



Adapting to Rising Tides

BAY AREA

SHORT REPORT

Summary of Regional
Sea Level Rise Vulnerability
and Adaptation
Study

MARCH 2020



METROPOLITAN
TRANSPORTATION
COMMISSION



Bay Area
Regional
Collaborative

SUGGESTED CITATION

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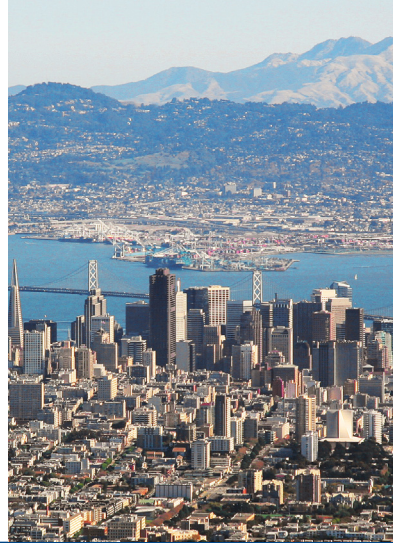
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Adapting to Rising Tides BAY AREA

Short Report: Summary of Regional Sea Level Rise Vulnerability and Adaptation Study

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Flooding at the San Francisco Embarcadero during King Tides in January 2020. King Tides are extreme high tides that show us what future sea level rise will look like. Photo courtesy of California King Tides Project.



A SHARED VISION FOR THE BAY

The Adapting to Rising Tides Bay Area (ART Bay Area) report presents a story of what consequences the Bay Area may face as sea levels rise in the absence of coordinated, prioritized adaptation. A product of a partnership between Caltrans District 4, the Metropolitan Transportation Commission/Association of Bay Area Governments (MTC/ABAG), Bay Area Regional Collaborative (BARC), the San Francisco Bay Conservation and Development Commission (BCDC) and many public, private, and nonprofit partners, this report represents a commitment by the agencies responsible to proactively managing the functionality and sustainability of our critical regional assets in an uncertain future. It also speaks directly to the Bay Area's most critical regional transportation and land use plan, Plan Bay Area 2050.

Flooding and rising sea level pose a risk everyone in the Bay Area, from local communities where homes and jobs may flood, to residents who rely on the regional-serving systems like transportation to connect us, keep our economy humming, and potentially play a role in mitigating the impacts of climate change down the line.

While the findings in this report may cause some alarm and concern, having this data at our fingertips gives us the information we need at the local, regional, state and federal levels to do what needs to be done to reduce the risks we face from flooding and rising sea level. In fact, while the vulnerability analyses in this report list many risks faced by the Bay Area from flooding and rising sea level, its underlining premise is that the severity of each of those risks can be avoided, and each of the challenges can be overcome, if we work together as a region to develop an ongoing adaptation strategy that embraces habitat, safeguards property, and protects people. In short, we can't let inaction or prejudice be our default, and we can't let perfect solutions be the enemy of workable and fair ones.

By wearing both our local and regional hats and taking the appropriate actions at each of those levels to reduce our risk, we can ensure that the entire Bay Area – its residents, its habitats, and its success – can prosper in the face of rising sea level. ART Bay Area lays out a blueprint for that future that involves all of our interests. Let's embrace it and make that future ours.



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Regional Risk: Where We Are Now

LAYING THE GROUNDWORK FOR INFORMED DECISION-MAKING

Shoreline flooding is no longer a question of if, but where and when: San Francisco Bay – our region’s iconic and unifying waterbody – is growing due to rising sea level. No matter where you live, shoreline flooding from rising sea level and storm events will impact everyone in the Bay Area. Even if your home is far from the shoreline, the roads, rails, and ferries we rely on; the schools, childcare, and hospitals we depend on; the jobs at which we work; and the beautiful natural areas we love are at risk. The Adapting to Rising Tides (ART) Bay Area report is the Bay Area’s first regional assessment of the interconnected impacts of rising sea level on people, the environment, and the regional systems we rely on.

This analysis illuminates potential impacts of flooding to four critical region-wide systems: transportation, future growth areas, natural lands, and vulnerable communities (Figure 1). Regional transportation systems include highways, ports, airports, freight and passenger rail, ferries, and bike trails. Future job and housing growth areas are areas already identified as critical for smart growth, including Priority Development Areas (PDAs)¹. Natural lands includes recreation, agriculture, and ecosystem along the shoreline, including those in Priority Conservation Areas (PCAs)². Lastly, vulnerable communities includes residents who are more vulnerable to flooding due to lower incomes or other socioeconomic factors or because they live near contaminated sites. To support the region-wide analysis, 32 local deep

dive studies were done to deeply understand how impacts play out within a community. These systems and locations were analyzed at a total of ten flood levels to show a wide range of impacts over time.

The impacts in ART Bay Area are the worst-case scenario for ten different flooding scenarios *in the absence of action*. These are potential impacts in the face of many uncertainties, including uncertainty about the exact timing of flooding, what kind of assets could be added to these locations now and into the future, and what actions could be taken to

ART Bay Area is the Bay Area’s first regional assessment of the interconnected impacts of rising sea level on people, the environment, and the regional systems we rely on.

1 Priority Development Areas, commonly known as PDAs, are areas within existing communities that local city or county governments have identified and approved for future growth. These areas typically are accessible by one or more transit services; and they are often located near established job centers, shopping districts and other services.

2 Priority Conservation Areas, or PCAs, are regionally significant open spaces which have broad agreement for long-term protection. These are lands that are being pressured by urban development and other factors, and they are supported through local government consensus.

help reduce the risk from flooding and rising sea level. ART Bay Area clearly illuminates the cost of *doing nothing*.

Developed through a funding and management partnership between Caltrans District 4, the Metropolitan Transportation Commission/Association of Bay Area Governments (MTC/ABAG), Bay Area Regional Collaborative (BARC), and the San Francisco Bay Conservation and Development Commission (BCDC)'s Adapting to Rising Tides program, ART Bay Area is designed to provide the region the foundational information needed to inform regional planning through Plan Bay Area 2050 and local planning tools to build a strong foundation for region-wide decision making about where, when, and how we adapt to rising sea level.

Throughout the nearly three-year project, ART Bay Area engaged nearly 600 community members, nonprofits, city and county planners, business representatives, elected officials, and state and federal staff in an inclusive and transparent process to deeply understand not just what may get flooded, but how the impacts of flooding will be felt by everyone in the Bay Area and beyond.

This report serves as the foundational document to help the Bay Area plan for rising sea level in a way that preserves and enhances the future for not just a select handful of cities or assets, but for everyone. It provides definitive answers about what gets wet, where and when, putting at the Bay Area's fingertips the data we need to clarify the values we hold for the region's future, prioritize how and when dollars get spent on adaptation, and to ensure that both local and regional planners make informed decisions about land use, transportation, the environment, and community development.

TRANSPORTATION NETWORKS VULNERABLE COMMUNITIES

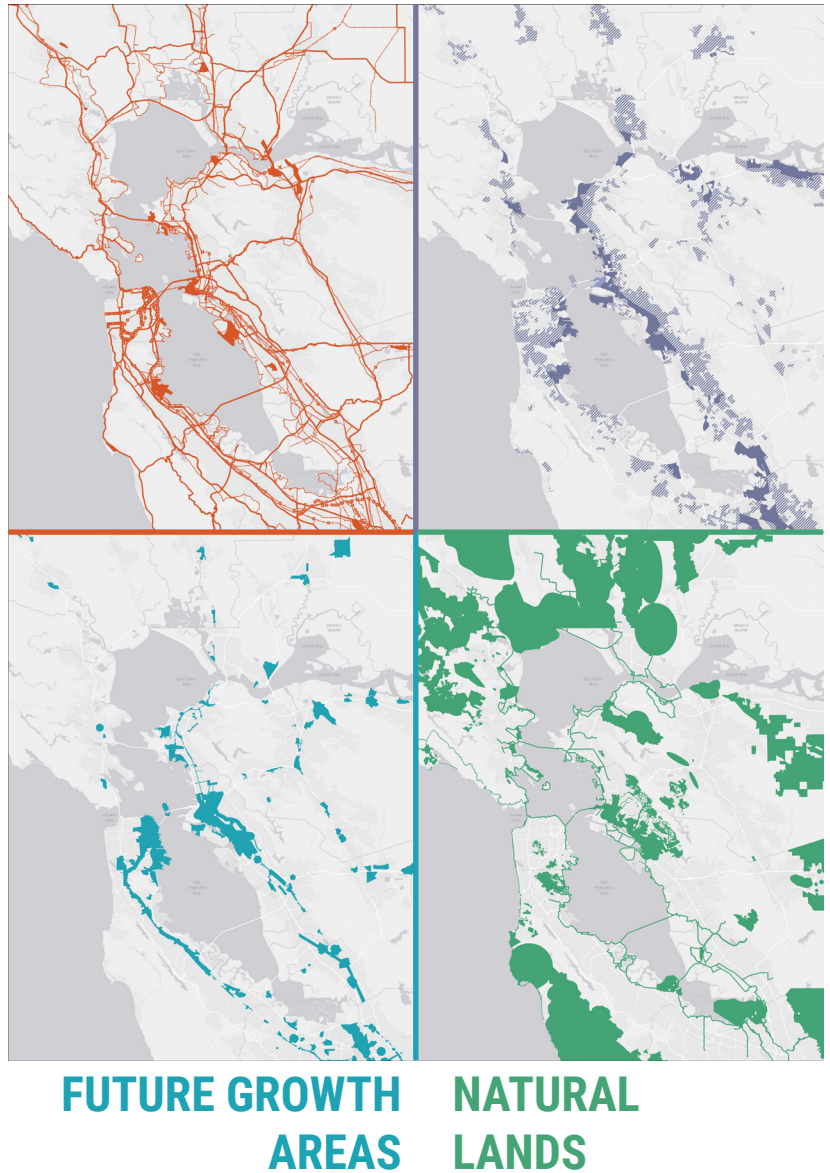


Figure 1. Maps of the four regional systems assessed in ART Bay Area, including Transportation networks, Vulnerable Communities, Future Growth Areas and Natural Lands. For Future Growth Areas and Natural Lands, only existing Priority Development Areas (PDAs) and Priority Conservation Areas (PCAs) are shown, respectively.



