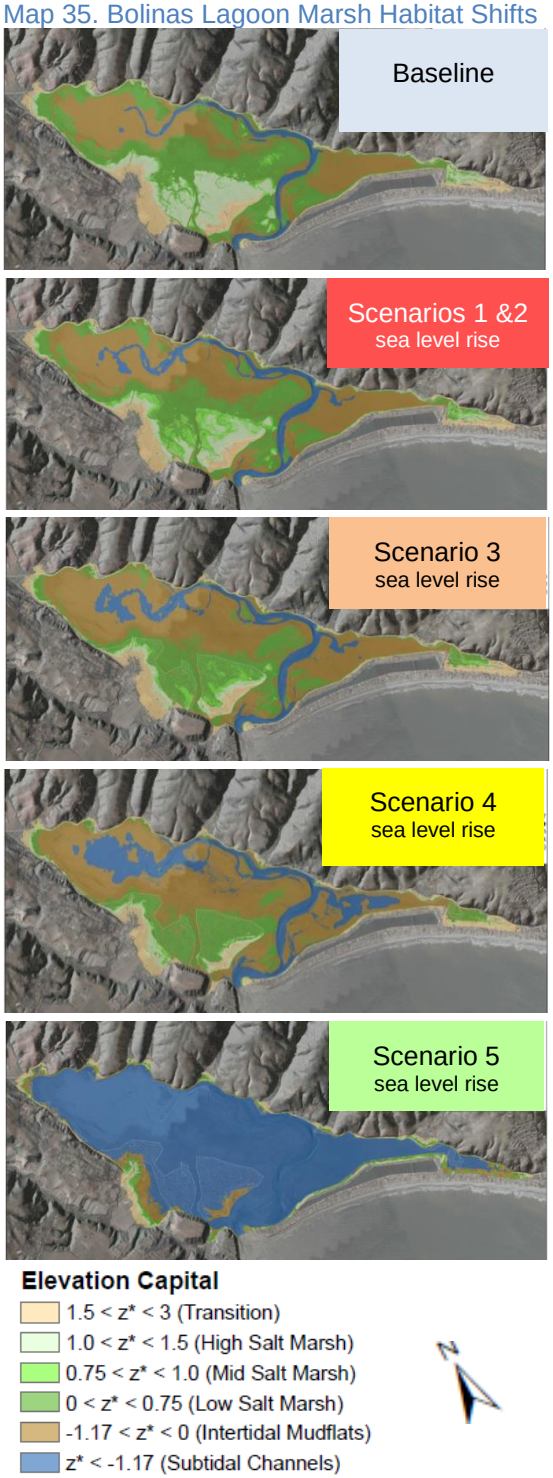
In addition, changes in salinity will affect vegetation. Lower salinities, common in winter and early spring, positively affect plant recruitment. Increases in salinity, especially during the summer growing season, negatively affect vegetation diversity, with a likely shift of more salt tolerant vegetation establishing inland. However, in some locations, migration of vegetation inland may be limited by different soil conditions.

[36] 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.

[37] 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.

NATURAL RESOURCES

Map 35. Bolinas Lagoon Marsh Habitat Shifts



Note: Maps consider accretion rate of 6.8 mm/year. 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

NATURAL RESOURCES

Table 24. 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	*1.6-3*
High salt marsh	164	95	478	42	27	*1.1-1.5*
Mid salt marsh	35	76	42	14	9	*0.85-1*
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	1,026	*< -1.04*
Vulnerability Level						
Low	255	184	140	115	49	*1.1-2.5*
Medium	257	234	221	78	77	*0.3 – 1*
High	662	772	849	1,048	1,180	*< 0.3*

Source: ESA, 2015

Bolinas Lagoon Marsh Lands. Credit: CDA

NATURAL RESOURCES

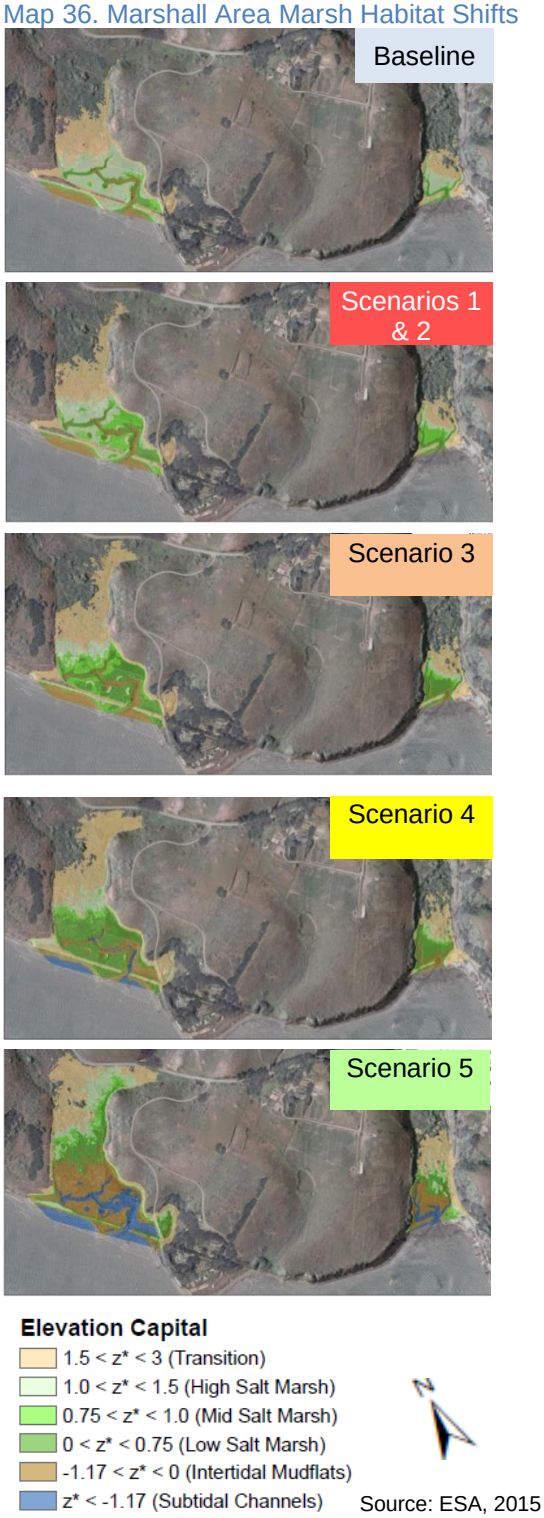
Tomales Bay - Marshall Area

Tomales Bay is formed by the San Andreas Fault with an incomplete sand barrier at Dillon Beach. Fresh water and coarse sediment supplies from the relatively large Walker Creek and Lagunitas Creek watersheds create local estuarine gradients within the Bay. Similar to Bolinas Lagoon, the largest tidal marshes are associated with the alluvial deltas of these creeks. The bay margins are indented with coves and gulches with small deltas, beaches, and discrete pocket tidal marshes, riparian vegetation, and lagoons.

The Lagunitas Creek delta expanded in the 19th century due to sediment deposition from watershed erosion. Similarly, the Walker Creek delta has expanded rapidly in recent decades due to watershed erosion. At the south end of Tomales Bay are diked bay lands, tidal flats, and tidal marshes including the Lagunitas Creek delta and Olema marshes.

Map 36 and Table 25 show habitat shifts in Marshall lagoons for scenarios 1-5 for the average historic sedimentation rate of 1.6 mm./year.[38] The most vulnerable marsh areas are those lowest in elevation. Relatively large areas of transition zone exist allowing the area of high and mid marsh to remain constant over time. The high marsh in 2100 is about the same acreage as in 2010. The acreage of mudflat does increase as the former low lying marsh areas are drowned. As sea level rises, the high marshes are able to transgress inland along the valley profile. While these are areas with gently sloping migrating transition zones, some realignment of infrastructure, such as roads and culverts, may be necessary.

Map 36. Marshall Area Marsh Habitat Shifts



Source: ESA, 2015

[38] 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

NATURAL RESOURCES

Table 25. Spatial Distribution of Marsh Area & Vulnerability in the Marshall Area at 1.6 mm/year of Sedimentation

Habitat Type	Area (acres)					Elevation Capital 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 (salt grass)	5	4	2	2	4	*1-1.5*
Mid salt marsh (pickleweed)	1	3	2	1	2	*0.75-1*
Low salt marsh (cordgrass)	1	2	4	6	4	*0-0.75*
Intertidal Mudflats	1	2	2	3	8	*-1.17-0*
Subtidal Channels & Shallows	na	na	0	1	4	*< -1.17*
Vulnerability Level						
Low	9	8	7	9	9	*1-2.5*
Medium	2	4	6	3	4	*0.3-1*
High	2	2	3	8	13	*below 0.3*

Source: ESA, 2015

Rocky Intertidal

This area is the rocky substrate found between high and low tide water levels. Key sensitivities include increased salinity, wave action, and erosion. The ecosystem depends on the abundance, distribution, and interactions of the vulnerable California mussel and the ochre sea star. Salinity plays a strong role in rocky intertidal tide pools. Studies on the effect of salinity extremes indicate that, when combined with temperature stress, salinity can negatively impact rocky intertidal invertebrates through increased embryonic mortality[39,40] and decreased adult aerobic performance.[41] In addition, projected increases in storm activity and wave action can remove larger intertidal organisms[42] and increase coastal erosion that may bury the habitat. If tides do not retreat as far as they currently do with sea level rise, these areas could shift from intertidal to underwater habitats. Rocky intertidal Muir Beach, Duxbury Reef (Bolinas), and Estero Americano (north of Dillon Beach).

Freshwater Resources

The *North-central California Coast and Ocean Vulnerability Assessment*[43] does not address freshwater habitats inland from the coast. However, according to CoSMoS, these habitats are also likely to see impacts from sea level rise and storm surges. Nearly 622 acres of freshwater emergent wetlands, 90 acres of shrub and forested wetlands, 36 acres of ponds, 291 acres of lake, and 123 acres of riverine areas could see sea level rise and storm impacts. These areas face varying degrees of vulnerability, much like their coastal equivalents, depending on location and surroundings. In Scenario 5, with 80 inches of sea level rise and 100-year storm, saltwater can travel inland up to 2 miles, especially in Walker, Stemple, and Americano creeks. This

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

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

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

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

[43] 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. 473 pp. http://sanctuaries.noaa.gov/science/conservation/pdfs/vulnerability-assessment-gfnms.pdf.

could significantly impact the existing freshwater habitat and increase brackish conditions. Creeks that could be affected by the rising Pacific Ocean include:

- Redwood Creek (Muir Beach)
- Green Gulch Creek (Muir Beach)
- Easkoot Creek (Stinson Beach)
- Pine Gulch Creek (Bolinas)
- Walker Creek (Bolinas)
- Lagunitas Creek
- Keys Creek (East Shore)
- Stemple Creek (North of Dillon Beach)
- Americano Creek (North of Dillon Beach).

Wildlife & Endangered Species

Select mammal, fish, invertebrate, and plant species were examined in the *North-central California Coast and Ocean Vulnerability Assessment*. Of the 31 species assessed for climate impacts, twelve are identified as vulnerable to sea level rise. Of these, seven are bird species, four are intertidal invertebrates, and one is an intertidal alga. The two most vulnerable species, Western snowy plover and black oystercatcher, received high scores for sensitivity and moderate adaptive capacity scores. The most vulnerable species are those that use beaches, estuaries, coastal marshes, and rocky intertidal habitat.

Along the coast are several mammal and bird habitats. Mammal haul-outs are widely used by pinnipeds. According to the Department of Fish and Wildlife, the following are recorded locations marine mammal populations inhabit (does not include Federal Park locations):

- Estero Americano
- Tomales Point
- Tomales Bay Northwest
- Sand Point
- Toms Point Sand Bars
- Double Point South
- Bolinas Point
- Duxbury Point
- Bolinas Lagoon

Seabirds are known to frequent a much larger geography, however, live out critical life phases in these locations (does not include Federal Park locations):

- Dillon Beach Rocks
- Tomales Point
- Stinson Beach to Rocky Point
- Gull Rock Area

In addition to the habitats and species assessed in the *North-central California Coast and Ocean Vulnerability Assessment*, several endangered and threatened species, and sensitive habitats warrant mention. The Natural Diversity Database[44] records where species and their habitats are observed. Species potentially located within the geographic extent of scenario 5 are listed in Table 26.

Finally, several marshland plant species are also vulnerable. Bolinas marshes contain populations of rare annual plants, such as cordylanthus and dichondra donnelliana. The vegetation of Tomales marshes is similar to that of Bolinas Lagoon.[45] Tomales tidal marshes also support some of the largest populations of rare tidal marsh plants, such as cordylanthus and owl's-clover.

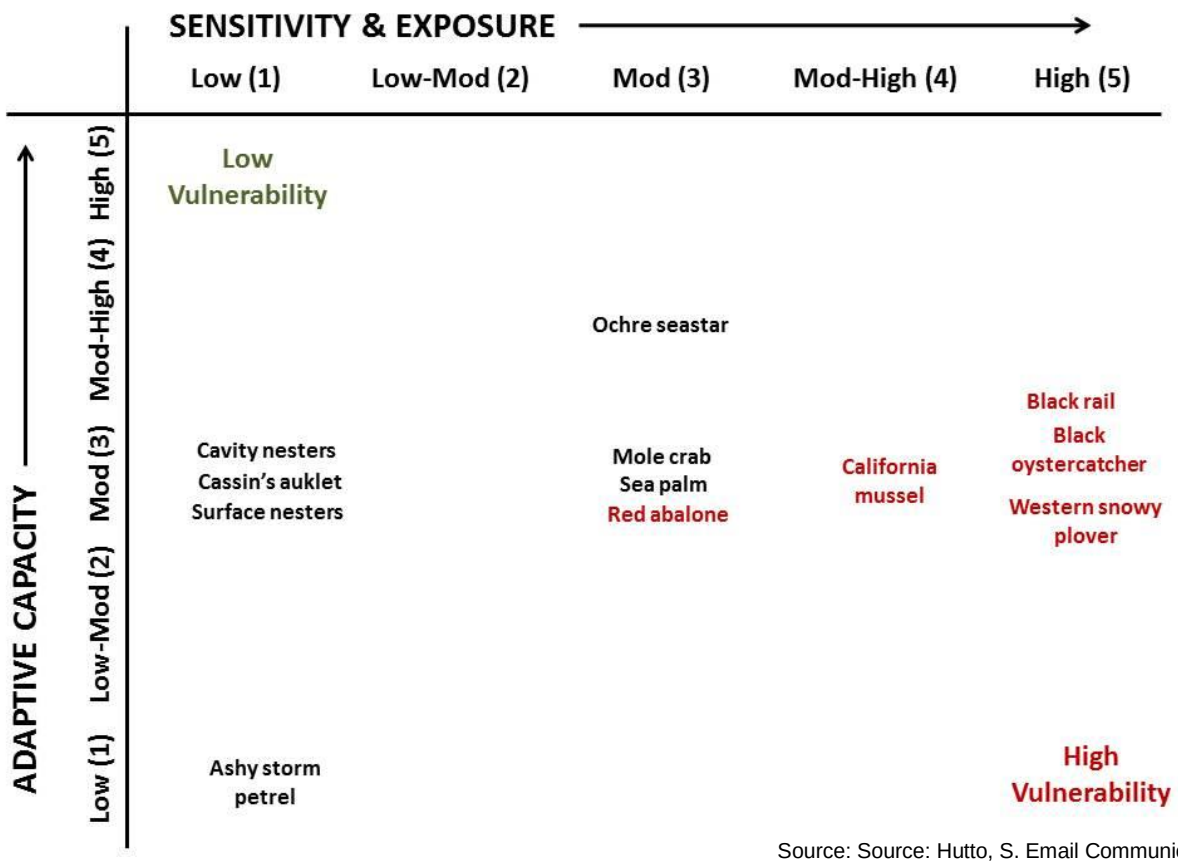
The maps on the following pages show only the available data sources. The *North-central California Coast and Ocean Vulnerability Assessment* does not provide digital geographic information for species and habitat locations, however, where known, this information is provided from other sources.

