Sea Level Rise & Overtopping Analysis for San Mateo County's Bayshore

Developed using BCDC's Adapting to Rising Tides Methodology

Final Report • May 2016

Acknowledgments

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EXECUTIVE SUMMARY

The San Mateo County Sea Change SMC project provides support, guidance, tools, and information to help agencies and organizations understand, communicate, and begin to address sea level rise (SLR). The project helps to identify and assess the community assets and natural resources that are most at risk to SLR and storm surge. The San Mateo County Office of Sustainability is completing a countywide SLR vulnerability assessment. The County is using both the Our Coast Our Future SLR maps as well as the maps in this report to ensure a comprehensive evaluation of vulnerability that is consistent with SLR preparedness efforts throughout region.

This report presents an assessment of San Mateo County's shoreline exposure to flooding or inundation from SLR scenarios of 0 to 66 inches and extreme tide events from the 1-year to the 100-year extreme tide event. This analysis, completed by AECOM, uses the San Francisco Bay Conservation and Development Commission's (BCDC) Adapting to Rising Tides (ART) methodology. The original ART project focused on Alameda County and included the development of map products and tools that highlight shoreline vulnerabilities and can assist in prioritizing adaptation strategies. This study, using funds from the California State Coastal Conservancy, extends the tools and products developed for Alameda County to San Mateo County.

The analyses presented in this report show that, as sea levels rise, the San Mateo County bayshore and flood protection infrastructure will become increasingly exposed to extreme tide levels and will no longer provide the same level of flood protection that they do today. Such shifts in the frequency of extreme tide levels will have important design implications for flood protection infrastructure and for the resilience and persistence of valuable shoreline habitats. This report also shows the location and timing of shoreline infrastructure overtopping, providing information on when and where these shoreline protection structures could fail and lead to flooding.

The data sets and information provided in this report can inform design and operational strategies, assist in managing climate-change-related risks, and help identify trigger points for implementing adaptation strategies. These efforts will increase the likelihood of achieving a consistent level of flood protection for San Mateo's bayshore communities over the coming decades and into the next century.

This study provides an overview of SLR and coastal hazards in San Mateo County, a summary of the state of the relevant climate science, and a discussion of the SLR scenario selection. The maps and data sets developed include:

- A county-specific matrix of SLR and extreme tide elevations;
- Inundation and overtopping maps for evaluating potential exposure to future SLR and extreme tide conditions;
- Shoreline delineation and shoreline type maps, which identify the highest point—or crests—of shoreline features and categorize these features into seven types of shoreline, such as engineered flood protection structure, embankment, and wetlands;
- Normalized shoreline maps, which provide an additional approach for assessing shoreline exposure by depicting the elevation of shoreline features relative to existing water levels; and
- Mapping assumptions and caveats.

The inundation maps are intended as a screening-level tool to assess exposure to future SLR and extreme tide/storm surge-induced coastal flooding. They rely on the best available and current information and data sources, but are still associated with a series of assumptions and caveats. The maps and associated analyses presented in this report do not consider:

- Wave effects or impacts from wave runup;
- Duration of flooding or potential mechanisms for draining floodwaters once extreme tide levels recede;
- Condition and integrity of flood protection infrastructure which could lead to episodic failure of levees during flood event;
- Event-based or longer-term shoreline change;
- Changes in land use or development; or
- Localized flooding that can occur during rainfall events.

The SLR and extreme tide inundation maps created for San Mateo County use an approach that allows one map to represent multiple potential future SLR and extreme tide combinations to inform when intervention may be required to reduce potential future inland flooding risks. In addition, the shoreline delineation, shoreline type, and overtopping potential maps and products can be used to identify shoreline areas where adaptation strategies may be warranted and provide information to support the development of appropriate adaptation strategies.

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INTRODUCTION

1.1 STUDY GOALS

1.2 OVERVIEW OF REPORT

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1. INTRODUCTION

San Mateo County has been the focus of an effort to identify and assess community assets and natural resources that are most at risk to sea level rise (SLR) and storm surge impacts. This effort, named the SeaChange SMC project, is a key step in taking action to prepare the County's communities at risk for these hazards. The San Mateo County Office of Sustainability leads the SeaChange SMC project and provides support, guidance, tools, and information to help agencies and organizations understand, communicate, and begin to address complex climate-change issues.

The first step of the project is to complete a sea level rise vulnerability assessment for the San Francisco Bay (Bay) and coastal areas of San Mateo County. The assessment is the first effort in the San Francisco Bay Area (Bay Area), and in the state, to evaluate the vulnerability of both the Pacific coast (North of Half Moon Bay) and bayshore communities in one study. Given the differences in dynamics between the Pacific coast and the Bay, the project team is using multiple modeling tools to evaluate vulnerability: the Our Coast, Our Future Tool[1] and the Adapting to Rising Tides (ART)[2] methodology described in this report. No single modeling tool can accurately predict future flooding. Each tool has strengths and weaknesses. Using both tools allows the project team to compare and contrast the different techniques, notice areas of overlap, and ensure a more robust assessment. The Our Coast Our Future Tool's ability to model waves and shoreline change make it a better fit for the coast, and the ART method's ability to represent levees and other shoreline infrastructure at a finer scale make it a better fit for the Bay.

As part of this assessment, AECOM created SLR and overtopping potential information for the San Mateo County Bay shoreline using the methods and tools developed for two award-winning Adapting to Rising Tides projects in Alameda County: the Transportation Vulnerability and Risk Assessment Pilot Project (AECOM et al. 2011), and the Climate Change and Extreme Weather Adaptation Pilot Project (AECOM 2014). The purpose of these Federal Highway Administration funded pilot projects was to understand, refine, and enhance our understanding of climate-change-related risks, with an emphasis on future SLR and storm surge impacts. The original ART project focused on Alameda County. This project, using funds from the California State Coastal Conservancy, extends the tools and products developed through the ART Program to San Mateo County. For this analysis, San Mateo County followed the San Francisco Bay Conservation and Development Commission's (BCDC) ART methodology to ensure coordination with the larger Bay Area. Other counties in the Bay Area that have used the ART methodology to evaluate shoreline exposure to SLR and storm surge include San Francisco and Contra Costa Counties. The five remaining Bay Area counties (i.e., Marin, Napa, Sonoma, Solano, and Santa Clara County) will receive the ART inundation mapping and tools as part of a Bay-wide assessment funded by the Bay Area Toll Authority in collaboration with BCDC by 2017.

This report presents a broad assessment of San Mateo County's shoreline exposure to flooding and inundation from SLR scenarios of 0 to 66 inches and extreme tide events from the 1-year to the 100-year extreme tide event Two distinct impacts (permanent inundation or flooding) can occur from sea level rise and storm surge, or a combination of both. Permanent *inundation* occurs when an area is regularly covered by daily tidal fluctuations. As sea levels rise, additional areas may be subjected to permanent inundation. In contrast, *flooding* occurs when an area is exposed to episodic, short-duration, extreme tide events of greater magnitude than normal tide levels. Inland areas may be temporarily flooded during an extreme tide event, but may resume their intended function once floodwaters recede. The analyses presented in this report show that, as sea levels rise, the San Mateo County bayshore and flood

[1] Our Coast Our Future website: http://data.prbo.org/apps/ocof/
[2] Adapting to Rising Tides website: www.adaptingtorisingtides.org

protection infrastructure will become increasingly exposed to tide levels currently considered extreme, and over time they will no longer provide the same level of flood protection that they do today. For example, the analysis demonstrates that the water level elevations currently associated with today's 50-year extreme tide will occur on an annual basis after 24 inches of SLR. After 36 inches of SLR, that same elevation will occur during daily high tides. Such shifts in the frequency of extreme tide levels will have important design implications for flood protection infrastructure and for the resilience and persistence of valuable shoreline habitats.

The data sets and information provided in this report can inform design and operational strategies, assist in managing climate-change-related risks, and help identify trigger points for implementing adaptation strategies. These efforts will increase the likelihood of achieving a consistent level of flood protection for San Mateo's bayshore communities over the coming decades and into the next century.

1.1 STUDY GOALS

Through the collective efforts of the various project partners, the project team developed a stepwise and systematic approach for investigating shoreline resilience:

1. Use county-scale SLR and extreme tide inundation maps to conduct high-level shoreline assessments.
2. Ground-truth findings with local experts and identify locations where the inundation maps do not represent local, on-the-ground knowledge of past flood events.
3. Conduct refined shoreline analyses to assess more-detailed vulnerabilities and identify locations where short-term actions would provide benefits.
4. Identify resilience-building actions and implementation options that could reduce shoreline vulnerabilities.
5. Investigate the feasibility of resilience-building actions.

The goal of this study is to develop the data sets and tools needed to support steps 1, 2, and 3, above. To meet this goal, AECOM created new SLR and extreme tide inundation maps for San Mateo County (Figure 1-1) using an approach that allows one map to represent multiple potential future SLR and extreme tide scenarios (Step 1). Local knowledge identified areas where the maps do not accurately represent past coastal flood events, such as inundation that occurs along the shoreline during King Tides. Further review of the underlying data supported refinements to the maps to increase the accuracy of depicting existing shoreline vulnerabilities (Step 2). The shoreline delineation approach developed for the ART Program to assess both shoreline type and overtopping potential highlights where adaptation strategies along the shoreline may be warranted and to inform when intervention may be required to reduce potential future inland flooding risks (Step 3).

Figure 1-1. San Mateo County ART Project Area

1.2 OVERVIEW OF REPORT

The organization of this report is summarized below:

- **Section 2. Sea Level Rise Science** provides an overview of SLR and coastal hazards, a summary of the state of the science, and a discussion of SLR scenario selection.
- **Section 3. Inundation Mapping** describes the leveraged model data, water level analysis, topographic data, and the inundation mapping methods used to create the SLR inundation maps.
- **Section 4. Shoreline Delineation** describes the approach to delineate the shoreline and identify shoreline type (e.g., engineered flood protection structure, non-engineered berm).
- **Section 5. Shoreline Overtopping Potential** describes the methods used to calculate overtopping potential along the shoreline (and adjacent areas) and outlines applications of the maps to identity potential shoreline vulnerabilities.
- **Section 6. Shoreline Exposure Analysis** presents the normalized shoreline approach for assessing shoreline exposure and vulnerabilities.
- **Section 7. Mapping Assumptions and Caveats** provides the key caveats associated with the overall approach for developing SLR and storm surge inundation maps that are appropriate as a screening-level tool for assessing exposure.
- **Section 8. Conclusions and Next Steps** provides a summary of the approach and an introduction to the more-detailed focused area analyses completed using these data.
- **Section 9. References.**

1.3 ACRONYMS/ABBREVIATIONS

AR5	The IPCC's Fifth Assessment Report (IPCC 2013)
ART	Adapting to Rising Tides Program
BART	Bay Area Rapid Transit
Bay	San Francisco Bay
Bay Area	San Francisco Bay Area
CCC	California Coastal Commission
CCMP	California Coastal Mapping Program
DEM	Digital Elevation Model
ENSO	El Niño–Southern Oscillation
FEMA	U.S. Department of Homeland Security's Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
FIS	Flood Insurance Study
ft	foot or feet
GHG	greenhouse gas
GIS	Geographic Information System
IPCC	Intergovernmental Panel on Climate Change
LiDAR	light detection and ranging
m	meter(s)
MHHW	Mean Higher High Water (tidal datum)
MLI	Midterm Levee Inventory
NAVD88	North American Vertical Datum of 1988
NOAA	National Oceanic and Atmospheric Administration
NRC	National Research Council
NTDE	National Tidal Datum Epoch
OPC	California Ocean Protection Council
QA/QC	quality assurance/quality review
SFEI	San Francisco Estuary Institute
SFO	San Francisco Airport
SLR	sea level rise
USACE	United States Army Corps of Engineers
USGS	United States Geological Survey

1.4 GLOSSARY

The following definitions describe each term as it is used in this report:

Annual maxima: The highest water level recorded during each year in a time series based on a July through June "storm year."

El Niños (within the El Niño–Southern Oscillation [ENSO][3] cycle): A phenomenon in the Pacific Ocean characterized by warmer-than-usual waters in the Eastern Pacific. El Niños are caused by specific changes in winds and currents across the equatorial Pacific, driven by an oscillation in air pressure differences across the Eastern and Western Pacific called the Southern Oscillation. El Niños may result in higher sea levels and larger, more-frequent storms along the California coast.

Extreme tide: Extreme tides are relatively infrequent water level events that are a result of relatively high astronomical tides coupled with a storm surge event. The absolute elevations reached during these events are due to short-term meteorological processes (such as low atmospheric pressure due to storms) and large-scale oceanographic conditions (such as King Tides or El Niño conditions). The extreme tide elevations discussed in this assessment do not include any local wind and wave effects.

Mean Higher High Water: Average height of the higher high tides of each day during the current National Tidal Datum Epoch, which is a specific 19-year period (1983 to 2001) adopted by the National Oceanic and Atmospheric Administration (NOAA) to perform tidal computations.

Normalized shoreline elevation: Shoreline elevation data can be normalized by dividing each shoreline elevation value by the local MHHW tide level. By normalizing the shoreline asset elevations, an asset's flooding threshold can be determined by comparing the "normalized shoreline elevation" to the normalized extreme tide curve. A normalized elevation value of 1.0 indicates an elevation equal to the local MHHW tide level. A normalized elevation value greater than 1.0 indicates an elevation above the local MHHW tide level, and a value less than 1.0 is below MHHW. The normalized shoreline elevation maps and extreme tide curves can be used together to assess exposure to flooding.

Normalized extreme tide curves: Normalizing elevation data allows the original data to be compared using a different scale. Elevation data are normalized by dividing each elevation value by a common denominator. For example, in the Bay, both the MHHW tide level and the 100-year tide level vary spatially; however, the ratio of a given extreme tide to MHHW is relatively constant across large geographic areas. For example, the ratio of the 100-year tide level divided by the MHHW tide level (the common denominator) is approximately constant within the project area (approximately 10.5 feet [ft] / 7.0 ft = 1.5). Normalized extreme tide curves were created to show the elevations of a 1-year through 100-year extreme tide event normalized to the MHHW elevation for both existing conditions and future conditions with SLR. The normalized elevation data allow comparisons across different spatial areas.

Overtopping potential calculation: Overtopping potential refers to the condition where the water surface elevation associated with a particular SLR scenario exceeds the elevation of a shoreline asset. Overtopping potential does not account for the physics of wave run-up and overtopping. It also does not account for potential vulnerabilities along the shoreline protection infrastructure that could result in complete failure of the flood protection infrastructure through scour, undermining, or breach after the initial overtopping occurs. The overtopping potential results visually show which segments of the

[3] El Niño–Southern Oscillation (ENSO) is a natural oceanic-atmospheric cycle. El Niño conditions are defined by prolonged warming in the Pacific Ocean sea surface temperatures. Typically, this happens at irregular intervals of 2 to 7 years, and it can last anywhere from 9 months to 2 years.

shoreline are first impacted and the depth to which each segment is overtopped during the mapped scenarios.

Storm surge: A storm surge is an abnormal rise of water generated by high winds and low atmospheric pressure in the presence of a storm that is over and above the predicted astronomical tide. The magnitude of a storm surge and the height of an astronomical tide are additive: when the sum of the two is unusually large, an extreme tide occurs.

Tidal datum: A tidal datum is the daily tide water level computed using records observed during the current National Tidal Datum Epoch (see definition for MHHW above)

Tides: The regular upward and downward movement of the level of the ocean due to the gravitational attraction of the moon and the sun and the rotation of the earth. Also called "astronomical tides." The Bay experiences two high tides and two low tides of unequal height each day.

2.0

SEA LEVEL RISE SCIENCE

2.1 SUMMARY OF THE SCIENCE

2.2 SEA LEVEL RISE AND COASTAL HAZARDS

2.3 SCENARIOS

2. SEA LEVEL RISE SCIENCE

2.1 SUMMARY OF THE SCIENCE

The science associated with SLR is continually being updated, revised, and strengthened. Although there is no doubt that sea levels have risen and will continue to rise at an accelerated rate over the coming century, it is difficult to predict with certainty what amount of SLR will occur within any given time frame. The uncertainties increase over time (i.e., the uncertainties associated with 2100 projections are greater than those associated with 2050 projections) because of uncertainties in future greenhouse gas (GHG) emissions trends, the sensitivity of climate conditions to GHG concentrations, and the overall capabilities of climate models. The projections presented in this document draw on the best available science for California as of January 2016.

In March 2013, the California Ocean Protection Council (OPC) adopted the National Research Council (NRC) report *Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present, and Future* (NRC 2012) as the best available science on SLR for the state (OPC 2013). The California Coastal Commission (CCC) also supported the use of the NRC 2012 report as best available current science, noting that SLR science is continually advancing and future research may enhance the scientific understanding of how the climate is changing, resulting in the need to regularly update projections (CCC 2015). The NRC report includes discussions of historic SLR observations, three likely SLR projections for the coming century, high and low extremes for SLR, and insight into the potential impacts of a rising sea for the California coast. After the release of the NRC 2012 report, the Intergovernmental Panel on Climate Change (IPCC) released the Fifth Assessment Report (AR5), *Climate Change 2013: The Physical Science Basis*, which provides updated consensus estimates of global SLR (IPCC 2013).