HAZARDS IN THE BAY AREA – HARBINGER OF THE FUTURE

The Bay Area has seen its share of natural disasters, ranging from floods to earthquakes to wildfires. Since the 1906 San Francisco earthquake, the region has a strong history of rising to the challenges thrown at us. But without definitive and timely action, rising sea level could cause cascading impacts far beyond anything in the region’s collective memory.

In December 2019, heavy rains in San Francisco caused flooding that not only made surface streets impassable but poured into underground Muni stations. Regular flooding from storm surges along the Embarcadero already occasionally impacts the ability to bike, walk, and drive along the shoreline, and routinely damages underground BART and Muni equipment.

Between 2060 and 2120¹ this flooding may not only be permanent, but far more widespread. Along the Embarcadero near the Ferry Building, four feet of flooding could permanently impact nearly 300 existing jobs; prevent nearly 7,000 passengers daily from accessing their ferries; force five Muni bus lines to reroute to other city streets; and reroute commutes for nearly 21,000 Muni passengers daily. Just a few more inches of flooding² would impact the 32,000 daily BART and Muni passengers that rely on the Embarcadero Station and threaten over 300 existing housing units and 11,700 existing jobs. Just one foot of flooding could potentially impact nearby vulnerable populations, jobs, and commuters relying on the ferries.

1 According to California State Guidance, under the H++ scenario, which represents the highest risk and least likely scenario, sea level rise could reach 46.8” by 2060, which corresponds to ART’s 48” TWL scenario. Under the Likely Range, or Low-Risk Aversion high-emissions scenario, 48” of sea level rise will not occur until 2120.

2 52” of flooding



Even the devastating October 2017 fires in the North Bay pale in comparison to the magnitude of potential impacts from future inundation. While the total acres inundated between 2060 and 2120 might be lower than the number of acres impacted by the 2017 wildfires³, the densely populated nature of many parts of the shoreline mean that far more homes may be at stake (Figure 2).

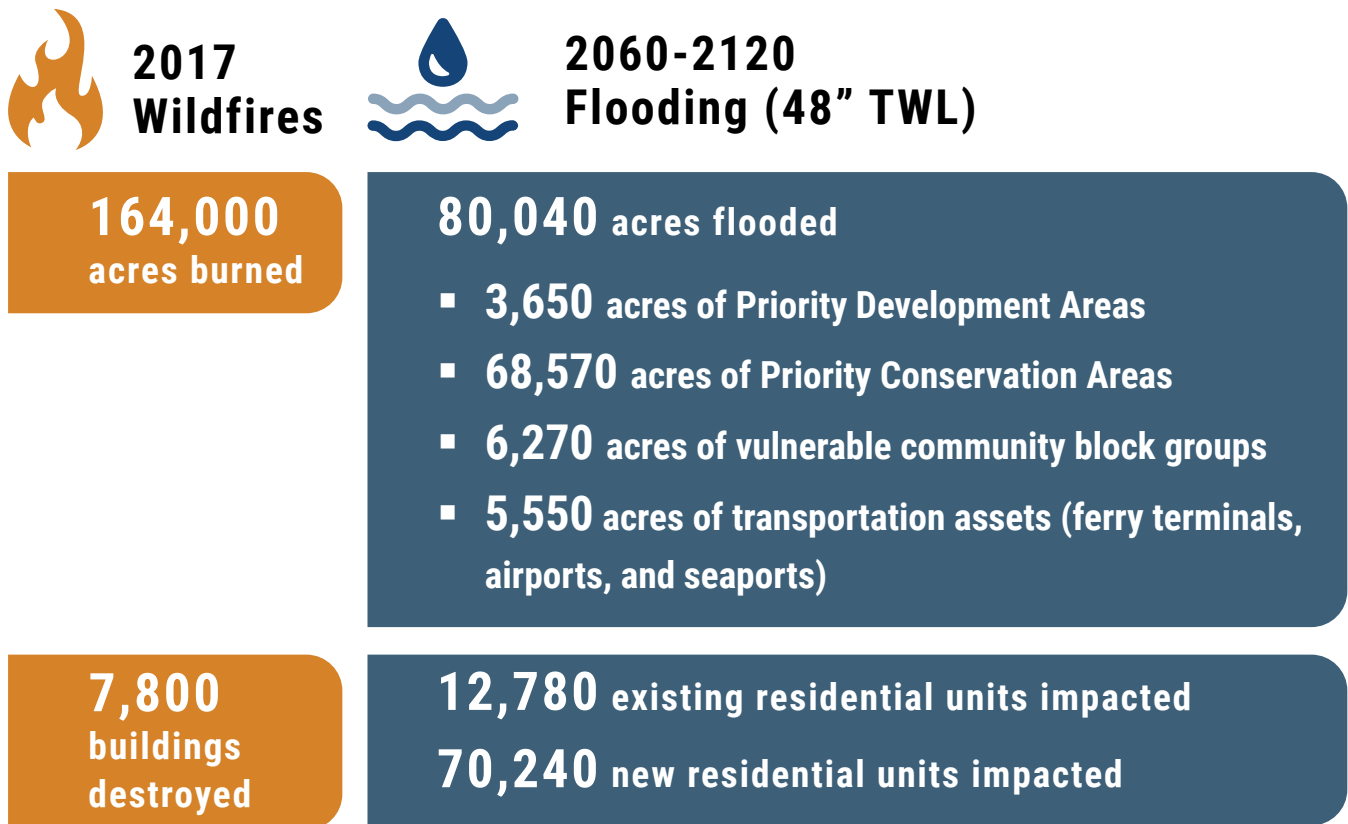


Figure 2. Comparison of impacts from the 2017 wildfires in the North Bay compared to potential impacts of flooding that could occur at 48" TWL.

³ https://en.wikipedia.org/wiki/October_2017_Northern_California_wildfires. Numbers refer to Bay Area counties only.

A RISING BAY WILL CHANGE WHAT IT MEANS TO LIVE IN THE BAY AREA

With rising sea level, permanent inundation will impact the entire bay shoreline at once. This is very different than how we experience storm flooding today, with big events like King Tides impacting parts of the bay shoreline very differently, or wildfires occurring only in certain parts of the region.

104,000
existing jobs

85,000 new,
planned jobs

13,000 existing
housing units

70,000 new,
planned housing
units

28,000 socially
vulnerable
residents

Snapshot of impacts that could occur at 48" (4 feet) of temporary or permanent flooding

Region-wide with four feet of flooding over the next 40 to 100 years¹, we could see impacts to:

- Nearly 104,000 existing jobs that will either need to relocate or be lost;
- Over 85,000 *new, planned jobs* (projected by 2040²) that either won't be created, or will be created elsewhere in the region or even outside the region;
- Nearly 13,000 existing housing units that will no longer be habitable, insurable, or desirable places to live;
- Over 70,000 badly needed *new, planned* housing units (projected to be built by 2040⁷) that either won't be built, or will be built elsewhere in the region or even outside the region;
- Nearly 28,000 socially vulnerable residents³ living near the shoreline who will become more vulnerable because they are dealing with daily flooding in their homes and neighborhoods;

1 According to California State Guidance, under the H++ scenario, which represents the highest risk and least likely scenario, sea level rise could reach 46.8" by 2060, which corresponds to ART's 48" TWL scenario. Under the Likely Range, or Low-Risk Aversion high-emissions scenario, 48" of sea level rise will not occur until 2120.

2 Planned new housing units in Priority Development Areas in Plan Bay Area 2040

3 Refers to community vulnerability assessment methodology developed by the Adapting to Rising Tides program. For more information, see the full ART Bay Area report



- Over 5 *million* highway vehicle trips daily that will need to be rerouted to surface streets, other highways, or transit, or not taken;
- Over 60,000 daily commuters who won't be able to board their commuter rail lines at their usual station; and
- Over 20,000 acres of habitats for depressional wetlands, lagoons and tidal marshes that will no longer be able to support a diversity of wildlife, habitat for endangered species, support recreation and tourism, provide climate resilience, among other ecosystem services.

These are only some of the major impacts we could experience due to flooding from rising sea levels and storms. Unlike the earthquakes, floods, and fires that have struck the Bay in collective memory, we know what to expect from rising sea levels and when to expect it. We have an unprecedented opportunity to prepare ourselves and choose a more resilient future.

5 million
daily highway
vehicle trips

60,000 daily
rail commuters

20,000 acres
of depressional
wetlands,
lagoon and tidal
marsh habitat

The Regional Picture

Regional analysis was based on factors that pointed to “regional significance” – impacts that would create rippling consequences that would be felt throughout the region. These factors – called *indicators* – vary from the number of average daily vehicles that would no longer be able to use a segment of a highway to the number of billions of dollars of cargo that would not be able to leave or enter a seaport. The 32 indicators across the four systems give a measure of impacts to people, the economy, and the environment that could happen as the shoreline floods.

Figure 3. Overview of major flooding impacts at 12”, 24” and 36” TWL. This graphic notes that snapshots of impacts at 48” TWL are discussed on following pages.

These findings are, like all projections, best guesses given current conditions and current data. They do not account for flood control projects that are currently being planned or implemented – they are primarily based on the shoreline as it stands today (the exception is identifying potential exposure of planned housing units and jobs within PDAs). Because of this, some impacts may be reduced upon completion of projects currently being built. But the findings nonetheless help to illustrate the power that shoreline flood management projects have to shape the kind of future we will be facing as a region.

OVERVIEW OF MAJOR IMPACTS

12”
TWL

- At 12” TWL, many shoreline endangered species habitats, including endangered species habitat for snowy plover, Ridgway’s rail, and salt marsh harvest mouse, marshes, and wetlands are flooded extensively, and ecosystem services like carbon sequestration and stormwater infiltration are significantly compromised. First impacts to crop production occur.
- On a typical morning commute, over 680,000 drivers on the highways could be impacted by flooding. Ferry parking lots may flood but not necessarily boarding docks.
- Over 2,000 existing jobs in Priority Development Areas may begin to be impacted.
- First impacts to 3,750 households in socially vulnerable communities, 1/3 of which are in or near contaminated sites.

24”
TWL

- At 24, TWL, additional significant impacts occur to shoreline habitats and ecosystem services, with particularly high jumps in impacts to snowy plover, depressional wetland, and lagoon habitat. Impacts to crop production continue to increase steadily.
- First impacts to airports are felt and are fairly significant for passengers and cargo, as well as first impacts to commuter rail stations. Impacts to daily highway vehicle traffic reaches nearly 1.5 million commuters who rely on US-101 in Marin, SR-37, US-101 in San Mateo County, and I-880 in Alameda County.
- Existing jobs within Priority Development Areas at risk jumps significantly, to over 30,000. Nearly 4,000 existing residential units also become exposed. But planned jobs and housing fare worse – 67,440 planned jobs and 24,640 planned residential units are at risk of flooding
- At-risk households in socially vulnerable communities nearly doubles, and contamination nearly triples.

