

UTILITIES

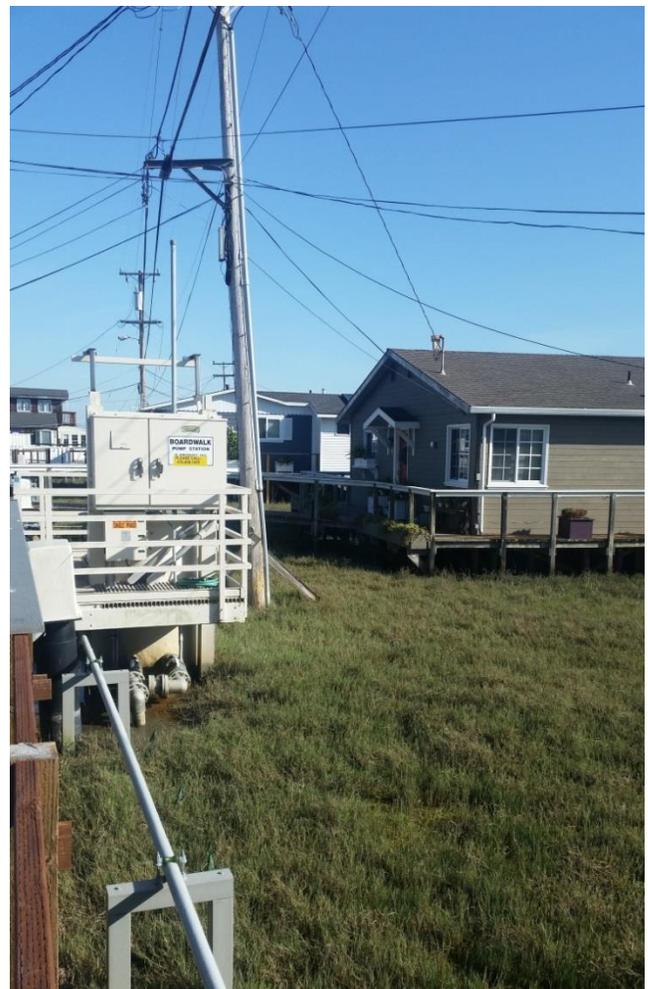
Asset Profile: Water, Wastewater, Stormwater, Gas, Electricity, & Telecommunications

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

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

IMPACTS-AT-A-GLANCE: SCENARIO 6

12,100 buildings+	Property Owners Marin County Public Works Municipalities Sanitary Districts North Marin Water District PG&E AT&T
100,000+ people affected	
Increased operation costs and energy demands	Local & Regional



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

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Potable Water

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

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

North Marin Water District (NMWD)

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

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

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

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

Marin Municipal Water District (MMWD)

Marin Municipal supplies drinking water to most of communities along the shore south of Novato. MMWD asset managers are confident that the water distribution system can sustain the impacts of

regular high tides. For example, it would take more than 5 feet of sea level rise to compromise the pressurized water pipes. However, in scenario 6, five feet of sea level rise with a 100-year storm surge, the MMWD headquarters in Corte Madera is impacted. The impacted area contains the corporation yard, operations laboratory, workshop, emergency generators, and above ground fuel tanks. And in both scenarios 5 and 6, access to the facility could be challenging during high tides. Increased exposure to saltwater could also cause more rapid degradation of trucks and other equipment brought in and out of the facility.

Table 35. Potable Water Vulnerabilities

Underground Issues	<ul style="list-style-type: none"> • Saltwater intrusion could contaminate water in pipes through air valves, and wells for drinking and fire protection. • Water distribution: Pipes must maintain 24" of space from the groundwater table, and 32" below ground. As the water table rises, pipes will be exposed to saltwater and shift underground. • Pipes may be vulnerable to increased saltwater corrosion and subsidence.
Above Ground Issues	<ul style="list-style-type: none"> • Some houseboats use flexible hose connections that would wear more quickly if submerged in saltwater more often. • Saltwater could damage pipes that line boardwalks serving over water or marsh homes.

Source: NMWD Asset Manager Interview

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Map 24. Northern Study Area Vulnerable Water Service Assets

Vulnerable Assets

● NMWD Facility

Pipeline

— Other

— Intermediate

— Recycled Water

— Potable Water

□ Water District Parcels

Location Indicators

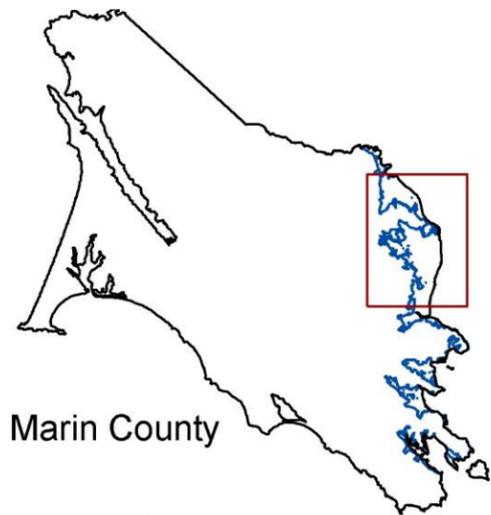
□ Unincorporated

□ Municipality

— Road

□ Bay

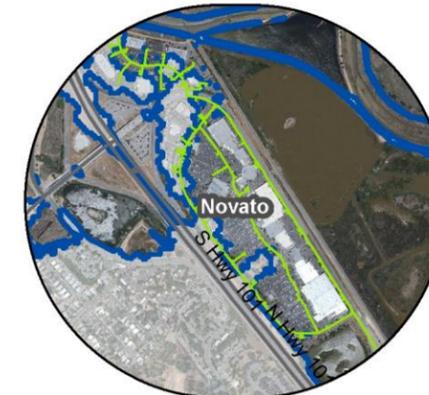
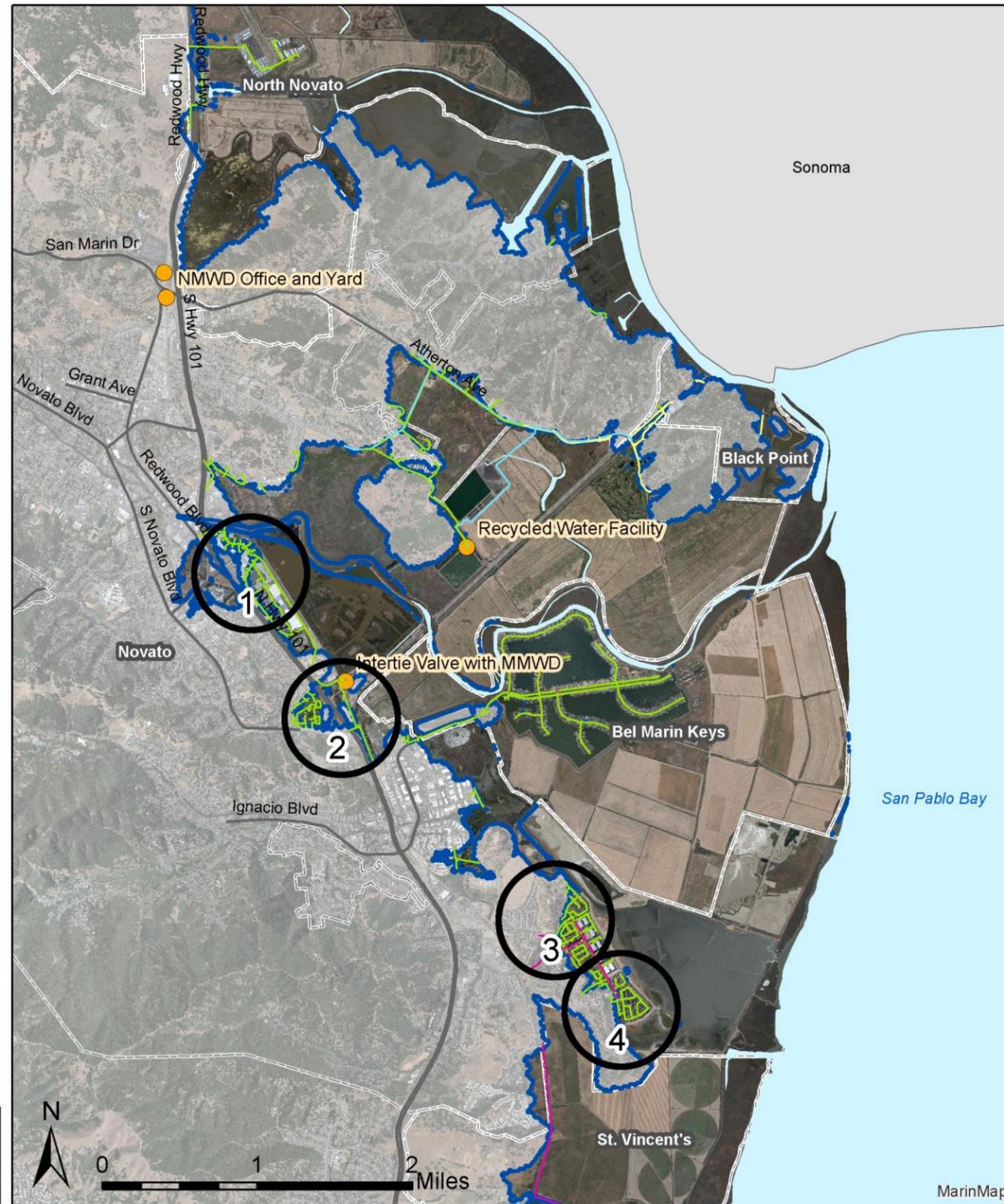
~ Inland Extent: Sea Level @ 60"+100-year Storm