The NRC projections for San Francisco relative to the year 2000 are appropriate for San Mateo County. Table 2-1 presents the local projections (mean ± 1 standard deviation). These projections (e.g., 6 ± 2.0 inches in 2030) represent the *likely* SLR values based on a moderate level of GHG emissions and extrapolation of continued accelerating land ice melt patterns plus or minus one standard deviation. The extreme limits of the *ranges* (e.g., 2 and 12 inches for 2030) represent *unlikely but possible* levels of SLR using both low and very high emissions scenarios and, at the high end, including significant land ice melt that was not anticipated at the time of publication but acknowledged as having potential to occur. The NRC report also provides regional estimates of *net SLR* for the Oregon, Washington, and California coastlines that include the sum of contributions from the local thermal expansion of seawater, wind-driven components, land ice melting, and vertical land motion. The chief differentiator among net SLR projections along the western coast of North America derives from vertical land motion estimates, which generally show uplift (reducing net SLR) of lands north of Cape Mendocino and subsidence (increasing net SLR) of lands south of Cape Mendocino.

The NRC ranges are higher than the global estimates presented in IPCC AR5, though the projections in the NRC report are similar to IPCC estimates. At this time, the use of NRC projections and ranges is appropriate for San Mateo County because they encompass the best available science, they consider local and regional processes and conditions, and their use is consistent with current state guidance.

Table 2-1. Sea Level Rise Estimates Relative to the Year 2000

Year	Most Likely Projections (inches)	Upper Range (inches)
2030	6 ± 2	2 to 12 in
2050	11 ± 4 *	5 to 24 in
2100	36 ± 10	17 to 66 in

Source: NRC 2012.

* As a simplifying assumption, the 2050 most likely value selected for the inundation mapping effort is 12 inches rather than the 11 inches noted in the table.

2.2 SEA LEVEL RISE AND COASTAL HAZARDS

Bay waters experience two low tides and two high tides of unequal height each day. MHHW is the average elevation of the highest daily tide. King Tides are unusually high but predictable astronomical tides that occur approximately two to four times per year, generally between December and February. As seas have risen, King Tides have begun to cause annual flooding of low-lying coastal areas. Some low-lying areas along the shoreline, including the Oyster Point Marina and the salt ponds, already experience inundation due to coastal hazards such as King Tides. A significant portion of the San Mateo County bayfront has been filled and is especially at risk, as rising sea levels may influence groundwater levels, resulting in increased subsidence and liquefaction hazards.

In addition, there are short-term factors that elevate the waters of the Bay along the San Mateo County shorelines, such as El Niño, storm surge and waves, and for some portions of the county, freshwater discharge from creeks and sloughs during rainfall-runoff events. When one or more of these factors combine to raise Bay waters above predicted tide levels, the result is a temporarily higher water level called an *extreme tide*. Extreme tides can reach several feet higher than King Tides and result in damaging coastal floods. Understanding the additive impact of such factors to produce temporary flooding is crucial for planning in the coastal environment. Extreme tides are generally characterized in terms of probability: a 1-percent-annual-chance tide (or 100-year extreme tide) is the coastal water level elevation that Bay waters have a 1 percent chance of reaching (or exceeding) in any given year. Likewise, a 20-percent-annual-chance tide (or 5-year extreme tide) is the coastal water level elevation that Bay waters have a 20 percent chance of reaching (or exceeding) in any given year. Section 3.2 discusses the water level elevation of various extreme tides in San Mateo County.

Table 2-2 summarizes several factors affecting existing water levels along the county shoreline. The table represents the relative magnitude of these components rather than a particular elevation.

Table 2-2. Factors That Influence Local Water Level Conditions in Addition to Sea Level Rise

Factors Affecting Water Level	Typical Magnitude [1, 2]	Period of Influence	Typical Frequency
Daily tidal range	5 to 7 ft	Hours	Twice daily
King tides	1 to 1.3 ft	Hours	One to four times/year
Storm surge	0.5 to 3 ft	Days	Several times a year to every 100 years, depending on height
Wind-driven waves	0.5 to 3 ft	Hours	Daily to several times a year
El Niño	0.3 to 1.5 ft	Months to Years	2 to 7 years

[1] DHI 2013.
[2] BakerAECOM 2013, 2015.

The following coastal flood hazards may increase due to SLR and other climate-change-induced changes to atmospheric-oceanic processes:

- **Daily tidal inundation:** As sea levels rise, the elevation of MHHW will continually increase. Without action, this increase in elevation will result in increased permanent future inundation of low-lying areas.
- **Annual high tide inundation (King Tides):** King Tides result in temporary inundation, particularly associated with nuisance flooding, such as inundation of low-lying roads, boardwalks, and waterfront promenades. Typical King Tides raise coastal waters approximately 14 inches above MHHW. In the winter (December, January, and February), King Tides may be exacerbated by winter storms, making these events more dramatic. Without protective action, this regular, predictable flooding will occur more frequently and affect larger areas as seas rise.
- **Extreme high tide inundation (storm surge):** Depending on the type and intensity of cause(s), extreme tides range from 15 inches above MHHW (1-year extreme tide) to 42 inches above MHHW (100-year extreme tides) or higher. One such event occurred on December 11, 2014, when Bay waters rose 18 inches above predicted tide levels due to coastal storm conditions during a heavy rain event.
- **Weather and weather cycles:** Climate change may affect the frequency and/or intensity of coastal storms, El Niño cycles, and related processes. During El Niño winters, atmospheric and oceanographic conditions in the Pacific Ocean produce severe winter storms that impact Bay shorelines. No clear consensus has emerged about these changes, but a commonly identified trend is a tendency toward increased elevation of snowpack and correspondingly more precipitation falling in Delta watersheds as rain. This trend may increase the frequency of higher Delta flows into the Bay.
- **Waves:** Large waves, whether generated within the Bay or by large Pacific storms, can damage unprotected shorelines and drive floodwaters even higher. Typical impacts include damage to coastal structures such as levees, docks and piers, wharves, and revetments; backshore inundation due to wave overtopping of structures; and erosion of natural shorelines.
- **Precipitation combined with high tides:** When large rainfall events co-occur with particularly high tides, coastal waters can impede the drainage of rivers, creeks, and stormwater systems to the Bay, resulting in inland flooding during storms. Typical impacts during high or extreme tides include failure of storm drainage infrastructure, drainage restrictions through outfalls, backup of

floodwaters into low-lying areas during precipitation events, road closures, and neighborhood flooding.

2.3 SCENARIOS

SLR is often visualized using inundation maps. Typically, maps represent specific SLR scenarios (e.g., 16 inches of SLR above MHHW) or extreme tide water level (e.g., the 1-percent-annual-chance tide). However, selecting the most appropriate SLR scenario to map in support of project planning, exposure analyses, or SLR vulnerability and risk assessments is not simple. This approach requires pre-selecting appropriate SLR and extreme tide scenarios that meet all project needs.

Rather than pre-selecting specific SLR scenarios for San Mateo County, the 10 individual sets of inundation maps represent a range of possible scenarios associated with extreme tide levels and SLR ranging from 12 to 108 inches, representing combinations of 0 to 66 inches of SLR with extreme tides from the 1-year to the 100-year extreme tide.[4] The scenario selection relied on the extreme water-level analysis described in Section 3. The goal of scenario selection was to identify 10 scenarios that can represent the current NRC SLR projections, as presented in Section 2.1, and also approximate a range of storm surge events. Since the concurrent study on the San Mateo open coast using the *Our Coast, Our Future* tool evaluates King Tide as the lowest scenario, it was also important that the analyses for the bayshore consider sea level rise scenarios of 1 foot and below to better align with county-wide vulnerability assessment.

Each of the following scenarios approximates either (1) permanent inundation scenarios likely to occur before 2100 or (2) temporary flood conditions from specific combinations of SLR and extreme tides. For example, the water elevation associated with 36 inches of SLR is similar to the water elevation associated with a combination of 24 inches of SLR and a 1-year extreme tide (King Tide). Therefore, a single map can visualize either event. Although inundation maps can approximate the temporary flood extent associated with an extreme tide, they illustrate neither the duration of flooding nor the potential mechanism(s) for draining floodwaters once the extreme tide recedes. Figure 2-1 presents a representative cross section of a shoreline that illustrates the distinction between permanent inundation and temporary flooding.

[4] Although the 500-year extreme tide was analyzed and is presented in Section 3, the 500-year extreme tide levels are considered approximate given the relatively short duration of the hydrodynamic model hindcast.

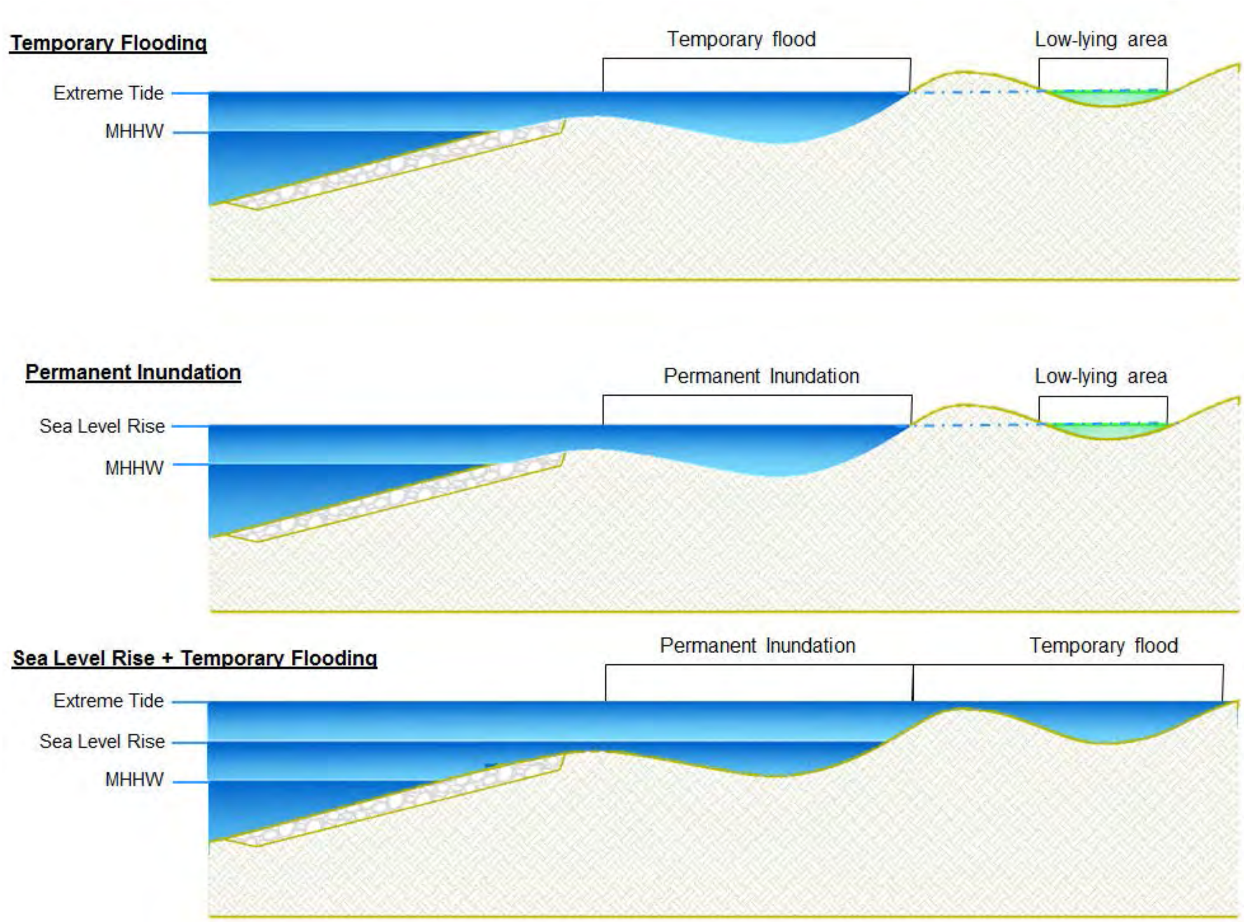

Figure 2-1. Shoreline Cross Section Showing Permanent Inundation and Temporary Flooding

The first six scenarios (12, 24, 36, 48, 54, and 66 inches of SLR above MHHW) relate directly to the NRC SLR estimates, and they capture a broad range of scenarios between the most likely scenario and the high-end of the uncertainty range at both mid-century and at the end of the century.

1. 12-inch SLR ≈ 2050 most likely SLR scenario
2. 24-inch SLR = 2050 high end of the range; or an existing 5-year extreme tide
3. 36-inch SLR = 2100 most likely SLR scenario; or an existing 50-year extreme tide
4. 48-inch SLR ≈ 2100 upper 85% confidence interval; or 6 inches of SLR plus a 100-year extreme tide
5. 54-inch SLR = 12-inch SLR plus 100-year extreme tide
6. 66-inch SLR = 2100 upper end SLR scenario; or 24-inch SLR plus 100-year extreme tide

Inundation maps were also created for Bay water level elevations of 77, 84, 96, and 108 inches above MHHW. These levels are above current predictions for SLR likely to occur before 2100, but they are helpful in illustrating short-term flooding that could occur when extreme tides are coupled with SLR.

7. 78 inches above MHHW ≈ 36-inch SLR plus 100-year extreme tide
8. 84 inches above MHHW ≈ 42-inch SLR plus 100-year extreme tide
9. 96 inches above MHHW ≈ 54-inch SLR plus 100-year extreme tide
10. 108 inches above MHHW ≈ 66-inch SLR plus 100-year extreme tide

The water levels along the shoreline were grouped using a tolerance of ± 3 inches to increase the applicable range of the mapped scenarios. For example, Scenario 3 (MHHW + 36 inches) can approximate all extreme tide/SLR combinations that produce a water level in the range of MHHW + 33 inches to MHHW + 39 inches (Table 2-3).

Although Table 2-3 presents the 10 mapped scenarios, Table 2-4 presents over 50 combinations of SLR and extreme tide levels that can be represented by the 10 inundation maps. For example, from Table 2-4, the inundation map of Scenario 3 (MHHW + 36 inches, dark orange cells, Table 2-4) represents all of these combinations:

- 1-year extreme tide event coupled with 24 inches of SLR;
- 2-year extreme tide event coupled with 18 inches of SLR;
- 10-year extreme tide event coupled with 12 inches of SLR;
- 25-year extreme tide event coupled with 6 inches of SLR, and
- 50-year extreme tide event under existing conditions (no SLR).

The colors shown in Table 2-3 are replicated in the matrix of water levels shown in Table 2-4 to indicate the combinations represented by each inundation map. Table 2-4 also identifies the combinations of SLR and extreme tide that may produce flooding at the higher end of the spectrum at the end of the century. For example, Scenario 9 (96 inches above MHHW) approximates the following (see light blue cells, Table 2-4):

- 66 inches of SLR with a 25-year extreme tide event;
- 60 inches of SLR with a 50-year extreme tide event; and
- 54 inches of SLR with a 100-year extreme tide event.

These scenarios provide a rich data set with which to evaluate vulnerabilities and risk from SLR and to better define the timing for effective adaptation strategies.

Table 2-3. Sea Level Rise Mapping Scenario (Inches above MHHW)

Mapping Scenario	Reference Water Level	Applicable Range for Mapping Scenario – (Reference ± 3 inches)
Scenario 1	MHHW + 12"	MHHW + 9 to 15"
Scenario 2	MHHW + 24"	MHHW + 21 to 27"
Scenario 3	MHHW + 36"	MHHW + 33 to 39"
Scenario 4	MHHW + 48"	MHHW + 45 to 51"
Scenario 5	MHHW + 54"	MHHW + 51 to 57"
Scenario 6	MHHW + 66"	MHHW + 63 to 69"
Scenario 7	MHHW + 78"	MHHW + 75 to 81"
Scenario 8	MHHW + 84"	MHHW + 81 to 87"
Scenario 9	MHHW + 96"	MHHW + 93 to 99"
Scenario 10	MHHW + 108"	MHHW + 105 to 111"

Table 2-4. San Mateo Sea Level Rise and Extreme Tide Matrix

Sea Level Rise Scenario	Daily Tide *Permanent Inundation*	Extreme Tide (Storm Surge) *Temporary Flooding*						
	+SLR	1-yr	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr
	Water Level above MHHW (in)							
Existing Conditions	0	15	19	24	27	32	37	42
MHHW + 6 inch	6	21	25	30	33	38	43	48
MHHW + 12 inch	12	27	31	36	39	44	49	54
MHHW + 18 inch	18	33	37	42	45	50	55	60
MHHW + 24 inch	24	39	43	48	51	56	61	66
MHHW + 30 inch	30	45	49	54	57	62	67	72
MHHW + 36 inch	36	51	55	60	63	68	73	78
MHHW + 42 inch	42	57	61	66	69	74	79	84
MHHW + 48 inch	48	63	67	72	75	80	85	90
MHHW + 54 inch	54	69	73	78	81	86	91	96
MHHW + 60 inch	60	75	79	84	87	92	97	102
MHHW + 66 inch	66	81	85	90	93	98	103	108

The development of this matrix is discussed in Section 3.6.