36”
TWL

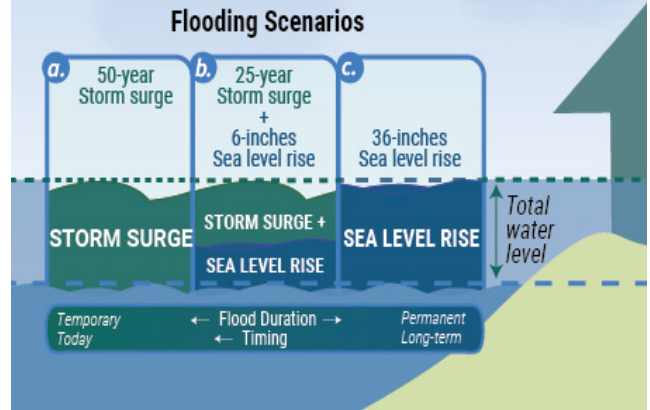
- At 36” TWL, impacts to critical regional habitats and ecosystem services reach near-peak levels.
- The Bay Bridge touchdown starts to flood, severely impacting cross-bay movement. Over 33 million annual passenger boardings and 1.6 billion pounds of cargo at airports are at risk.
- Significant jumps in impacts continue in Priority Development Areas, with 154,640 planned jobs and 64,400 planned housing units at risk around the region.
- Impacts in socially vulnerable communities reaches nearly 15,000 households, with over 2/3 of these also exposed to contaminated sites.

Looking across ten flooding scenarios, some impacts will be felt early and intensely, while others will slowly accumulate over time. Many impacts have a clear “threshold” – a jump in flooding that seriously worsens impacts in a short timeframe.

Figure 3 provides a summary of some of the impacts the region could see at flooding scenarios from 12” (1 foot) to 36” (3 feet) total water level (TWL). TWL is a concept used in the ART program to communicate flooding scenarios (Figure 4).

The following pages provide snapshots of exposure and highest consequences of potential impacts at 48” TWL (4 feet), an extreme risk scenario, but one that is not out of the realm of possibility between 2060 and 2120 as sea levels continue to rise. The full ART Bay Area report includes analyses of exposure and consequence across all ten TWLs.

Figure 4. “One Map, Many Futures” refers to using Total Water Levels to signify different flooding scenarios.



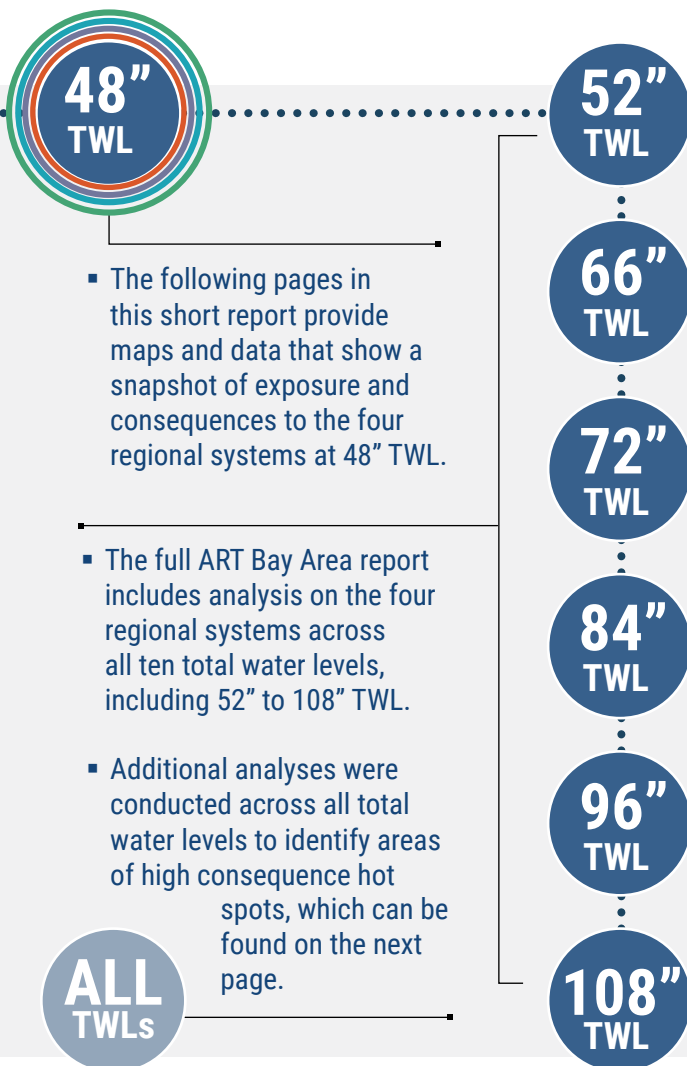
One Map, Many Futures: The Total Water Level (TWL) Concept

ART Bay Area uses the concept of total water level (TWL) to estimate exposure. The TWL approach accounts for multiple combinations of rising sea level and storm surge. This approach allows us to address temporary impacts of today’s winter storms while simultaneously planning to address permanent flooding from rising sea level tomorrow.

While permanent flooding due to rising sea level will likely be extensive and relatively consistent throughout the region, temporary flooding due to storm events will impact some areas more than others, depending on how widespread the storm is. This is why we do not necessarily see the depth and breadth of exposure and consequences anticipated across the region for 12” TWL during temporary storm events, but instead only in isolated locations.

All impacts for any given total water level represents the worst case scenario for that level of flooding – actual impacts from storm events are likely to be less than from permanent inundation.

ART Bay Area focuses on what impacts could occur at 10 total water levels between 12 to 108 inches higher than current sea level.





Regional Hot Spots

Overview of Shared Consequences



HIGH CONSEQUENCE HOT SPOTS

In this analysis, ART Bay Area has identified locations around the bay where many of our regionally significant assets in transportation, future growth areas, vulnerable communities and natural lands come together. These locations are areas ripe for coordinated adaptation planning at the local and regional level. This study identified regional “hot spots” where high-consequence assets are clustered.

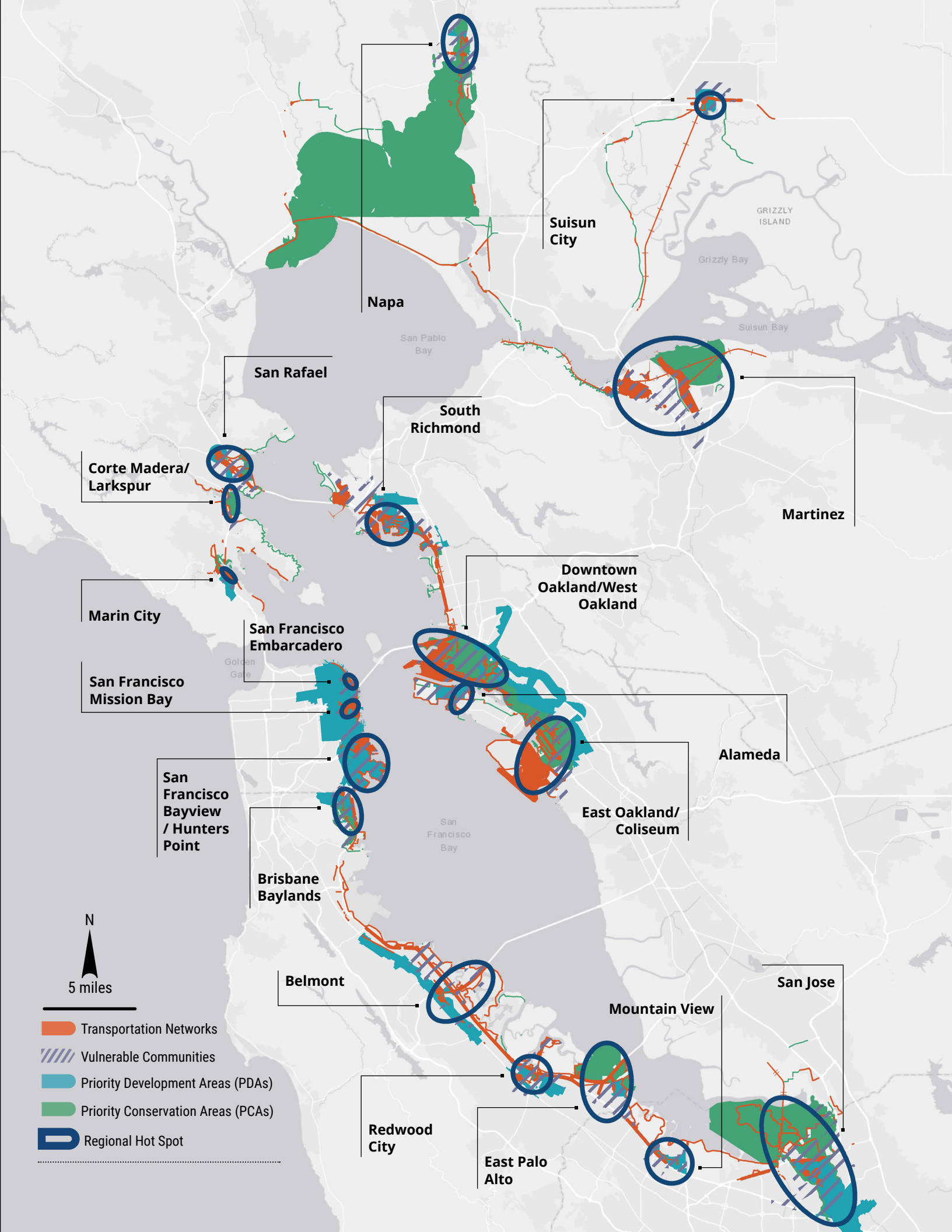
Hot spots were identified because they contained at least one high-consequence transportation asset, a Priority Development Area slated for particularly high job or housing growth or a Priority Conservation Area facing significant impacts, and a community facing social vulnerability and/or contamination. These areas could benefit from support from the region through technical assistance, resources, or incentives to ensure that these areas are protected first, and may be areas where a single adaptive approach – such as a single green or gray flood control project or zoning change – could protect many assets at once.