Black Oyster Catcher. Credit: Drechsler

[44] Natural Diversity Database
[45] USFWS, 2013. Recovery plan for tidal marsh ecosystems of Northern and Central California. US Fish and Wildlife Service, Sacramento, California. Xviii

NATURAL RESOURCES

Figure 6. North-central California Coast and Ocean Species Vulnerable to Sea Level Rise



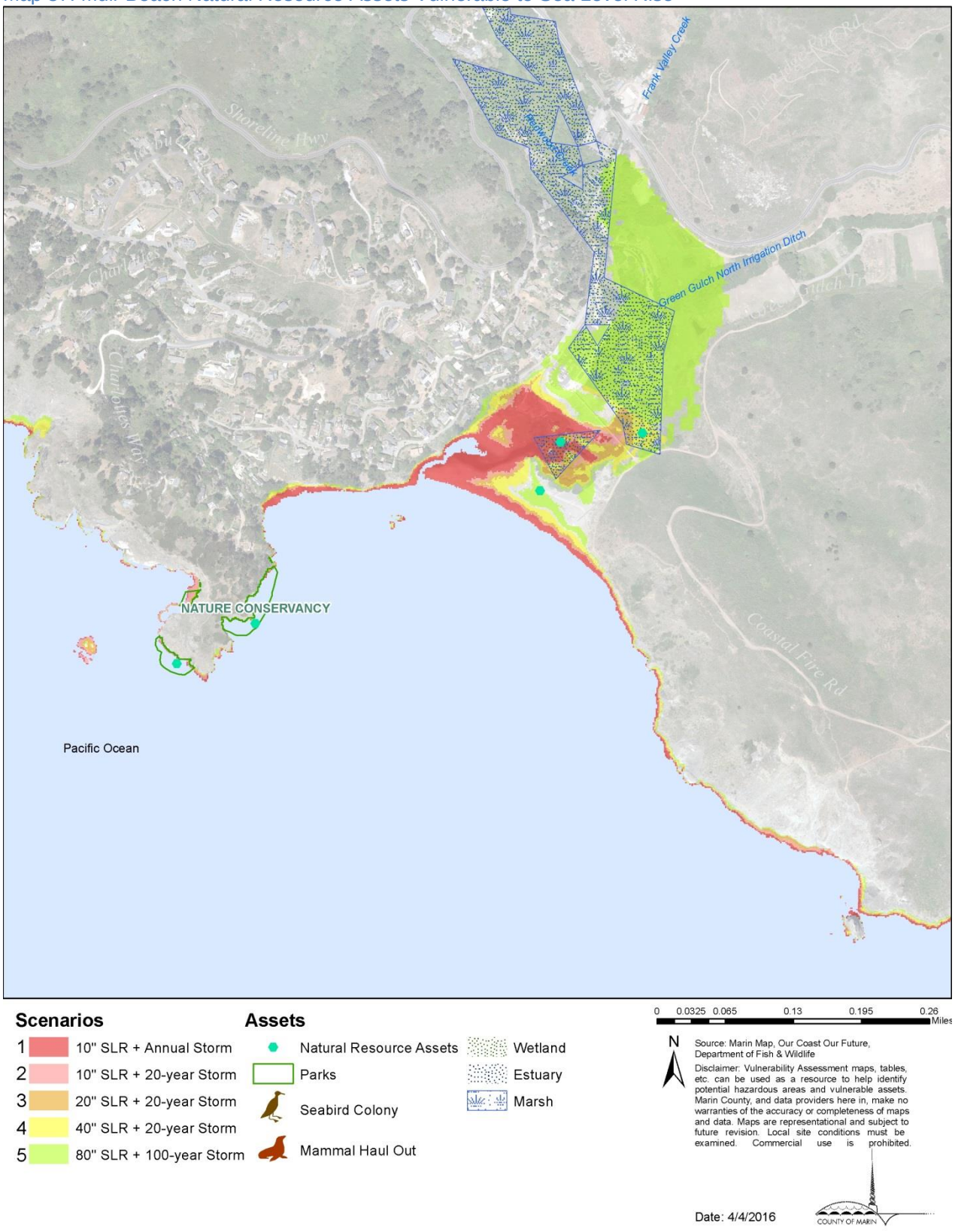
Source: Source: Hutto, S. Email Communication. 2015

Table 26. Threatened and Endangered Species Exposed to Sea Level Rise-Scenario 5

Endangered	Threatened	Candidate
BIRDS • California clapper rail **PLANTS** • Baker's larkspur • Beach layia • Golden larkspur • Showy rancheria clover • Sonoma shortawn foxtail • Sonoma spineflower • Tiburon paintbrush • Tidestrom's lupine **INSECTS** • San Bruno elfin butterfly **FISH/CRUSTACEAN** • California freshwater shrimp • coho salmon • tidewater goby	**BIRDS** • Western snowy plover **AMPHIBIAN** • California red-legged frog **FISH** • Steelhead trout	**FISH** • Longfin smelt

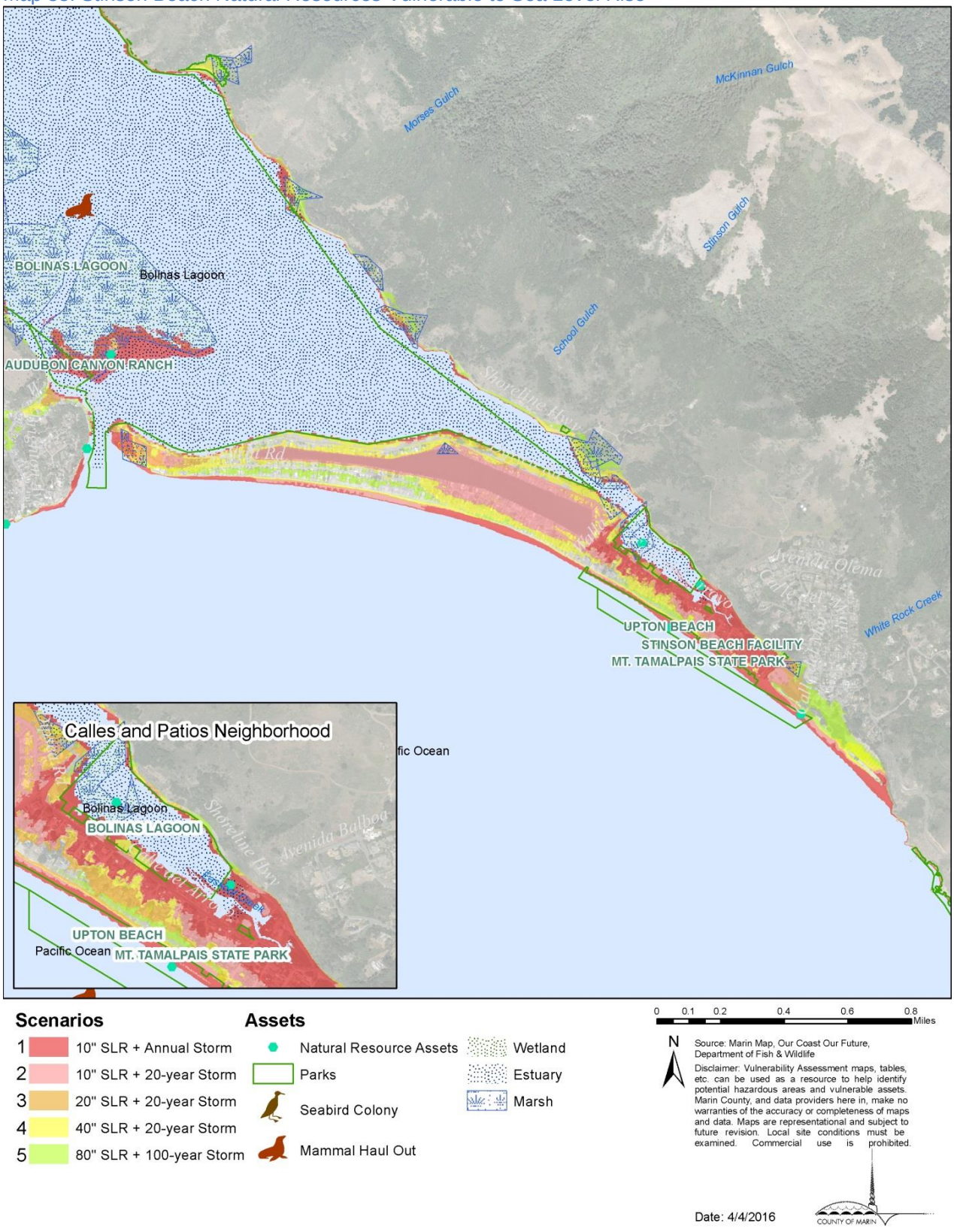
NATURAL RESOURCES

Map 37. Muir Beach Natural Resource Assets Vulnerable to Sea Level Rise



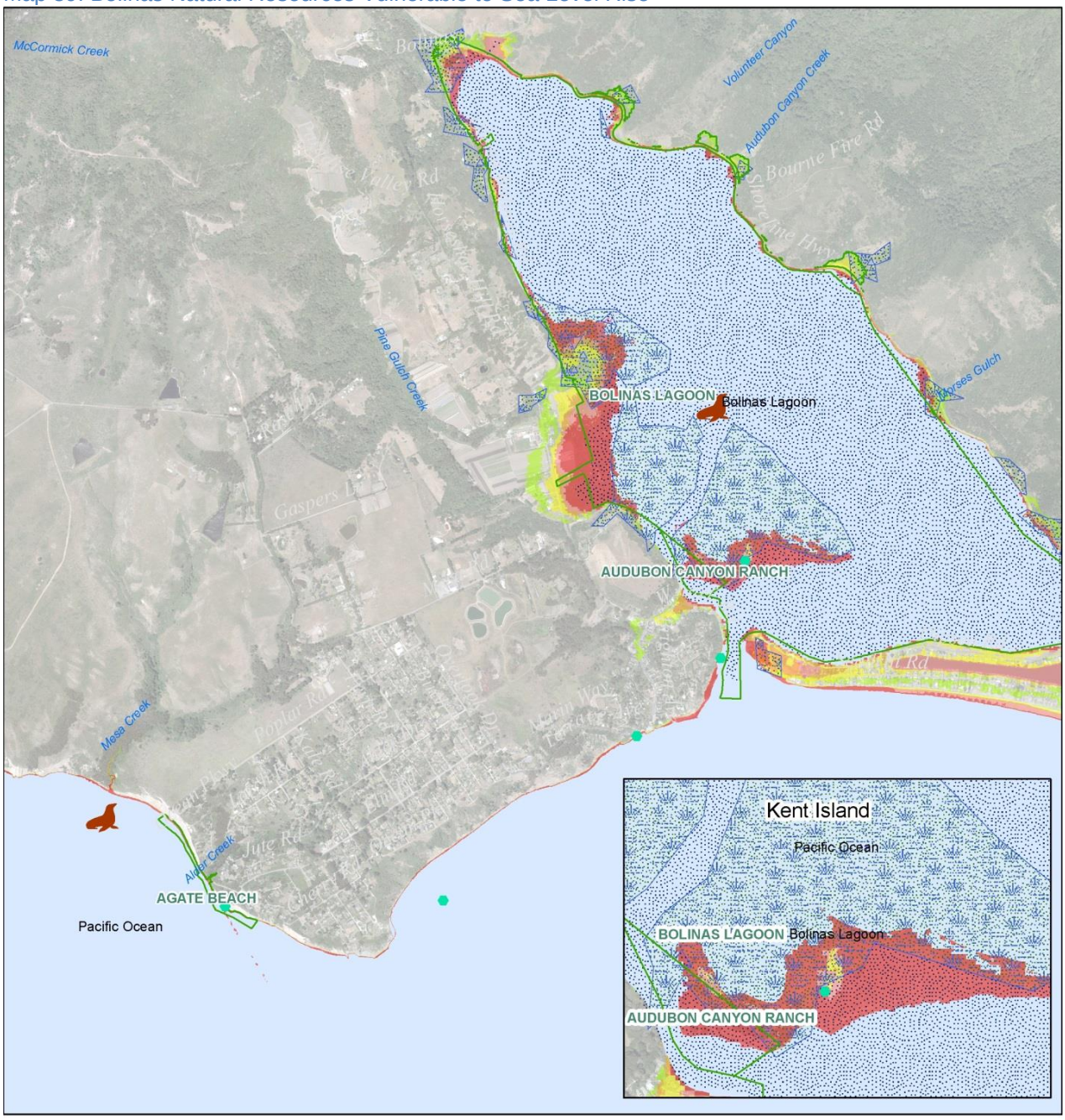
NATURAL RESOURCES

Map 38. Stinson Beach Natural Resources Vulnerable to Sea Level Rise



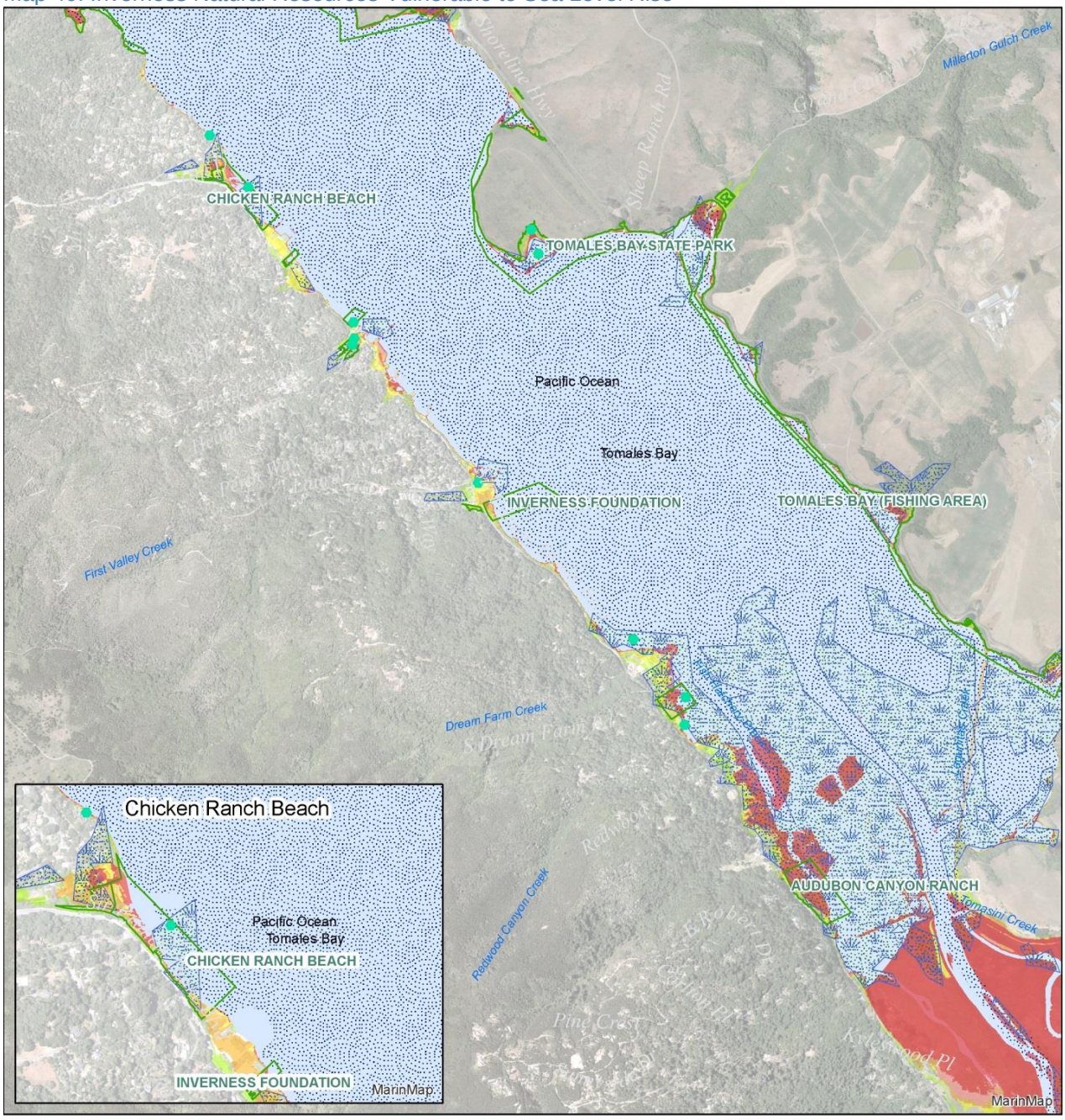
NATURAL RESOURCES

Map 39. Bolinas Natural Resources Vulnerable to Sea Level Rise



NATURAL RESOURCES

Map 40. Inverness Natural Resources 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