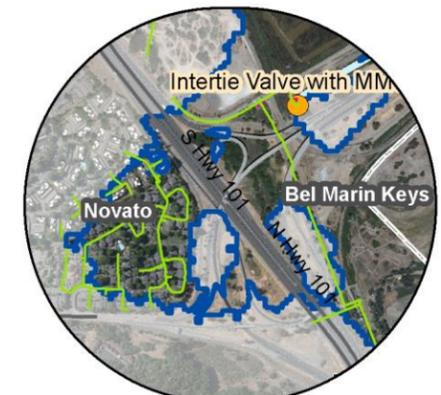
Marin County



Date: 4/1/2017



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



2: U.S. Hwy. 101 @ State Route 37



3: Upper Hamilton



4: Lower Hamilton

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

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Map 25. Southern Study Area Vulnerable Water Service Assets

Vulnerable Assets

 Water District Parcels

Location Indicators

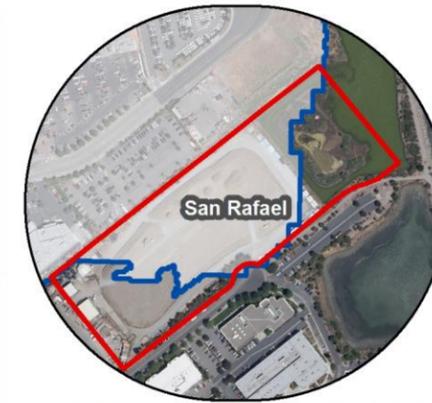
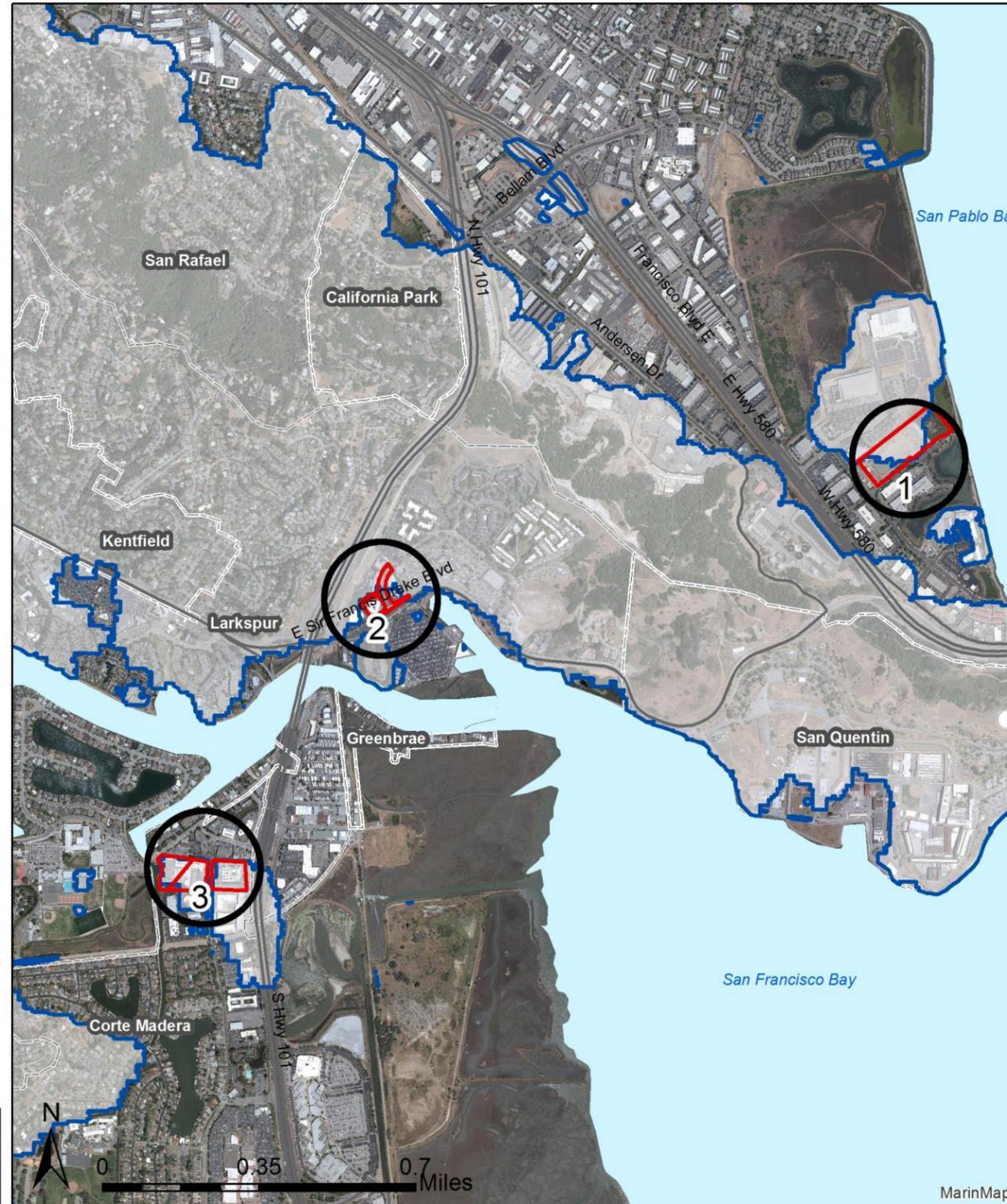
 Unincorporated

 Municipality

 Road

 Bay

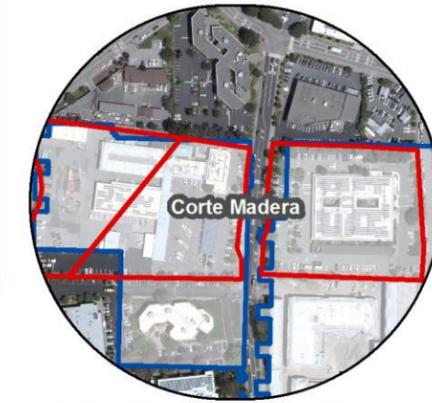
 Inland Extent: Sea Level @ 60"+100-year Storm



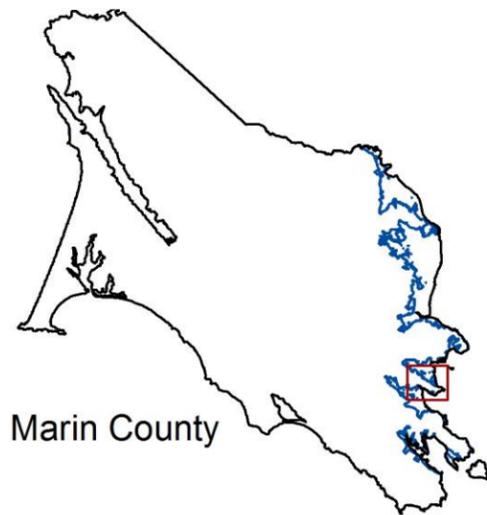
1: Kerner Business District



2: Sir Francis Drake Blvd.