Because exposure and consequence changes as water levels rise, this analysis was conducted for all 10 water levels. While the hot spots shifted around the region as water levels rose, many locations remained consistently critical over many water levels. Overall, identifying the clusters that emerge as significant early on and *stay* significant is the best indicator of regional importance across time. The 18 hot spots that emerged are shown in Figure 5.

These locations are areas ripe for coordinated adaptation planning at the local and regional level.

Regional Hot Spots: High Consequence Asset Clusters in the San Francisco Bay Area

Figure 5. Regional hot spots at all total water levels. New hot spots emerge as water levels rise from 12” to 48” TWL. After 48” TWL, hot spots remain relatively stable. The few exceptions include new clusters in Corte Madera, West Oakland/Emeryville and Foster City/San Mateo, as well as Suisun and Brisbane Baylands.



Corte Madera/
Larkspur

Marin City

San Francisco
Mission Bay

San
Francisco
Bayview
/ Hunters
Point

San Francisco
Embarcadero

Brisbane
Baylands

Belmont

Napa

San Rafael

South
Richmond

Downtown
Oakland/West
Oakland

East Oakland/
Coliseum

Redwood
City

East Palo
Alto

Mountain View

Suisun
City

Martinez

Alameda

San Jose

San Pablo
Bay

Grizzly Bay

Suisun Bay

GRIZZLY
ISLAND

San Francisco
Bay

Golden
Gate

Transportation Networks

Vulnerable Communities

Priority Development Areas (PDAs)

Priority Conservation Areas (PCAs)

Regional Hot Spot

N
5 miles



Transportation Networks

Snapshot of Highest Consequences




48"
TWL

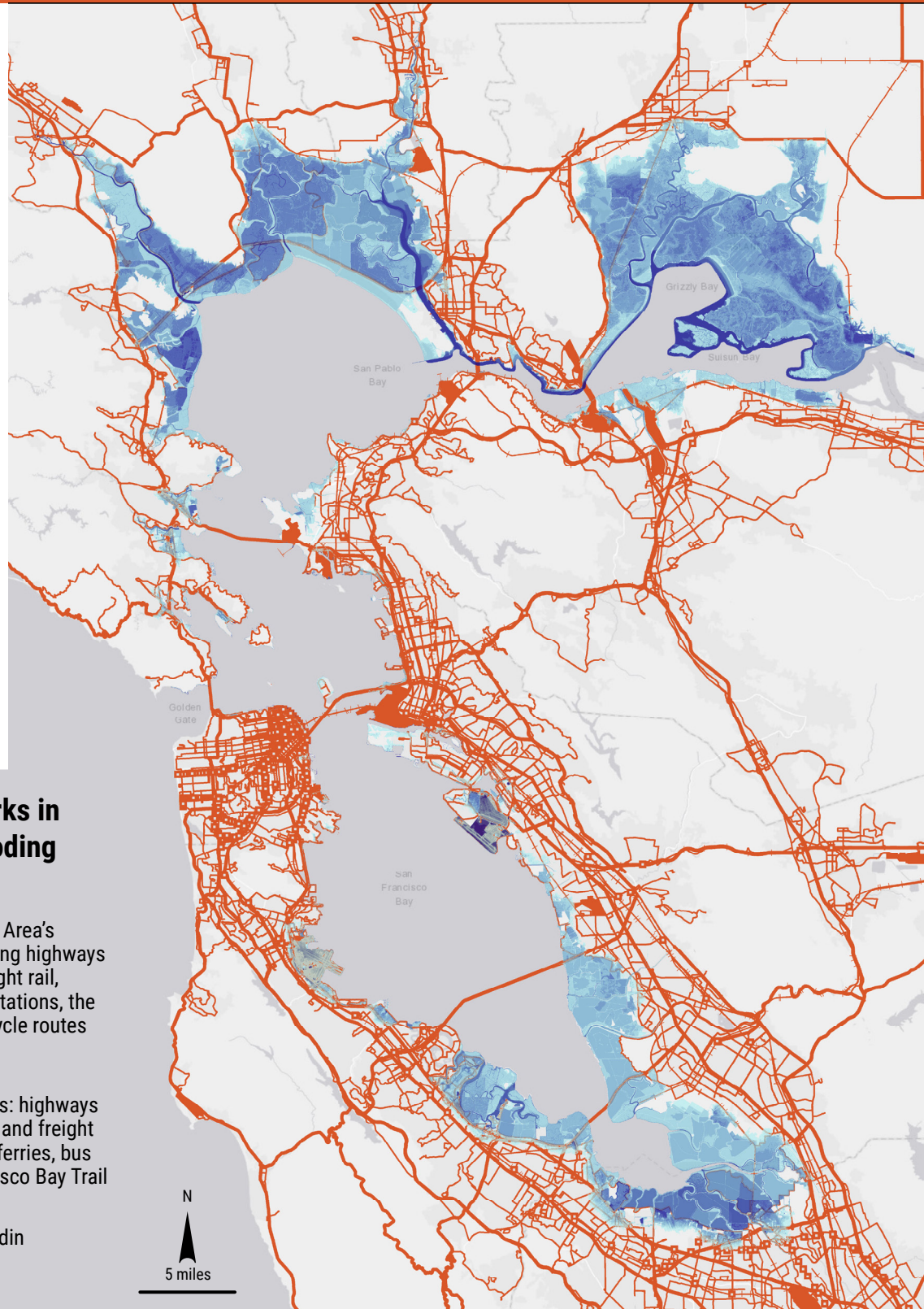
Transportation assets are often clustered along the shoreline. This network moves people, goods, and services throughout the region and beyond and links them with community facilities, jobs, family and friends, recreation, services.

Exposure and major impacts from flooding to the transportation system at 48" TWL are shown on the following pages (Figure 6).

Transportation Networks in the Bay Area With Flooding (2060 - 2120)

Figure 6. Distribution of the Bay Area's transportation networks, including highways and bridges, commuter and freight rail, airports, seaports, ferries, bus stations, the San Francisco Bay Trail and bicycle routes with flooding at 48" TWL.

-  Transportation networks: highways and bridges, commuter and freight rail, airports, seaports, ferries, bus stations, the San Francisco Bay Trail and bicycle routes
-  Shallower depth of flooding
-  Deeper depth of flooding



HIGHWAYS AND BRIDGES



59 miles exposed (3% of system)

5 million daily vehicle trips

227,000 daily truck trips

SEAPORTS



780 acres exposed (11% of system)

\$2.1 billion dollars in annual imports and exports

COMMUTER RAIL



Passenger rail lines

20 miles exposed (12% of system)

84,340 daily weekday passengers

Passenger rail stations

17 stations exposed (18% of system)

60,490 daily weekday passengers

FERRY TERMINALS



11 acres exposed (22% of system)

14,740 passengers per weekday

HIGH QUALITY BUS ROUTES



4 miles exposed (2% of system)

FREIGHT RAIL



48 miles exposed (18% of system)

216 freight trains per day

AIRPORTS



4,670 acres exposed (39% of system)

33.3 million annual passenger boardings

1,590 trillion tons of cargo

ACTIVE TRANSPORTATION



Regional Bicycle Network

78 miles exposed (18% of system)

San Francisco Bay Trail

189 miles exposed (28% of system)

Unless otherwise stated, values above refer to potential impacts. The full ART Bay Area report includes exposure and consequence across 10 total water levels (TWLs) for transportation assets from 12" TWL to 108" TWL.



Vulnerable Communities

Snapshot of Highest Consequences

48"
TWL

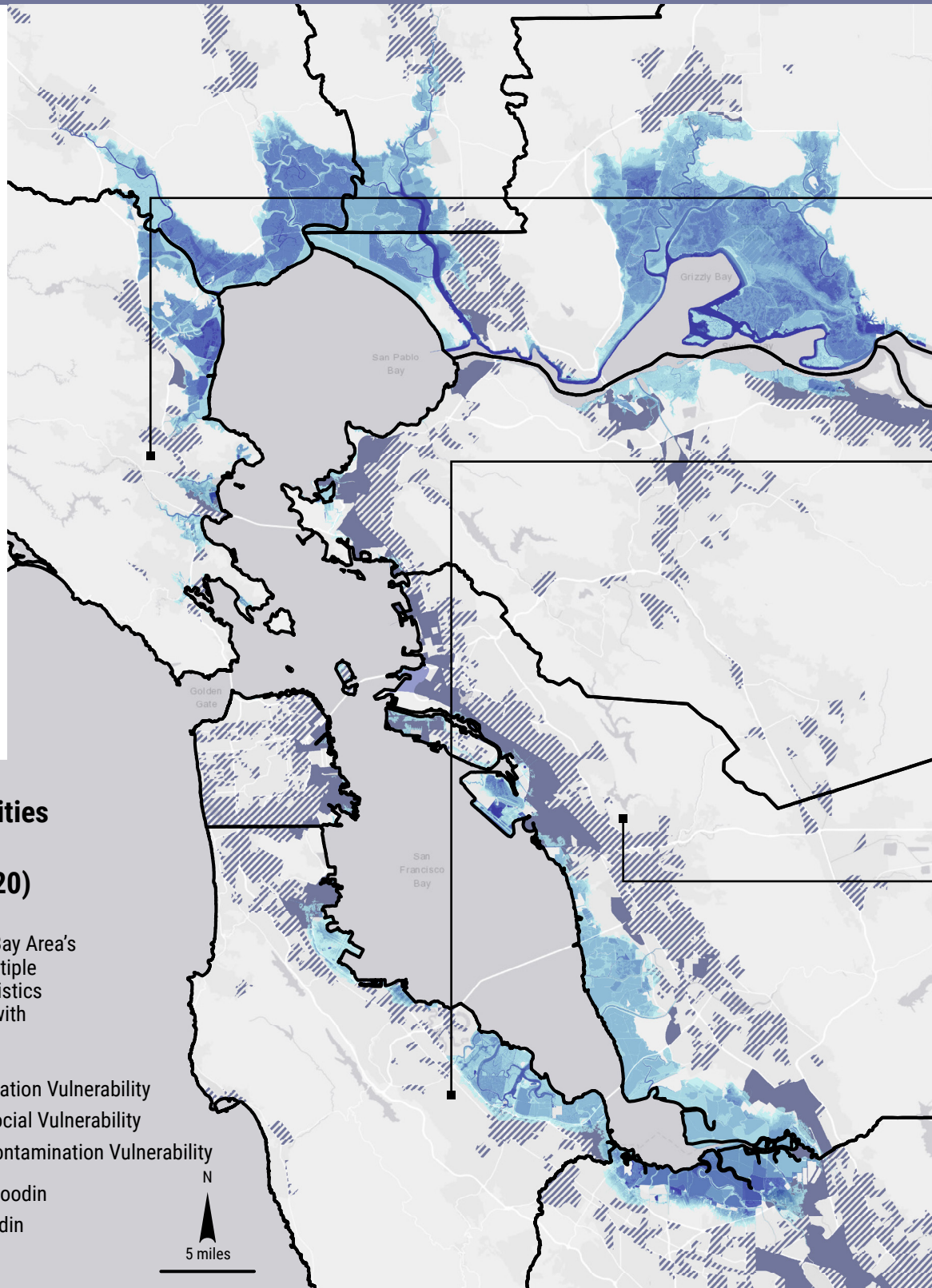
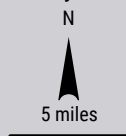
Some **Bay Area communities** experience social and economic conditions that make it more difficult to prepare for, respond to, and recover from flooding.