Due to the Bay's geometry and hydrodynamics, tidal characteristics such as the elevation of MHHW and the magnitude of extreme tides vary along the Bay shoreline. In general, daily and extreme tide elevations increase with increasing distance from the Golden Gate Bridge into the South Bay. For example, the MHHW tide level at the San Mateo bayshore increases from approximately 6.7 NAVD88 (north of the Brisbane Lagoon) to 7.4 ft NAVD88 (south of Cooley Landing). Similarly, the 100-year tide level increases from 9.9 to 11.0 ft NAVD88. Section 3.2 presents additional information on extreme tide levels for the San Mateo bayshore.

The daily and extreme tide levels above MHHW in Table 2-4 represent an average of the water levels at all points along the San Mateo bayshore. The application of the SLR and extreme tide matrix can improve understanding of the increasing frequency of periodic flooding as seas rise.

3.0

INUNDATION MAPPING

3.1 LEVERAGED DATA SOURCES
3.2 EXISTING TIDAL DATUMS AND EXTREME TIDE LEVEL
3.3 FUTURE TIDAL DATUM AND EXTREME TIDE LEVELS
3.4 WATER SURFACE DIGITAL ELEVATION MODEL CREATION
3.5 DEPTH AND EXTENT OF FLOODING

3. INUNDATION MAPPING

Inundation maps are a valuable tool for evaluating potential exposure to future SLR and extreme tide conditions, and the most up-to-date maps should be used during project planning and design. The maps help evaluate when (under what amount of SLR and/or extreme tide) and by how much (what depth of inundation) an asset will be exposed. This section presents the methods and data sources used to develop the inundation maps presented in Appendix A. Figure 3-1 illustrates the SLR mapping project area.

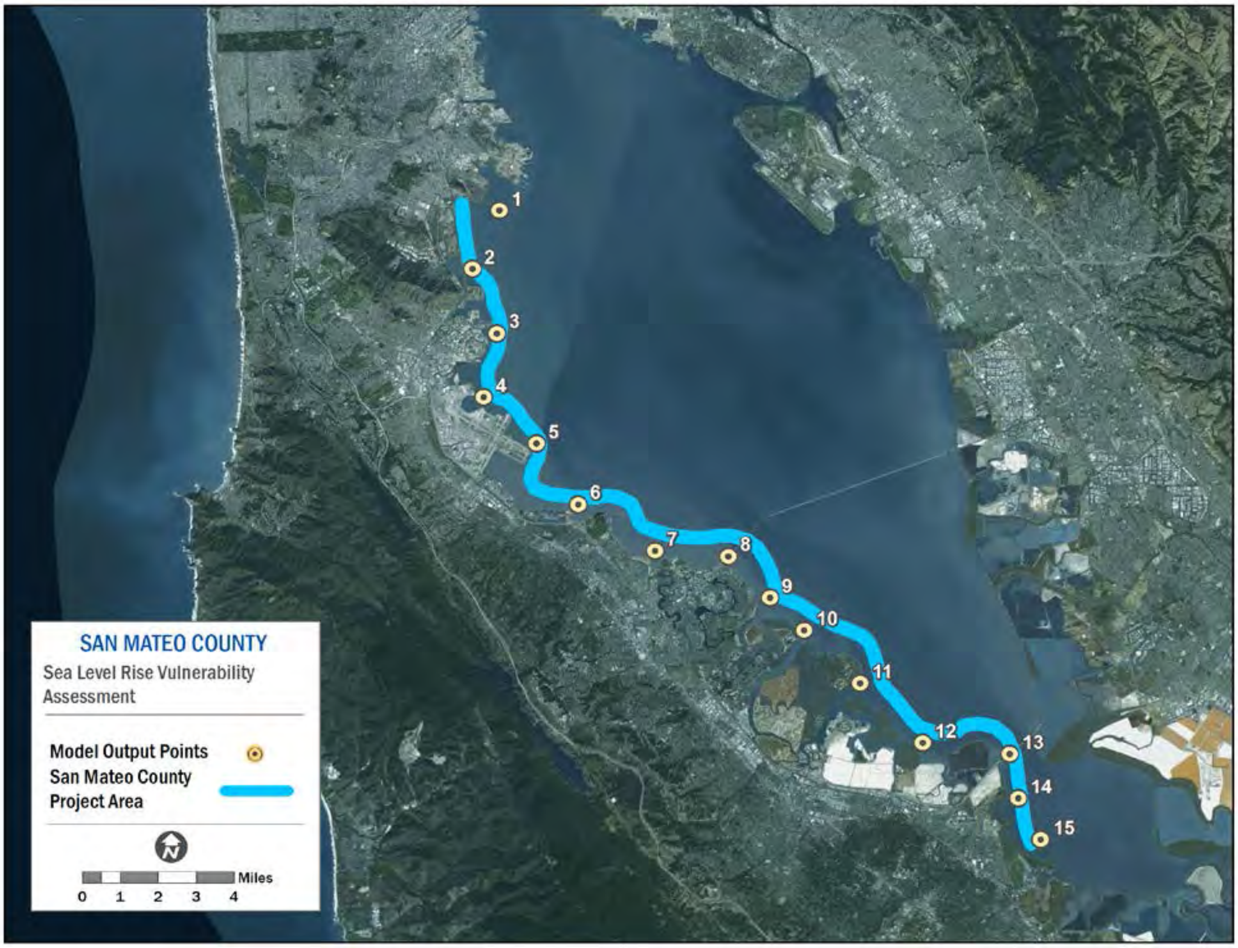

Figure 3-1. San Mateo County ART Project Area and Sample Water Level Analysis Locations

3.1 LEVERAGED DATA SOURCES

The San Mateo County SLR and extreme tide inundation mapping relied on two primary data sources:

- **Hydrodynamic modeling data:** Hydrodynamic model output was required to assess daily and extreme tide levels throughout San Mateo County. The use of modeled water levels was preferred over individual tide gage analyses because of the high spatial density provided in the model output for the entirety of the San Mateo County shoreline. This study leveraged water levels from a regional San Francisco Bay hydrodynamic modeling study completed as part of the U.S. Department of Homeland Security's Federal Emergency Management Agency (FEMA) San Francisco Bay Area coastal study (DHI 2013).

The FEMA model output was archived in 15-minute time steps, as described in DHI (2013). The water level simulations extended from January 1, 1956, to December 31, 2009 (54 years). The regional model was calibrated and validated to observed historical data from nine tide stations within the Bay. A total of 132 output points along the San Mateo County shoreline were used to characterize the spatial variability of water levels throughout the study area. Out of these 132 locations, a subset of 15 representative points was selected to present the results of the water level analysis (see Section 3.2).

- **Topographic data:** High-quality topographic data were leveraged for the shoreline delineation task. The primary data set was the light detection and ranging (LiDAR)[5] data collected by the United States Geological Survey (USGS) as part of the California Coastal Mapping Program (CCMP) (OPC 2016). USGS managed the data collection in south San Francisco Bay. The south Bay LiDAR data were collected in June to November 2010. This data set provides complete coverage of the coastal areas up to the 16-foot (5-meter [m]) elevation contour. The collected LiDAR data for the south Bay have a vertical accuracy of +/- 0.05 m based on the tested root mean square error for all checkpoints (Dewberry 2011). This accuracy exceeds the USGS National Geospatial Program LiDAR Guidelines and Base Specifications (USGS 2010). Additional topographic, bathymetric, survey, and field verification data sets were leveraged to build a new seamless Digital Elevation Model (DEM). This complete set of data includes:
    1. 2010 USGS LiDAR
    2. 2011 OPC LiDAR
    3. Additional survey data
        a. United States Army Corps of Engineers (USACE) south Bay bathymetric survey (2009)
        b. USACE dredging surveys (2003)
        c. City of San Mateo Bayfront Levee Improvements (2012)
        d. San Mateo Creek Flood Control Improvements (2002)
        e. Redwood Shores Exterior Levee Segment III Maintenance Project (2009)
        f. Redwood Shores Levee Improvement Project (2009)
        g. East Palo Alto Runnymede Storm Drain Phase II Project (2014)
        h. Foster City Levee Surveys (received 2016)
        i. City of Foster City – Levee Pedway Topographic Survey (2011)
        j. Survey data from the San Francisco Airport (SFO) shoreline protection system (received 2015)
        k. Survey data for the U.S. Coast Guard property (received 2016)
    4. Additional field verification data
        a. Burlingame floodwall along the San Francisco Bay Trail (2016)

    The total 1-m DEM built using these data sets extends inland well past the 5-m contour. The USGS LiDAR and the associated DEM derived from the LiDAR data provided the topographic base data for the mapping and shoreline delineation effort. The DEM uses bare-earth LiDAR, which means that all vegetation, buildings, and structures (e.g., bridges and buildings) are removed. The shoreline delineation effort also uses the raw LiDAR elevation data points and the 1-m DEM derived from the USGS LiDAR. The inundation mapping, overtopping potential

[5] LiDAR, which stands for light detection and ranging, is an aerial-based topographic survey method that uses optical sensors to map topographic landforms and elevations.

calculations, and shoreline normalization efforts were completed using the 1-m DEM. The DEM is of sufficient resolution and detail to capture the shoreline levees and flood protection assets.

3.2 EXISTING TIDAL DATUMS AND EXTREME TIDE LEVELS

This section describes the calculation of the existing conditions daily and extreme tide levels at each model output point along the project area shoreline. The daily and extreme tide levels are primary data sets used to develop the extreme tide matrix (Table 2-4) and normalized shoreline elevation maps (Section 6).

The MHHW tide level was selected to represent the typical daily high tide. The MHHW tide level for existing conditions was calculated using model hindcast data corresponding to the most recent National Tidal Datum Epoch (NTDE), spanning from 1983 through 2001. The MHHW tide level is the average of the higher high tides of each day recorded during the NTDE.

Calculating the extreme tide elevations required using the 54-year record of the simulated time series from the FEMA model output locations. The water level statistics used to represent the extreme tides include the 1-, 2-, 5-, 10-, 25-, 50-, 100-, and 500-year extreme tide levels. The 500-year extreme tide levels are presented for reference and to convey to stakeholders that the potential exists for events with greater than 100-year severity to occur; however, estimates of the 500-year tide level are only approximate, given the relatively short duration of the hydrodynamic model hindcast. These values are consistent with the values FEMA used for the preliminary Flood Insurance Rate Maps (FIRMs) and Flood Insurance Studies (FISs) for San Mateo County released on August 13, 2015.

The following steps were completed to calculate the extreme tide elevations using the time series of modeled water levels from each model output point:

- Annual maximum water levels were extracted based on a July–June “storm year,” consistent with the FEMA coastal hazard analysis.
- A Generalized Extreme Value probability distribution was fit to the annual maxima data set, and extreme tide elevations were calculated at each return period.
- The 1-year extreme tide elevation for each model output point was determined by extrapolating the extreme tide curves out to the 1-year level.
- Figure 3-2 shows an example water level time series and the extracted annual maxima for one model output point. Table 3-1 presents a subset of computed daily and extreme tide levels at 15 representative model output points. The density of points is sufficient to capture the variability in tides from the northern project limit (Point 1) to the southern project limit (Point 15). See Figure 3-1 for point locations.

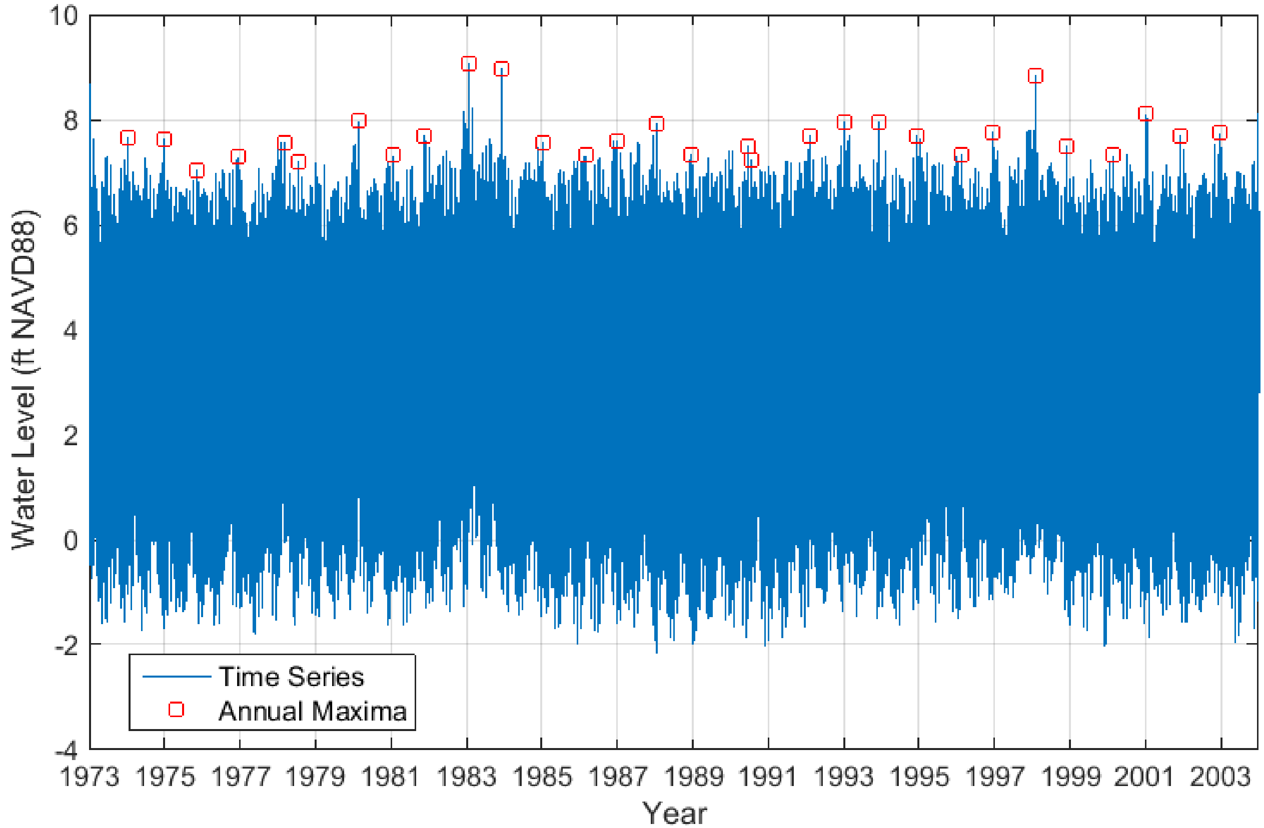

Figure 3-2. Example Water Level Time Series and Annual Maxima Data Set

Table 3-1. Sample Existing Conditions Daily and Extreme Tide Elevations

Point ID	MHHW (ft NAVD)	Extreme Tide Elevations (ft-NAVD)							
		1-yr	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr
1	6.65	8.00	8.26	8.62	8.89	9.27	9.58	9.92	10.82
2	6.69	8.03	8.30	8.66	8.94	9.32	9.64	9.99	10.93
3	6.75	8.06	8.36	8.72	9.00	9.40	9.75	10.13	11.21
4	6.77	8.08	8.39	8.75	9.03	9.45	9.81	10.21	11.35
5	6.81	8.09	8.42	8.78	9.06	9.49	9.86	10.28	11.50
6	6.84	8.11	8.44	8.80	9.09	9.52	9.90	10.33	11.61
7	6.89	8.16	8.49	8.84	9.13	9.55	9.93	10.36	11.64
8	6.94	8.21	8.55	8.90	9.18	9.61	9.99	10.42	11.72
9	7.00	8.26	8.60	8.95	9.23	9.65	10.03	10.46	11.75
10	7.04	8.31	8.65	9.00	9.28	9.71	10.09	10.54	11.87
11	7.12	8.40	8.75	9.10	9.39	9.83	10.23	10.69	12.10
12	7.18	8.45	8.81	9.16	9.45	9.90	10.30	10.77	12.21
13	7.27	8.55	8.92	9.27	9.56	10.02	10.42	10.90	12.38
14	7.32	8.61	8.98	9.33	9.62	10.07	10.48	10.96	12.46
15	7.35	8.63	9.01	9.36	9.65	10.11	10.54	11.04	12.63
Average	6.98	8.26	8.60	8.95	9.23	9.66	10.04	10.47	11.74

3.3 FUTURE TIDAL DATUMS AND EXTREME TIDE LEVELS

This section presents the methodology for estimating future tidal datums and extreme tide levels within the project area.

Tide levels (tidal amplitude and range) in the Bay generally remain stationary over time, which was confirmed with the FEMA San Francisco Bay regional modeling effort and by the modeling efforts completed by Holleman and Stacey (2014), which considered both existing conditions and future SLR. Based on current modeling and neglecting significant changes to the landscape such as constructing levees around large portions of the Bay, SLR does not result in a significant change to the tidal hydraulics. Therefore, future Bay water levels can be approximated by linearly adding SLR to existing MHHW. Holleman and Stacey (2014) showed that this linear approach is appropriate within the Bay. Although small changes in tidal range were observed, the changes were small compared to the amounts of SLR.