3: Madison Metropolitan Water District Office & Yard



Marin County



Date: 6/15/2017



MarinMap

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Sewer Service

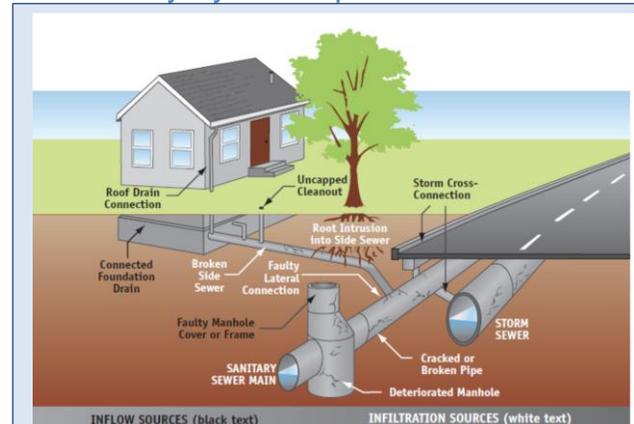
The majority of businesses, facilities, and residences on the eastern shoreline of Marin County depend on community wastewater systems, and in several cases these systems connect to a treatment plant, or NMWD and MMWD water recycling systems. Sanitary districts with vulnerable assets include:

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

Because of its low lying nature, development on bay mud, and population density, southern Marin communities are most vulnerable to wastewater treatment issues. The most vulnerable are those dependent on the Sewerage Agency of Southern Marin (SASM) treatment plant. However, all sanitary districts could be impacted by inflow and infiltration into sanitary pipes and manholes. The excess water creates inefficiencies in treatment, and potentially flooding the system. Impacts to buildings near damaged pipeline or backed up systems is also possible in all of these districts. Cleaning up an individual single-family residence from sanitary sewer back-ups can cost more than \$5,000.⁷² If this combines with additional flooding, costs would soar even higher. In addition, subsiding pipes, mains, and pump stations are also a common concern. Finally, if the power is out for extended periods of time, diesel emergency sources for back-up generators at pump stations could at least be significantly more expensive to operate. If pump stations fail, sewage could back up and out of manholes and into the streets, parks, or yards where they exist. If the area is also flooded, harmful sewerage could spread widely throughout the flooded area creating significant public health risks.

⁷² 2016 dollars

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



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

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

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

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

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

Table 36. Sanitary District System Vulnerabilities

Pump Stations	<ul style="list-style-type: none"> • Lift stations or pumps below water. • Pump stations can be overburdened by saltwater infiltration into the pipelines.
Pipes	<ul style="list-style-type: none"> • Older underground metal pipes are corroding and more susceptible to increased saltwater exposure. • Older clay or metal pipes have cracks and wear that allow for inflow and infiltration. If not replaced, this will likely worsen, and could burden treatment plants. • Not all systems are pressurized and vulnerable to changes in the ebb and flow of the tides. • Subsidence can place bending forces on pipes. • Manholes extend below grade. If flooded, access will be lost and inflow and infiltration could occur.
Treatment Plants	<ul style="list-style-type: none"> • Levees protecting low-lying treatment plants could be overtopped, flooding the plants, offices, and exposing the facility to corrosive saltwater. • Facilities built on mud may experience increased rates of subsidence. • Administrative and maintenance buildings are vulnerable to flooding.
Utility Users	<ul style="list-style-type: none"> • The lateral pipes connecting each building to the sewer mains could be vulnerable to infiltration of saltwater. This decreases efficiency and effectiveness of treatment. • Excess water can cause back-up into and damage buildings.

Source: Sanitation District Asset Manager Interviews

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

Sewerage Agency of Southern Marin (SASM)

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

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

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

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

⁷³ SASM Master Plan. 2014.

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

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

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

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

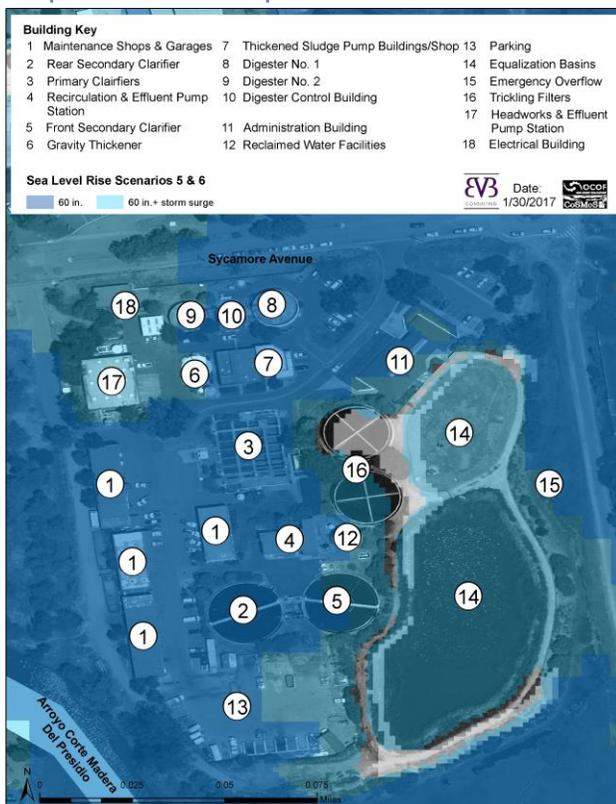
The SASM Technical Flood Study also provides proposals for protecting the site. According to the report, protecting the site for the long-term, not accounting for the ocean storm surge, with a berm, wall, and tide gates could cost more than \$2.5 million. Marin County Public Works is also working with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

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

Sausalito Marin City Sanitary District (SMCSD)

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

Map 26. SASM Exposure to Sea Level Rise



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

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

Sanitary District No. 2

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

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

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

Las Gallinas Valley Sanitary District (LGVSD)

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

LGVSD vulnerabilities include:

- Santa Venetia relies on several pump stations located in the exposure area with tidal water infiltration.
- Marin Lagoon relies on 9 pump stations in the exposure area with tidal water infiltration.

- Solar energy produced on site is located in the sea level rise exposure area.
- Santa Venetia and Marin Lagoon residents may flee the area in the face of sea level rise and reduce service needs.

Ross Valley Sanitary District

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

San Rafael Sanitation District

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

Sanitary District No. 5

The smaller of two treatment plants in the District, the Paradise Cove Plant, is impacted at scenario 6, 5 feet of sea level rise, plus 100-year storm surge. The main issues are worsening erosion and flooding at this site, saltwater intrusion for sewer lines along Tiburon Blvd. that run along the beach, a manhole at Beach and Tiburon Blvd. that already floods, and pump station electrical panels.

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

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

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

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Novato Sanitary District

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

On-site Waste Water Treatment (OWTS)

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

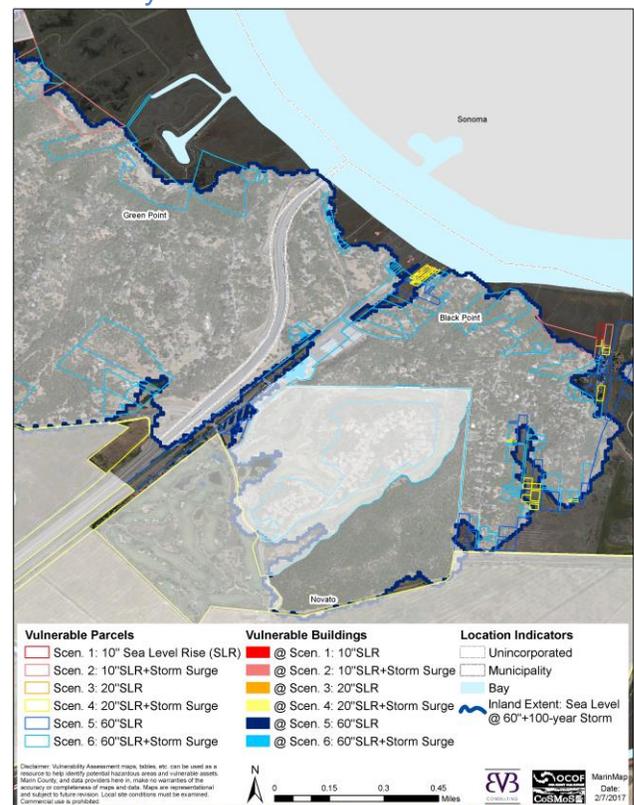
These systems are privately managed by the land owner and regulated by Marin County and the Regional Water Quality Control Board. Septic systems in are regulated by the Marin Countywide Plan (CWP), the Marin County Development Code, and the State Water Control Board's Onsite Wastewater Treatment Systems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

Table 37. OWTS System Vulnerabilities

Land Area	<ul style="list-style-type: none"> Erosion can reduce the land area available to percolate waste. Saltwater intrusion into the leach field could impact percolation rates and reduce useable area.
Materials/ Models	<ul style="list-style-type: none"> Older single field gravity systems are more susceptible to storm flooding than modern systems equipped with “flip” switches that turn off percolation when groundwater elevates too high. Newer systems are vulnerable to power outages.