N

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

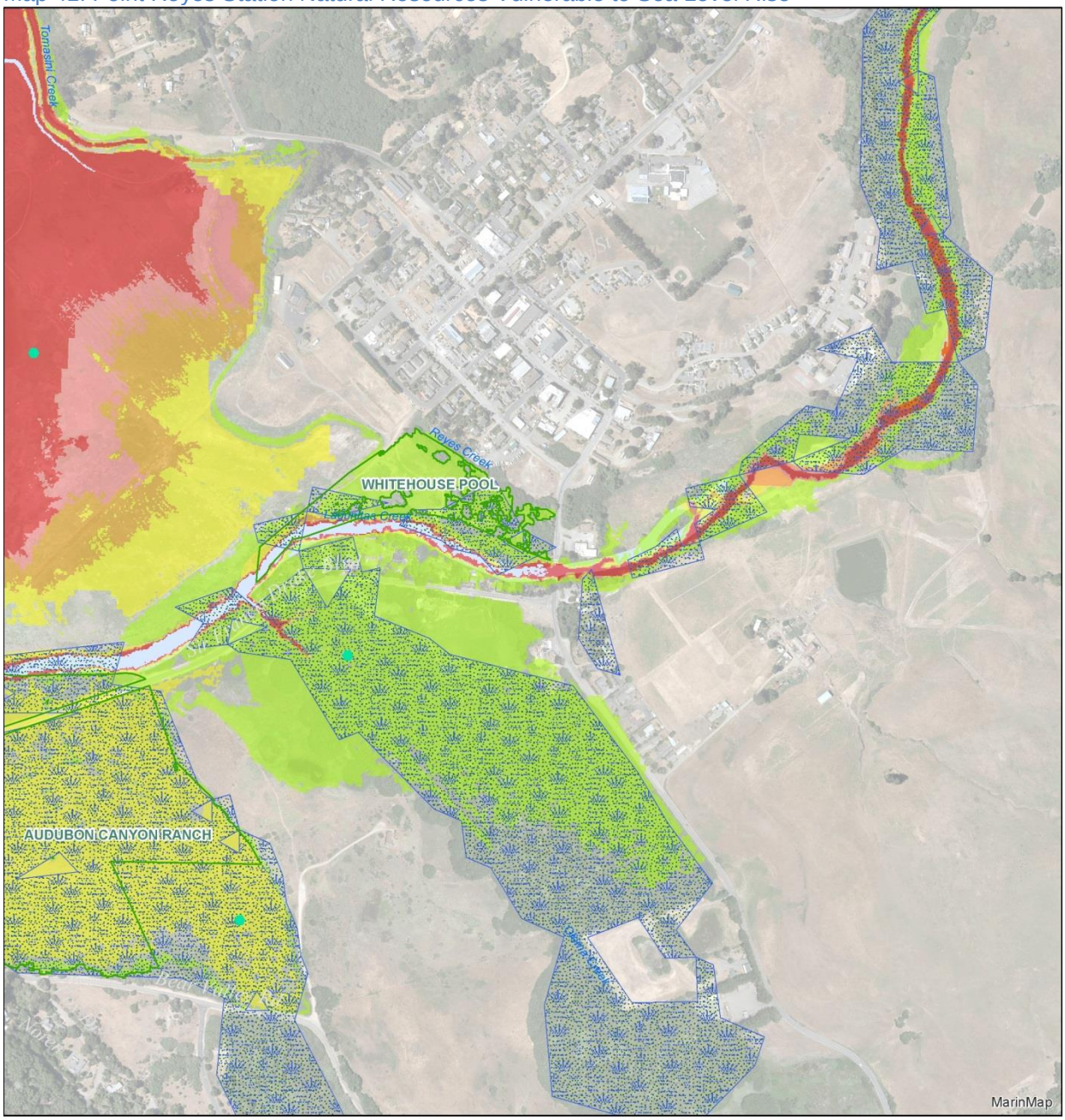
Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data providers here in, make no warranties of the accuracy or completeness of maps and data. Maps are representational and subject to future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

Date: 4/4/2016

COUNTY OF MARIN

NATURAL RESOURCES

Map 41. Point Reyes Station Natural Resources 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

N

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.

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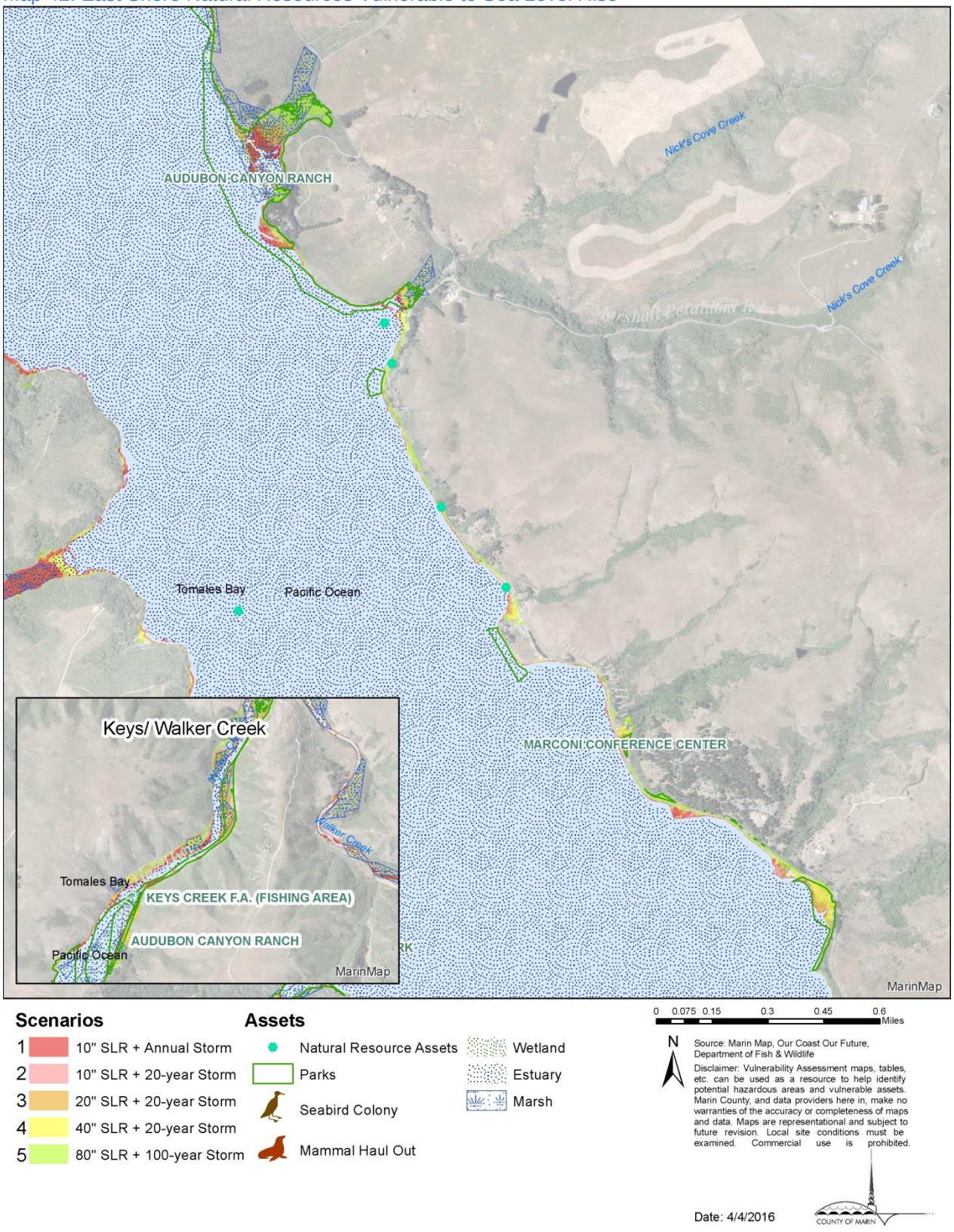
COUNTY OF MARIN

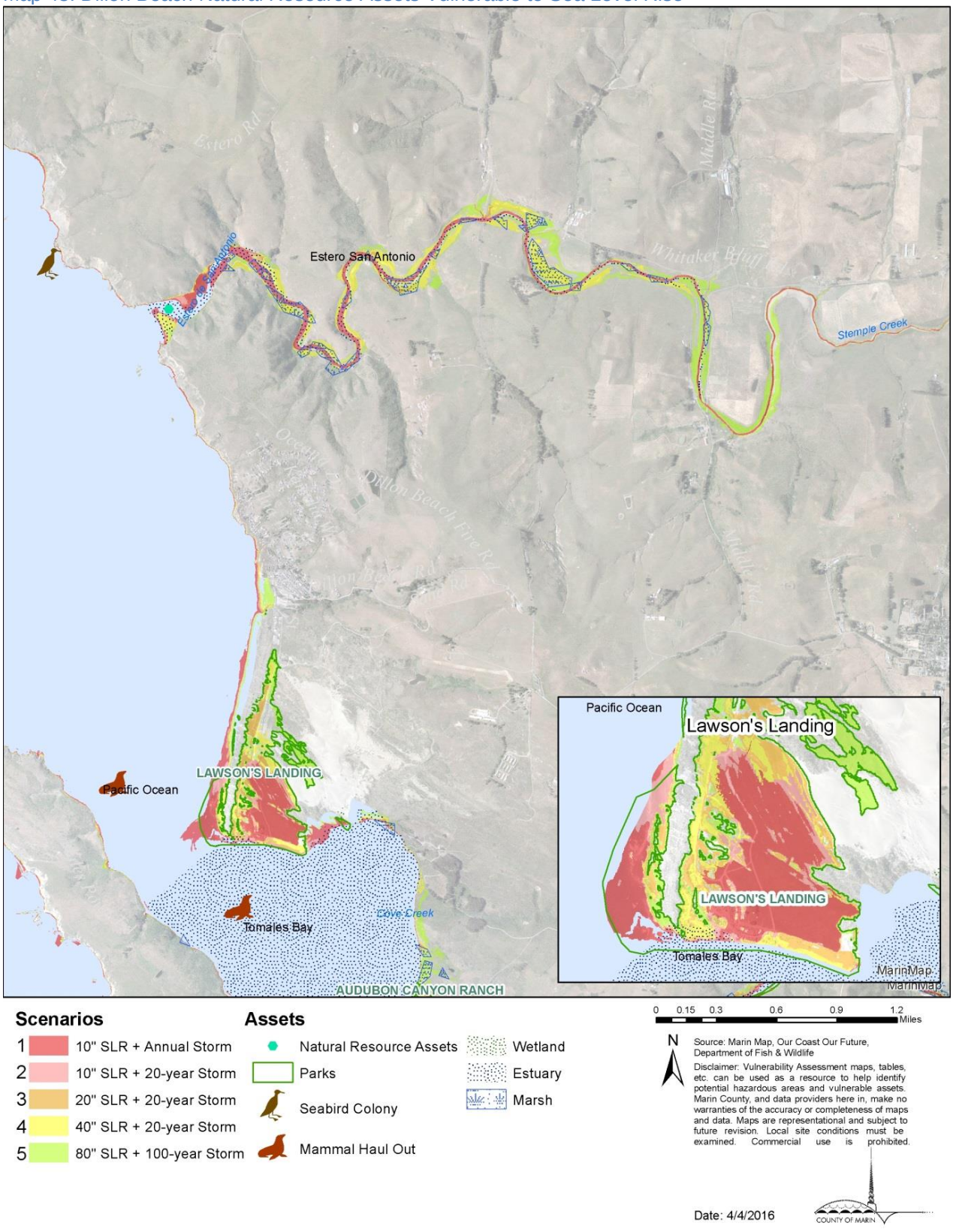
NATURAL RESOURCES

Map 42. East Shore Natural Resources Vulnerable to Sea Level Rise



NATURAL RESOURCES

Map 43. 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

0 0.15 0.3 0.6 0.9 1.2 Miles

N

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

COUNTY OF MARIN

NATURAL RESOURCES

Existing Policies

Protecting Marin County's natural environment is an overarching goal of Marin County. The Marin County Draft Local Coastal Program (DLCP) guides protecting natural resources and sensitive habitats when land is developed, preserving public access to the coast, and maintaining and enhancing coastal resources.

An environmentally sensitive habitat area (ESHA) is any area where plant or animal life, or their habitats, are either rare, of special nature, or perform a special role in an ecosystem that could be easily disturbed or degraded by human activities. ESHA consists of four general categories: wetlands, streams, riparian vegetation, and terrestrial ecosystems (dunes, roosting and nesting sites). Buffers are established to protect ESHAs from development impacts, and a coastal permit is required for the removal of major vegetation (not for agricultural purposes). Relevant natural resource policies from the Marin County DLCP are provided in Figure 7.

Other Considerations

The coast's natural resources are among Marin's greatest assets. With a majority of coastal land preserved in national, state, county parks, and other easements, these assets are a major draw for visitors from around the world. Damage and destruction to these assets could have serious consequences across all aspects of coastal life in Marin.

Economic

Active and passive recreation on western Marin's miles of beaches, trails, and roads are critical economic contributors to Marin Coast and County residents (see the Recreation Profile for more information). Wildlife viewing is a major draw to the region and the inability to do so could significantly reduce tourism. At the same time, the public values recreation and tourism greatly, and will likely adjust the location of recreation and tourism activities.

The loss of fishing and aquaculture commercial trade could have far reaching economic impacts. Employees, restaurants near and far, shipping companies, and other commercial sectors would bear the loss. For more information on these activities see the Working Lands profile.

Estuaries, beaches, bluffs, marine wetlands, and marshes also provide ecosystem services as buffers protecting development from waves and floods. Their loss could increase the cost of maintaining flood protection.

Figure 7. Marin County DLCP Natural Resource Policies

C-BIO-5 Ecological Restoration. Encourage restoring, enhancing, and creating ESHAs, and streamline regulatory processes.

C-BIO-7 Coastal Dunes. Prohibit development and non-emergency motor vehicles in coastal dunes.

C-BIO-8 Preventing Beach Encroachment. Where most lots are developed, no part of a proposed new development (other than an allowable shoreline protective device), shall be built farther onto a beachfront than the most seaward portions of the adjacent structures. Enclosed living space in a new unit or addition shall not extend farther seaward than a second line drawn between the most seaward portions of the enclosed living space of the adjacent structures.

C-BIO-9 Stinson Beach Dune and Beach Areas. Prohibit development west of Mira Vista, including fences, signs, or other structures. Pursue land trade between the lots seaward of Mira Vista and the street right-of-way. New development on shorefront lots in Stinson Beach consistent with LUP Policy C-BIO-7 (Coastal Dunes), where no dunes are evident, shall be set back behind the first line of terrestrial vegetation per Policy C-EH-2, avoid the need for protective works, protect sandy beach habitat, and provide a buffer area between private and public use areas.

C-BIO-14 Wetlands. Preserve and maintain wetlands.

C-BIO-15 Diking, Filling, Draining and Dredging. Strictly limited in coastal waters, wetlands, and estuaries.

C-BIO-29 Marin County Parks. Support Marin County Parks environmental conservation, land and easement acquisition, and habitat restoration efforts.

Reflects CCC Suggested Modifications to DLCP Amendment. ***Subject to change.***

NATURAL RESOURCES

Environmental

The complete or partial loss of tidal or managed marsh systems will increase the reliance on structural shoreline protection, and will place shoreline residents at a greater risk of flooding. Multiple utilities, including a telecommunications cable under the Bolinas Lagoon, transect these resources and habitats. Damage to these structures could damage the habitat and relocating them could have serious temporary environmental impacts. Finally, efforts to protect vulnerable built assets with new coastal armoring could have detrimental impacts on coastal habitats by reducing their ability to adapt.

Social Equity

Coastal beaches, estuaries, wetlands, and marshes offer opportunities to view wildlife, provide access to the shoreline, and offer scenic and aesthetic benefits. The loss of these functions could negatively impact the people that use these areas for recreation, and could ultimately diminish the desirability of living in these coastal communities. As preparations are made to protect existing areas, or create new public areas, expenses could increase, therefore increasing or requiring entrance fees. These added costs could make visiting federal and state parks cost prohibitive for those of lesser means.

Management

Protecting natural resources and wildlife can be highly controversial. For example, protecting breeding areas may limit public access or economic activity. Limited financial resources could reduce priorities for wildlife protection, park maintenance, and investment. Developing and implementing large projects will require multiple agencies and private partners to coordinate and contribute financially.

RECREATION

Asset Profile: Recreation & Public Access

Marin County is treasured for its immense recreation opportunities. Vulnerable recreational assets are beaches and surfing locations in Stinson Beach, Bolinas, and Inverness where little room for beach retreat exisits. Several other recreational activities, such as hiking trails, wildlife viewing, and kayaking may simply shift as sea level rises, or require minimal management actions. However, ensuring continued safe public access to existing recreation areas could be a challenge.

Most exposed recreation areas are managed by county, state, and federal agencies for public use. Major examples include: Golden Gate National Recreation Area (including the Marin Headlands, Muir Beach, and Stinson Beach), Mt. Tamalpais State Park, Point Reyes National Seashore, Tomales Bay State Park, and Tomales Bay Weltand Reserve. A few are held by non-profit organizations that require appointments.