Residents in these communities face stressors such as housing displacement pressures or job instability that make them more vulnerable to the instabilities further introduced by rising sea level. (Figure 7).

Vulnerable Communities in the Bay Area With Flooding (2060 - 2120)

Figure 7. Distribution of the Bay Area's block groups that exhibit multiple social vulnerability characteristics and contamination burdens with flooding at 48" TWL.

- Social and Contamination Vulnerability
- Block groups with Social Vulnerability
- Block groups with Contamination Vulnerability
- Shallower depth of floodin
- Deeper depth of floodin



48"
TWL

MARIN COUNTY



37% of socially vulnerable block groups exposed

5,050 existing residential units in socially vulnerable block groups



36% of block groups with contamination vulnerability exposed

2,000 existing residential units in block groups with contamination vulnerability

SAN MATEO COUNTY



14% of socially vulnerable block groups exposed

7,800 existing residential units in socially vulnerable block groups



17% of block groups with contamination vulnerability exposed

3,640 existing residential units in block groups with contamination vulnerability

ALAMEDA COUNTY



4% of socially vulnerable block groups exposed

6,470 existing residential units in socially vulnerable block groups



9% of block groups with contamination vulnerability exposed

3,870 existing residential units in block groups with contamination vulnerability

Vulnerable communities include residents who are low-income, non-English speakers, non-white, disabled, elderly, or do not hold college degrees, as well as those that live adjacent to contaminated sites. At 48" TWL, 27,950 residential units in socially vulnerable block groups region-wide will potentially be impacted by flooding, with 19,000 of these units near or in contaminated sites.

This number only includes units already built today – if more units are built in flood areas, or if vulnerable populations continue to move to more vulnerable areas, this number may significantly increase. This data is intended to help cities and counties make informed decisions about where residents, especially vulnerable ones, can most safely live along the shoreline in the future, and take appropriate action to make sure people are not moving into harm's way.

The following statistics reflect counties with the highest socially vulnerable residential units impacted at 48" TWL. Unless otherwise stated, values refer to potential impacts. The full ART Bay Area report includes exposure and consequence across 10 total water levels (TWLs) for all block groups with social or contamination vulnerability in the region.



Future Growth Areas

Snapshot of Highest Consequences

48"
TWL





In ART Bay Area, future growth areas are assessed using the **Priority Development Area (PDA)** framework developed by MTC/ABAG.

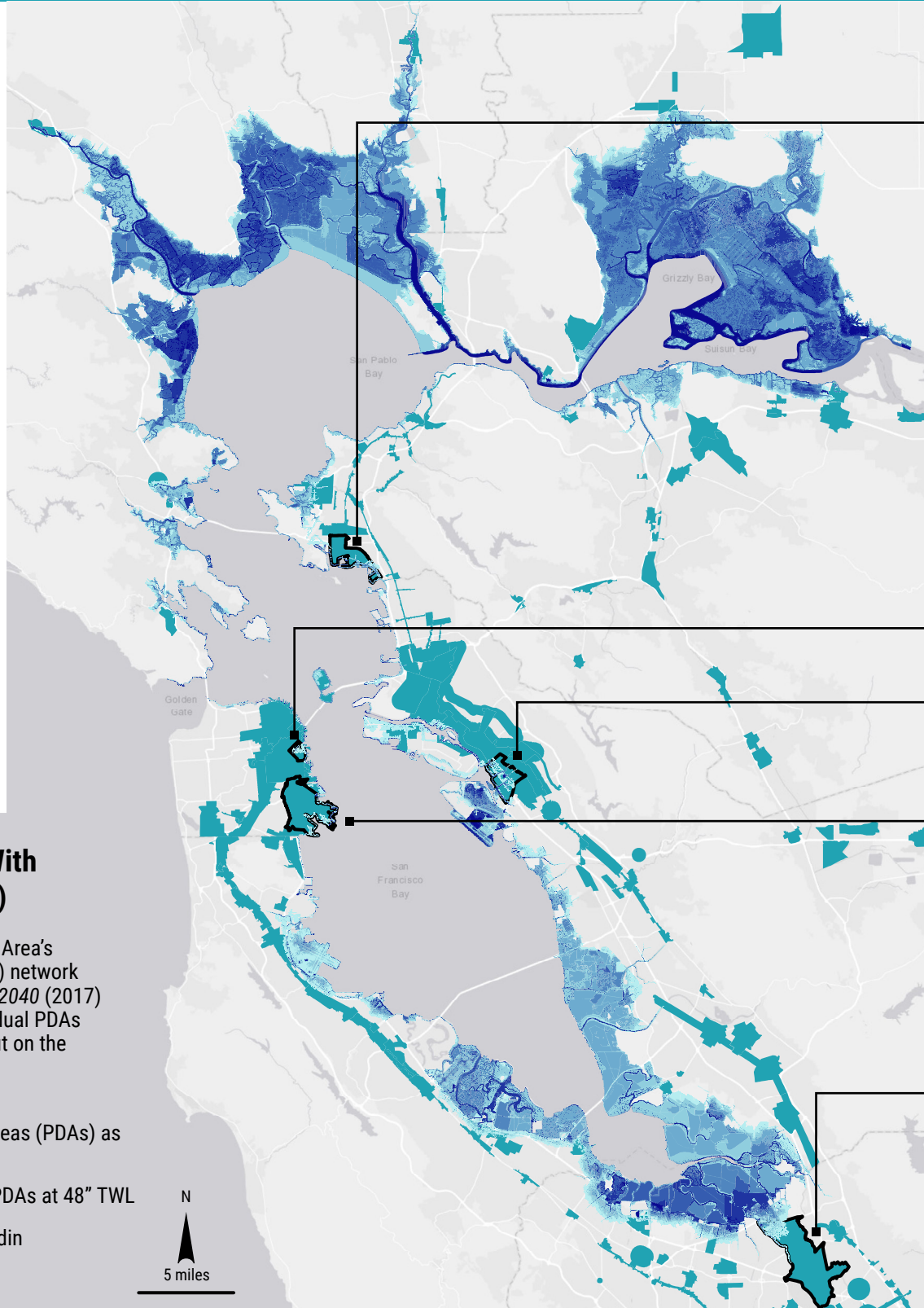
By 48" TWL, 3,650 acres of existing designated PDAs could be flooded, representing 3 percent of the region's current PDA system (as of 2019).

Consequences of flooding within PDAs include not just existing residents and jobs, but those planned for the future. Impacts to some of the highest consequence PDAs are shown on the following pages (Figure 8).

Future Growth Areas With Flooding (2060 - 2120)

Figure 8. Distribution of the Bay Area's Priority Development Area (PDA) network as designated by *Plan Bay Area 2040* (2017) with flooding at 48" TWL. Individual PDAs with black outlines are called out on the following page.

-  Priority Development Areas (PDAs) as of Plan Bay Area 2040
-  Highest Consequence PDAs at 48" TWL
-  Shallower depth of floodin
-  Deeper depth of floodin



SOUTH RICHMOND PDA

2,079 existing residential units

2,751 new residential units (change in growth from 2010 to 2040 projections)

13,344 new job spaces (change in growth from 2010 to 2040 projections)

MISSION BAY PDA

2,158 existing residential units

6,853 existing job spaces

3,235 new residential units (change in growth from 2010 to 2040 projections)

3,325 new job spaces (change in growth from 2010 to 2040 projections)

COLISEUM BART STATION AREA PDA

9,064 existing residential units

9,789 new residential units (change in growth from 2010 to 2040 projections)

1,677 new job spaces (change in growth from 2010 to 2040 projections)

BAYVIEW / HUNTERS POINT SHIPYARD / CANDLESTICK POINT PDA

4,190 existing job spaces

11,161 new residential units (change in growth from 2010 to 2040 projections)

14,922 new job spaces (change in growth from 2010 to 2040 projections)

NORTH SAN JOSE PDA

4,618 existing residential units

20,154 existing job spaces

8,832 new residential units (change in growth from 2010 to 2040 projections)

31,167 new job spaces (change in growth from 2010 to 2040 projections)

Values above refer to potential impacts. The full ART Bay Area report includes exposure and consequence at 10 total water levels (TWLs) for all 188 PDAs in the region from 12" TWL to 108" TWL. It also includes an analysis of flooding exposure and consequence of impacts to existing, future and growth in housing units and job spaces within PDAs and in PDA-eligible areas.