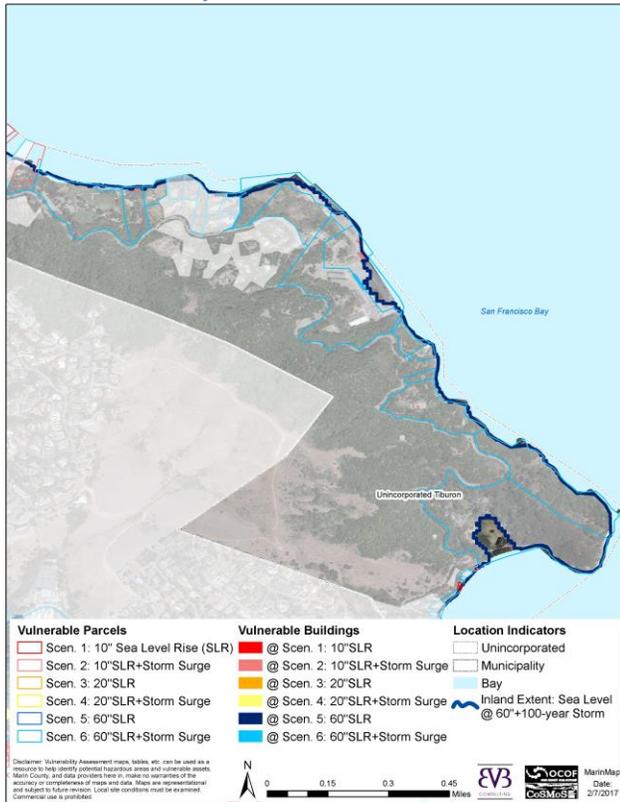
Source: Marin County Environmental Health and Safety

Map 27. Black Point Properties with Potentially Vulnerable OWTSs



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Map 28. Unincorporated Tiburon Properties with Potentially Vulnerable OWTs



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Map 29. Southern Study Area Vulnerable Wastewater Assets

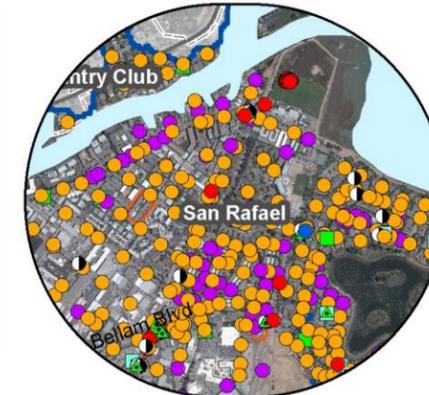
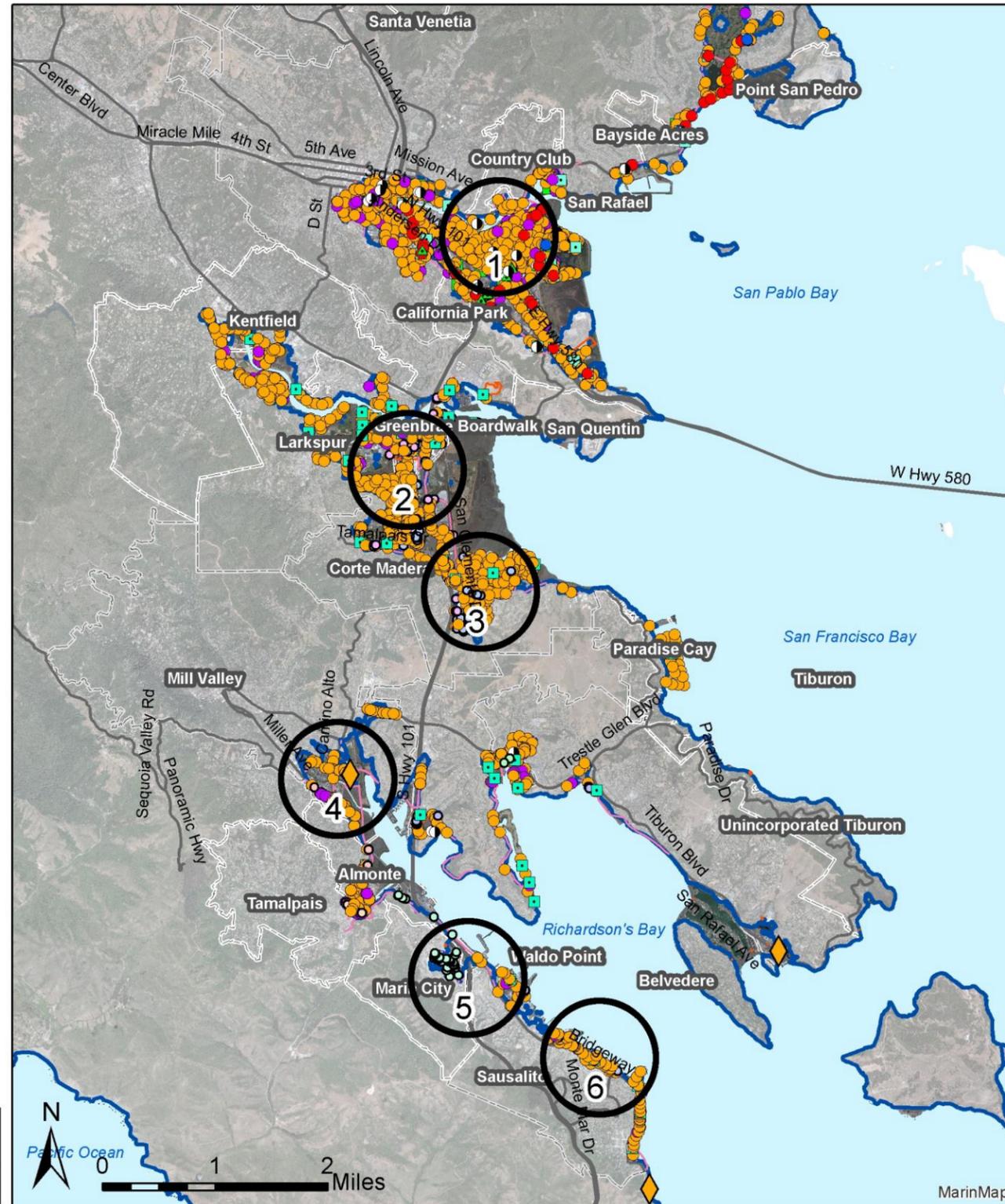
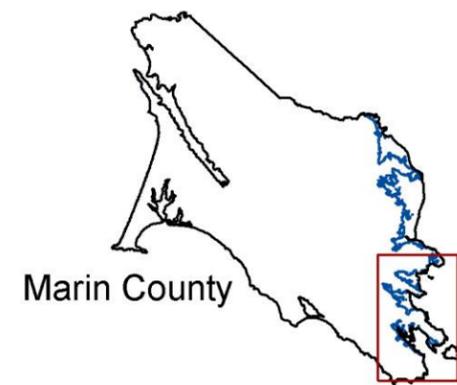
Vulnerable Assets

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

— Pipe

Location Indicators

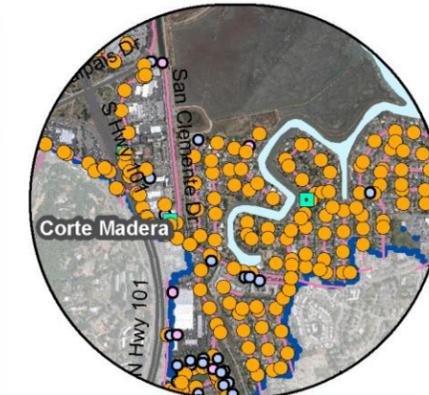
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- Municipality
- Road
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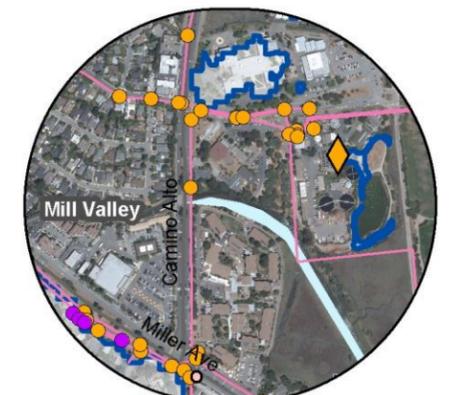
1: San Rafael Canal



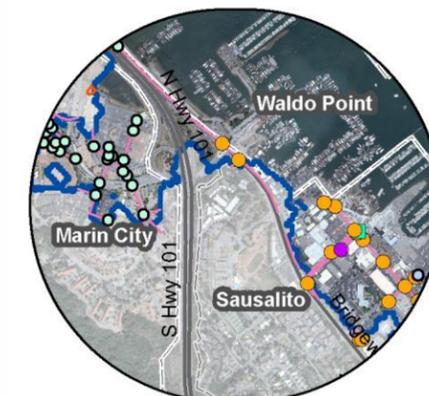
2: Larkspur



3: Corte Madera



4: Mill Valley



5: Marin City/Waldo Point



6: Sausalito Shoreline

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Date: 1/31/2017



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Fuels (Home and Automotive)

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

As part of their own Natural Hazards Asset Performance initiative, PG&E found that nearly 30 percent of its gas transmission pipelines in Marin County are located in FEMA's 100-year flood zones, and about 9 percent are located within areas modeled for two feet of sea level rise, similar to scenario 3.⁷⁶ According to CoSMoS and Marin Map, PG&E has one above ground natural gas facility in San Rafael located in the exposed area. Distribution pipelines could be vulnerable in several locations from Tamalpais to Black Point. These include:

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

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

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

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

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

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

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



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

UTILITIES

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

Storm Flooding	<ul style="list-style-type: none">• Reduced soil cover on pipeline or unsupported pipeline spans due to soil scour or erosion.• Damage from floating debris—such as tree limbs—coming into contact with gas pipelines (known as dynamic loading) and potentially collecting against the pipeline like a dam (known as static loading), resulting in bending stress.• Bending stress on the gas pipeline from unstable soil.
Sea Level Rise	<ul style="list-style-type: none">• Damage from buoyancy forces on pipeline segments, and potential for erosion around segments

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

Electricity

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

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

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

UTILITIES

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

Vulnerable Assets

⊕ Solar Array

PG&E Assets

— Electric Transmission Line

— Natural Gas Pipeline

⬠ Substation

▲ Transmission Tower

▭ PG&E Property

▭ PG&E Buildings

Location Indicators

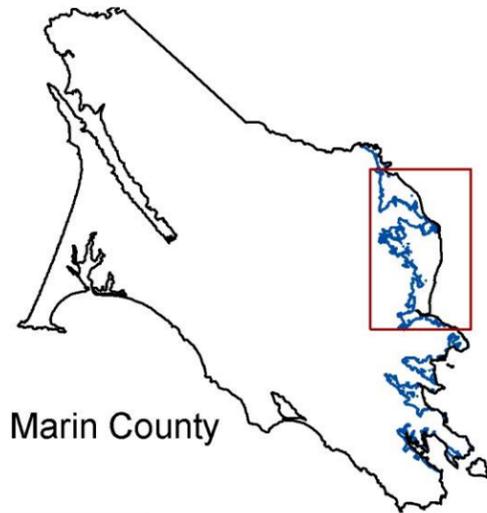
▭ Unincorporated

▭ Municipality

— Road

— Bay

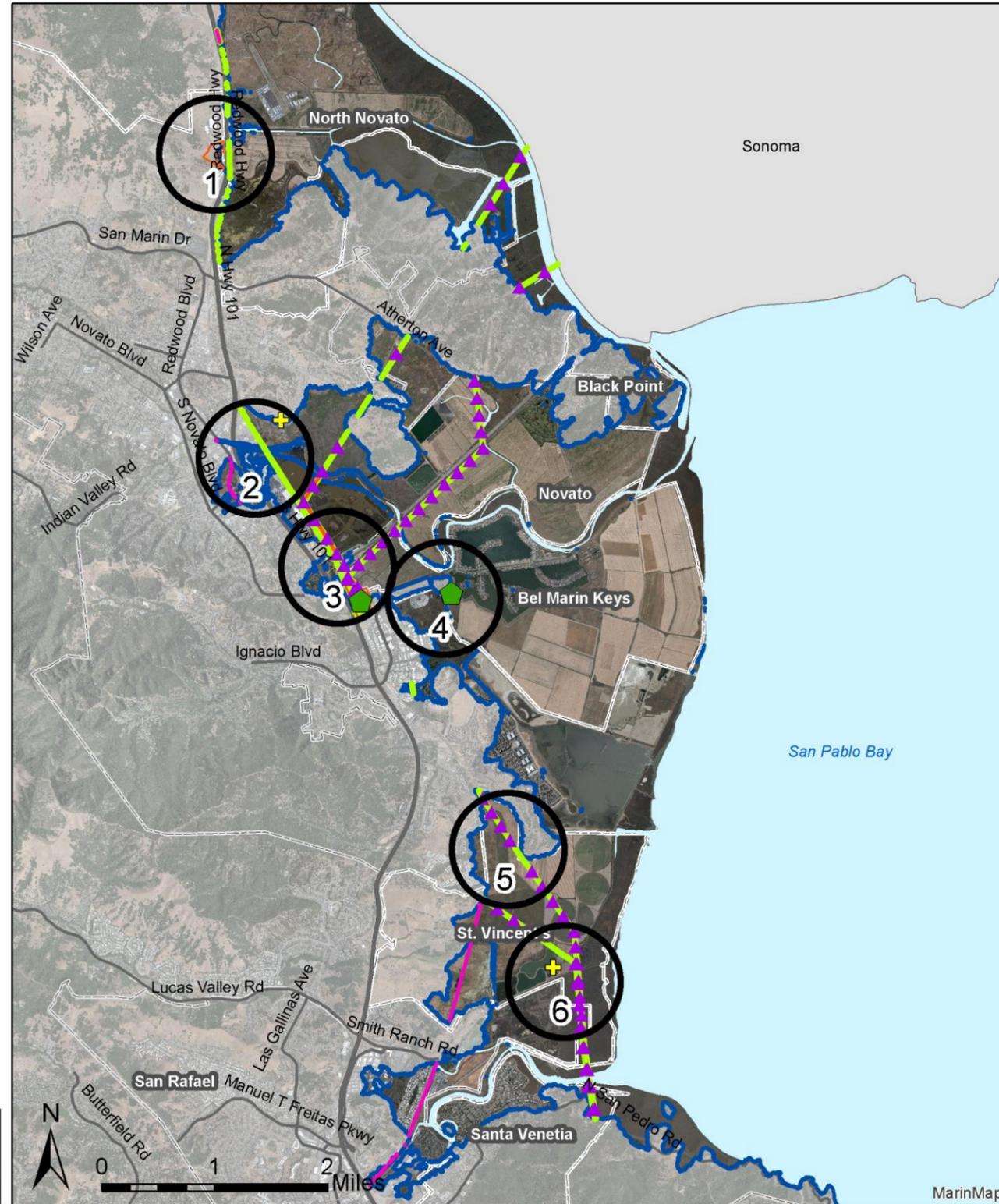
— Inland Extent: Sea Level @ 60"+100-year Storm



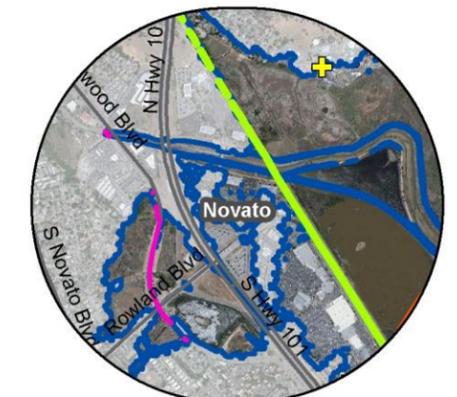
Marin County



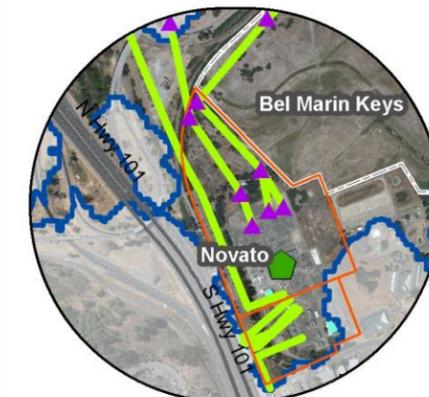
Date: 3/30/2017



1: North Novato



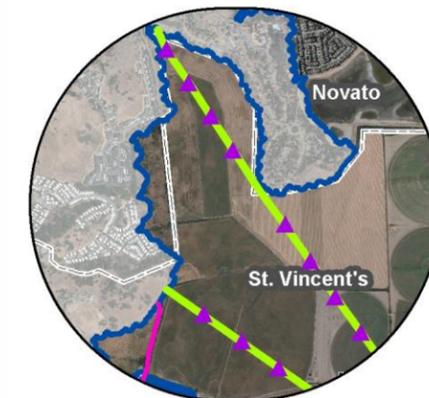
2: U.S. Hwy. 101 @ Rowland Blvd.



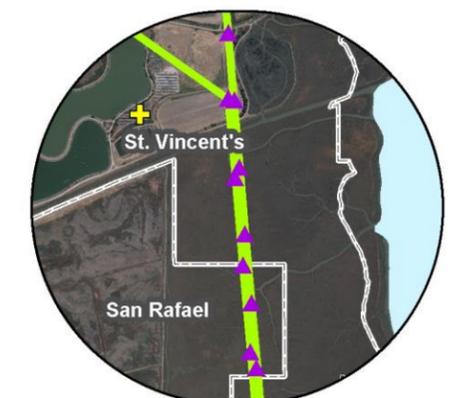
3: U.S. Hwy. 101 @ Bel Marin Keys Blvd.



4: San Clemente Dr.