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

- Sea level rise may push coastal recreation opportunities inland where possible. Where not possible, the asset could be lost.
- Access to recreational areas may be impeded as Shoreline Highway, local roads, and trails flood and erode.
- Tour buses could be impeded from visiting the area.
- Visitor serving businesses, such as restaurants, hotels and inns, boat rentals, oyster farms, and others, could be exposed to sea level rise and susceptible to storm damage.

Table 27 lists some of the potentially vulnerable recreational assets in the study area. This list measures onset and tidal mean higher high water (MHHW) and extreme event flood depths; however many recreational assets are shoreline based or water features. This list is not exhaustive of all the recreational assets that could be exposed to sea level rise and storm impacts in the study area.

IMPACTS AT-A-GLANCE

Thousands of residents, millions of visitors

Site specific

8 Beaches

20 Parks

Property Owners
CSP
County Parks & Roads
Caltrans

Beach Access during King Tide. Credit: Rapapport

RECREATION

Table 27. Recreation Assets Ranked by Onset and Flood Depth (feet and inches)

Location	Asset (not exhaustive)	Tidal & Extreme Event Flooding Depth Estimates (Underlined values indicate tidal flooding at mean higher high water (MHHW) based on one geographic point placed at the landward limit of the first scenario where it overlaps the asset. Values not underlined represent temporary flooding. Groups of buildings are ranked by maximum flood depth. Roads received a high and low value along the line segment.)					Vulnerability (TF: Temp. Flooding; 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	
Stinson Beach	Calle del Arroyo	7"-6'11"	3"-6'8"	8"-9'6"	2'5"-12'2"	5'11"-13'9"	I, TF
Stinson Beach	Upton Beach	4'7"	6'2"	7'5"	9'8"	14'9"	I, E
Stinson Beach	Patios and Calles Buildings	10"+1"4"	10"+6"3"	1'6"+ 7'	4'9"+5'10"	6'5"+ 6'8"	I, WT, WS, TF
Inverness	Inverness Yacht Club	3'2"	4'1"	4'11"	6'10"	10'1"	I, WS, HW
Inverness	Brock Schreiber Boathouse	2'7"	3'6"	4'	5'10"	9'2"	I, E
East Shore	Walker Creek Access Point	2'4"	3'3"	4'2"	6'1"	9'3"	I
East Shore	Brighton Beach	2'2"	3'5"	4'11"	6'	9'11"	E, WS
East Shore	Livermore Marsh Cypress Grove	2'1"	3'1"	3'11"	5'10"	9'2"	I
East Shore	Hog Island Oyster	2'1"	2'1"	2'10"	4'10"	8'1"	I
Inverness	Martinelli Park	1'1"	2'	2'2"	4'1"	7'3"	I, E
Bolinas	Downtown Buildings	1'8"+1'5"	1'8"+2'2"	2'7"+2'	4'5"+2'1'	7'9"+1'7"	I, WT, WS, TF
Inverness	Shoreline Buildings	2'+1'2"	2'+2'	2'10"+2	4'8"+2'	8'+8'8"	I, WT, WS, TF
East Shore	Shoreline Buildings	1'9"+1'	1'9"+1'11"'	2'6"+2'	4'3"+2'2"	7'8"+2'2"'	I, WT, WS, TF
Bolinas	Wharf Road	6"-2'1"	3"-2'4"	2"-2'9"	1"-5'4"	10"-7'4"	I, TF
East Shore	Shoreline Hwy	3"-1'7"	3"-2'4"	3"-3'	2'-4'6"	6"-8'1"	I, TF
Bolinas	Agate & Brighton Beaches	2'1"	1'11"	2'8"	4'8"	9'3"	I
Stinson Beach to Bolinas	Shoreline Hwy	0"- 1'8"	0"-2'3"	0"-3'1"	0.4"-4'10"	0.4"-8'6"	I, TF
East Shore	Marconi Boat Launch	1'1"	2'	2'11"	4'10"	8'2"	I
Inverness	Tomales Bay State Park	10"	1'10"	2'8"	4'7"	7'10"	I, HS
East Shore	Tony's Restaurant	8"	1'8"	2'6"	4'5"	7'9"	I
East Shore	Tomales Bay Oyster Company	8"	1'5"	2'3"	4'1"	7'5"	I, TF
Stinson Beach	Walla Vista Walkway	3"	1'8"	2'	4'4"	10'4"	I, E
Dillon Beach	Lawson's Landing Facilities	2"	1'1"	2'11"	3'10"	7'3"	I, E, WS, HW, HS
Inverness	Sir Francis Drake Blvd.			1"-3'6"	1"-4'6"	1"-7'10"	I, TF, WS
Bolinas	Olema-Bolinas Road			2'8"	4"-4'4"	2"-7'11"	I, TF

RECREATION

Location	Asset (not exhaustive)	Tidal & Extreme Event Flooding Depth Estimates (Underlined values indicate tidal flooding at mean higher high water (MHHW) based on one geographic point placed at the landward limit of the first scenario where it overlaps the asset. Values not underlined represent temporary flooding. Groups of buildings are ranked by maximum flood depth. Roads received a high and low value along the line segment.)					Vulnerability TF: Temp. Flooding; 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	
Pt. Reyes Station	White House Pool/Trail			2'5"	2'3"	5'11"	I
Inverness	Inverness Store			2'5	4'4"	7'6"	TF, I, WT
Bolinas	Bolinas Super Market			8"	2'6"	6'1"	I, E, SI
Pt. Reyes Station to Inverness	Shoreline Hwy			6"	3"-1'5"	1'9"-9'7"	I, TF
Inverness	Dana Marsh & Beach Access				3'	6'2"	I, E, SI, HS
Inverness	Motel Inverness				2'9"	5'10"	I, WS, HW
East Shore	Nick's Cove				2'6"	5'10"	
East Shore	Millerton Point				2'5"	5'8"	I, E
Inverness	Shell Beach Tomales Bay SP				5"	3'4"	TF, I, WT
Stinson Beach	CA Coastal Trail				0.4"	1'3	TF, E
Bolinas	Bob Stewart Trail					4'8"	I, TF
Inverness	Tomales Bay Resort					4'	TF
East Shore	Shoreline Hwy					3'5"	I, E
Bolinas	Bolinas People's Store					3'	I, TF
Bolinas	Bolinas Post Office					2'9	TF, I
Point Reyes Station	Olema Marsh Trail					2'9"	I
Dillon Beach	Dillon Beach Resort Parking Lot					1'6"	I
Dillon Beach (north)	Stemple Creek Recreation Area	X	X	X	X	X	HS
Stinson Beach / Bolinas	Bolinas Lagoon	water resource					HS
Inverness / East Shore	Tomales Bay	water resource					HS
North of Dillon Beach	Estero Americano	water resource					HS

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

RECREATION

The *Climate Change Vulnerability Assessment for the North-central California Coast and Ocean*, concludes that beaches and estuaries are vulnerable to sea level rise and erosion.[46] The sections below summarize the report's findings.

Beaches

Beaches are used for wildlife viewing, sunbathing, and accessing the ocean waters for swimming, surfing, kayaking, exercising, and fishing. Sea level rise could inundate existing beaches and increase rates of shoreline erosion. This could potentially force beach recreation opportunities inland where beaches are not impeded by development, roads, or bluffs.[47] Beaches commonly used for recreation that could be vulnerable to sea level rise and storms include:

- Nude Beach (South of Stinson Beach),
- Brighton Beach (Bolinas),
- Agate Beach (Bolinas),
- Stinson Beach/ Upton Beach,
- Heart's Desire Beach (Inverness),
- Chicken Ranch Beach (Inverness),
- Shell Beach (Inverness),
- Lawson's Landing (Dillon Beach), and
- Dillon Beach.

For more information on beaches, including maps showing potential future beach widths at select locations, see the Natural Resources Profile.

Estuaries, Wetlands, & Marshes

Tomales Bay and Bolinas Lagoon are vulnerable. Primary recreational activities in estuarine areas are hiking, kayaking, paddle boarding, boating, bird watching, fishing/crabbing, swimming, and other passive forms of recreation. Without a comparable increase in land elevation from sediment delivery, these coastal recreation areas could flood.[48,49] Like beaches, estuaries can be prevented from moving landward when bordering development or cliffs. Vulnerable Marin coast estuaries, wetlands, and marshes include:

- Bolinas Lagoon,
- Giacomini Wetlands (may have room to retreat landward),
- Olema Marsh (may have room to retreat landward),
- Tomales Bay (may have room to retreat landward),
- Shields Salt Marsh,
- Estero San Antonio (may have room to retreat landward), and
- Estero Americano (may have room to retreat landward).

Brighton Beach, Bolinas. Credit: CDA

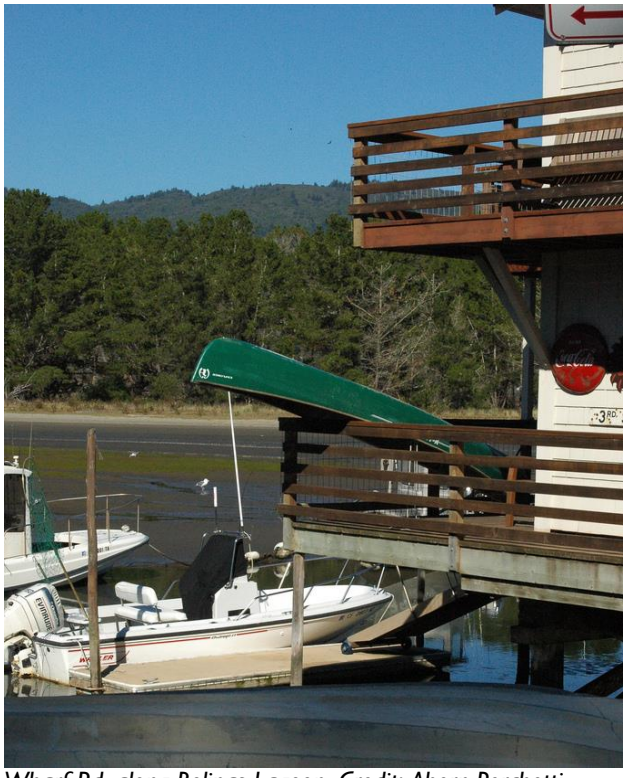
46 Hutto, S.V., K.D. Higgason, J.M. Kershner, W.A. Reynier, D.S. Gregg. 2015. *Climate Change Vulnerability Assessment for the North-central California Coast and Ocean*. Marine Sanctuaries Conservation Series ONMS-15-02. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Office of National Marine Sanctuaries, Silver Spring, MD. 473 pp.

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

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

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

RECREATION



Wharf Rd. along Bolinas Lagoon. Credit: Ahern-Perchetti

Freshwater Resources

In scenario 5, with 80 inches of sea level rise and 100-year storm, saltwater can travel inland up to two miles, especially in Walker, Stemple, and Americano creeks. This could significantly alter the habitat and wildlife viewing opportunities. Creeks with recreational opportunities that could be impacted by sea level rise include:

- Redwood Creek (Muir Beach)
- Pine Gulch Creek (Bolinas)
- Walker Creek (Bolinas)
- Lagunitas River (Point Reyes Station)
- Keys Creek (East Shore)
- Stemple Creek (North of Dillon Beach), and
- Americano Creek (North of Dillon Beach)

Public Access

The Coastal and Bob Stewart trail, Olema Marsh Trail, White House Pool/Trail, Walker Creek Access Point, and several locations at Tomales State Park and a few in Stinson Beach and Bolinas are vulnerable in the medium- and long-terms. In general, exposed parks in the study area include:

- Agate Beach (Bolinas)
- Audubon Canyon Ranch sites (private)
- Bolinas Lagoon
- Chicken Ranch Beach (Inverness)
- Golden Gate National Recreational Area (federal)
- Inverness Foundation Park
- Keys Creek Fishing Area (East Shore)
- Lawson's Landing (private)
- Marconi Boat Launch (East Shore)
- Martinelli Park
- Miller Park Boat Launch
- Mt. Tamalpais State Park
- Nature Conservancy (private)
- Point Reyes National Seashore (federal)
- Stinson Beach Facility
- Tomales Bay Fishing Area
- Tomales Bay State Park (w/Millerton Point)
- Upton Beach
- Walker Creek Marsh, and
- Whitehouse Pool

The National Park Service released *Adapting to Climate Change in Coastal Parks: Estimating the Exposure of Park Assets to 1 m of Sea-Level Rise*.[50] Note that the National Parks report uses a different methodology than this Assessment to determine vulnerability. While outside of the study area for this report, these federal park lands draw tourists and residents to Marin's Coast. Report highlights for Point Reyes National Seashore reveal that high sea level exposure could impact 614 national park assets (96 percent), including buildings and other facilities valuing $704,396,200. High exposure to sea level rise could also impact 43 assets valued at $57,870,724 in the Marin County portion of the Golden Gate National Recreation Area, for a combined value of nearly $800 million.

Private Recreation

Several private entities support recreation activities on the coast that could be vulnerable. These include hotels, boat suppliers, surfing schools, restaurants, markets, tours, and other activities.

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

- Inverness Yacht Club
- Tomales Bay Resort
- Motel Inverness
- Lawson's Landing Fishing Pier, Marina, and Boat House
- Lawson's Landing Marina
- Hog Island Oyster
- Nick's Cove
- Marshall Boat Works
- Tony's Restaurant
- Love Athletic Field and Venue
- Brock Schreiber Boathouse
- Bolinas Super Market
- Bolinas People's Store
- Inverness Store
- Tomales Bay Oyster Co.
- West Marin Food & Farm Tours, and
- Dillon Beach Resort.

Existing Policies

The Draft Local Coastal Program (DLCP) seeks to preserve recreational opportunities for both coastal residents and visitors, and to maintain and expand opportunities for public access. The Coastal Commission retains Coastal Development Permit (CDP) authority over tidelands (below mean high tide), submerged lands, and public trust lands. The Coastal Open Area (C-OA) district provides for open space, outdoor recreation, and other open lands, including areas suited for park and recreational purposes, access to beaches, and areas that link major recreation areas.

Public Trust Lands

Public trust lands include submerged land and tidelands below the mean high tide level. As sea level rise advances, the boundary of public trust lands will also move inland. The California Coastal Act provides for the protection and mitigation of coastal hazards for existing and new development. However, some shoreline protection measures, such as coastal armoring, may have significant impacts to public trust resources, including public beach and shoreline access. If coastal armoring impedes or eliminates coastal access or recreational opportunities, the installation and ongoing maintenance of the armoring could constitute a public trust violation. [51]

A number of court cases throughout the U.S. are indicative of the tension between the right of the public to use open space and the right of homeowners to their property. To make public beaches accessible, perpendicular access is needed for people to get to the shore. Home owners and public agencies sometimes come into conflict over whether an access way is open for public use.[52]

The *California Coastal Commission Sea Level Rise Policy Guidance: Interpretive Guidelines for addressing Sea Level Rise in Local Coastal Programs and Coastal Development*[53] encourages local governments to, "recognize that sea level rise will cause the public trust boundary to move inland. New shoreline protective devices should not result in the loss of public trust lands." Homes in Stinson Beach and Bolinas are protected by existing shoreline armoring that could eventually impede public access or infringe on public trust lands. In other cases, such as Brighton Beach in Bolinas, sea walls protect the pedestrian access point, armoring can facilitate public access.