For simplicity, this linear approach has also been used to approximate future extreme tide levels (i.e., SLR has been added to the existing 100-year extreme tide levels). However, it should be noted that this approach may be a conservatively low estimate for future extreme conditions because it does not consider climate change factors that may increase the frequency and severity of large storm events over time. At present, trends in increasing storm surge associated with climate change are not clear for the Northern California coast and the San Francisco Bay Area (NRC 2012).

3.4 WATER SURFACE DIGITAL ELEVATION MODEL CREATION

The first step in creating the inundation maps was to create the MHHW water surface DEM. The MHHW elevation calculated at approximately 58 model output points along the entire bayshore is projected inland along shore-perpendicular transects to provide complete coverage across the entire shoreline delineation. Transects extend inland beyond the expected limit of inundation under the highest SLR scenario and are spaced at an appropriate density (approximately 2,500 feet apart, on average) to capture variations in tidal surface and the underlying topography. The resulting MHHW DEM has a horizontal resolution of 1 m by 1 m to match the resolution of the topographic DEM. Each SLR scenario (e.g., 12, 24, 36, 48 inches) was added to the MHHW water surface DEM to develop the future conditions water surface DEMs.

The resulting water surface DEMs are an extension of the tidal water surface at the shoreline over the inland topography. This approach represents a conservative estimate of the inland area that may be inundated every day by tidal action. The MHHW tidal water surface represents an average of the daily high tide conditions over the 19-year NTDE, and therefore daily high tide levels may exceed this average elevation approximately 50 percent of the time.

This method does not take into account the associated physics of overland flow, dissipation, levee overtopping, storm duration, or potential shoreline or levee erosion associated with extreme water levels and waves. To account for these processes, a more sophisticated modeling effort would be required. However, given the uncertainties associated with SLR and future land use changes, development, and geomorphic changes that will occur over the next 100 years, a more sophisticated modeling effort may not necessarily provide more accurate results. Section 7 presents additional key caveats associated with the overall approach for developing the inundation maps appropriate for assessing exposure at a screening-level.

3.5 DEPTH AND EXTENT OF FLOODING

AECOM created depth of flooding raster[6] layers by subtracting the land surface DEM from the water surface DEM. Both DEMs have a 1 m horizontal resolution with the same grid spacing to allow for grid cell to grid cell subtraction. The resultant DEM (or “inundation depth raster”) provides both the inland extent and the depth of inundation without considering hydraulic connectivity.

The final step used in creating the depth and extent of flood maps is an assessment of hydraulic connectivity. The method described by Marcy et al. (2011) employs two rules for assessing whether a grid cell is inundated. A cell elevation must be below the assigned water surface DEM elevation, and it must be connected to an adjacent grid cell that is flooded or open water (i.e., the Bay). This method applies an “eight-side rule” for connectedness, where the grid cell is considered “connected” if any of its cardinal or diagonal directions is connected to a flooded grid cell. Compared to earlier inundation mapping efforts, this approach better identifies inundated areas. Earlier efforts showed areas as inundated solely based on its elevation (i.e., even if there was no hydraulic pathway to the Bay to allow flooding). This assessment removes areas from the inundation zone that are protected by levees or other topographic features that prevent inland inundation. This assessment also removes areas that are low lying but inland and not directly connected to an adjacent inundated area.

Appendix A presents the 10 SLR inundation maps. The shades of blue represent various depths of inundation, shown in 2-foot depth increments, ranging from 0 feet to greater than 16 feet of inundation. Hydraulically disconnected low-lying areas are displayed in green. These areas are lower in elevation than the mapped water surface, but a flow path from the Bay has not been identified. It is possible that the low-lying areas are, or may become, connected through culverts, storm drains, or other features not captured within the DEM; therefore, it is important to note that there may be an existing or future flood risk within these areas. In addition, these low-lying areas may be at risk of flooding from below due to increasing groundwater elevations. Figure 3-3 illustrates an inland disconnected low-lying area.

Figure 3-3. Example Shoreline Cross Section Showing Disconnected Low-Lying Area

The 10 SLR inundation maps also do not consider the potential mechanism for draining the floodwaters from the inundated land once the extreme high tide levels recede. For example, the reduction in extent and depth of inundation at inland areas with the ability to hydraulically pump floodwaters to the Bay are not reflected in the mapping. To account for these processes, a more sophisticated modeling effort would be required. Section 7 presents additional key caveats associated with the overall approach for developing the inundation maps appropriate for assessing exposure at a screening-level.

[6] A raster consists of a matrix of pixels organized into a surface area grid where each grid cell contains a value representing information (e.g., water depth values).

4.0

SHORELINE DELINEATION

4.1 SHORELINE BY TYPE DELINEATION

4.2 APPROACH

4. SHORELINE DELINEATION

The San Mateo County bay shoreline comprises a variety of shoreline types and features. These include natural tidal marshes and mudflats, a network of non-engineered berms, engineered flood protection structures (e.g., levees and floodwalls) and engineered shoreline protection features (e.g., bulkheads, revetments, and rip-rap) all serving as the first line of defense to protect the densely built inland areas from coastal hazards.

Former salt ponds separate the majority of developed areas south of Redwood Shores from the Bay. These large ponds (often in excess of 1-mile in width) are ringed by non-engineered berms that were built over the past century to hydraulically separate the pond areas from the Bay. Engineered flood protection features such as accredited levees or shoreline protection features protect the majority of developed areas north of Redwood Shores.

The San Francisco Estuary Institute (SFEI) delineated the San Mateo County shoreline, building upon the ART methods developed for Alameda County (SFEI 2016). AECOM used this shoreline delineation to evaluate levels of shoreline flood protection and coastal flood vulnerability. Although not all shoreline features provide equal flood protection, in general shoreline features such as bluffs, berms, embankments, roads, railroad embankments, sea walls, levees, tide gates, and upland hills all act to constrain the tidal influence of the Bay. The shoreline delineation identifies the highest point—or crests—of these features as they occur along the shoreline, and the delineation includes information on the feature type and its crest elevation. The delineation also includes river and creek banks within the downstream tidally influenced areas.

This shoreline delineation is used in three ways:

1. To produce shoreline-by-type maps (Section 4.2). Eight types of shoreline features were identified in San Mateo County. This information aids in understanding both the level of existing flood protection and the appropriate adaptation strategies necessary to prevent local flooding.
2. To produce overtopping maps (Section 5). Overtopping maps identify shoreline low points and flood pathways for each of the 10 mapped scenarios. In many cases, large areas of flooding may occur through localized low points. Overtopping maps are necessary to identify the scale of strategy necessary to prevent local flooding.
3. To produce normalized shoreline maps (Section 6). The normalized shoreline layer depicts the elevation of shoreline features relative to existing MHHW and provides an indication of whether delineated features are near, below, or above MHHW. Shoreline features below existing MHHW may occur on the bayward side of levees, berms, dunes, or wetland shorelines.

4.1 SHORELINE TYPE DELINEATION

The shoreline was classified into types to support coastal vulnerability and risk assessments. An understanding of shoreline type is helpful for examining how certain shorelines may respond to future conditions. For instance, assets behind highly erodible shorelines may be at increased risk compared to assets behind less erodible shorelines of the same elevation. Also, some types of low coastal areas may in fact provide significant flood protection. For example, while wetlands will react to SLR differently than levees, they may provide additional flood protection, depending on the specific characteristics of the feature.

The shoreline categorization identified the main lines of shoreline defense. Eight primary types of shoreline profiles were identified within the project area. Figure 4-1 shows the profiles of the eight primary shoreline type categories. The final shoreline type delineation maps are presented in Appendix B.

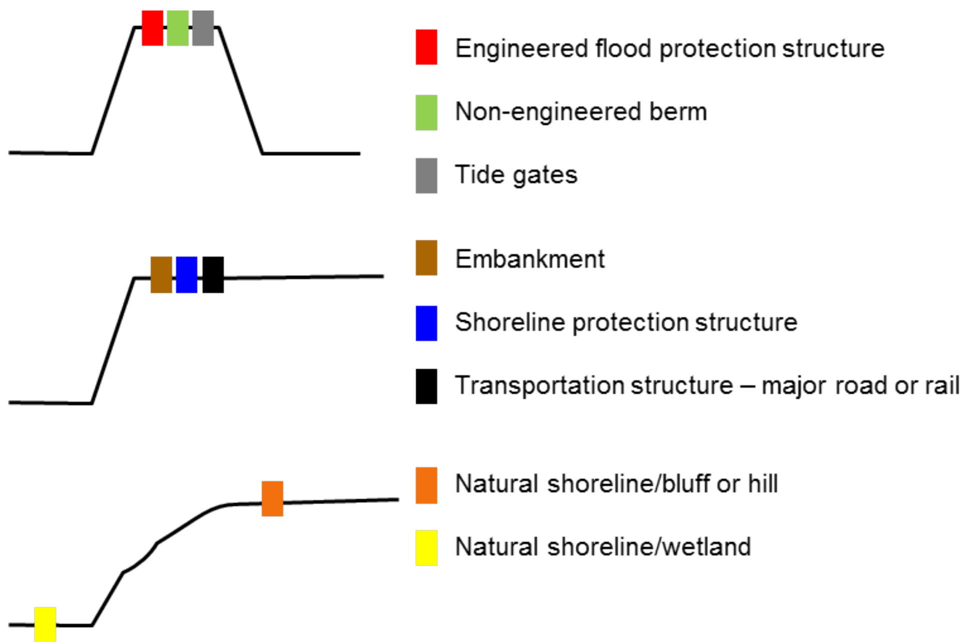

Figure 4-1. Shoreline Type Profiles

- **Engineered flood protection structures:** These structures are designed and built to protect inland areas from flooding, including from major storm events and extreme water levels that may also be accompanied by waves. This category includes both engineered levees and flood walls. Levees within this category have a FEMA accreditation date in the FEMA Midterm Levee Inventory (MLI) Database or in information provided by San Mateo County and cities stating that the structure has been engineered. A flood wall is a vertical barrier with a similar design standard to that of a levee. These features were delineated following the high point on the DEM.
- **Non-engineered berms:** Non-engineered berms include other levees or levee-like structures that do not have current or previous FEMA accreditation. These features are similar in shape to a levee, but do not provide a standard level of flood protection. They may still serve as a line of defense against flood hazards during storm events. These features were delineated following the high point on the DEM.
- **Embankments:** Embankments are typically an earthen slope within an inland area (e.g., channel banks upstream of the coastal shoreline) that transitions to flat or hilly inland areas. Unlike levees and berms, which have a crest and two slopes, embankments have only one slope. These barrier features do not provide a standard level of flood protection, but serve as a line of defense against flood hazards during storm events. Embankments were delineated at the top of slope on the DEM.
- **Shoreline protection structures:** These features share the same single-slope profile as embankments, but are Bay-facing, rather than inland. They generally abut development or a modification to the Bay shoreline. These features were delineated at the top of slope on the DEM.
- **Transportation structures – major roads/rail:** These features were built for transportation purposes and do not provide a standard level of flood protection, but can serve as a line of defense against flood hazards during storm events. Only major roads and rail lines were delineated for this assessment to evaluate potential hazards to these assets. These features were delineated following the high point on the DEM.
- **Natural shorelines/wetlands:** These features include tidal marshes along the edge of the Bay or within larger creek channels. Boundaries were defined by identifying the high point on the DEM

either adjacent to a channel or tidal flat and digitizing an isoline (contour) to terminus with the nearest identified levee or protection structure. The hardscape behind each wetland has also been defined primarily by the most bayward levee.

- **Natural shorelines or hills:** These features are areas where engineered flood protection or shoreline protection structures are absent, and no clear landward structure that provides a level of flood protection is visible. The natural landscape provides a steep elevation in the form of a bluff or hill. Such areas may have a defined high point in the DEM profile, but are not engineered structures.
- **Tide gates:** These structures are barriers that span creeks or channels but allow tidal flushing to occur, and they can provide a level of flood protection for upstream areas. Thirty-six tide gates in total were identified within the shoreline delineation for San Mateo County.

In addition to the maps contained in this report, the shoreline delineation layer for San Mateo County is available as a digital shapefile. The digital shapefile contains information on the most bayward shoreline type ("Frontage") for each of the major shoreline types listed above. Features that are too narrow to be useful for this assessment, such as fringe wetlands, beaches, or a combination of the two, are only identified under the primary backshore shoreline segment and are not delineated. For example, narrow fringe wetlands in front of a non-engineered berm segment of the shoreline are only tagged under the Frontage sub-category and were not delineated in a Geographic Information System (GIS). In addition, fortified shoreline segments (i.e., with riprap or concrete on the bayward slope) are attributed within the digital shoreline shapefile.

4.2 APPROACH

The shoreline for San Mateo County leveraged a delineation completed by the San Francisco Estuary Institute (SFEI) using GIS tools (SFEI 2016). The approach used by SFEI to digitize the shoreline follows the methods used for the ART Program (AECOM et al. 2011) and the Alameda County Shoreline Vulnerability Assessment (AECOM 2015). SFEI's shoreline delineation includes information on the major shoreline types that may impact coastal flooding (SFEI 2016) and was used for the overtopping potential and normalized shoreline analyses following a quality assurance/quality control (QA/QC) review by AECOM.

Major features that could provide flood protection up to a Bay water level of 120 inches (10 ft) above existing MHHW[7] were delineated, including embankments along open channels of rivers and creeks. LiDAR data were used as the primary source for locating and delineating the shoreline, in conjunction with high-resolution aerial photography. Levee information from San Mateo County and the FEMA MLI were also used for reference (FEMA 2012).

A combination of both high-resolution planar and oblique imagery was also crucial in distinguishing both the locations and the types of features. Aerial imagery (planar) from ArcGIS Online was used while digitizing in GIS. This imagery was flown in June 2014 and has a 1.0 m horizontal resolution. Oblique imagery was used from Google maps (45-degree) to assist in delineating and reviewing shoreline segments.

In locations where shorelines had natural features in the foreshore (e.g., wetlands) and man-made or natural features in the backshore (e.g., levees), both features were delineated. In these cases, the shoreline feature at the backshore was used to evaluate overtopping. Also, flood barriers (e.g., tide gates) in channels, major roads, rail lines, and embankments are included in the shoreline delineation.

[7] This scenario was not selected for inundation mapping as part of this assessment, but is used by SFEI to complete the shoreline delineation for the entire Bay and represents an upper boundary beyond the extent of inundation and flooding expected for the remainder of the century.

5.0

SHORLINE OVERTOPPING POTENTIAL

5.1 METHODS
5.2 APPLICATION OF OVERTOPPING POTENTIAL MAPS

5. SHORELINE OVERTOPPING POTENTIAL

5.1 METHODS

Overtopping potential refers to the condition where the water surface elevation under a particular SLR scenario exceeds the elevation of the shoreline. This method, using overtopping potential, provides a high-level assessment of where Bay waters may be overtopping the shoreline, resulting in inland inundation. The overtopping potential layer depicts the depth of water over the delineated shoreline features described in Section 4 under each of the 10 SLR scenarios. Overtopping could occur temporarily during a large flood or permanently after a particular amount of SLR. This layer illustrates not only where overtopping may occur, but how deep the water may be on average over any particular section of shoreline.

The pathways for inundation from the Bay and overland cannot always be assessed when viewing the inundation maps by themselves. The overtopping data identify the potential sources of future flood events and, when combined with the inundation layer, help to determine the actual flow paths that lead to inland flooding. By identifying specific locations along the shoreline that are overtopped, this layer provides critical insight for flood protection planning.

The average depth of inundation along the shoreline delineation is calculated for each 100 ft segment. To calculate overtopping potential, the shoreline delineation described in Section 4 was overlain on each of the 10 inundation depth rasters (i.e., one raster for each of the 10 inundation scenarios described in Section 2), and average depths of inundation for each shoreline segment were extracted. Figure 5-1 illustrates overtopping depth (i.e., water level exceeds the shoreline elevation) and freeboard (i.e., shoreline elevation exceeds the water level). As sea level rises, additional lengths of shoreline are inundated.

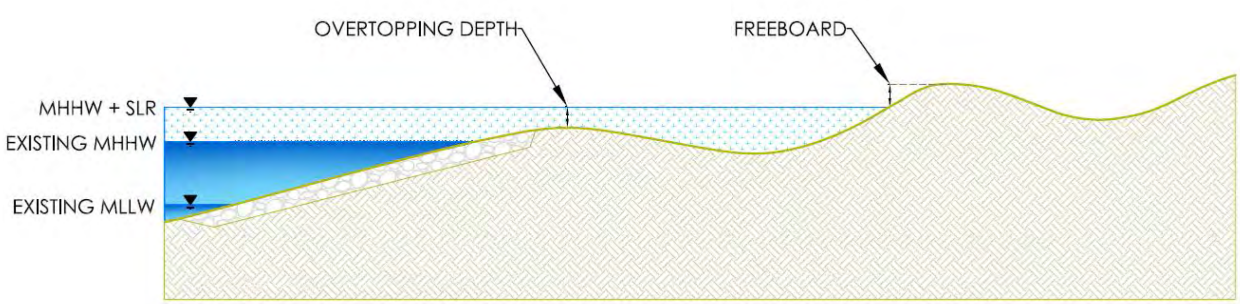

Figure 5-1. Representative Shoreline Cross Section Illustrating Overtopping Depth and Freeboard

5.2 APPLICATION OF OVERTOPPING POTENTIAL MAPS

Appendix A presents the overtopping potential for each of the 10 SLR scenarios. The overtopping depths are grouped into l 1-ft depth increments for visualization purposes only. The overtopping depths are more varied than shown[8]. In addition to the maps contained in this report, the shoreline overtopping potential data layers are available as digital shapefiles that provide additional information on overtopping depth.