Natural Lands

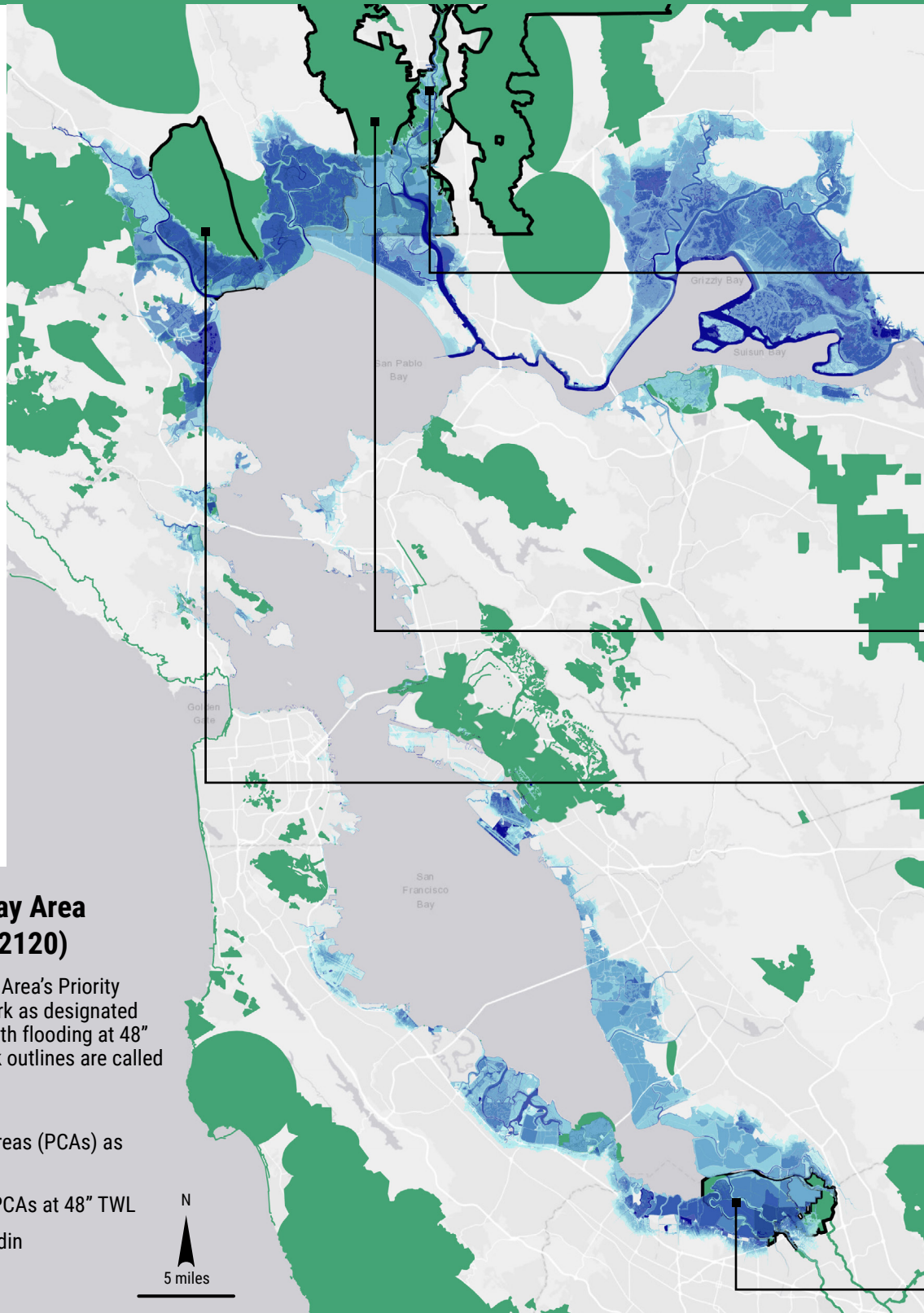
Snapshot of Highest Consequences

48"
TWL

ART Bay Area's natural lands assessment emphasizes areas both within the **Priority Conservation Area (PCA)** network and other natural land designations.





Overall, 68,570 acres of the PCA system will be exposed by 48" TWL (3% of the region's PCA system), but these exposed areas are critical for certain habitats and other ecosystem services.

Impacts to some of the highest consequence PCAs are shown on the following pages (Figure 9). Findings from other natural land designations are in the full report.



Natural Lands in the Bay Area With Flooding (2060 - 2120)

Figure 9. Distribution of the Bay Area's Priority Conservation Area (PCA) network as designated by *Plan Bay Area 2040* (2017) with flooding at 48" TWL. Individual PDAs with black outlines are called out on the following page.

-  Priority Conservation Areas (PCAs) as of Plan Bay Area 2040
-  Highest Consequence PCAs at 48" TWL
-  Shallower depth of floodin
-  Deeper depth of floodin



48"
TWL

NAPA VALLEY-RIVER CORRIDOR PCA

2.5 square miles depressional wetlands

3.4 square miles tidal marsh habitat

0.9 square miles Ridgway's rail habitat

2.3 square miles snowy plover habitat

0.7 square miles salt marsh harvest mouse habitat

164 million cubic feet stormwater runoff retention

23.1 million cubic feet stormwater infiltration (groundwater recharge)

\$6.5 million annual crop production

64,500 acres of carbon storage

NAPA COUNTY AGRICULTURAL LANDS AND WATERSHED PCA

6.5 square miles depressional wetlands

5.7 square miles tidal marsh habitat

1.2 square miles Ridgway's rail habitat

3.3 square miles snowy plover habitat

0.7 square miles salt marsh harvest mouse habitat

166 million cubic feet stormwater runoff retention

28 million cubic feet stormwater infiltration (groundwater recharge)

\$4.4 million annual crop production

64,500 acres of carbon storage

PETALUMA WATERSHED SOUTHEASTERN PORTION PCA

1.6 square miles Ridgway's rail habitat

1.3 square miles salt marsh harvest mouse habitat

387 million cubic feet stormwater runoff retention

19.6 million cubic feet stormwater infiltration (groundwater recharge)

\$1.3 million annual crop production

6,400 acres of carbon storage

BAYLANDS PCA

7.9 square miles lagoon habitat

4.3 square miles snowy plover habitat

2,810 daily visitors for recreation

\$2.2 million annual crop production

21,000 acres of carbon storage

Values above refer to potential impacts. The full ART Bay Area report includes exposure and consequence at 10 total water levels (TWLs) for all PCAs in the region from 12" TWL to 108" TWL. It also includes an analysis of ecosystem services of natural lands both within and outside the PCA system.

Local Risk – Local Vulnerabilities, Regional Impacts

Regional systems are made up of tens of thousands of individual components. The transportation system alone is comprised of thousands of different segments of highways, light and heavy rail, commuter rail lines and stations, as well as seaports, airports and ferry terminals, among others. Hundreds of block groups contain vulnerable communities, and the PDA and PCA systems collectively contain over 300 unique and individual designated areas.

While it's critical for the Bay Area to understand vulnerability and consequence region-wide across the four systems, ART Bay Area also includes 32 local analyses to understand shared vulnerability and consequences of individual assets in each of these four systems in specific, illustrative locations. These assessments provide:

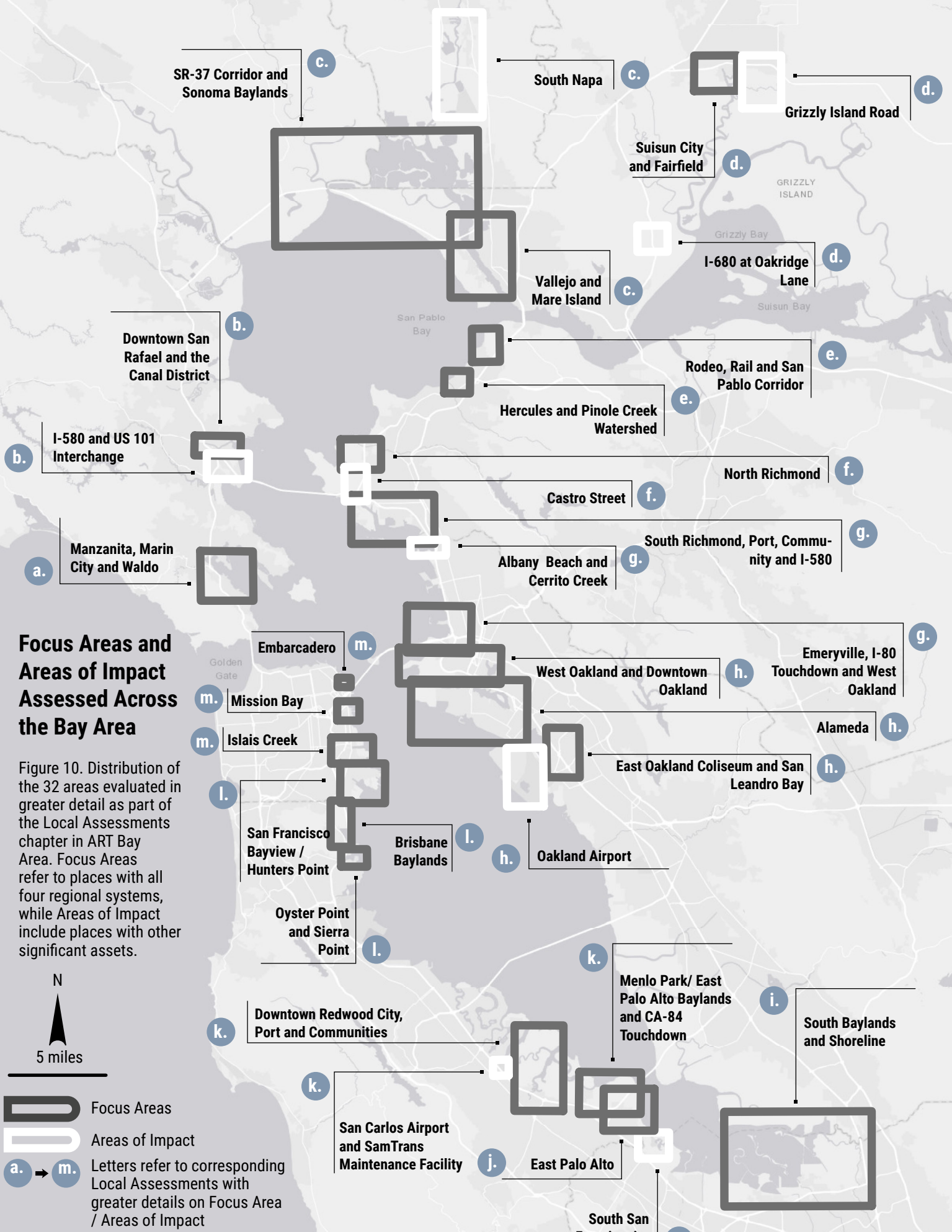
- 1. Descriptions of specifically how and where regional systems are vulnerable to flooding with site-specific vulnerability details about individual assets;**
- 2. Exploration of how regional systems are spatially and functionally interconnected and interdependent in specific geographic locations; and**
- 3. Connection of vulnerabilities identified locally to consequences felt regionally to shed light on some of the region's potential shared priorities.**

Local assessment areas – which include Focus Areas and Areas of Impact – differ from hot spots, which were identified through the lens of regional significance only, in that they look at areas that may also contain locally significant assets as well. However, many of these locations do overlap (Figure 10).