5: St. Vincent's



6: McInnis Marsh

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

UTILITIES

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

Vulnerable Assets

⊕ Solar Installation

PG&E Assets

— Electric Transmission Lines

— Natural Gas Pipeline

⬠ Substation

▲ Transmission Tower

▭ PG&E Property

▭ PG&E Buildings

Location Indicators

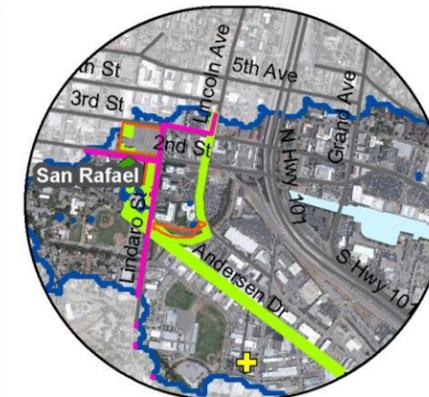
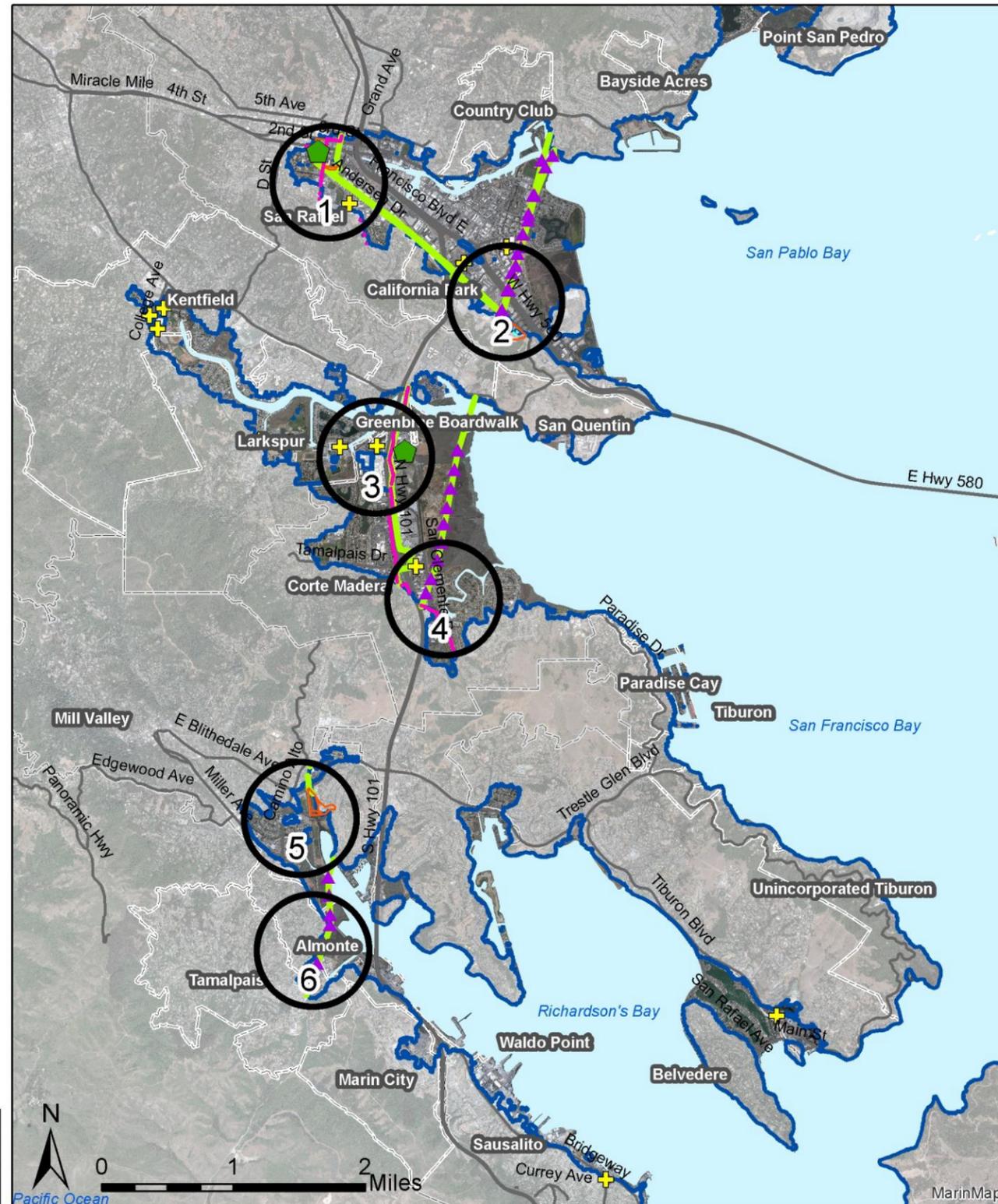
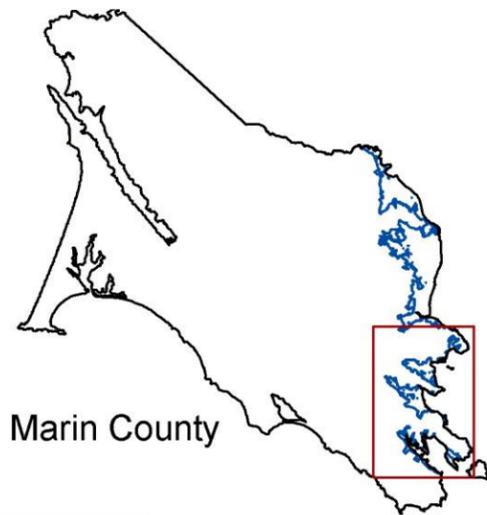
▭ Unincorporated

▭ Municipality

— Road

— Bay

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



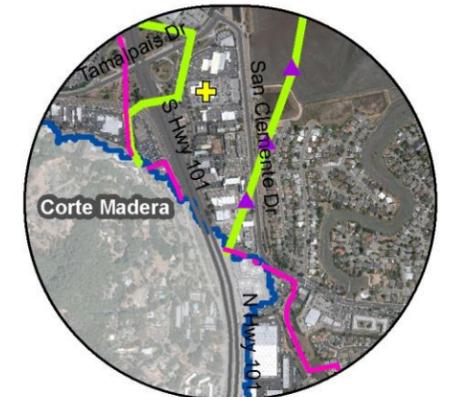
1: San Rafael Canal



2: Andersen Dr.



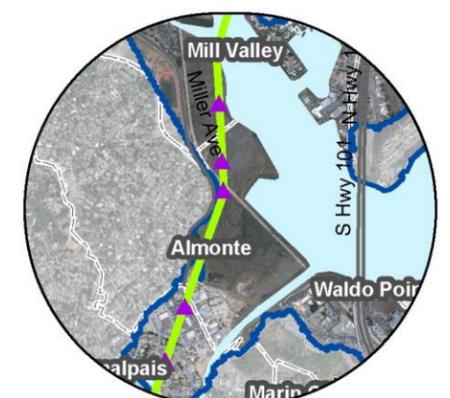
3: Larkspur Industrial Area



4: San Clemente Dr.



5: Sutton Marsh



6: Bothin Marsh

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Date: 1/29/2017



UTILITIES

Telecommunications

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

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



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

Stormwater Systems

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

Pump stations that are under tidal and storm surge influence could become ineffective and over worked. Tidal inundation of these facilities may impact their ability to convey upland stormwater downstream and may lead to flooding⁷⁸. Exposed pump station in the study area are also vulnerable to extended power outages as other others outside the study area. If back-up generator, diesel fuel supplies, and stormwater professionals cannot perform under these conditions, these systems could malfunction. Stormwater pump stations at risk are they are Crest Marin, Cardinal Court, Shoreline pump stations in the Mill Valley and Tamalpais Valley corridor, and the Seminary and Reed Creek pump stations in Strawberry could face tidal flooding. In Tiburon,

Map 32. AT&T Yard & Office at MHHW



⁷⁸ San Rafael Public Works Asset Manager Interview.