[8] Overtopping depth is calculated to the nearest hundredths of a foot, and then grouped into 1 ft depth increments for mapping purposes.

The overtopping assessment should be considered a planning-level tool only, as it does not account for the physics of wave run-up. This assessment also does not account for the condition and structural integrity of the shoreline flood protection infrastructure (or roadway or railway embankments that are providing ad hoc flood protection) that could result in partial or complete failure through scour, undermining, or breach after an initial overtopping occurs.

The maps show overtopping potential for inland high ground that can act as a barrier to flooding and inundation. Showing inland overtopping can illustrate increases in overtopping depth as floodwaters progress landward after overtopping the bayfront shoreline. Overtopping and flooding over inland areas can also occur without overtopping at the adjacent bayfront shoreline, if there is “backdoor” pathway of flooding from a different portion of the shoreline. The overtopping maps can highlight these pathways of flooding to inland areas.

Figure 5-2 shows an example cross section of a shoreline where the primary bayfront shoreline is not overtopped, but lower lying areas directly behind it could be inundated or flooded to an elevation that is equal to the Bay. In this case, a flood pathway has allowed flooding to reach the inland areas without overtopping the immediate bayfront shoreline. Since the overtopping and SLR inundation maps do not consider the duration of storms nor potential mechanisms for draining floodwaters from inundated land once extreme high tide levels recede, the maps will show flooding of inland areas at an elevation equal with the Bay. This means that the depth of flooding and overtopping shown on the maps may be more severe, especially for areas with flood management strategies in place. For example, Foster City has the ability to hydraulically pump floodwaters from inland areas to the Bay during rainfall driven flood events, and the pumps can also remove Bay floodwaters if needed. The following case study for Foster City highlights how the inundation maps and overtopping potential maps can be used together to identify where shoreline improvements or adaptations strategies are needed to reduce inland flood risks.

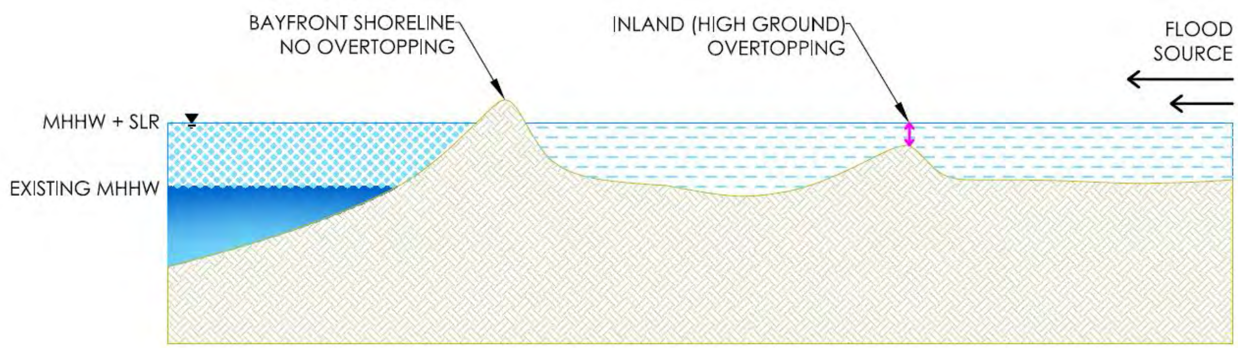

Figure 5-2. Shoreline Cross Section Illustrating Inland Flood Elevations Equal to the Bay Water Level

CASE STUDY: FOSTER CITY

This case study illustrates how implementing adaptation strategies *within one jurisdiction* can reduce flood risks *in some instances*, while also highlighting the importance of regional coordination in adaptation planning *in reducing flood risks*.

Introduction

Foster City is a planned community in San Mateo County that was constructed in the 1960s by placing engineered earthen fill along the Bay margin and on former tidal wetlands. Bayfront levees provide protection from coastal floodwaters, and an engineered lagoon system provides stormwater flood protection as well as recreation and a vibrant waterfront aesthetic. Like many communities in the Netherlands, Foster City is a community engineered to live with water.

During the winter months, when storms can bring high Bay water levels and intense precipitation, the water level in the lagoon is lowered to increase the floodwater retention capacity. As the lagoon fills with rainfall runoff, a series of pumps can pump the stormwater from the lagoon into the Bay to reduce the risk of interior flooding. Although the Bayfront levees have not been overtopped during a coastal storm event to date, higher water levels from sea level rise or a 100-year extreme tide will make these structures more vulnerable to potential overtopping and wave action. If overtopping occurs, flood waters may run into storm drains and into the lagoon. The floodwaters are pumped out to the Bay as long as they are functional. The ability to lower the lagoon water levels and pump water means the City can reduce the community's exposure to coastal flooding. The flood-management capabilities of the lagoon are not included in the inundation maps presented within this report. Therefore, Foster City may be more resilient than depicted on the maps.

Existing Conditions

Bay waters may overtop the existing levee system at several locations during a 100-year extreme tide coupled with ~12 inches (in) of sea level rise [SLR] (see Figure A). The inundation maps show that if the Bayfront levees are overtopped, the entire city would be flooded to a depth of water that is consistent with the Bay water level on the outboard side of the levee (see Figure 5-2 in Section 5.2). This is a conservative approach, but it can overestimate the potential flood exposure associated with temporary extreme flood conditions. This is particularly evident in Foster City because of its internal drainage and pump infrastructure. However, the inundation maps and the overtopping assessment are still useful tools for evaluating the overall vulnerability of the city. The overtopping maps highlight the need to improve the Bayfront flood defense in the near term, and they show where along the shoreline improvements are most needed (see overtopping locations on Figure A).

Evaluating Adaptation Strategies

Foster City is committed to reducing flood risks within their community, and the City is currently evaluating potential shoreline adaptation strategies intended to reduce overtopping from extreme high tides, wave hazards, and sea level rise. At the time of this study, a preferred solution has not been selected. Therefore, for simplicity, this case study uses an example adaptation strategy consisting of the traditional grey infrastructure technique of raising the Bayfront levee by 3 feet along its entire length. In practice, a variety of adaptation strategies could provide a similar level of flood protection, including "green infrastructure" solutions such as living shorelines. The Baylands

Ecosystem Habitat Goals Science Update (Goals Project 2015) provides examples of green infrastructure and integrated solutions that can meet both Bay habitat restoration and flood protection goals.

Under existing site conditions, the Bayfront levees are overtopped at 12 in of SLR coupled with a 100-year extreme tide (see Figure A). If the levee height is increased by 3 feet (36 in), the improved levee should provide protection above this flood level (see Figure B). If this flood protection system is self-contained, the levee improvements would reduce the risk to additional storm hazards until 48 in of SLR coupled with a 100-year extreme tide.

Figure C shows the shoreline length within the Foster City limits where 3 feet of levee height was added to the digital elevation model for this case study. If these shoreline improvements are completed, Figure C shows Foster City would have a low flood risk during a 100-year extreme tide coupled with 12 in of SLR. However, despite the levee height improvements, Foster City would still be exposed to flooding prior to 48 in of SLR coupled with a 100-year extreme tide. Figure D shows that Foster City remains vulnerable to the 100-year extreme tide coupled with 24 in of SLR – *even though the Bayfront levee would not be overtopped*. Under this scenario, the vulnerabilities are located outside of the Foster City limits, as identified by locations 1, 2 and 3 in Figure D.

1. Overtopping may occur along the banks of San Mateo Creek
2. Overtopping may occur between J. Hart Clinton Dr. and Starboard Dr. (near Marina Lagoon Pump Station)
3. Overtopping may occur near the intersection of Highway 101 and the Bay Trail

Local and Regional Solutions

This analysis shows that Foster City may best address potential flood risks (beyond 12 in of SLR coupled with a 100-year extreme tide) by collaborating with the neighboring communities. Although the vulnerabilities shown in Figure D can be easily addressed through small-scale adaptation efforts, these areas are located outside of the Foster City limits, and therefore outside of Foster City's direct control. This situation is not unique to Foster City. Throughout the Bay Area, communities are grappling with complicated flooding issues that may originate from areas outside of their jurisdictional boundaries.

Although communities are responsible for locating and addressing local vulnerabilities, collaboration and regional planning efforts are needed to increase the overall resilience of the region. The mapping tools and products presented within this report are intended to support these collaborations, and to help identify where and when collaboration is likely required. As part of an initiative named Sea Change San Mateo County, the San Mateo County Office of Sustainability is also actively identifying communities that need to collaborate across jurisdictional boundaries, and is helping to coordinate and plan efforts to address sea level rise vulnerabilities Countywide.

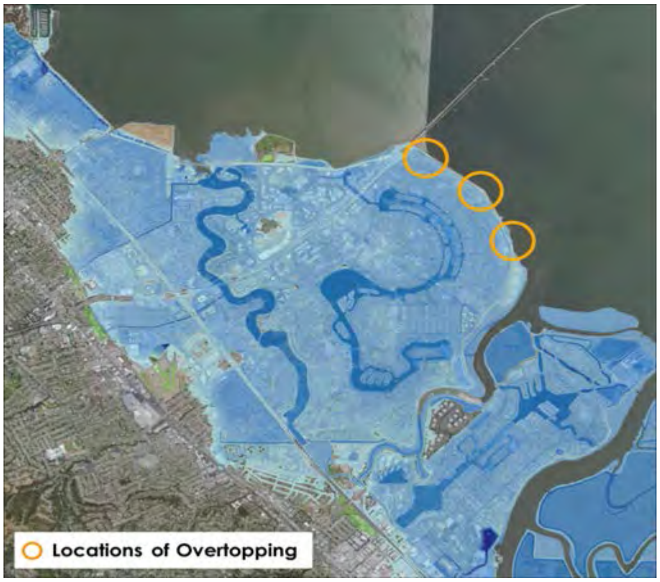

Figure A.
Overtopping and Inundation at 12” SLR + 100-yr

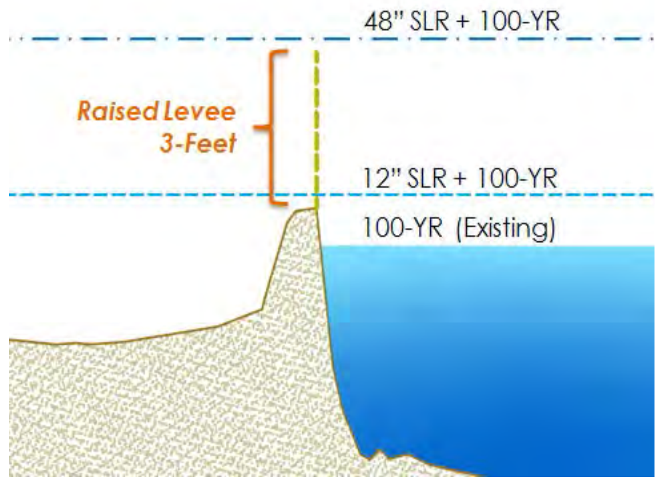

Figure B.
Example Profile Showing Increase in Levee

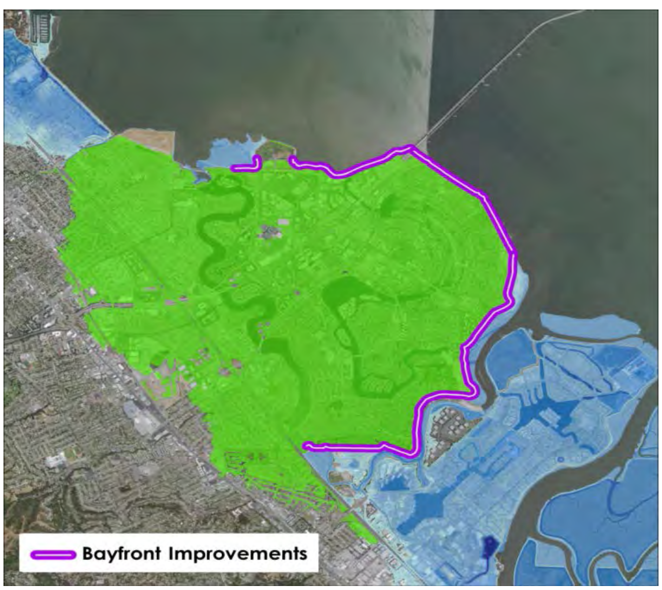

Figure C.
Bayfront Improvements at 12” SLR + 100-yr

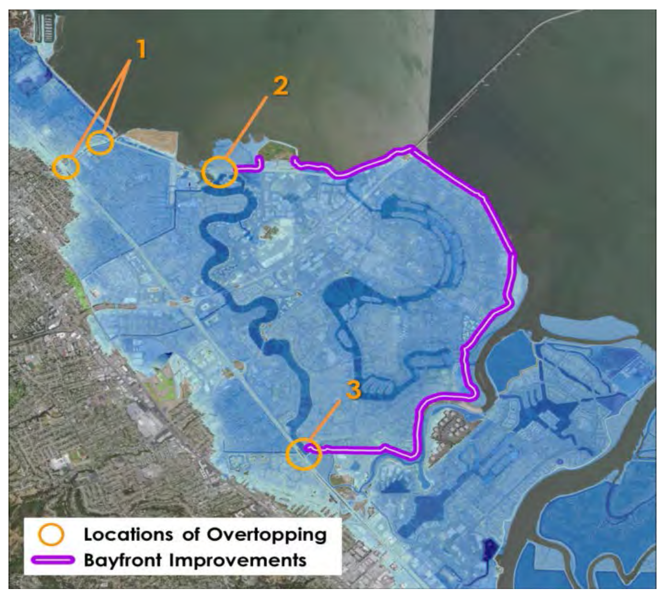

Figure D.
Inundation of Inland Areas at 24” SLR + 100-yr

6.0

SHORELINE EXPOSURE ANALYSIS

6.1 NORMALIZED SHORELINE ELEVATIONS

6.2 EXISTING NORMALIZED EXTREME TIDE CURVES

6.3 NORMALIZED EXTREME TIDE CURVES (FUTURE)

6.4 APPLICATION OF OF NORMALIZED TIDE CURVES AND NORMALIZED SHORELINE MAPS

6. SHORELINE EXPOSURE ANALYSIS

6.1 NORMALIZED SHORELINE ELEVATIONS

The concept of “normalized elevation” is a key component of this study. The normalized shoreline layer compares the elevation of shoreline features relative to existing MHHW. It is calculated by dividing the shoreline elevation by the local MHHW elevation. For example, along the San Mateo County shoreline, both the MHHW tide level and the 100-year tide level vary spatially. Although the absolute elevations of both daily and extreme tides vary, the ratio of a given extreme tide to MHHW is relatively constant across large geographic areas. For example, the ratio of the 100-year tide level divided by the MHHW tide level (the common denominator) is approximately constant within the project area (approximately 10.5 ft / 7.0 ft = 1.5).

A normalized value of 1.0 indicates the shoreline elevation is equal to the local MHHW elevation, or that it is at an elevation with the potential for the Bay waters to get this area wet daily. A normalized elevation value greater than 1.0 indicates the shoreline is higher than the local MHHW elevation, and a value less than 1.0 indicates the shoreline area is below MHHW. These low values may occur on the bayward side of levees, berms, or wetland shorelines.

Normalized shoreline elevation maps may be used to visually identify existing and near-term vulnerable reaches of shoreline. The southern portion of San Mateo County is characterized by tidal marsh and managed pond complexes fronting the developed shoreline. The majority of these bayfront features experience daily inundation during high tides, and therefore have normalized values of less than 1.0. The majority of the landward, developed edge of the San Mateo County shoreline is built up at higher elevations where much of the shoreline has a normalized value above 1.4. For reference, this is just below the normalized elevation equal to today’s 100-year extreme tide, which is 1.5. Shoreline segments with a normalized elevation of 1.5 or greater provide protection against today’s 100-year extreme tide, but with sea level rise lesser storms will overtop these shorelines. A few vulnerable locations with normalized values of 1.2 or below exist along the developed shoreline, including areas along Redwood Creek (Port of Redwood City) and along the Millbrae shoreline (adjacent to SFO).

Appendix C presents the normalized shoreline elevation maps for use in combination with the normalized extreme tide curves presented in Sections 6.2 and 6.3 to assess flooding thresholds for shoreline assets under existing and future conditions. Section 6.4 describes applications of normalized tide curves in more detail.

AECOM used the shoreline delineation layer described in Section 4 as a basis for calculating the normalized shoreline elevations. The following outlines the steps using GIS-based tools to develop the normalized shoreline elevation maps:

- An existing conditions MHHW water surface DEM was developed using the MHHW elevations calculated at the FEMA model output points (Section 3).
- The shoreline delineation layer (Section 4) was subdivided into segments with a maximum length of 100 ft.
- The segmented shoreline delineation layer was overlain on the MHHW water surface DEM and the LiDAR-based topographic DEM.
- The average elevation of the MHHW water surface within each shoreline segment was computed using the MHHW water surface DEM.
- The average elevation of the shoreline within each segment was computed using the topographic DEM.