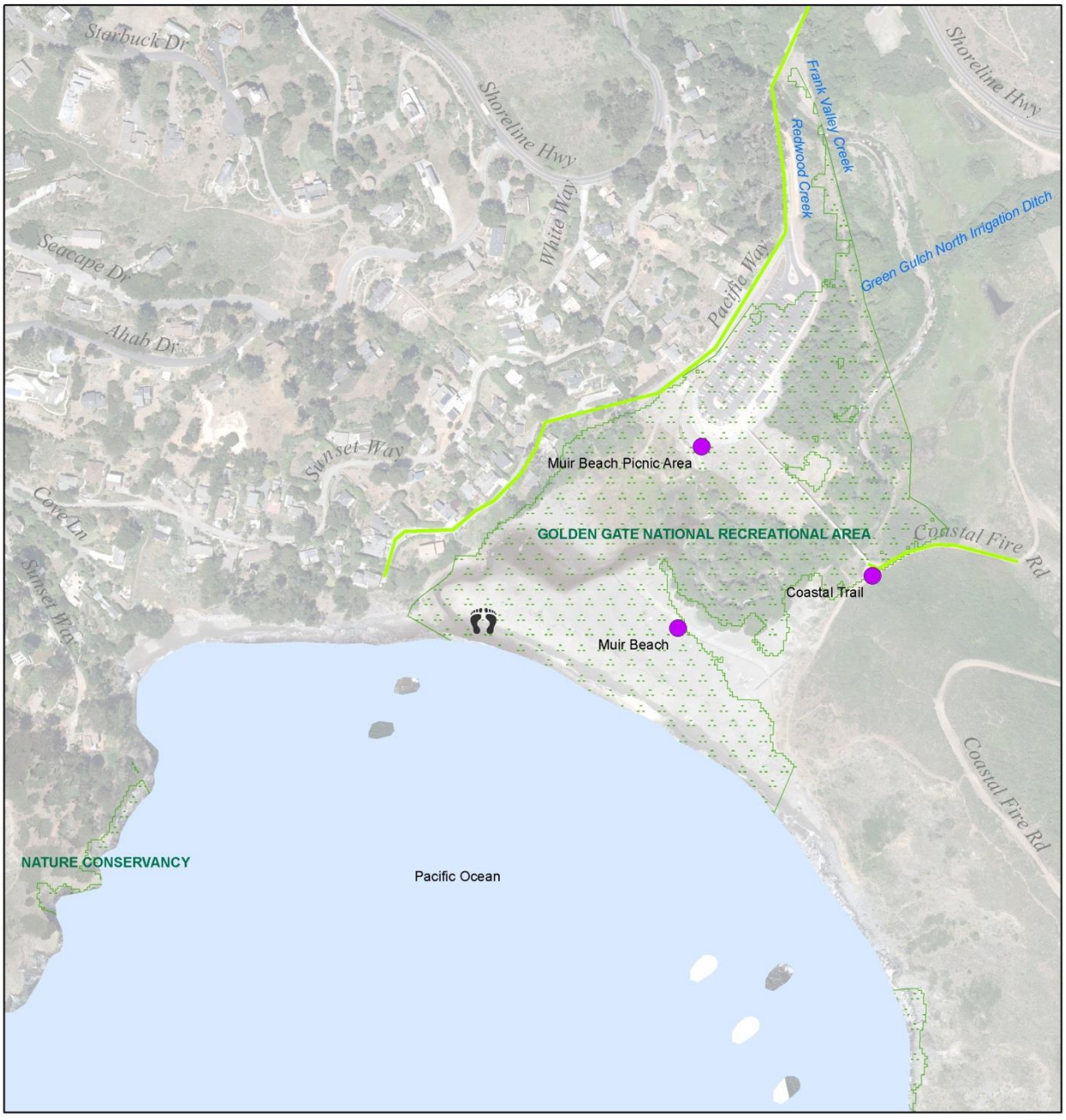
[51] Melius, Molly Loughner and Caldwell, Margaret R. *California Coastal Armoring Report: Managing Coastal Armoring and Climate Change Adaptation in the 21st Century.* Stanford Law School, Environment and Natural Resources Law & Policy Program. 2015.

[52] Boerner, Heather. *A Line in the Sand: What happens when the boundaries between private property and public space get washed away?* American Planning Association, June 2015.

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

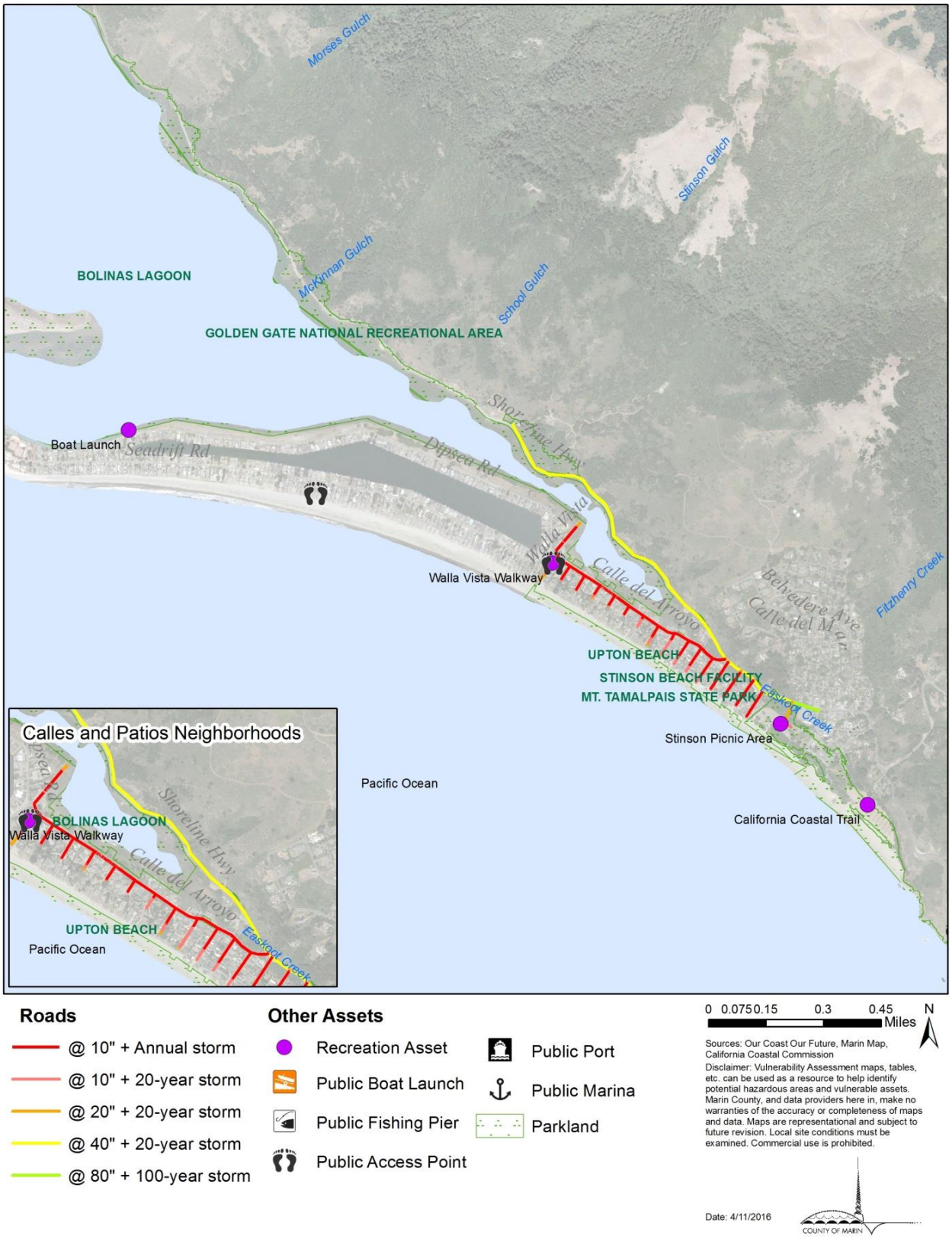
RECREATION

Map 44. Muir Beach Recreation Assets Vulnerable to Sea Level Rise



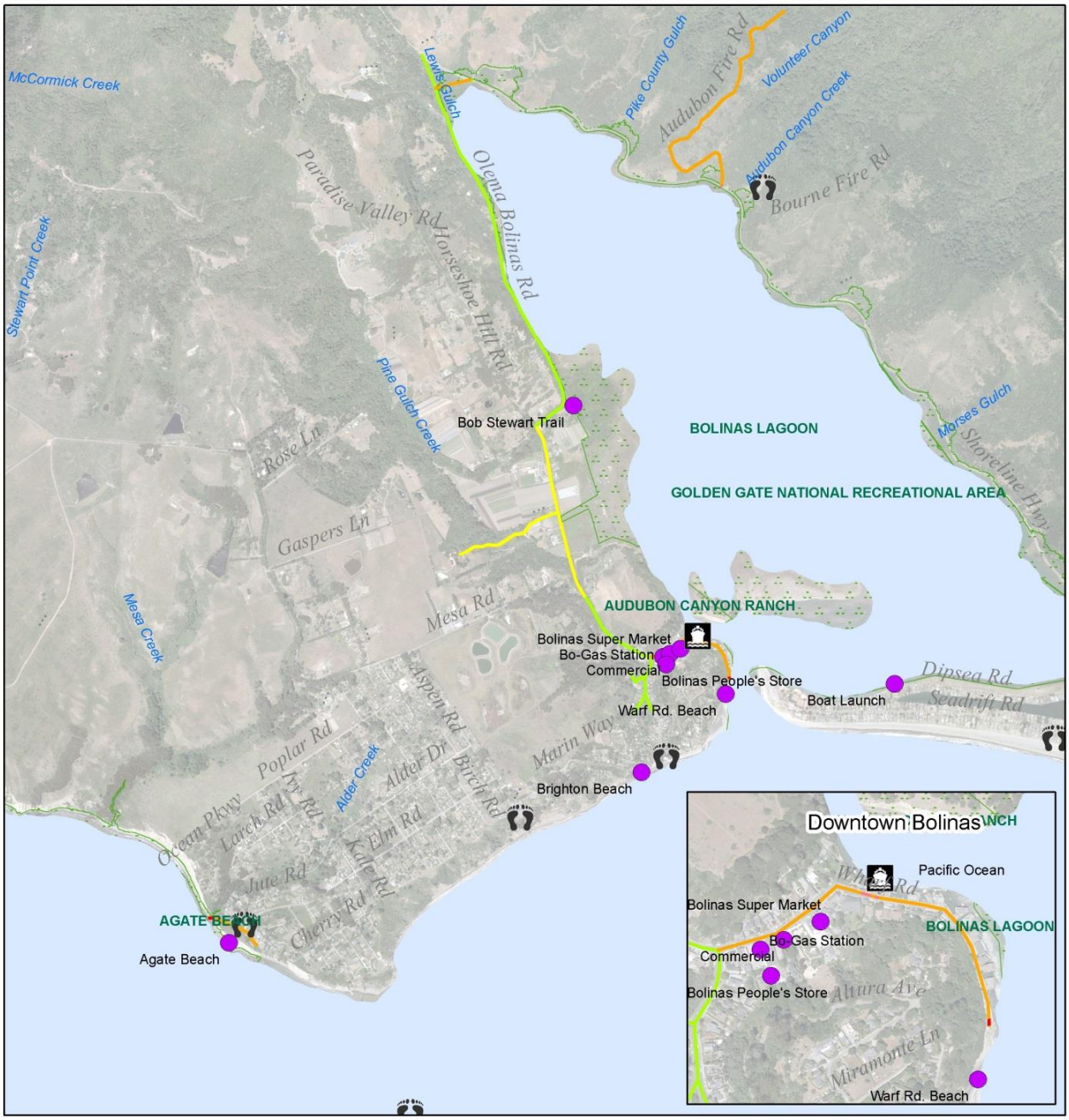
RECREATION

Map 45. Stinson Beach Recreational Assets Vulnerable to Sea Level Rise



RECREATION

Map 46. Bolinas Recreational Assets Vulnerable to Sea Level Rise



Roads

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

Other Assets

- Recreation Asset
- Public Boat Launch
- Public Fishing Pier
- Public Access Point
- Public Port
- Public Marina
- Parkland

0 0.1 0.2 0.4 0.6 Miles N

Sources: Our Coast Our Future, Marin Map, California Coastal Commission

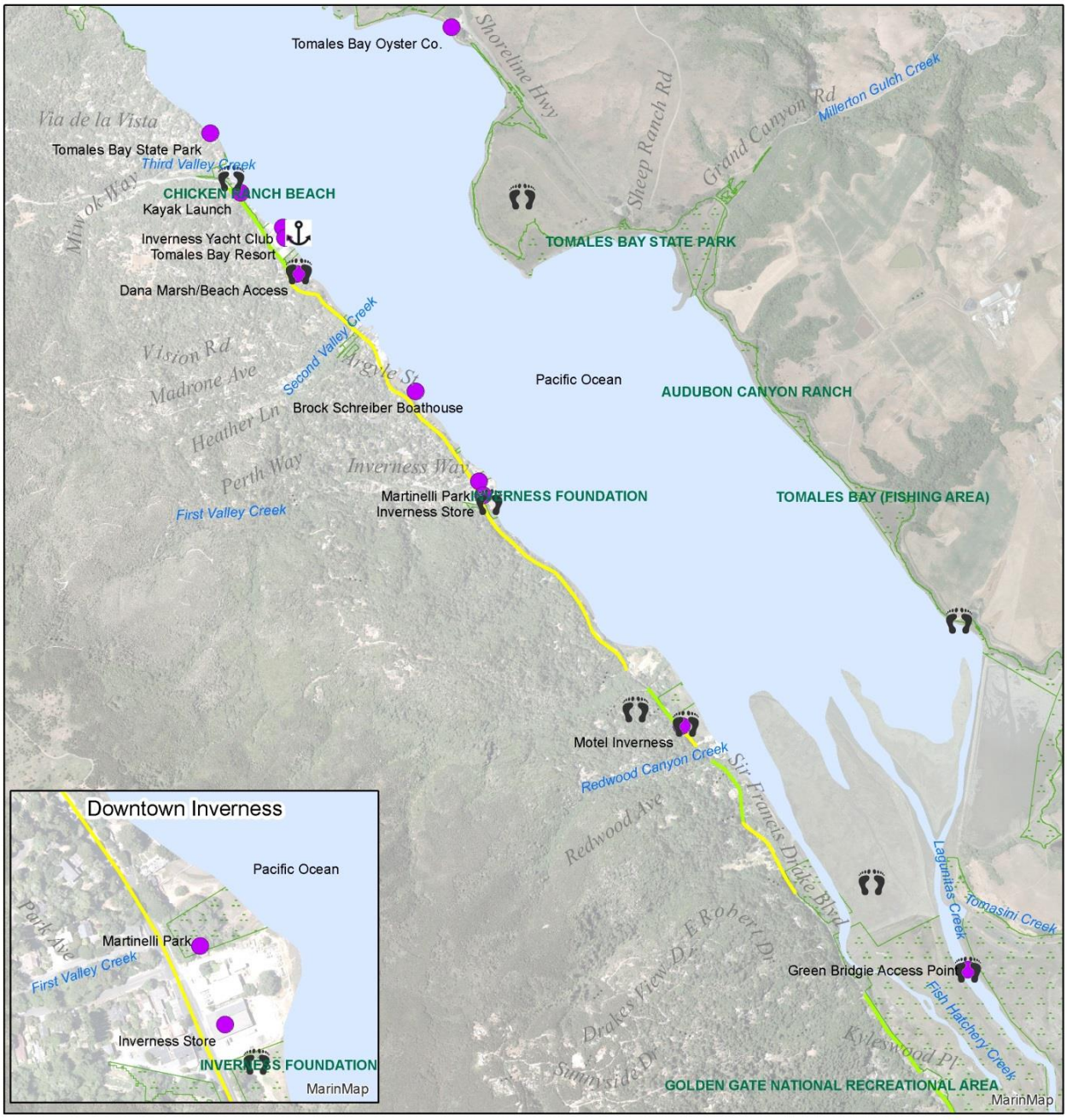
Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data providers here in, make no warranties of the accuracy or completeness of maps and data. Maps are representational and subject to future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