Local assessments can support more in-depth local analysis done by cities or counties to advance decision-making and implementation of adaptation solutions at the local level where land use authority lies. Adaptation decisions rely on in-depth local understanding of vulnerability coupled with an understanding of where local vulnerability intersects with larger regional patterns.

Local assessments can be downloaded from the online ART Bay Area full report. Each assessment contains in-depth information on the assets that were assessed; localized exposure descriptions including current shoreline conditions, where overtopping occurs, and where flooding occurs; descriptions of shared vulnerability in the focus area; and descriptions of possible consequences to society and equity, the economy, and the environment.





Assessments are organized into thirteen geographies – to find the geography for your location, refer to the number on the map (right), then download from the full report the appropriate local assessment for your community.



Focus Areas and Areas of Impact Assessed Across the Bay Area

Figure 10. Distribution of the 32 areas evaluated in greater detail as part of the Local Assessments chapter in ART Bay Area. Focus Areas refer to places with all four regional systems, while Areas of Impact include places with other significant assets.



-  Focus Areas
-  Areas of Impact
-  →  Letters refer to corresponding Local Assessments with greater details on Focus Area / Areas of Impact

SR-37 Corridor and Sonoma Baylands **c.**

South Napa **c.**

Grizzly Island Road **d.**

Suisun City and Fairfield **d.**

I-680 at Oakridge Lane **d.**

Vallejo and Mare Island **c.**

Downtown San Rafael and the Canal District **b.**

Rodeo, Rail and San Pablo Corridor **e.**

I-580 and US 101 Interchange **b.**

Hercules and Pinole Creek Watershed **e.**

North Richmond **f.**

Manzanita, Marin City and Waldo **a.**

Castro Street **f.**

South Richmond, Port, Community and I-580 **g.**

Albany Beach and Cerrito Creek **g.**

Embarcadero **m.**

West Oakland and Downtown Oakland **h.**

Emeryville, I-80 Touchdown and West Oakland **g.**

Mission Bay **m.**

Alameda **h.**

Islais Creek **m.**

East Oakland Coliseum and San Leandro Bay **h.**

San Francisco Bayview / Hunters Point **l.**

Brisbane Baylands **l.**

Oakland Airport **h.**

Oyster Point and Sierra Point **l.**

Menlo Park/ East Palo Alto Baylands and CA-84 Touchdown **k.**

South Baylands and Shoreline **i.**

Downtown Redwood City, Port and Communities **k.**

San Carlos Airport and SamTrans Maintenance Facility **j.**

East Palo Alto **j.**

South San Francisco **j.**

Adapting to sea level rise in the Bay Area will require a multi-scale effort involving planning and policy changes, capacity-building, built projects, and financing within individual jurisdictions and across jurisdictional boundaries.

Responding to Risk – Regional Adaptation

ART Bay Area identified eight regional planning issues that arose from hundreds of examples of qualitative vulnerability and consequence cutting across the four asset categories and 32 deep-dive local analyses. These issues require the collective focus of the region, either because they represent challenges larger than any single jurisdiction could solve on its own, or are challenges that are common to many locations and would benefit from a coordinated approach.

Over 80 adaptation responses were developed to address these eight regional planning issues.

Adapting to rising sea level in the Bay Area will

require a multi-scale effort involving planning and policy changes, capacity-building, built projects, and financing within individual jurisdictions and across jurisdictional boundaries. Adaptation responses in the ART Bay Area study consist of more than just built projects, but include a variety of different risk reduction actions. The ART program organizes adaptation actions into five major categories (Table 1).

Adaptation Action Types



Strategy Category	Description	Examples
CAPACITY BUILDING 	<ul style="list-style-type: none"> Actions that increase the ability to solve problems and implement actions. 	<ul style="list-style-type: none"> Local: Supporting capacity-building for local and regional government decision-makers to incorporate rising sea level into daily decision-making and existing plans and processes. Regional: Establishing regional priorities and guiding principles.
PLANS AND POLICIES 	<ul style="list-style-type: none"> Actions to update, revise, or develop new local and regional plans, policies, and guidelines to address rising sea level. 	<ul style="list-style-type: none"> Local: Encouraging local land use policies that ensure new development is resilient. Regional: Working closely with MTC/ABAG to ensure that regional goals for adaptation are included in Plan Bay Area’s transportation, land use, housing, future growth, and conservation area assessments, programs, incentives, and funding.

Table 1. Categories of adaptation strategies used in the ART Program are divided into capacity building, policies and plans, programs and operations, funding and financing mechanisms, and build a project.



Adaptation Action Types




Strategy Category	Description	Examples
<p>PROGRAMS AND OPERATIONS</p> 	<ul style="list-style-type: none"> ▪ Actions to include new or ongoing programs to improve procedures or management activities to address rising sea level. 	<ul style="list-style-type: none"> ▪ Local: Expanding community engagement and education programs to integrate more voices into adaptation decision-making. ▪ Regional: Supporting and expanding accelerated shoreline permitting through the Bay Restoration Regulatory Integration Team or a similar team.
<p>FUNDING AND FINANCING MECHANISMS</p> 	<ul style="list-style-type: none"> ▪ Actions that identify funding mechanisms that can be used for planning and implementing strategies. 	<ul style="list-style-type: none"> ▪ Local: Considering tax mechanisms to finance or incentivize protection of vulnerable land from future development. ▪ Regional: Identifying existing regional funding programs that can be adapted to provide adaptation co-benefits.
<p>BUILD A PROJECT</p> 	<ul style="list-style-type: none"> ▪ Actions that employ best available science to identify large-scale shoreline adaptation solutions that may be appropriate around the Bay. 	<ul style="list-style-type: none"> ▪ Local: Maintaining and expanding existing flood control structures to extend their life as sea levels rise. ▪ Regional: Protecting areas appropriate for nature-based solutions that protect or expand regional ecosystem values and/or flood protection benefits

Table 1 (cont.). Categories of adaptation strategies used in the ART Program are divided into capacity building, policies and plans, programs and operations, funding and financing mechanisms, and build a project.

REGIONAL PLANNING ISSUES AND STRATEGIC RESPONSES

While each regional planning issue needs to be solved by a suite of actions supported by a variety of stakeholders, the working group identified some initial starting points for strategic regional action. Building support for these actions will require additional buy-in, funding, and designation of roles and responsibilities.

Eight Regional Key Planning Issues were identified across the region. The following pages provide a brief description on each Regional Key Planning Issue and one example of a strategic response. It also lists selected Key Players needed to address this challenge, and the adaptation action type. Additional information on Regional Key Planning Issues and Adaptation Responses are in the full ART Bay Area report.

#1 *Transportation Hubs Come Together and Flood Together*



Regional Vulnerability: Many shoreline areas contain clusters of multiple transportation assets vulnerable to flooding that are critical to a functioning transportation system. In many cases, these assets lack redundancy and are networked such that loss of function of an asset or segment of the system would cause significant regional impacts to commuters, access to recreation and services, and movement of goods.

Strategic Response: Establish regional priorities for high consequence transportation clusters (“critical nodes”) that connect multiple transportation types (e.g. roadways, rail, and other forms of transit), scales of service (local, sub-regional, or regional system), types of service (e.g. moving people or goods), and service to vulnerable communities, and use regional funding mechanisms to plan and implement protection measures in these locations.

Key Players:

MTC/ABAG, Caltrans, BART, County Transportation Authorities, US DOT

Programs and Operations



The I-80 Bay Bridge east touchdown during King Tides 2020. Photo by SF Baykeeper Robb Most and LightHawk.

#2

Sea Level Rise Decision-Making is Complicated by Ownership, Governance, Management, and Regulatory Issues



Regional Vulnerability: Addressing local and regional sea level rise vulnerability will require multi-disciplinary planning among the many stakeholders that need to work together to identify shared goals and priorities, assign value to different assets, and agree on the types of strategies needed to reduce flooding and sea level rise risks. Of critical importance is the involvement of the local community in this process, as they are the largest stakeholder in many projects, and the one most likely to be overlooked.

Strategic Response: Develop a regional technical assistance program that provides training, education, and tools for the development of local adaptation projects, including support for vulnerability assessments, identifying and evaluating adaptation strategies and improving governance, community engagement, and coordination with partners.

Key Players:

MTC/ABAG, BCDC, BARC, Cities and Counties



Capacity Building

#3

Interconnected Local and Regional Emergency and Critical Service Functions are at Risk



Regional Vulnerability: In the event of a significant emergency, many critical services are required to move people and goods within as well as in and out of the region. Many emergency management assets are located in flood areas, putting their functions at risk. Critical services such as water, wastewater, electricity, and communications also may be at risk, and community-serving centers like schools, places of worship, and libraries that serve critical functions in emergencies may be inundated and unable to serve residents.

Strategic Response: Encourage and support the ongoing development and timely updating of Local Hazard Mitigation Plans at the city and county level that include future hazards such as rising sea level, and are coordinated with other local plans, such as the General Plan Safety Element.

Key Players:

FEMA, CalOES, MTC/ABAG, Cities and Counties



Plans and Policies

Left: Railroad tracks along San Pablo Bay. Right: San Francisco waterfront. Photos by SF Baykeeper, Cole Burchiel, and LightHawk.

Left: Industry along the Bay shoreline. Photo by SF Baykeeper, Cole Burchiel, and LightHawk. Right: Homes along the water in the North Bay. Photo courtesy of California Bay King Tides Project.

#4 Contamination Complicates and Exacerbates Flooding Issues



Regional Vulnerability: Many areas at risk of flooding are on or near former industrial sites that have been designated as contaminated areas. Many vulnerable communities live adjacent to or even on contaminated sites. There is significant uncertainty about how flooding and rising groundwater will exacerbate contamination and increase public health concerns if contaminants are mobilized, or how dry land cleanup standards will perform if lands become submerged.