- The normalized shoreline elevation for each segment was computed by dividing the segment's average elevation by its average MHHW value.

In addition to the maps presented in this report, the normalized shoreline elevation data layer is available as a digital shapefile.

6.2 EXISTING NORMALIZED EXTREME TIDE CURVES

This section presents normalized tide curves for existing conditions within the project area. A higher normalized extreme tide level reflects a greater difference between an extreme tide elevation and the local MHHW at a particular model output point. As shown in Table 6-1, although there is moderate spatial variability in the elevation of the MHHW tide level throughout San Mateo County, the ratio of a specified return period extreme tide level to MHHW (elevation/MHHW) remains fairly constant, especially for adjacent model output points.

Table 6-1. Existing Conditions Normalized Extreme Tide Levels

		Normalized Extreme Tide Level (Elev./MHHW)							
Point ID	MHHW (ft NAVD88)	1-yr	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	500-yr
1	6.65	1.20	1.24	1.30	1.34	1.40	1.44	1.49	1.63
2	6.69	1.20	1.24	1.30	1.34	1.39	1.44	1.49	1.63
3	6.75	1.19	1.24	1.29	1.33	1.39	1.44	1.50	1.66
4	6.77	1.19	1.24	1.29	1.33	1.40	1.45	1.51	1.68
5	6.81	1.19	1.24	1.29	1.33	1.39	1.45	1.51	1.69
6	6.84	1.18	1.23	1.29	1.33	1.39	1.45	1.51	1.70
7	6.89	1.18	1.23	1.28	1.32	1.39	1.44	1.50	1.69
8	6.94	1.18	1.23	1.28	1.32	1.38	1.44	1.50	1.69
9	7.00	1.18	1.23	1.28	1.32	1.38	1.43	1.50	1.68
10	7.04	1.18	1.23	1.28	1.32	1.38	1.43	1.50	1.69
11	7.12	1.18	1.23	1.28	1.32	1.38	1.44	1.50	1.70
12	7.18	1.18	1.23	1.28	1.32	1.38	1.43	1.50	1.70
13	7.27	1.18	1.23	1.27	1.31	1.38	1.43	1.50	1.70
14	7.32	1.18	1.23	1.27	1.31	1.38	1.43	1.50	1.70
15	7.35	1.17	1.23	1.27	1.31	1.38	1.43	1.50	1.72
Average	6.98	1.18	1.23	1.28	1.32	1.38	1.44	1.50	1.68

An example standard extreme tide curve is compared to an example normalized extreme tide curve on Figure 6-1. The standard extreme tide curve (Figure 6-1a) shows the actual elevations for each return period (from 1 to 100 years) on the y-axis, and the comparable normalized extreme tide curve (Figure 6-1b) shows the normalized ratio on the y-axis.

The existing conditions normalized extreme tide values for the corresponding points were averaged to create a single consolidated curve for the project area. The resulting normalized extreme tide levels are shown on Figure 6-1b.

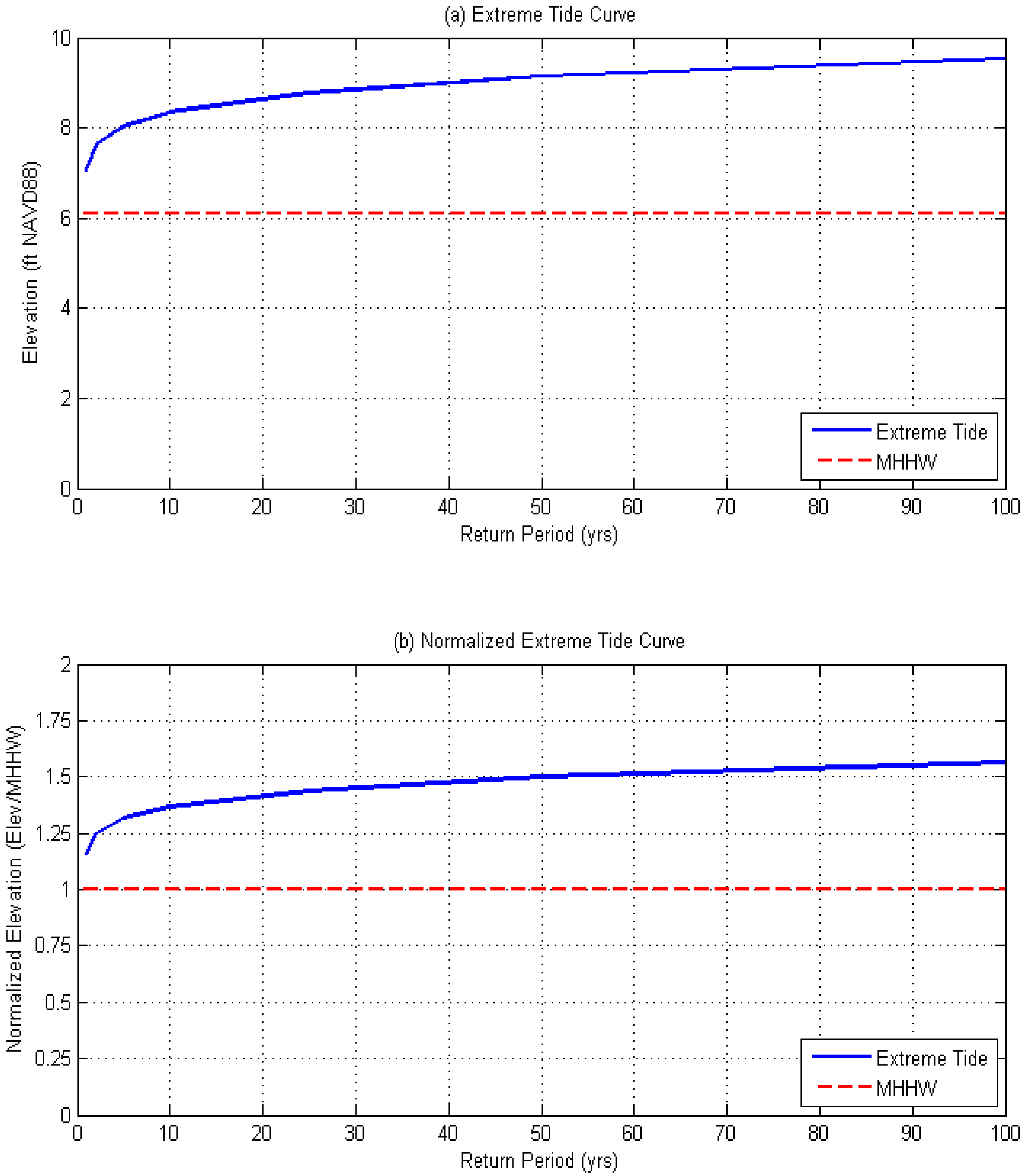

Figure 6-1. Example Tide Curves in San Francisco Bay:
(a) Extreme Tide Curve and (b) Normalized Extreme Tide Curve

6.3 NORMALIZED EXTREME TIDE CURVES (FUTURE)

To transform the existing conditions extreme tide curve to future conditions, the entire range of SLR values (from 6 to 60 inches) was added to the existing conditions tide elevations presented in Table 6-1, and the resulting curves were normalized using the present-day MHHW elevations. The future conditions normalized extreme tide curves are shown in Table 6-2. All normalized extreme tide levels are presented relative to the existing conditions average MHHW tide level along the San Mateo County shoreline. Figure

6-2 presents the normalized extreme tide curve. The black curve represents the extreme tide curve derived from model output data for existing conditions. The colored curves represent the future conditions normalized extreme tide curve for each SLR projection from 6 to 60 inches.

Table 6-2. Future Conditions Normalized Extreme Tide Curves

		Inches of Sea Level Rise above Existing MHHW									
Return Period	**Ex.**	**+6**	**+12**	**+18**	**+24**	**+30**	**+36**	**+42**	**+48**	**+54**	**+60**
Existing	1.00	1.07	1.14	1.22	1.29	1.36	1.43	1.50	1.57	1.65	1.72
1	1.18	1.26	1.33	1.40	1.47	1.54	1.61	1.69	1.76	1.83	1.90
2	1.23	1.30	1.38	1.45	1.52	1.59	1.66	1.73	1.81	1.88	1.95
5	1.28	1.35	1.43	1.50	1.57	1.64	1.71	1.78	1.86	1.93	2.00
10	1.32	1.40	1.47	1.54	1.61	1.68	1.75	1.83	1.90	1.97	2.04
25	1.38	1.46	1.53	1.60	1.67	1.74	1.81	1.89	1.96	2.03	2.10
50	1.44	1.51	1.58	1.65	1.73	1.80	1.87	1.94	2.01	2.08	2.16
100	1.50	1.57	1.64	1.72	1.79	1.86	1.93	2.00	2.07	2.15	2.22

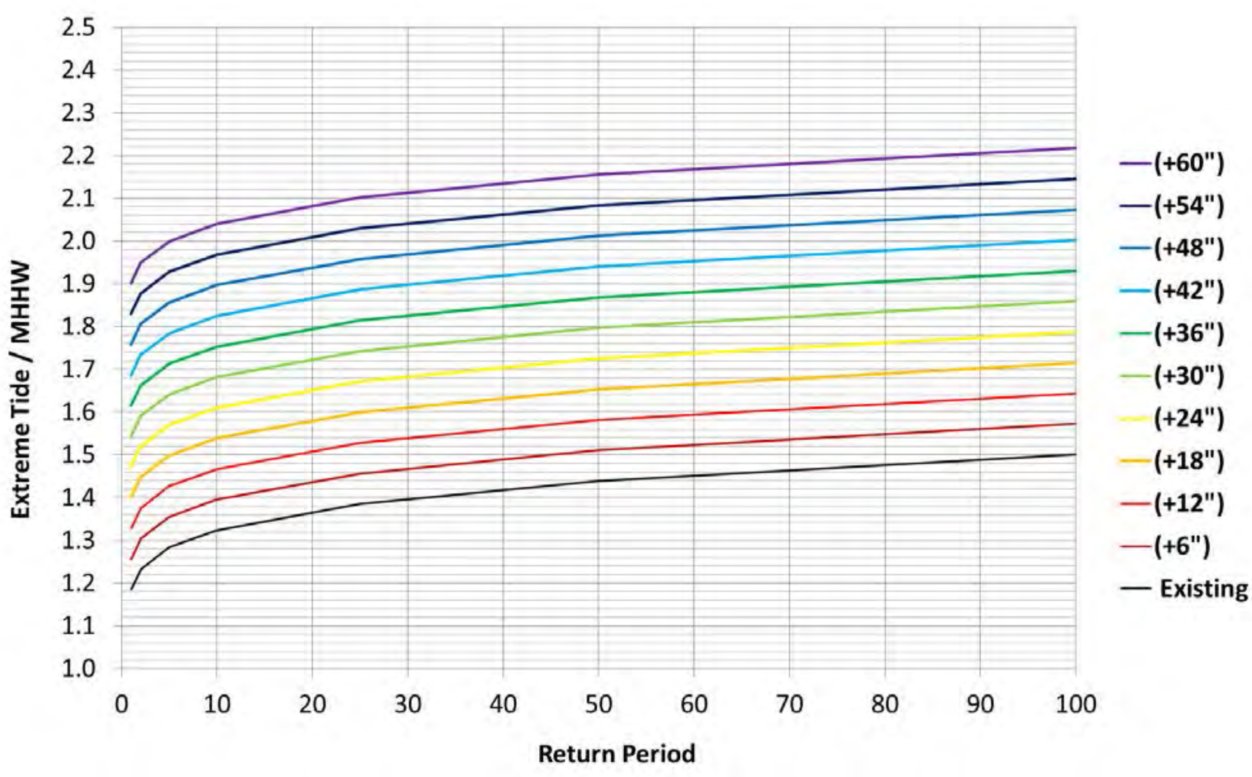

Figure 6-2. Existing and Future Conditions Normalized Extreme Tide Curves

6.4 APPLICATION OF NORMALIZED TIDE CURVES AND NORMALIZED SHORELINE MAPS

The existing and future conditions normalized extreme tide curves are presented in tabular and graphical format. The future conditions normalized extreme tide curves are used in tandem with the normalized shoreline elevation maps presented in Appendix C. The information from the normalized extreme tide curves and corresponding values in tabular format are similar to the SLR and storm surge matrix. The normalized extreme tide curves shown on Figure 6-2 are a graphical representation of combinations of SLR and storm surge scenarios that can impact a selected shoreline segment. Table 6-2 shows the same information in tabular format—combinations of SLR and storm surge scenarios that can inundate shoreline segments above the same normalized extreme tide value.

The maps and curves can help assess flooding thresholds for existing and future conditions. Two potential scenarios for application are outlined below and illustrated on Figure 6-3:

1. Determine the flooding threshold for a particular shoreline segment given a specified amount of SLR.
2. Determine the approximate design elevation for a shoreline asset given a specified amount of SLR and preferred/required level of flood protection.

In the first scenario, a stakeholder might be interested in the level of flood protection provided by a particular shoreline asset for some future condition with SLR. For example, an asset might provide 100-year flood protection under existing conditions, but with SLR, the level of protection would decrease over time. Figure 6-3a illustrates this example for a shoreline asset with a normalized shoreline elevation of 1.5 (which indicates an elevation of 1.5 times MHHW). The flooding threshold is evaluated by plotting a horizontal line at a normalized elevation of 1.5 and intersecting it with the selected extreme tide curve. For the selected extreme tide curve, this asset's flooding threshold is reduced to the 50-year level for future conditions with SLR.

In the second scenario, a stakeholder might want to know how high a shoreline asset would need to be raised to provide a 100-year flood protection under future SLR conditions. Figure 6-3b illustrates this example. The approximate design elevation is evaluated by plotting a vertical line at a return period of 100 years and intersecting it with the selected extreme tide curve. For the selected return period, a normalized shoreline elevation of 1.54 is required. Using the local MHHW elevation to convert the normalized elevation to an absolute elevation (i.e., relative to NAVD88), an approximate design elevation for the shoreline asset can be estimated. However, asset elevations estimated in this manner are appropriate, and are not appropriate for detailed engineering design.

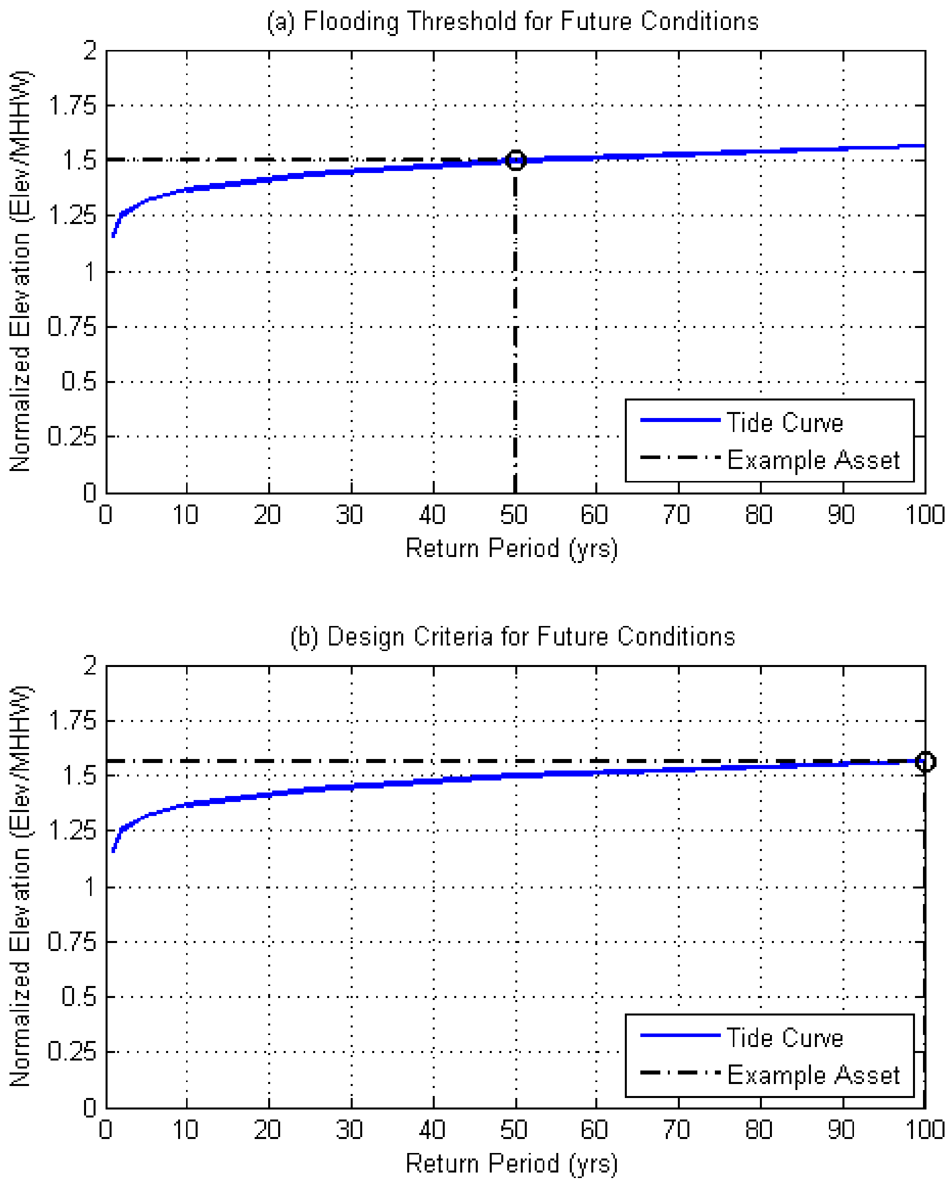

Figure 6-3. Example Application of Future Conditions Normalized Extreme Tide Curves

In summary, to interpret the flooding thresholds for a particular area of interest, the following steps are used:

1. Identify the shoreline segment of interest and its normalized elevation using the shoreline maps in Appendix C.
2. Select an existing or future conditions normalized extreme tide curve for evaluation.
3. Intersect the existing or future conditions normalized extreme tide curve with either a horizontal or vertical line to estimate the resulting normalized elevation or return period of interest.