Date: 4/7/2016

COUNTY OF MARIN

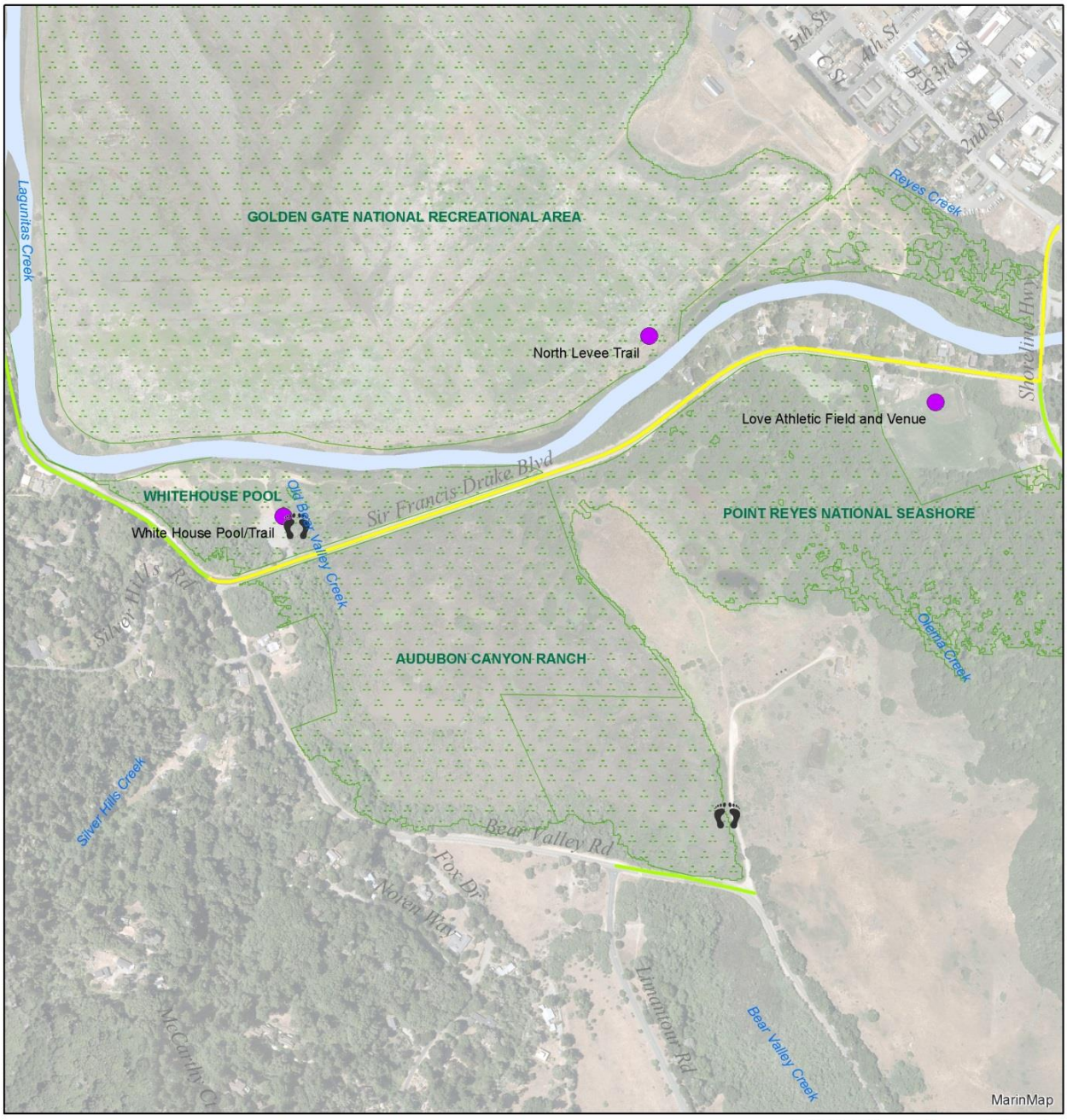
RECREATION

Map 47. Inverness Recreational Assets Vulnerable to Sea Level Rise



RECREATION

Map 48. Point Reyes Vulnerable Recreational Assets



Roads

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

Other Assets

- Recreation Asset
- Public Boat Launch
- Public Fishing Pier
- Public Access Point
- Public Port
- Public Marina
- Parkland

0 0.0275 0.055 0.11 0.165 Miles N

Sources: Our Coast Our Future, Marin Map, California Coastal Commission

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Date: 4/7/2016

COUNTY OF MARIN

RECREATION

Map 49. East Shore Recreational Assets Vulnerable to Sea Level Rise

Roads

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

Other Assets

- Recreation Asset
- Public Boat Launch
- Public Fishing Pier
- Public Access Point
- Public Port
- Public Marina
- Parkland

0 0.0750.15 0.3 0.45 Miles

N

Sources: Our Coast Our Future, Marin Map, California Coastal Commission

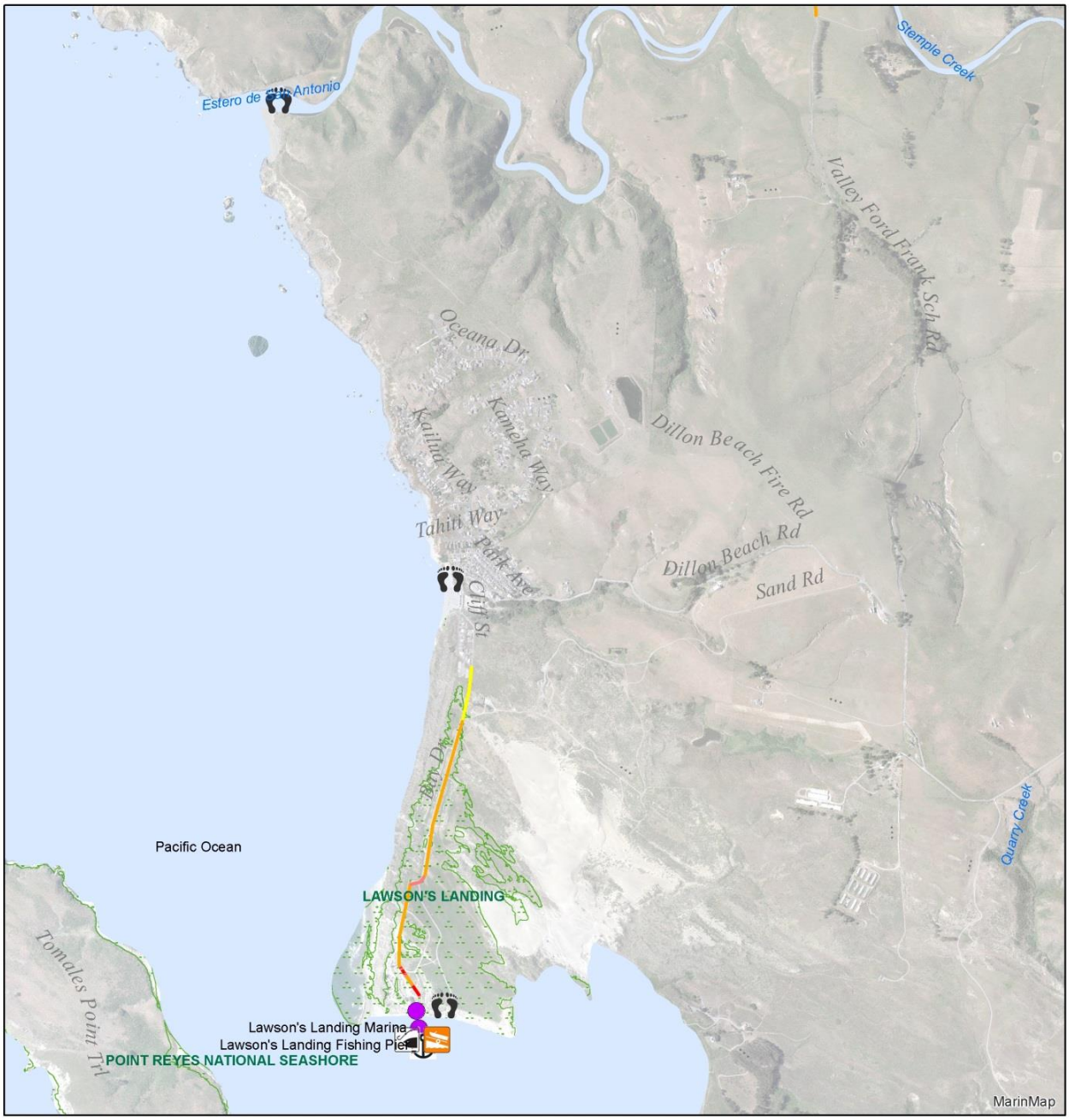
Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data providers here in, make no warranties of the accuracy or completeness of maps and data. Maps are representational and subject to future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

Date: 4/7/2016

COUNTY OF MARIN

RECREATION

Map 50: Dillon Beach Vulnerable Recreation Assets



Roads

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

Other Assets

- Recreation Asset
- Public Boat Launch
- Public Fishing Pier
- Public Access Point
- Public Port
- Public Marina
- Parkland

0 0.1 0.2 0.4 0.6 N
Miles

Sources: Our Coast Our Future, Marin Map, California 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: 4/7/2016

COUNTY OF MARIN

RECREATION

Other Considerations

Economic
Active and passive recreation on West Marin's miles of beaches and roads are critical economic contributors to the regional economy that could diminish with rising seas.

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

Social Equity
Coastal beaches, estuaries, wetlands, and marshes provide unique low cost opportunities for wildlife viewing, shoreline access, and scenic enjoyment that could be lost to sea level rise.[54] The losses could be felt unequally across income levels because as free or low cost public access points are lost to the rising sea there could be less capacity to accommodate lower income brackets.

Management
Protecting public access to natural resources and wildlife is a state and local priority. However, as Marin Coast residents' daily lives become more and more vulnerable, preserving recreation opportunities could become a lower priority. National priorities could also affect Marin public lands and sanctuaries under federal jurisdiction. The Public Trust Doctrine, as described in the Existing Policies section of this profile could also prompt regulatory issues coastal residents may have to face.

Marshall businesses between Tomales Bay and Shoreline Hwy. Credit: CDA

[54] BCDC Vulnerability Assessment.

EMERGENCY SERVICES

Asset Profile: Emergency Services

West Marin is susceptible to earthquakes, tsunamis, fires, and more. Sea level rise and storms could create additional hazards and impede emergency response. The primary vulnerability in this sector is continued safe vehicle and boat access to people and places needing aide. The West Marin Disaster Council works with local fire departments in disaster planning and response for Pt. Reyes Station, Inverness Park, and Marshall; Inverness, and Bolinas. Emergency Response Teams of trained volunteers for Dillon Beach, Inverness, and Muir Beach supplement public agencies' capacity and help with disaster response.

Table 28 lists some of the potentially vulnerable emergency service assets in the study area. This list measures onset and tidal mean higher high water (MHHW). This list is not exhaustive of all the emergency service assets that could be exposed to sea level rise and storm impacts in the study area.

Sheriff
While no sheriff facilities are exposed in the study area, lack of emergency access, power outages, and high demand could strain or disrupt service.

Fire Protection Districts
Losing vehicle access could be the main vulnerability for fire service. Additionally, disruptions in water supply could compromise fire service. Of the stations, Stinson Beach Fire Station No. 2 is vulnerable.

Fire protection districts provide a variety of services including ambulance, rescue and first aid, land clearing, fire prevention, and public education. West Marin fire protection districts include Bolinas and Stinson Beach. Additionally, the Marin County Fire Station in Pt. Reyes serves the Pt. Reyes Station, Marshall, Olema, and Inverness Park areas. A flood evacuation boat also serves the area. Inverness has a volunteer fire department. Marshall is also served by the Tomales Fire District, where crossing Walker Creek could be challenging. Moreover, as marinas and boat launches become vulnerable, the ability to conduct fire services or conduct search and rescue operations in the bay and ocean could be compromised.

IMPACTS AT-A-GLANCE

Thousands of residents, millions of visitors		Property Owners Office of Emergency Services Fire Departments County Sheriff
Emergency Access Routes Hydrants	Stinson Fire Station No.2	

Stinson Beach Fire Station No. 2 is vulnerable. Credit: CDA

Tsunami Evacuation Routes
Six recorded tsunamis have hit Marin County. The 1964 Tsunami caused one death and $100,000 in damage to boats and docks. Tsunami evacuation routes follow roads, thus, they are as vulnerable as the roads. Vulnerable evacuation routes are:

- Stinson Beach: Dipsea and Seadrift Roads to Calle de Arroyo. Shoreline Highway to Buena Vista Avenue headed north.
- Bolina: Wharf to Olema-Bolinas Road. And Olema-Bolinas Road to Horseshoe Hill Road.
- Inverness: Sir Francis Drake Boulevard to upland areas. Vision Road and Inverness Way.
- Dillon Beach: Bay Drive to Beach Avenue and Band Road to Dillon Beach Road.

Helicopter Landing Pads
The helicopter landing pad, or helispot in Inverness is vulnerable, but can be relocated easily.[55]

[55] Ursula Hanks, Marin County Sheriff's Office of Emergency Services, personal communication – 3/9/15

EMERGENCY SERVICES

The maps on the following pages highlight where vulnerable emergency facilities and routes exist. The subsequent sections detail these key vulnerabilities and others in greater detail.

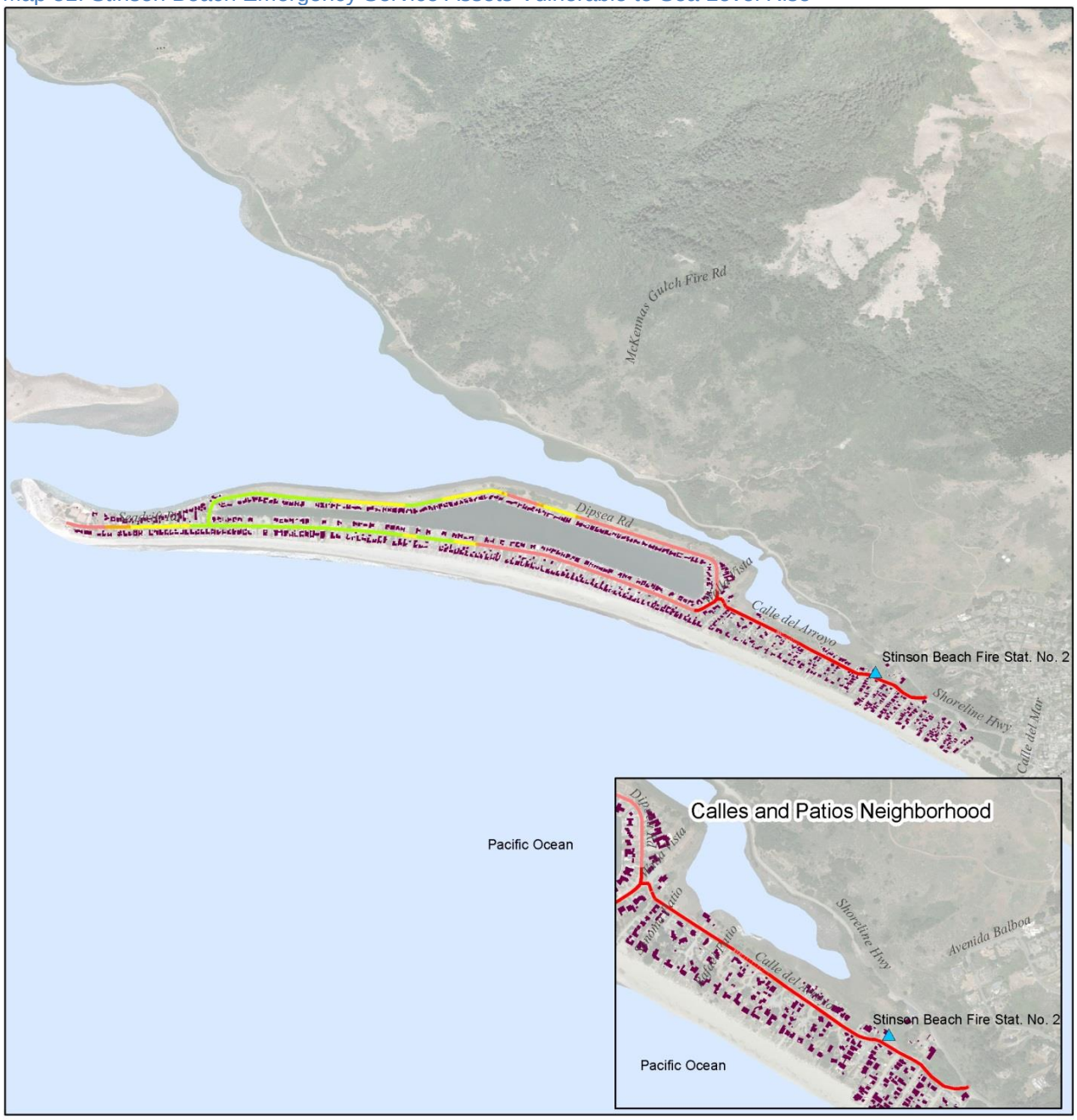
Table 28. Emergency Service Assets Ranked by Onset and Flood Depth (feet and inches

Community	Asset (not exhaustive)	Tidal & Extreme Event Flooding Depth Estimates (Underlined values indicate tidal flooding at mean higher high water (MHHW) based on one geographic point placed at the landward limit of the first scenario where it overlaps the asset. values absent the underline represent temporary extreme event flooding. Roads received a high, used for ranking, and low value along the exposed line segment.)					Vulnerability TF: Temp. flooding; I: Inundation; E: Erosion; WT: Water Table; SI: Saltwater Intrusion; WS: Wave Surge;
		Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	
Stinson Beach	Calle del Arroyo	7"-6'11"	3"-6'8"	8"-9'6"	2'5"-12'2"	5'11"-13'9"	I, TF
Bolinas	Tsunami Evac. Rte	2'4"	1'8"	2'5"	4'2"	7'9"	TF, I, WS, E
Bolinas	Wharf Rd.	6"-2'1"	3"-2'4"	2"-2'9"	1"-5'4"	10"-7'4"	I, TF
East Shore	Shoreline Hwy.	3"-1'7"	3"-2'4"	3"-3'	2'-4'6"	6"-8'1"	I, TF
East Shore	Marconi Boat Launch	1'1"	2'	2'11"	4'10"	8'2"	I
Stinson Beach	Fire Station #2		3'6''	5'3"	6'10"	9'1"	I, TF, WT
Inverness	Sir Francis Drake Blvd.			1"-3'6"	1"-4'6"	1"-7'10"	I, TF, WS
Bolinas	Olema-Bolinas Rd.			2'8"	4"-4'4"	2"-7'11"	I, TF
Pt. Reyes Station to Inverness	Shoreline Hwy.			6"	3"-1'5"	1'9"-9'7"	I, TF
Bolinas	Community Center				1'7"	5'2"	I, E
East Shore	Shoreline Hwy .					3'5"	I, E