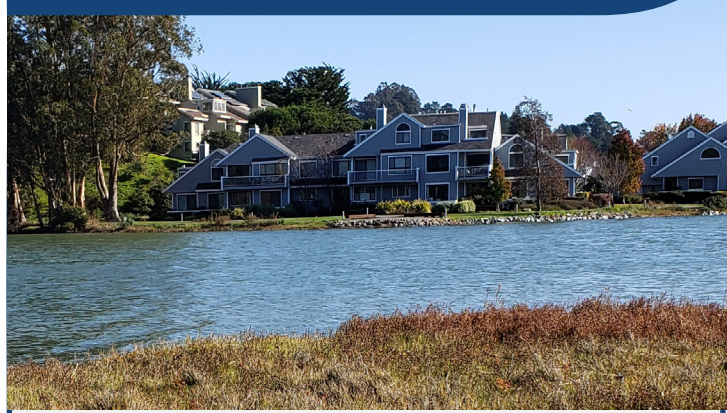
Strategic Response: Conduct studies of dryland site remediation standards to determine their efficacy if sites are impacted by temporary flooding, permanent flooding, or changes in groundwater or salinity levels.

Key Players: Department of Toxic Substances Control, Regional Water Quality Control Board, County Health Departments, US Environmental Protection Agency, US Department of Defense



Programs and Operations

#5 Rising Sea Level will Amplify Existing Housing and Displacement Concerns



Regional Vulnerability: Throughout the Bay Area, a severe housing affordability crisis has led to unprecedented displacement risk. This pressure is felt most acutely by communities subject to marginalization. Many vulnerable communities also are more vulnerable to displacement due to rising sea level. Displacement, in turn, contributes to loss of community cohesion and social networks, which further adds to vulnerability to hazards like flooding.

Strategic Response: Establish regional protection priorities for vulnerable communities identified to be at high risk of displacement, and use regional funding mechanisms to plan and implement protection measures in these locations.

Key Players: MTC/ABAG, Cities and Counties, Community Groups, Nonprofits



Programs and Operations

#6

Future Development Areas can be Critical Tools for Resilience



Regional Vulnerability: A strong economy has added a large number of jobs and people to the region in recent years. There is significant region-wide pressure to add new development to accommodate these jobs as well as to provide much-needed affordable housing. New development presents an opportunity to make smart choices about how much new risk we create for future generations.

Strategic Response: Ensure that future Plan Bay Area updates incorporate land use resilience goals, specifically around planning future housing and jobs to avoid placing more of the region’s population at risk; and include programs, incentives, and funding, such as the PDA program/OBAG grant program or new planning tools and funding source(s) that support resilient existing and future development.

Key Players:

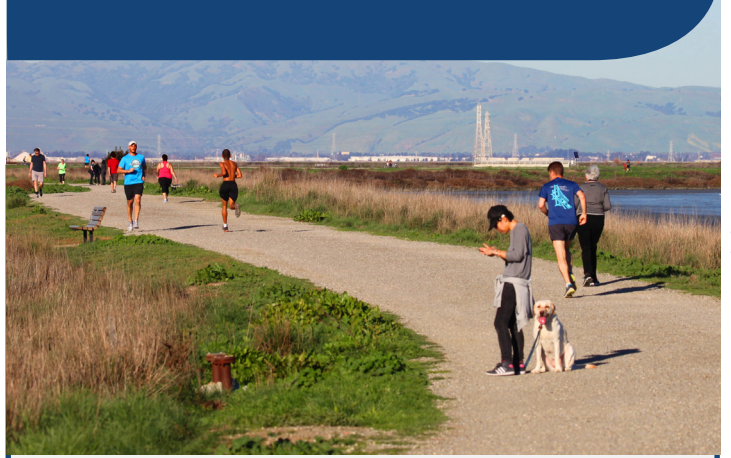
MTC/ABAG, Cities and Counties, Developers, Community Groups



Capacity Building

#7

Rising Sea Level will Put Pressure on the Relationship Between Regional Recreation and Habitat



Regional Vulnerability: Many of the region’s vulnerable recreation areas are near sensitive habitat areas that are at risk. Many of these areas also could play critical roles in flood management through nature-based solutions. Different stakeholders may have differing priorities for the management of natural shoreline areas that prioritize people, natural systems, or flood control, amongst other things, over one another.

Strategic Response: Develop policies, guidance or incentives to encourage setbacks and buffers adjacent to tidal marshes that protect sensitive species, and/or establish zoning or conservation of upland locations for marsh migration while maintaining appropriate types of public access and recreation uses.

Key Players:

Cities and Counties, State Coastal Conservancy, San Francisco Estuary Partnership, San Francisco Bay Trail



Plans and Policies

Left: Naval Air Station PDA in Alameda. Photo by SF Baykeeper, Cole Burchiel, and Lighthawk. Right: People enjoying trails along the Bay. Photo by Jitze Couperus licensed under CC by 2.0.

#8

Nearshore Habitats and the Ecosystem Services they Provide are Sensitive to Sea Level Rise Early On



Regional Vulnerability: Nearshore habitats provide significant natural and ecosystem services, such as habitats for endangered species, carbon sequestration, wave attenuation, and contribution to recreation and regional character. In many locations, natural ecosystems will be the first locations to be impacted by rising sea level. Protecting, restoring, and enhancing nearshore habitats can provide many benefits.

Strategic Response: Organize collaborative regional discussions to explore where legal, policy or regulatory changes are needed to promote nature-based solutions, such as constructing oyster and eelgrass reefs in a living shorelines approach, to address existing and future infrastructure adaptation challenges.

Key Players:

BCDC, San Francisco Bay Restoration Authority, Bay Restoration Regulatory Integration Team, US Army Corps of Engineers, Cities and Counties

Capacity Building



Different habitats support different compositions of species.
Photo by SF Baykeeper Cole Burchiel and LightHawk.

Where We Are Heading

ART Bay Area provides an extensive and detailed foundation for future sea level rise planning in the Bay Area, with analysis that can be used to inform local, regional, and state level planning. These findings provide definitive answers about what is anticipated to get wet, where, and when -- in the absence of significant intervention. A valuable outcome of this project has been the robust network of action-oriented practitioners and community leaders from across the region who are ready to move into this critical phase of work.

The findings of this report are not final decisions about where and what the region should do to respond to flooding and rising sea level. The region must come together, using the findings to guide *shared* decision making. Data on its own does not make decisions – another layer of coordinated regional priorities and decision-making criteria is necessary to fully engage the power of the data.

DEVELOPING SHARED PRIORITIES

To support the prioritization of one location over another, or one type of adaptation approach over another, stakeholders across the region can work together to develop shared priorities and goals that can be applied to decision making at the local level. While striving for “win-win” situations is the ideal, many decisions regarding adaptation planning and actions will require choosing between conflicting values or priorities and will involve a set of tradeoffs.

The region must come together, using the findings to guide shared decision making. A shared set of priorities will help the region decide what it values to help inform decisions about what to pay for, what types of adaptation strategies are most appropriate, and what actions should be taken first.

The region must come together, using the findings to guide shared decision making.



Stakeholders participating in the ART Bay Area Regional Working Group. Photo by BCDC.

TAKING ACTION TOGETHER

Once shared priorities are developed, the next step will be to identify a suite of priority actions at various scales. Many of these actions are outlined in the ART Bay Area report, but others likely will emerge as well. Critical to the development and implementation of priority actions are:

- **Balancing Local and Regional Priorities** – What actions can or should only happen locally or regionally? Land use authority rests with local government. So many planning, zoning, and building strategies can only be initiated, permitted, and implemented locally. Even today, some jurisdictions are already planning for and implementing flood control projects that they believe will help reduce their localized risk to flooding. However, it also will be important to identify cross-jurisdictional, cross-agency strategies that provide greater benefit than if each local jurisdiction or agency were to conduct adaptation – on wetlands restoration, major infrastructure projects, multi-benefit projects – on its own.
- **Pulling the Right Levers** – Identifying the most appropriate levers at local, regional, and statewide scales can help operationalize decisions that support shared regional goals. Many levers are outlined in the regional adaptation responses, including local and regional planning documents such as General Plans and Plan Bay Area; capacity-building initiatives like education, training, and data-sharing; programs like ongoing monitoring or research; and financial tools such as tax incentives. Even these levers may not be sufficient – new mechanisms may be needed.
- **Articulating Roles and Responsibilities** – Adaptation action across the region will rely on a wide variety of local and regional actors to play both independent and coordinated roles as planners, implementers, conveners, coordinators, and funders. How do we organize these different stakeholders – who each have critical skills and expertise – within a larger framework that groups key activities and approaches, while helping to measure and monitor how these activities add up to greater regional resiliency?

BALANCING CURRENT AND FUTURE NEEDS

While the data on sea level rise exposure and consequences is compelling, it also competes with many other current challenges, such as housing affordability, insufficient and aging infrastructure, and wildfires. Rising sea level is a slow-moving disaster with a long time horizon, and there is significant uncertainty about exact timing and impacts. Yet flooding is happening now. And while today's flooding may not be as extensive or damaging as future flooding, it is critical that we treat rising sea levels as a *now* problem, not a *future* problem.

These challenges are not independent. Housing and transportation issues will only worsen as sea level rise progresses. Wildfires are the first signal of the climate crisis, but as sea levels rise, we may find ourselves increasingly squeezed between wildfire-ravaged hills and an encroaching shoreline. Approaches to address any one challenge must also consider the whole range of challenges the region faces.

Many of the crises we find ourselves in today reinforce the lesson that after-the-fact reaction is more stressful and damaging to society than before-the-fact preparation. Both with the housing crisis and the wildfire crisis, the writing on the wall was clear far ahead of time. Housing underproduction and rising prices were occurring for decades, but there was no urgent need to correct the problem. Similarly, we knew that power infrastructure was aging and our forest management practices were out of date; yet devastating wildfires nonetheless killed dozens of people and caused billions of dollars in damage.

We know that rising sea levels are coming. And we know what the potential impacts will be. What will catalyze us to action *before* people, the environment, the economy, and our infrastructure are extensively impacted? And what is the cost if we fail to act?

A CALL TO ACT

There will never be a perfect time to act – there will always be uncertainty and lack of information about what the future may bring. But it's never the wrong time to do the right thing. The Bay Area is at a tipping point, poised between a growing body of information, tools, and awareness, and the beginnings of irreversible impacts, especially to sensitive shoreline ecosystems and our most vulnerable populations. The time is ripe is for the Bay Area to come together to clearly lay out the overall planning framework that will allow appropriate and informed actions that reflect shared priorities and values and that move the region forward towards greater resiliency.

The ART Bay Area project team hopes that this report will help catalyze this era and serve as a foundation upon which to build the region's future.

There will never be a perfect time to act - but the Bay Area is at a tipping point.

Prepared by:



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