UTILITIES

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

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

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

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

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



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

UTILITIES

Map 33: Northern Study Area Vulnerable Stormwater Management Assets

Vulnerable Assets

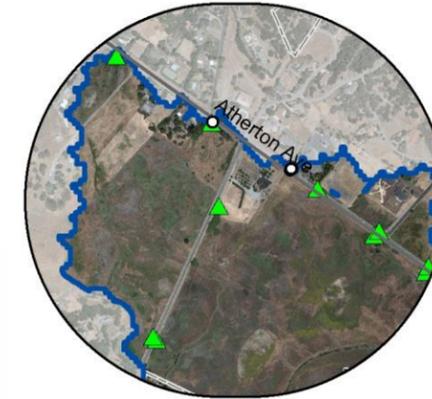
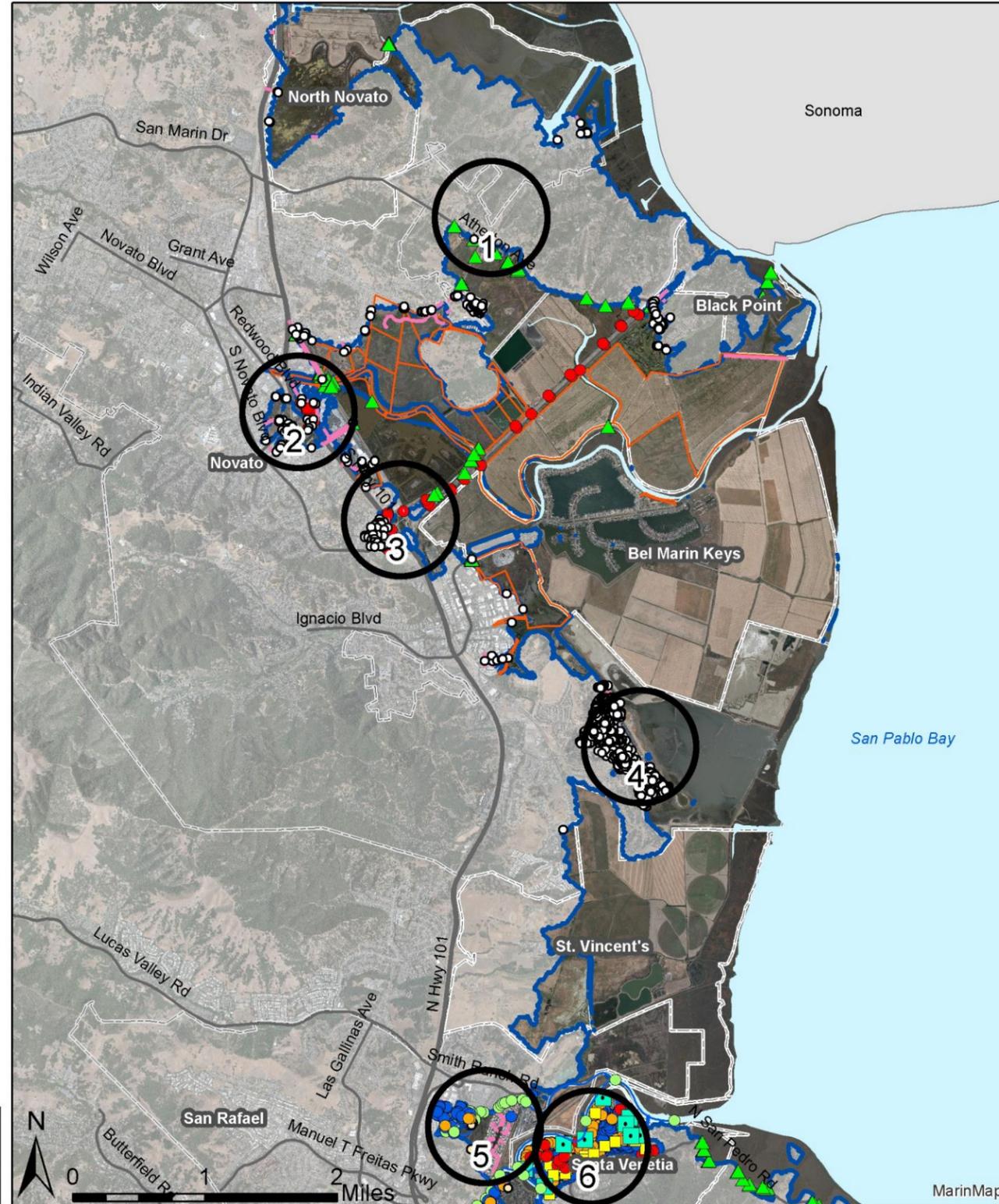
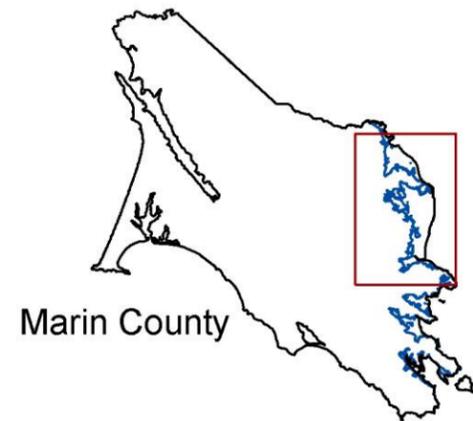
- ▲ Culvert
- Catch Basin
- Manhole
- Structures
- Pipe Inlet/Outlet
- Pump Station

- Channel
- Unspecified Node

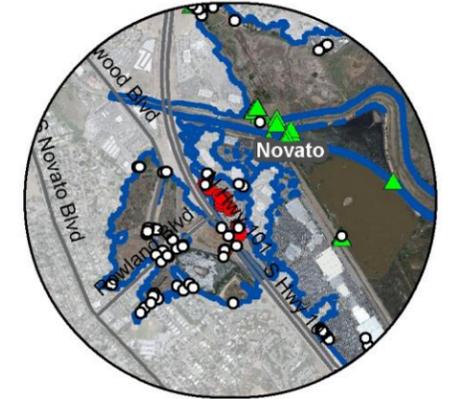
- Pipe
- Flood Control Parcels

Location Indicators

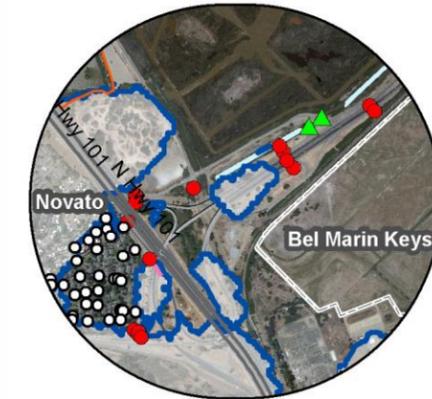
- Unincorporated
- Municipality
- Road
- Bay
- ~ Inland Extent: Sea Level @ 60"+100-year Storm



1: Green Point



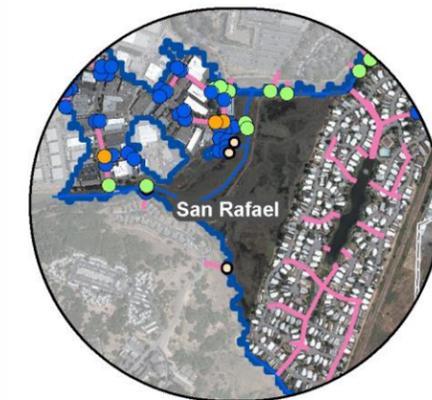
2: State Route 101 @ Rowland Blvd.