7.0

MAPPING ASSUMPTIONS + CAVEATS

7. MAPPING ASSUMPTIONS AND CAVEATS

The inundation maps are intended as a screening-level tool to assess exposure to future SLR and extreme tide/storm surge-induced coastal flooding. These maps represent a "do nothing" future scenario, and although they rely on the best available and current information and data sources, they are still associated with a series of assumptions and caveats as detailed below.

- The inundation scenarios associated with an increase in future MHHW (SLR above MHHW) represent areas that could be inundated permanently on a regular basis by tidal action. The inundation scenarios associated with extreme tide levels and storm surge represent periodic or temporary inundation associated with coastal flooding. The inundation maps for extreme tide scenarios do not consider the duration of flooding or the potential mechanism for draining the floodwaters from the inundated land once the extreme high tide levels recede.
- The bathymetry of San Francisco Bay and the topography of the landward areas, including levees and other flood and shore protection features, are assumed to remain constant. No potential physical shoreline changes are included in the analysis and mapping. The accumulation of organic matter in wetlands, potential sediment deposition and/or resuspension, and subsidence that could alter San Francisco Bay hydrodynamics and/or bathymetry are not captured within the SLR scenarios.
- The maps do not account for future construction or levee upgrades. The mapping methods also do not consider the existing condition or age of the shore protection assets. No degradation or levee failure models have been analyzed as part of the inundation mapping effort.
- The maps do not account for flooding from potential increases in the groundwater table as sea levels rise.
- The maps do not account for water flow through water control structures such as culverts or tide gates.
- The levee heights and the heights of roadways and/or other topographic features that may affect floodwater conveyance are derived from the USGS 2010 LiDAR data. Although this data set represents the best available topographic data, the data have not been extensively ground-truthed, and levee crests may be overrepresented or underrepresented by the LiDAR data. It is possible that features narrower than the 1 m horizontal map scale may not be fully represented.
- The inundation depth and extent shown on the MHHW maps are associated with the typical high tide to approximate the maximum extent of future daily tidal inundation. This level of inundation can also be referred to as "permanent inundation" because it represents the area that would be inundated regularly. Tides in San Francisco Bay exhibit two highs and two lows in any given day, and the daily high tide on any given day may be higher or lower than the MHHW tidal elevation.
- The depth and extent of inundation for an extreme coastal storm event (i.e., including local wind and wave effects) were not included in this study. These processes could have a significant effect on the ultimate depth of inundation associated with a large coastal wind/wave event, especially near the shoreline.
- The inundation maps do not account for localized inundation associated with any freshwater inputs, such as rainfall-runoff events, or the potential for riverine overbank flooding in the local tributaries associated with large rainfall events. Inundation associated with changing rainfall patterns, frequency, or intensity as a result of climate change is also not included in this analysis.
- The science of climate change is constantly evolving, and SLR projections have a wide range of values.

8.0

CONCLUSIONS + NEXT STEPS

8. CONCLUSIONS AND NEXT STEPS

This shoreline vulnerability assessment for San Mateo County led to the development of a variety of geo-spatial tools and data layers that can assist with the next steps of identifying shoreline vulnerabilities and formulating and implementing adaptation strategies, where necessary. These tools and data layers include the following:

- SLR inundation maps;
- Shoreline overtopping potential maps;
- SLR and extreme tide matrix;
- Shoreline type delineation maps;
- Daily and extreme tide elevations;
- Normalized shoreline elevation maps; and
- Normalized existing and future extreme tide curves.

The SLR inundation maps provide a first step for identifying assets exposed to increased flooding and/or inundation from rising seas and storm surge. The overtopping maps help illustrate the primary inundation pathways from the Bay, and show the depth of potential inundation over shoreline segments for each inundation scenario. The normalized shoreline elevation maps are a useful tool for landowners and managers to identify flooding thresholds for existing and future conditions. Using these tools, stakeholders can understand shoreline asset exposure to a broad range of SLR projections. In addition, the tools help identify where shoreline vulnerabilities may exist, and roughly identify the timing for adaptation actions to maintain or improve existing levels of shoreline flood protection. Several case studies completed in Alameda County serve as examples for how to use the tools to understand sources, mechanisms, and timing of inundation and flooding in specific focus areas[9].

The tools and data sets highlight areas where near-term shoreline adaptation strategies may be necessary, and they can also illustrate when local adaptation efforts are no longer sufficient and regional collaboration is required to reduce or mitigate flood risks. Foster City is an excellent example of the need for coordination with neighboring communities. As shown on the Foster City Case Study, the existing flood protection infrastructure protecting this waterfront community requires near-term improvements. However, if Foster City implements improvements that are constrained within their city limits, they can only achieve limited benefits. Improvements are required within the adjacent communities as well to achieve longer-term resilience to SLR and storm surge.

The tools and data layers are for planning-level assessments only. They should not be used for engineering design or construction purposes without consultation with a qualified engineering professional. However, these products help identify where additional detailed information is needed to confirm shoreline vulnerabilities, and can support the need for additional engineering analysis.

Several next steps can improve upon the foundation provided in this study. Most notably, the consideration of wave hazards, precipitation-based flooding, changes in future storm intensity and frequency, and changes in groundwater levels associated with sea level rise would all inform future adaptation needs.

For shorelines and developments directly along the bayshore, the consideration of wave hazards is required. Wave hazards, such as wave runup and overtopping, are dependent on the shoreline type,

[9] Four case studies (Hayward Shoreline, Oakland Coliseum, Bay Farm Island, and the Bay Bridge Touchdown), are available on the ART Program website under Art Supplies: http://www.adaptingtorisingtides.org/howto/art-supplies/

roughness, slope, and other factors that require more detailed analysis than presented within this study. In addition, wave runup may not increase linearly with sea level rise (i.e., a 1-foot increase in sea level rise may lead to more than a 1-foot increase in wave runup). A coastal engineering assessment is required for both existing conditions and proposed adaptation strategies to adequately consider wave hazards.

Extreme storm events in the Bay Area, particularly during El Niño winters, often include extreme Bay water levels and precipitation. The cumulative impacts of rainfall runoff and storm surge were not considered in this study; however, the combination of these factors would further exacerbate inland flooding. In nearshore developed areas, particularly in areas behind flood protection infrastructure with topographic elevations below the Bay water surface elevation during an extreme event, it is important to consider the impacts of heavy rainfall and storm surge occurring together. Changes in storm frequency and magnitude due to climate change were also not examined in this study, but an evaluation of these dynamics may provide further insight into when adaptation strategies need to be implemented.

Rising groundwater tables, primarily associated with SLR, can also impact flooding and drainage by reducing infiltration and sub-surface storage of runoff. The impacts of rising groundwater tables on watershed flooding are not well understood. With higher groundwater tables and rising sea levels, existing drainage systems will become less effective over time, and they may become completely ineffective with higher levels of SLR. Evaluation of these factors is recommended as a next step before adaptation strategies are implemented.

9.0

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9. REFERENCES

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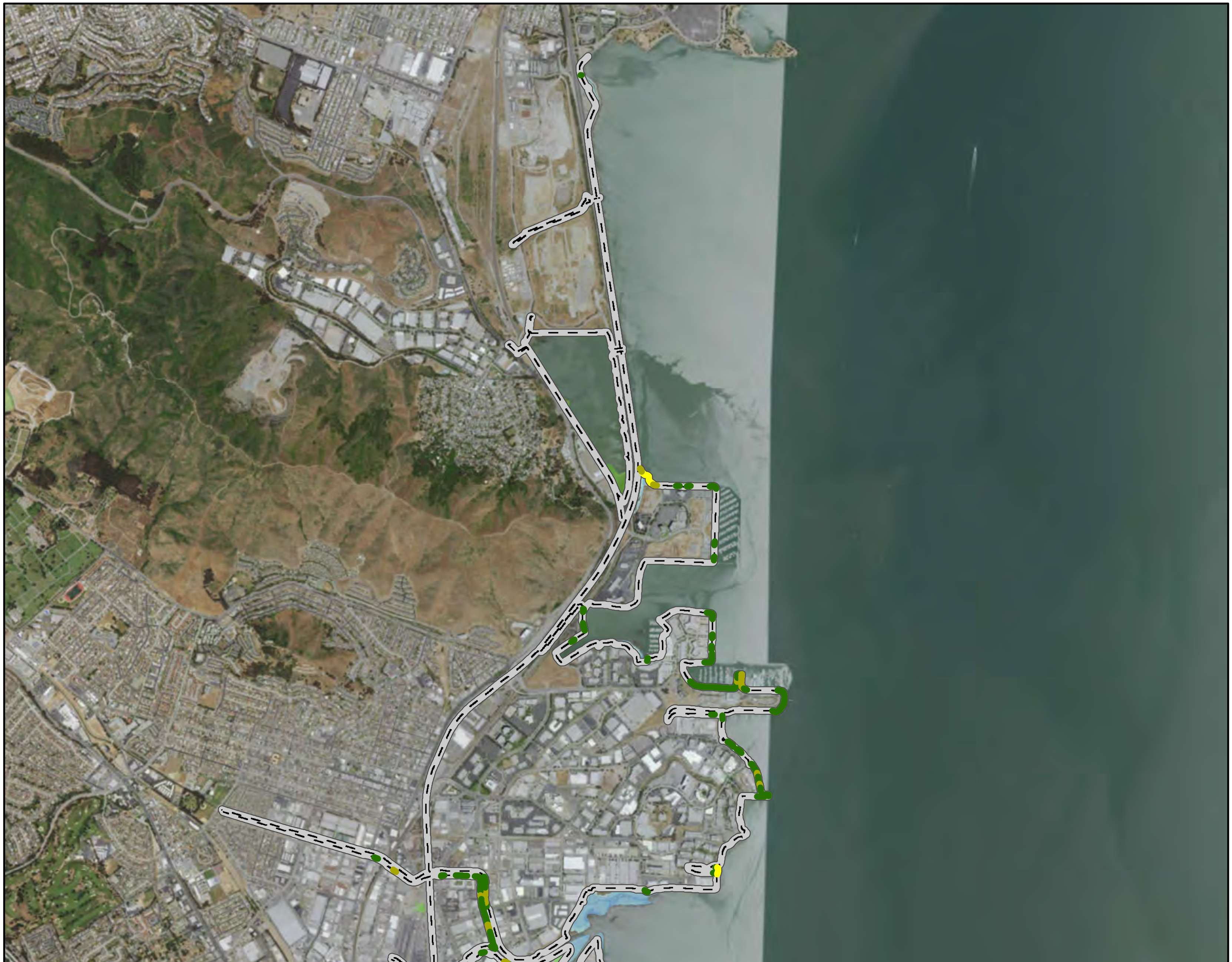
A

SEA LEVEL RISE INUNDATION MAPS



SAN MATEO COUNTY
Inundation Mapping

MHHW + 12” SEA LEVEL RISE

SLR + STORM SURGE SCENARIOS LISTED BELOW COULD BE APPROXIMATED BY THE INUNDATION SHOWN ON THIS MAP.

0” SLR + 1-YEAR STORM SURGE

Shoreline Overtopping Potential

Depth in Feet

- 0 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- 4 - 5
- > 5
- No Overtopping

Sea Level Rise Inundation

Depth in Feet

- 0 - 2
- 2 - 4
- 4 - 6
- 6 - 8
- 8 - 10
- 10 - 12
- 12 - 14
- 14 - 16
- 16+
- Disconnected Areas > 1 Acre

0 0.2 0.4 0.6 0.8 Miles

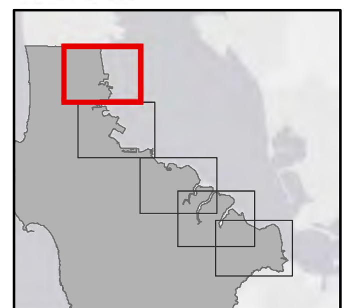
0 1,000 2,000 3,000 4,000 Feet

N

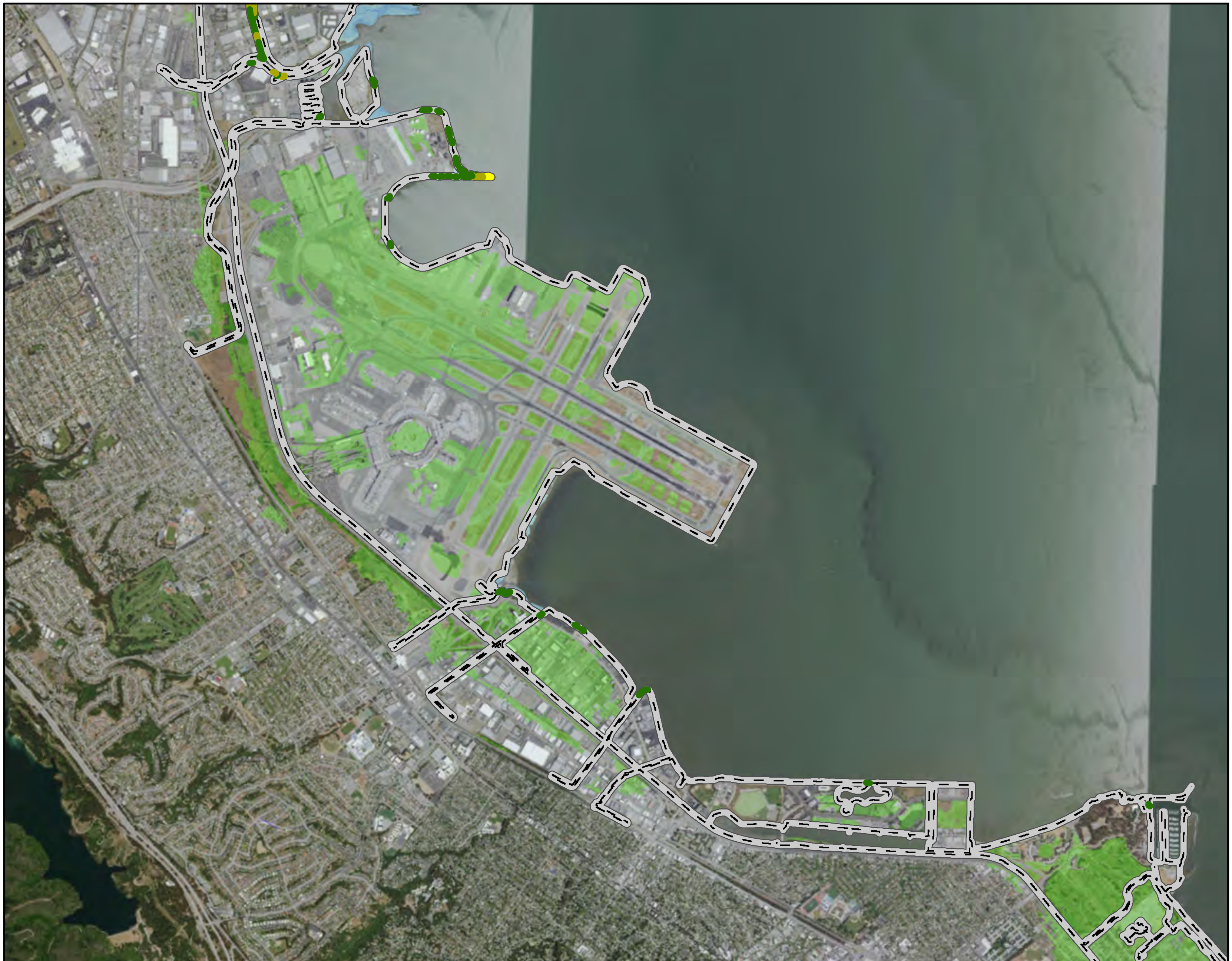
Projection:
Universal Transverse Mercator NAD83 Zone 10N

AECOM

May, 2016



The inundation maps and the associated analyses provide a regional-scale illustration of inundation and coastal flooding due to specific sea level rise and storm surge scenarios, and are intended to improve sea level rise awareness and preparedness. The maps are not detailed to the parcel-scale and should not be used for navigation, permitting, regulatory, or other legal uses. Flooding due to sea level rise and storm surges is possible in areas outside of those predicted in these maps, and the maps do not guarantee the safety of an individual or structure. Nor do the maps model flooding from other sources, such as riverine or surface water flooding from rainfall-runoff events. The contributors and sponsors of this product do not assume liability for any injury, death, property damage, or other effects of flooding. The maps relied on a 1-meter digital elevation model created from LiDAR data collected in 2010 and additional survey data (where available). Although care was taken to capture all relevant topographic features and coastal structures that may impact coastal inundation, it is possible that structures may not be fully represented, especially those that are narrower than the 1-meter horizontal map scale. The maps are based on model outputs and do not account for all of the complex and dynamic San Francisco Bay processes or future conditions such as erosion, subsidence, future construction or shoreline protection upgrades, or other changes to San Francisco Bay or the region that may occur in response to sea level rise. More context about the maps and analyses, including a description of the data and methods used, are documented in the Sea Level Rise and Overtopping Analysis for San Mateo County's Bayshore Report (May 2016).