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

EMERGENCY SERVICES

Map 51: Stinson Beach Emergency Service Assets Vulnerable to Sea Level Rise



Exposed roads w/ evacuation routes

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

- Emergency Services
- Buildings

N

0 0.125 0.25 0.5 Miles

Sources: Our Coast Our Future Flood Map (2014), Marin Map, Marin County Tsunami Annex 01/15

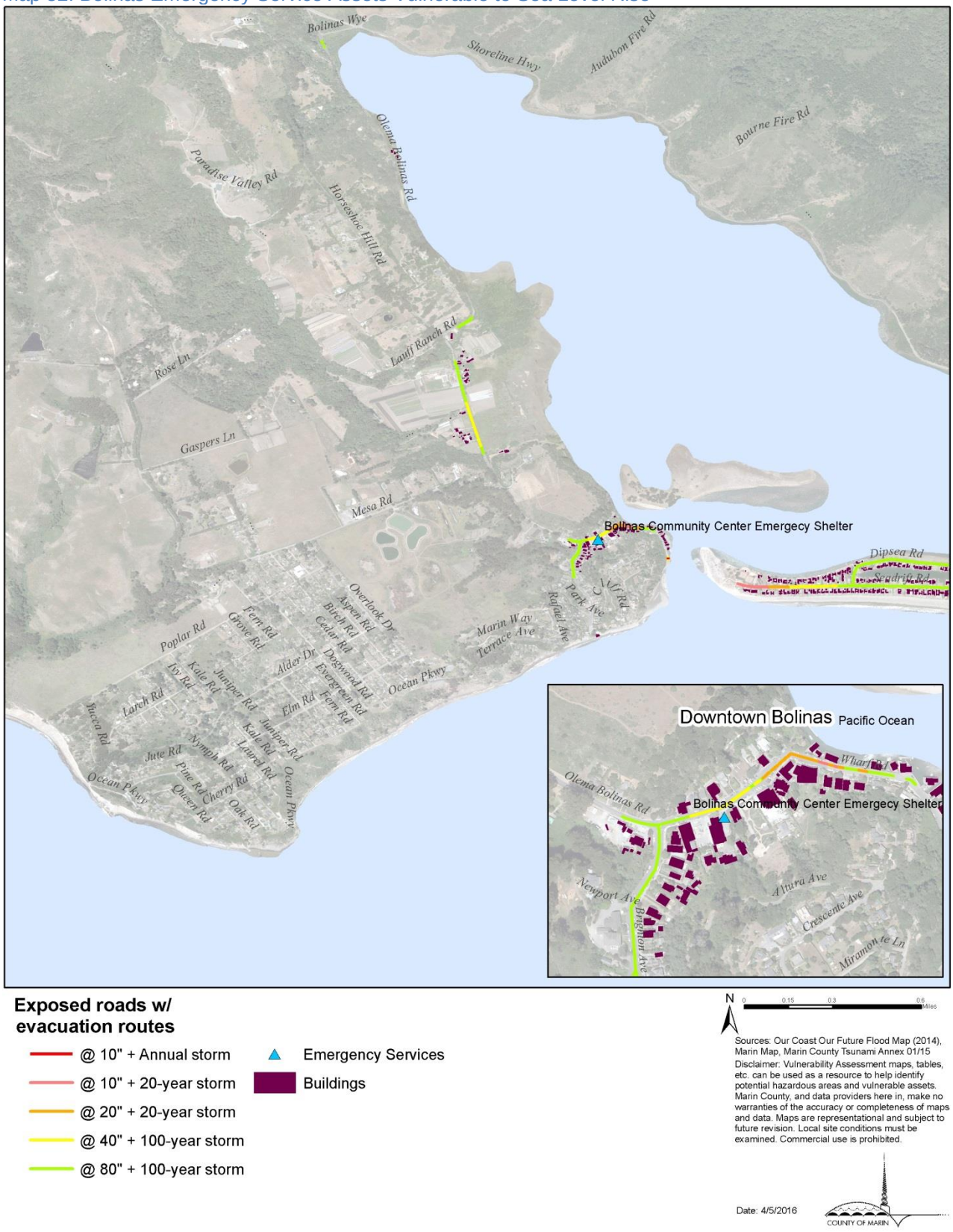
Disclaimer: Vulnerability Assessment maps, tables, etc. can be used as a resource to help identify potential hazardous areas and vulnerable assets. Marin County, and data providers here in, make no warranties of the accuracy or completeness of maps and data. Maps are representational and subject to future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

Date: 4/5/2016

COUNTY OF MARIN

EMERGENCY SERVICES

Map 52: Bolinas Emergency Service Assets Vulnerable to Sea Level Rise



Exposed roads w/ evacuation routes

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

- Emergency Services
- Buildings

N

0 0.15 0.3 0.6 Miles

Sources: Our Coast Our Future Flood Map (2014), Marin Map, Marin County Tsunami Annex 01/15

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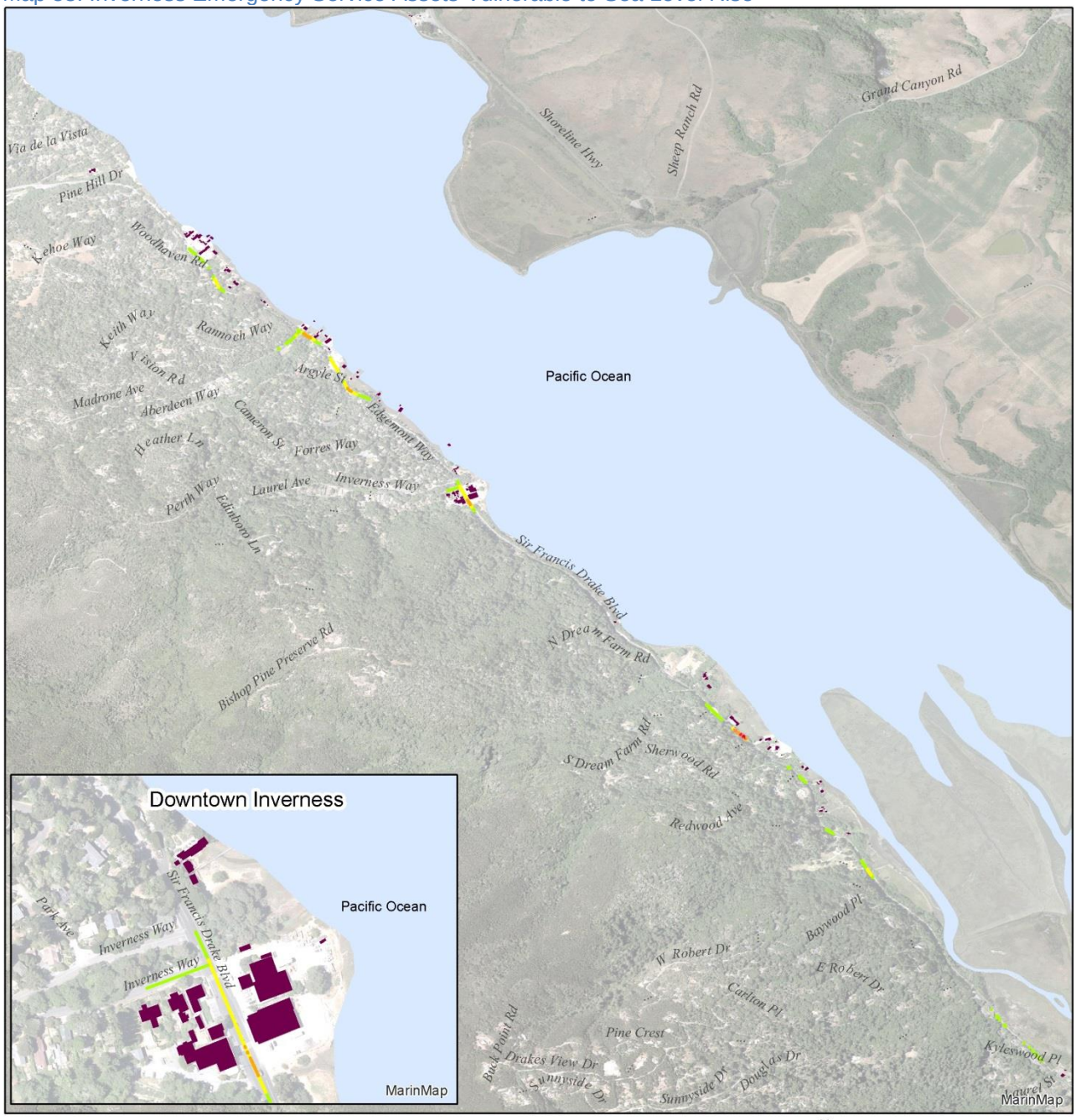
Date: 4/5/2016

COUNTY OF MARIN

EMERGENCY SERVICES

Map 53: Inverness Emergency Service Assets Vulnerable to Sea Level Rise



Exposed roads w/ evacuation routes

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

- Emergency Services
- Buildings

N

0 0.125 0.25 0.5 Miles

Sources: Our Coast Our Future Flood Map (2014), Marin Map, Marin County Tsunami Annex 01/15

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: 4/5/2016

COUNTY OF MARIN

EMERGENCY SERVICES

Map 54. Dillon Beach Emergency Service Assets Vulnerable to Sea Level Rise

Exposed roads w/ evacuation routes

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

- Emergency Services
- Buildings

N

0 0.1 0.2 0.4 Miles

Sources: Our Coast Our Future Flood Map (2014), Marin Map, Marin County Tsunami Annex 01/15

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: 4/5/2016

COUNTY OF MARIN

EMERGENCY SERVICES

Existing Policies

The Marin County Sheriff's Department established the Office of Emergency Services (OES) to coordinate efforts to develop disaster-resistant communities and to educate residents on emergency preparedness. In the event of a major emergency or disaster, the OES has established a fully functional centralized Emergency Operations Center (EOC). The County maintains an Emergency Operations Plan to provide preparation and agency response to disasters that threaten the health or property of residents and businesses. Simultaneously, the plan recognizes that in the first 72 hours following a major event, community members must be self-sufficient.

In addition, the Marin County Local Hazard Mitigation Plan (LHMP) was developed to meet the requirements of the Disaster Mitigation Act of 2000 and maintain eligibility for certain FEMA hazard mitigation programs. Strategies focus on safety and protection during earthquakes, fires, floods, and other disasters with high priority mitigation projects identified. The LHMP is currently being updated with an effort to reflect the full scope of hazard issues including climate change impacts.

Relevant programs of the Marin Countywide Plan include: maintain effective communication systems and adequate response resources, distribute public information, conduct disaster awareness efforts, promote community involvement, locate emergency facilities appropriately, promote agency emergency planning, and develop evacuation plans (Marin Countywide Plan, 2007).

Other Considerations

Economic

Lack of emergency services or access for emergency services could lead to injury or death, which could result in costly medical expenses, death related expenses and cause financial complications for dependents of the victims.

Environmental

Lack of fire services or access could prevent adequate protection of homes or entire communities. Wildfire may be able to consume greater acreages if local and fire roads are compromised.

Social Equity

Losing public emergency services could impact all residents and visitors regardless of socioeconomic status, though certain demographic factors may increase an individual's vulnerability in the face of an emergency. The Association of Bay Area Governments identifies several indicators that reduce a community's ability to prepare for, respond to, and recover from major disasters. These include:

- Low educational attainment,
- Transit dependence (persons without vehicles),
- Non-English speakers,
- Young children and aging adults,
- Significant housing cost burden,
- Household income,
- Home ownership.[56]

Loss or compromised emergency services could be more devastating to communities with higher populations that fall under such demographics, such as Bolinas.

Management

Protecting emergency services will require coordination amongst federal, state, county and local agencies. Sea level rise planning efforts should collaborate with Local Hazard Mitigation Plans and the Office of Emergency Services to ensure emergency response systems and ammenities are planned with the consideration of sea level rise.

[56] Bay Conservation and Development Commission and Association of Bay Area Governments. *Creating Safe Growth Strategies for the San Francisco Bay Area.* 2015

HISTORIC & ARCHEOLOGICAL RESOURCES

Asset Profile: Historic & Archeological Resources

Coastal Marin is rich with prehistoric and historic resources reflective of the area's unique history and past inhabitants. Miwok Indians inhabited the area for thousands of years before being displaced by foreign settlers in the mid-1800's.[57] English explorer Sir Francis Drake's most likely landing spot during his 1579 circumnavigation of the world was in West Marin. The Gold Rush and the 1875 completion of the North Pacific Coast Railway catalyzed population growth, and lumber, dairy, and agricultural industries. The following are key issues relevant to archaeological and historical resources:

- Archaeological sites can be vulnerable to sea level rise and erosion. Site disturbance can harm valuable historic information and intrinsic losses for Native Americans.
- Additional vulnerabilities lie in lack of comprehensive data about West Marin's archaeological resources. Not all of the coastline is surveyed, and without a staff archaeologist, it is not possible to acquire existing confidential datasets.
- Several locally-identified historic districts and one national register site in the study area are vulnerable to sea level rise and storms. Their loss or degradation could lead to negative economic and sense of place impacts.
- Marin County's Local Coastal Program Historic Study is 30 years old. An updated study could inventory additional sites to assess for sea level rise vulnerability.

IMPACTS AT-A-GLANCE

3 Historic Districts		Property Owners Marin County Society for CA Archaeology Federated Indians of Graton Rancheria
Archaeological Sites		
Irreplaceable	Intrinsic Values	

Point Reyes Shipwreck, Inverness. Credit: Klingel

Archaeological Resources

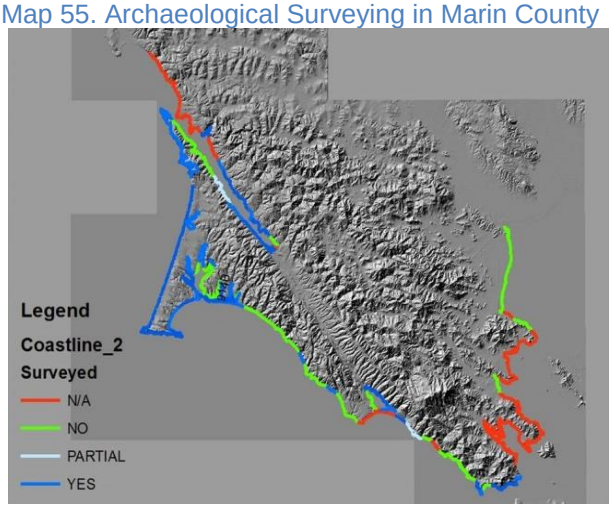
The State of California recognizes 630 archaeological sites in Marin County including permanent settlements, seasonal camps, hunting camps/special use sites, and petroglyphs covering thousands of years of Miwok Indian history. The Anthropological Studies Center at Sonoma State University is currently inventorying additional sites in anticipation of sea level rise and erosion.

[57] Newland, M. 2015. The Potential Effects of Climate Change on Cultural Resources Within Point Reyes National Seashore (Public Final Release, 2015). Prepared for the National Park Service. p. 20.

HISTORIC & ARCHEOLOGICAL RESOURCES

As depicted in Map 54, a total of sixty-nine miles of public lands were surveyed, and eight miles are partially surveyed. Inventorying has not occurred on private property due to access restrictions.

Map 55. Archaeological Surveying in Marin County



Source: Anthropological Studies Center, 2015

Table 29. Number of Known Vulnerable Archaeological Sites

Near-term	10
Medium-term	1
Long-term	9

Source: Marin County CDA (confidential dataset), OCOF Exposure and Flood Depth data

Specific locations of archaeological sites must remain confidential and Marin County CDA does not have a staff archaeologist to maintain and protect this sensitive information. Given these restrictions, not all of the aforementioned data is available to the Marin County CDA, thus currently restricting CDA's capability to conduct a comprehensive vulnerability assessment of archaeological sites. However, based on the limited available spatial information, a total of 20 vulnerable sites fall within the purview of this assessment (non-federal land). Sites are considered vulnerable if they lie within the exposure zones, as impacts including temporary flooding, inundation and erosion could disturb the sites.