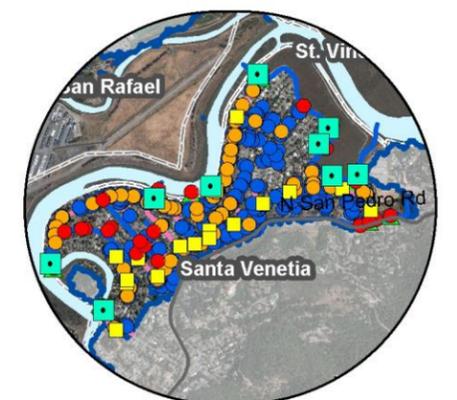
3: State Route 101 @ State Route 37



4: Hamilton



5: Las Gallinas



6: Santa Venetia

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Date: 4/1/2017



UTILITIES

Map 34. Southern Study Area Vulnerable Stormwater Management Assets

Vulnerable Assets

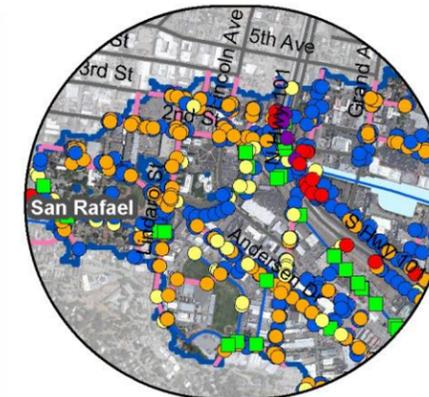
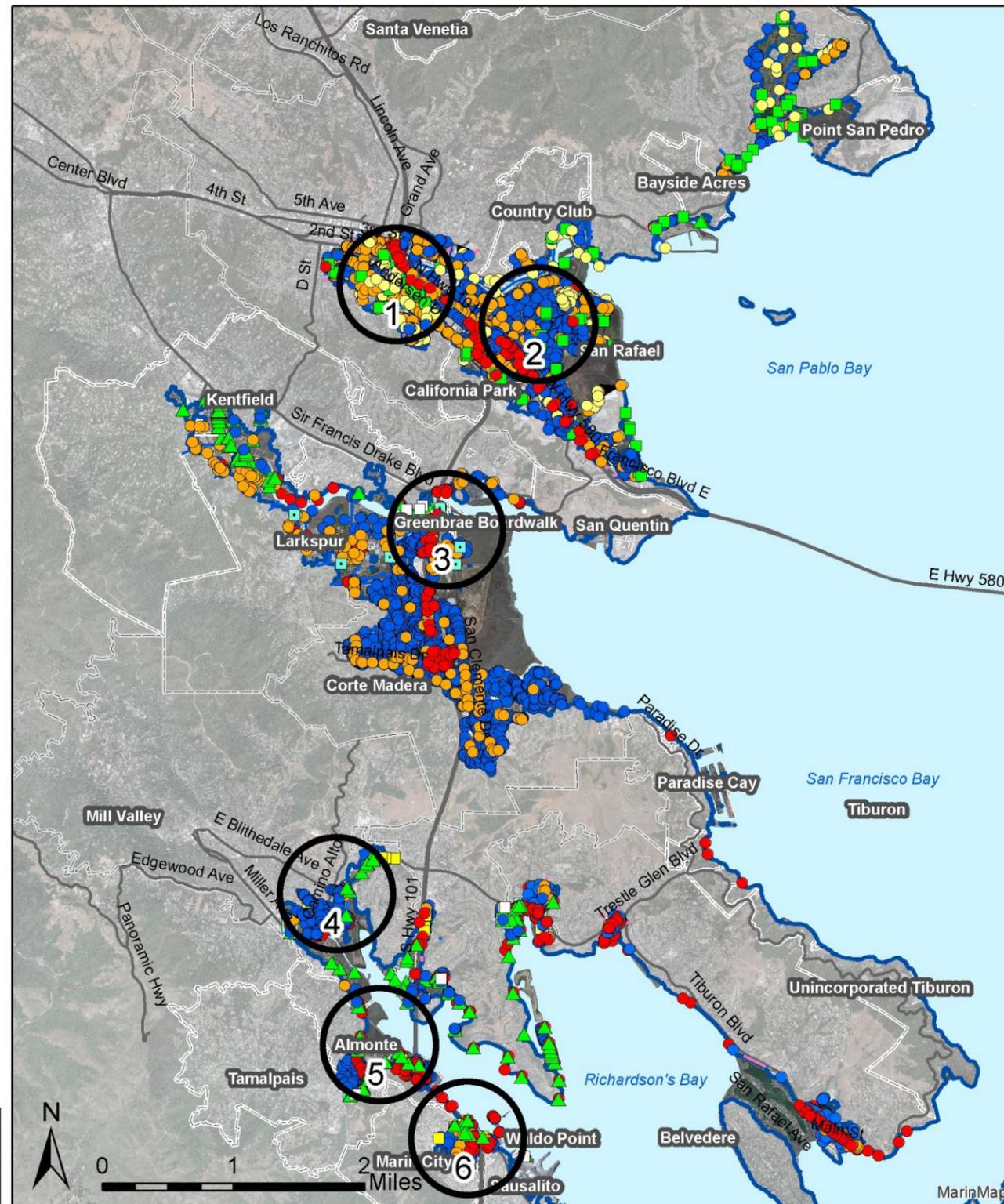
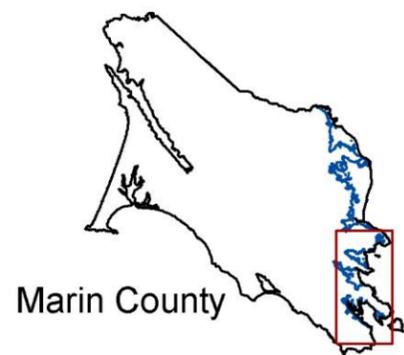
- Pump Station
- Manhole
- Structures
- Pipe End
- Catch Basin
- ▲ Culvert
- Box
- Flap Gate
- Node
- Wall

- Channel
- Pipe
- Pond

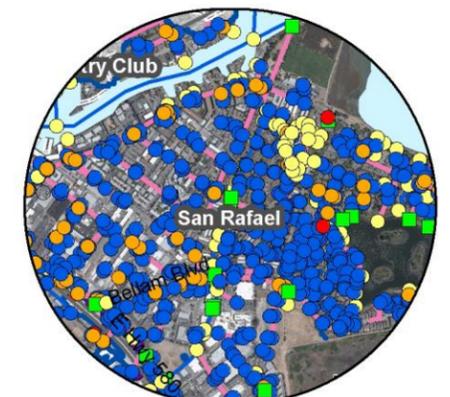
Location Indicators

- Unincorporated
- Municipality
- Road
- Bay

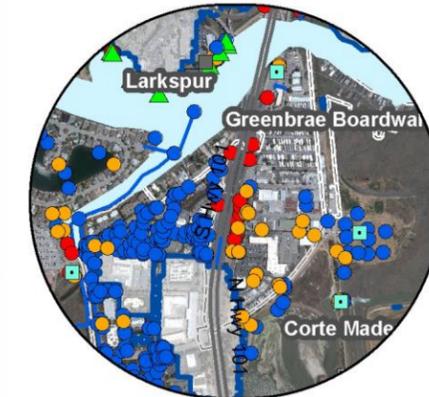
~ Inland Extent: Sea Level @ 60"+100-year Storm



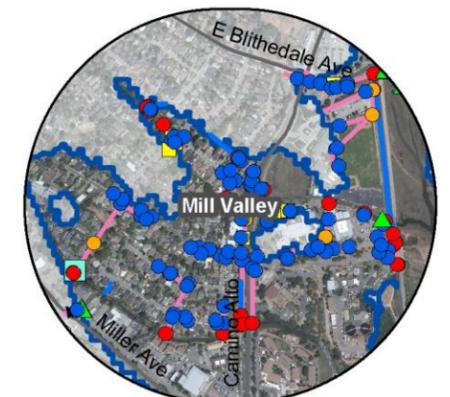
1: Central San Rafael



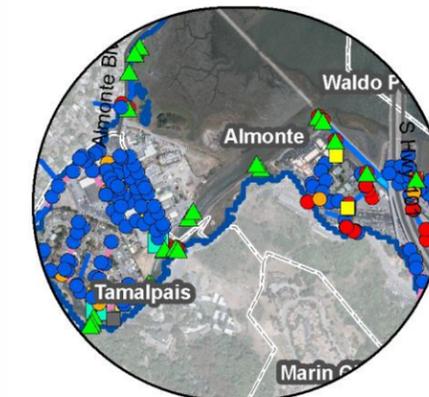
2: Canal Area



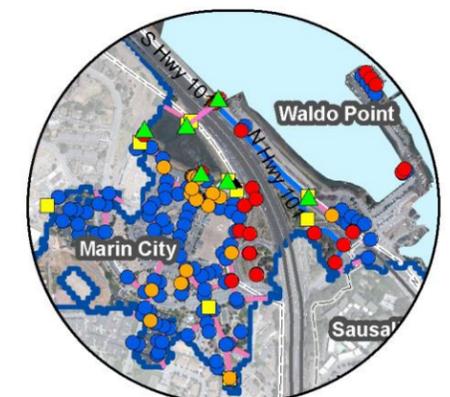
3: Greenbrae/
Larkspur



4: Mill Valley



5: Tamalpais
Valley/Almonte



6: Marin City/
Walden Point

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Date: 2/14/2017



UTILITIES

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

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

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

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

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

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

Source: MarinMap, CoSMoS, Asset Manager Interviews

UTILITIES

Other Considerations

Economic

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

Environmental

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

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

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

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

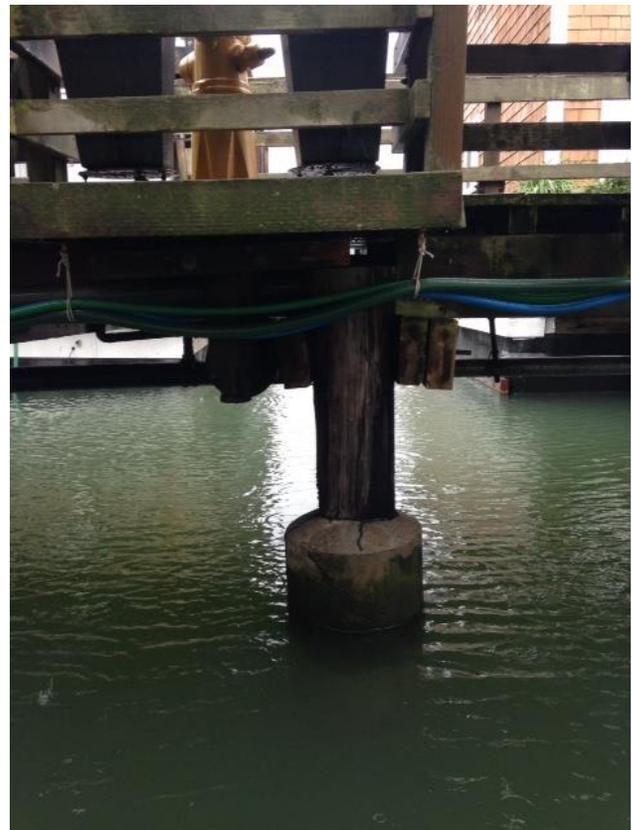
Social Equity

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

separation could divide the community into factions, increase tension, and reduce community cohesion and resiliency.

Management

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



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