Sites will be impacted different depending on location. Vulnerable sites generally fall along cliff edges, adjacent to interior bays and in dune areas. While there is little research on the effects of rapid sea level rise on archaeological sites, the field of 'wet site archaeology' suggests that coastal sites threatened by large waves, long fetch and strong winds can be destroyed or significantly damaged.[58] Coastal cliff erosion may have the most detrimental impact, as it can completely destroy relevant site's archaeological contexts, through inundation dispersal across the ocean floor.[59] Finally, dune erosion can also be quite damaging, and cause the collapse of some sites while covering/concealing others.[60]

Existing Policies

The Marin County Draft Local Coastal Program (DLCP) supports the inventorying and protection of archaeological and paleontological resources. Mitigation measures are required in cases that development would negatively impact such resources.

Marin Coastal Archaeological Site – 2001 (above) and 2013 (below) Credit: Anthropological Studies Center.

[58] Newland, M. 2015. The Potential Effects of Climate Change on Cultural Resources Within Point Reyes National Seashore. Prepared for the National Park Service.
[59] Ibid.
[60] Ibid.

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Figure 8. Marin County DLCP Archaeological Resources Policies (abridged)

C-HAR-1 Maintenance of Information on Archaeological and Paleontological Resources. Maintain a file on known and suspected sites.

C-HAR-2 Potential Impacts of Development on Archaeological and Paleontological Resources. Prior to approving a coastal permit for development proposed in an area of known or likely archaeological or paleontological significance require a field survey by a state-qualified archaeologist recommended by the Federated Indians of Graton Rancheria or by a qualified paleontologist at the applicant's expense. Where development would adversely impact resources, require mitigation measures.

C-HAR-3 Monitoring of Construction on Archaeological Sites by Appropriate Experts. Require that new development on sites identified as archaeologically sensitive include onsite monitoring by a qualified archaeologist(s) and appropriate Native American consultant(s) of grading, excavation, and other earth moving. Provide mitigation measures if significant resources are present.

Reflects California Coastal Commission Suggested Modifications to Marin County LCP Amendment (May 2014). ***Subject to change.***

Table 30. Historic Assets Ranked by Onset and Flood Depth (feet and inches)

Community	Asset (not exhaustive)	Tidal & Extreme Event Flooding Depth Estimates (Underlined values indicate tidal flooding at mean higher high water (MHHW) based on one geographic point placed at the landward limit of the first scenario where it overlaps the asset. Values not underlined represent temporary flooding.)					Vulnerability TF: Temp. Flooding during extreme events; I: Inundated at MHHW; E: Erosion
		Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	
Inverness	Brock Schreiber Boathouse	2'7"	3'6"	4'	5'10"	9'2"	I, E
Bolinas	Historic District		3'10"	4'8"	6'4"	10'	I, E
Bolinas	Bolinas Super Market			8"	2'6"	6'1"	I, E, SI
East Shore	Historic District				2'5"	4'5"	I
Inverness	Historic District				2'1"	5'1"	TF
Bolinas	Church: Calvary Presbyterian					5'10"	I, TF
Inverness	Inverness Post Office					3'7"	TF, I, E

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

Historic Resources

Historic sites are irreplaceable resources and may be used to interpret stories about past events, people, industries, and/or movements. Many historic buildings serve as commercial centers, supporting local businesses and are integral to community fabric and character. Some historic sites have spiritual, or intrinsic importance valued by current and past residents.

Marin County's Local Coastal Program Historic Study (1981),[61] identifies historic districts based on architectural styles of pre-1930 structures. Communities' characters have changed little since, and this study can serve as a basis for a historic resources vulnerability assessment. However, it is difficult to fully assess historic resource vulnerabilities as other sites more recently could

[61] Duthie, j. Williams, C., Bonos, N., Curry, D. Nov. 1981. *Marin County Historic Study*. Marin County Local Coastal Program.

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qualify as historic based on age (50+ years), or uniqueness beyond architecture (e.g., industry, government, settlement, etc.). If local interest/resources exist, an updated study could document additional vulnerable historic sites before they are negatively impacted by sea level rise.

Table 30 lists some of the potentially vulnerable historic assets related assets in the study area. This list measures onset and tidal mean higher high water (MHHW) and extreme event flood depth. This list is not exhaustive of all the historic assets that could be exposed to sea level rise and storm impacts in the study area.

Historic Sites

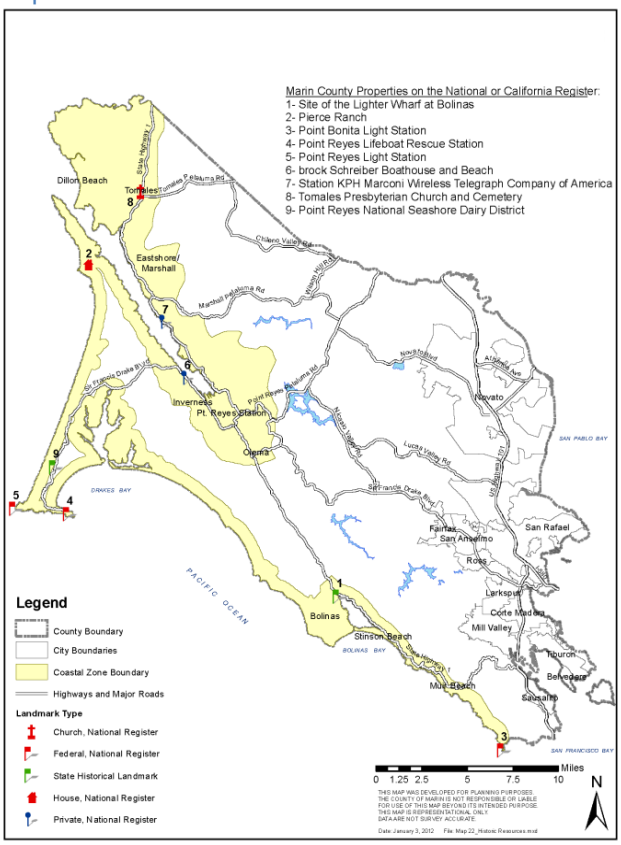
Map 56 depicts designated historic sites in West Marin. Several sites lie on federal land, and therefore not within the purview of this assessment. Two sites within the Study Area are exposed to the sea level rise and storm scenarios:

- *The Brock Schreiber Boathouse and Beach- National Register of Historic Places, Private.*
  The boathouse lies within the Inverness Historic District, was built in 1913, and its significance lies in being one of the few surviving reminders of a time when row-boating was a major recreational activity.[62] The site falls directly on Tomales Bay, and is therefore considered vulnerable in the near-term and has already sustained severed wave damage from a December 2014 storm.
- *Site of Lighter Wharf in Bolinas State Historic Landmark.* The Lighter Wharf was built in the 1850s to load lumber for transport to deeper water near the channel, where it was transferred to seagoing vessels for shipment to San Francisco. While it was significant in supporting Bolinas's historic lumber industry, the wharf decayed long ago, and no interpretive/commemorative marker exists.[63] The site is exposed, even at the baseline scenario, and more of the surrounding area will become permanently inundated as the seas continue to rise.

[62] NoeHill Travels in California. *National Register Sites in Marin County.* http://noehill.com/marin/nat1978000702.asp. Accessed July 29, 2015.

[63] NoeHill Travels in California. *California Historical Landmarks in Marin County.* http://noehill.com/marin/cal0221.asp. Accessed July 29, 2015

Map 56. Historic Resources



Credit: Marin County Local Coastal Program Land Use Plan Proposed Amendment, 2013

Historic Districts

The Local Coastal Program's Marin County Historic Study delineated historic districts based on architectural styles; including Greek Revival, Italianate, Queen Anne, Shingle Style, Mission Revival, Western Stick Style, and California Bungalow. Of the seven study area communities, three historic districts (Bolinas, Inverness, and Marshall) may be exposed to sea level rise and increased storm impacts.

- **Bolinas Historic District**
  Bolinas's original ranch was established in 1837 as part of the Baulenes Mexican land grant. Once the original settler's brother-in-law acquired property ownership, it became a logging operation with lumber shipped to San Francisco. By 1850, Bolinas was a large logging town, followed by dairy ranching once logging operations ceased. More settlers came to the area by stagecoach, and in the 1880's summer homes were built. Historic

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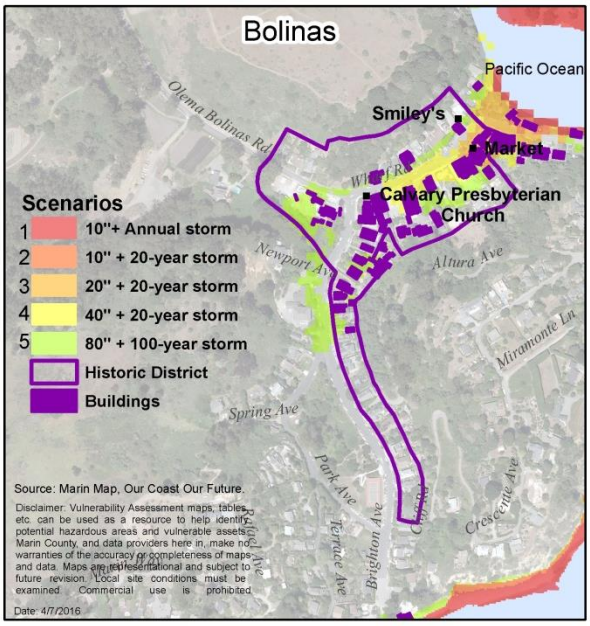
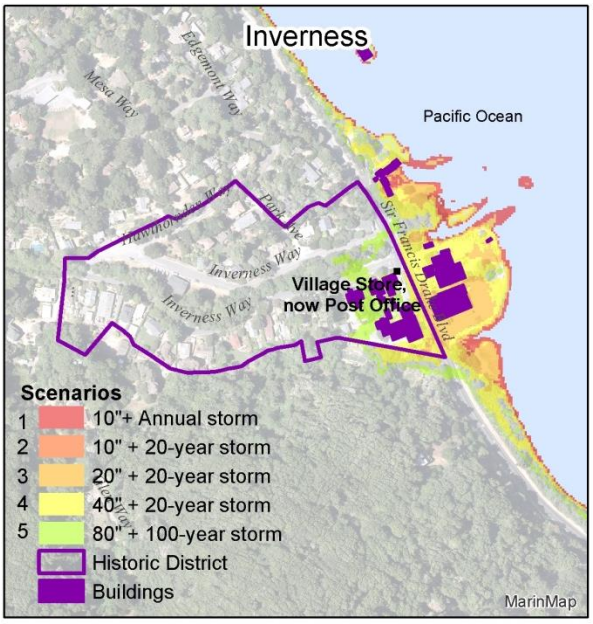
structures vulnerable to sea level rise, all under mid to long term scenarios, include: the Bolinas Market, Smileys, and the Calvary Presbyterian Church.

Map 57. Bolinas Historic District Vulnerable to Sea Level Rise



- **Inverness Historic District**
  Inverness Ridge was founded by Superior Court Judge James McMillan Shafter in 1889 and began as a planned subdivision intended for the wealthy. In 1949 UC Berkeley students prepared Marin County's first master plan. Inverness's post office is in a building vulnerable to medium-term sea level rise. The Brock Schreiber Boathouse could be impacted in the near-term.
- **Marshall Historic District**
  Marshall is a fishing and dairy ranching community, named after four brothers from Ireland in the early 1860's, and was an important shipping center during the railroad days. Marshall's historic district is particularly unique because of its sensitive siting of the strip of land between the Tomales Bay and Highway 1.

Map 58. Inverness Historic District Vulnerable to Sea Level Rise



Map 59. Marshall Historic District Vulnerable to Sea Level Rise

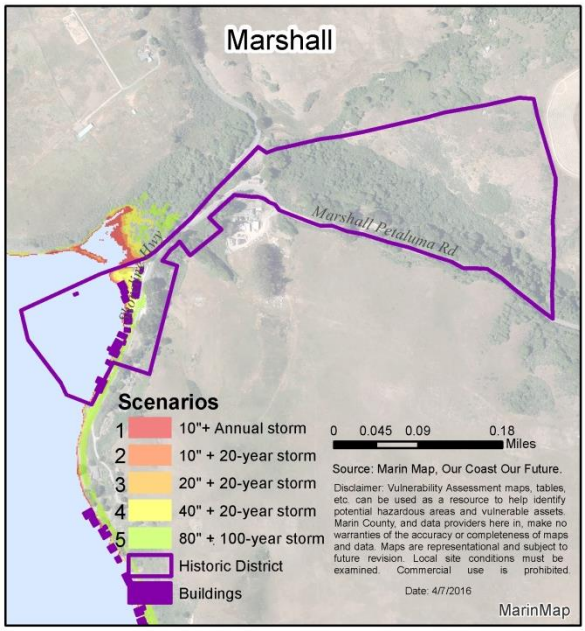


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Figure 9. Marin County DLCP Historical Resources Policies

C-HAR-4 Structures of Special Character and Visitor Appeal. Preserve and restore structures with special character and visitor appeal.

C-HAR-6 Alterations and Additions to Structures of Special Character and Visitor Appeal. Require a permit for substantial alterations or additions to any structure built prior to 1930 that would otherwise be exempt from a permit, except for maintenance or repair (a) consistent with its original architectural character and (b) including replacement with in-kind of building components.

C-HAR-7 Proposed Demolition of Structures of Special Character and Visitor Appeal. Review the proposed demolition of any structure built prior to 1930 for impacts on community character.

C-HAR-8 Village Areas with Special Character and Visitor Appeal. Ensure that all new development conforms in siting, scale, design, materials, and texture with surrounding community character in areas of special character including historic areas.

Reflects CA Coastal Commission Suggested Modifications to Marin County DLCP Amendment. ***Subject to change.***

Existing Policies

The Marin County Draft Local Coastal Program (DLCP) provides for protection of key Coastal Zone resources that reflect the legacy of the past. In furtherance of this goal, DLCP policies protect historic buildings and ensure that new development will be compatible with the existing character of the surrounding community (see Figure 9).

Other Considerations

Economic

Historic preservation has proven to be an effective tool for small business sustainability, community development, renewal, and revitalization, heritage tourism development, and more.[64] Some of West Marin's vulnerable historic sites house local businesses important to local economic well-being. Loss or deterioration of these resources could lead to business closure, thus having negative impacts on the local economies; or force relocation which could be financially taxing on the owner. In instances which the historic building houses a civic use (e.g., the Inverness Post Office), the loss/compromise could require public money to support relocation. Additionally, West Marin's historic districts contribute to the communities' unique charm and character, adding to their appeal as tourism hubs, thus assisting with economic development through increased visitor spending and sales tax.

In the case of Marshall, historic buildings adjacent to Tomales Bay have the co-benefit of coastal armoring to protect State Highway 1 and other assets to the East. The loss or deterioration of these structures could therefore lead to increased flooding of the roadway causing costly repairs, maintenance, relocation, etc.

Environmental

In addition to valuable information on cultural history, some archaeological sites are valuable information sources on natural history, which may be of increased importance as global temperatures rise. Through analysis of elements such as pollen, seeds, shells, and bones, archaeological data can reveal which plants and animals thrived during past climactic periods (e.g., the mid Holocene) with land and water temperatures comparable to potential future conditions with climate changes, including secondary impacts such as increased ocean acidification.[65] Such data could be of great value to inform future ecosystem restoration and management plans.

Building reuse is almost always less taxing on the environment then new construction, and it can take decades for moderately more energy efficient new buildings to overcome climate change impacts from the construction process than average performing

[64] Rypkema, Donovan D., 2005. *The Economics of Preservation: A Community Leader's Guide.*

[65] Newland, Michael (Sonoma State Anthropological Studies Center). 2015. Personal Communications

existing buildings.[66] Materials production/transport, building construction, and demolition waste disposal are all components of new construction which yield environmental impacts, which could be minimized through preserving/protecting existing buildings.

Social Equity

West Marin's Archaeological sites convey information on thousands of years of Miwok Indian history and many remain sacred to the Federated Indians of Graton Rancheria for recognition/commemoration of ancestors, while still contributing to current sense of place. The loss of these irreplaceable resources could represent an unprecedented loss of history and culture, and no established processes exist to protect/mitigate for their disappearance.

Management

The loss of archaeological sites can present management challenges including the need for increased documentation and protection of certain sites, particularly those of high intrinsic value. Close coordination with the Federated Indians of Graton Rancheria is critical to ensure that adaptation strategies protect vulnerable archaeological sites. Little guidance exists to inform the challenge of protecting historic integrity and community character.

[66] National Trust for Historic Preservation. 2011. *The Greenest Building: Quantifying the Environmental Value of Building Reuse.*