SAN MATEO COUNTY
Inundation Mapping

MHHW + 12" SEA LEVEL RISE

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Sea Level Rise Inundation

Depth in Feet

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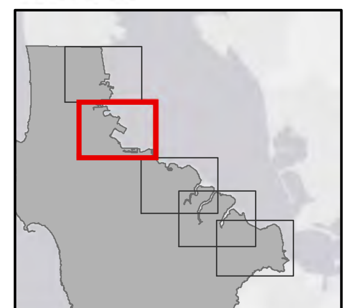
AECOM

May, 2016



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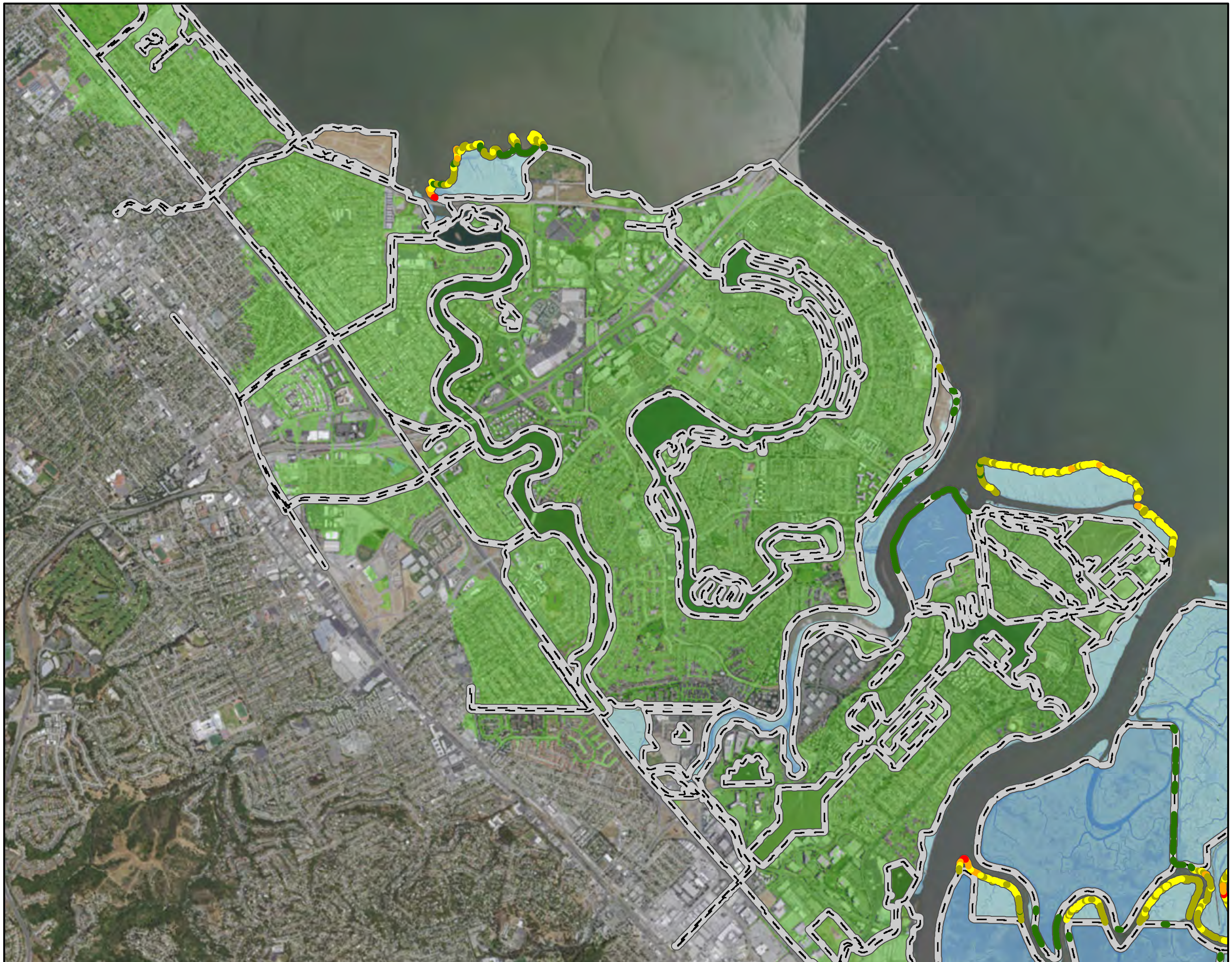

SAN MATEO COUNTY
Inundation Mapping

MHHW + 12" SEA LEVEL RISE

SLR + STORM SURGE SCENARIOS LISTED BELOW COULD BE APPROXIMATED BY THE INUNDATION SHOWN ON THIS MAP.

0" SLR + 1-YEAR STORM SURGE

Shoreline Overtopping Potential

Depth in Feet
- 0 - 1
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- > 5
- No Overtopping

Sea Level Rise Inundation

Depth in Feet
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Projection:
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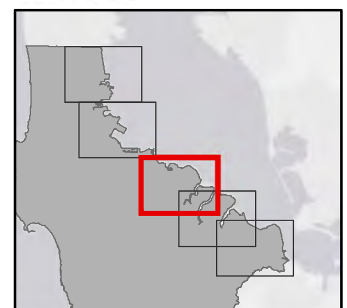
AECOM May, 2016



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SAN MATEO COUNTY
Inundation Mapping

MHHW + 12" SEA LEVEL RISE

SLR + STORM SURGE SCENARIOS LISTED BELOW COULD BE APPROXIMATED BY THE INUNDATION SHOWN ON THIS MAP.

0" SLR + 1-YEAR STORM SURGE

Shoreline Overtopping Potential

Depth in Feet

- 0 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- 4 - 5
- > 5

No Overtopping

Sea Level Rise Inundation

Depth in Feet

- 0 - 2
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Disconnected Areas > 1 Acre

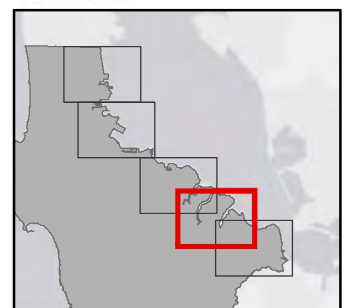
0 0.2 0.4 0.6 0.8 Miles

0 1,000 2,000 3,000 4,000 Feet

N

Projection:
Universal Transverse Mercator NAD83 Zone 10N

AECOM May, 2016



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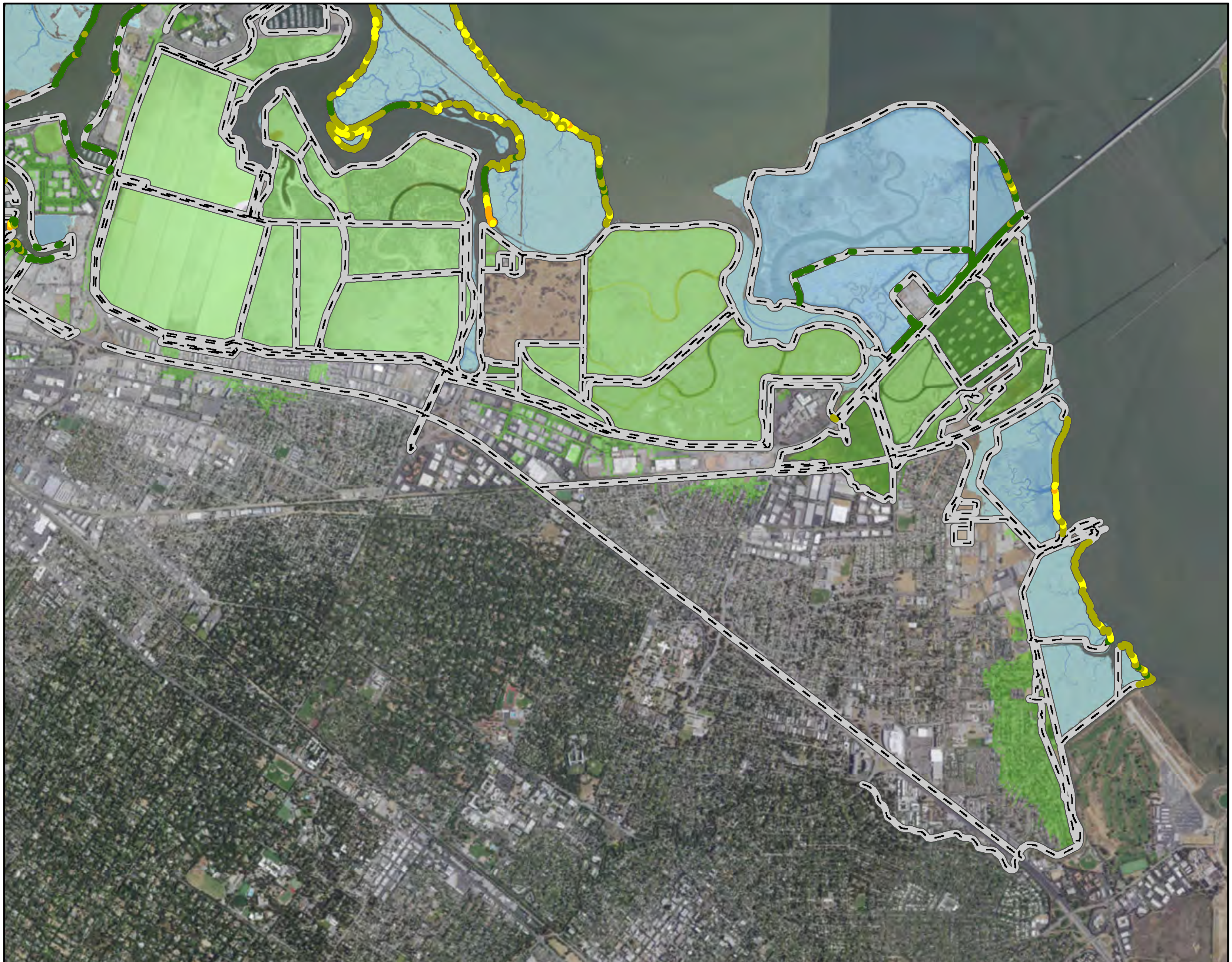

SAN MATEO COUNTY
Inundation Mapping

MHHW + 12” SEA LEVEL RISE

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0” SLR + 1-YEAR STORM SURGE

Shoreline Overtopping Potential

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Sea Level Rise Inundation

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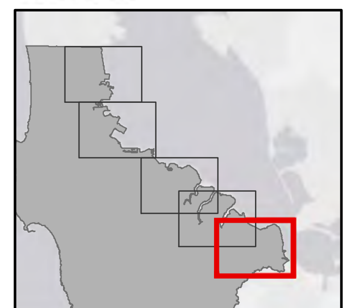

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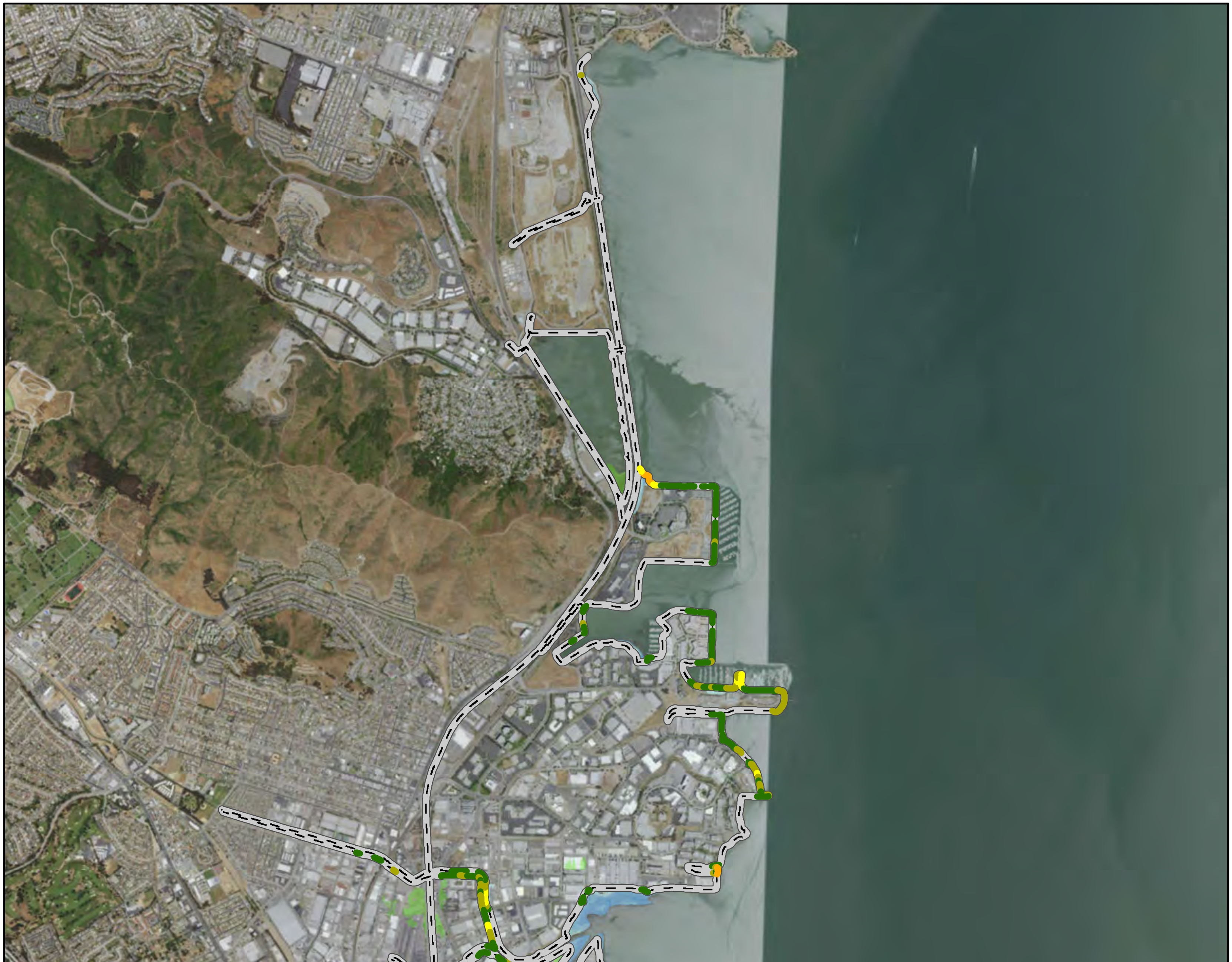

SAN MATEO COUNTY
Inundation Mapping

MHHW + 24" SEA LEVEL RISE

SLR + STORM SURGE SCENARIOS LISTED BELOW COULD BE APPROXIMATED BY THE INUNDATION SHOWN ON THIS MAP.

0" SLR + 10-YEAR STORM SURGE
6" SLR + 2-YEAR STORM SURGE
12" SLR + 1-YEAR STORM SURGE

Shoreline Overtopping Potential

Depth in Feet

- 0 - 1
- 1 - 2
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- 3 - 4
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- > 5
- No Overtopping

Sea Level Rise Inundation

Depth in Feet

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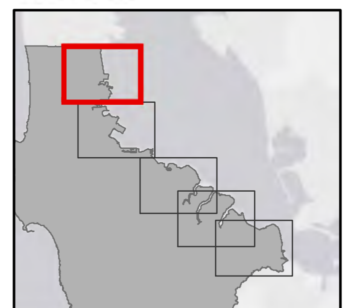

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SAN MATEO COUNTY
Inundation Mapping

MHHW + 24" SEA LEVEL RISE

SLR + STORM SURGE SCENARIOS LISTED BELOW COULD BE APPROXIMATED BY THE INUNDATION SHOWN ON THIS MAP.

0" SLR + 10-YEAR STORM SURGE
6" SLR + 2-YEAR STORM SURGE
12" SLR + 1-YEAR STORM SURGE

Shoreline Overtopping Potential

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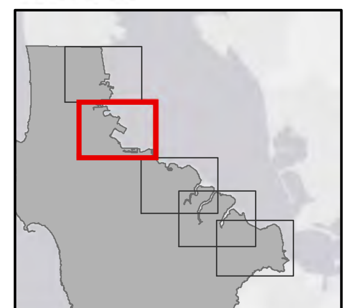

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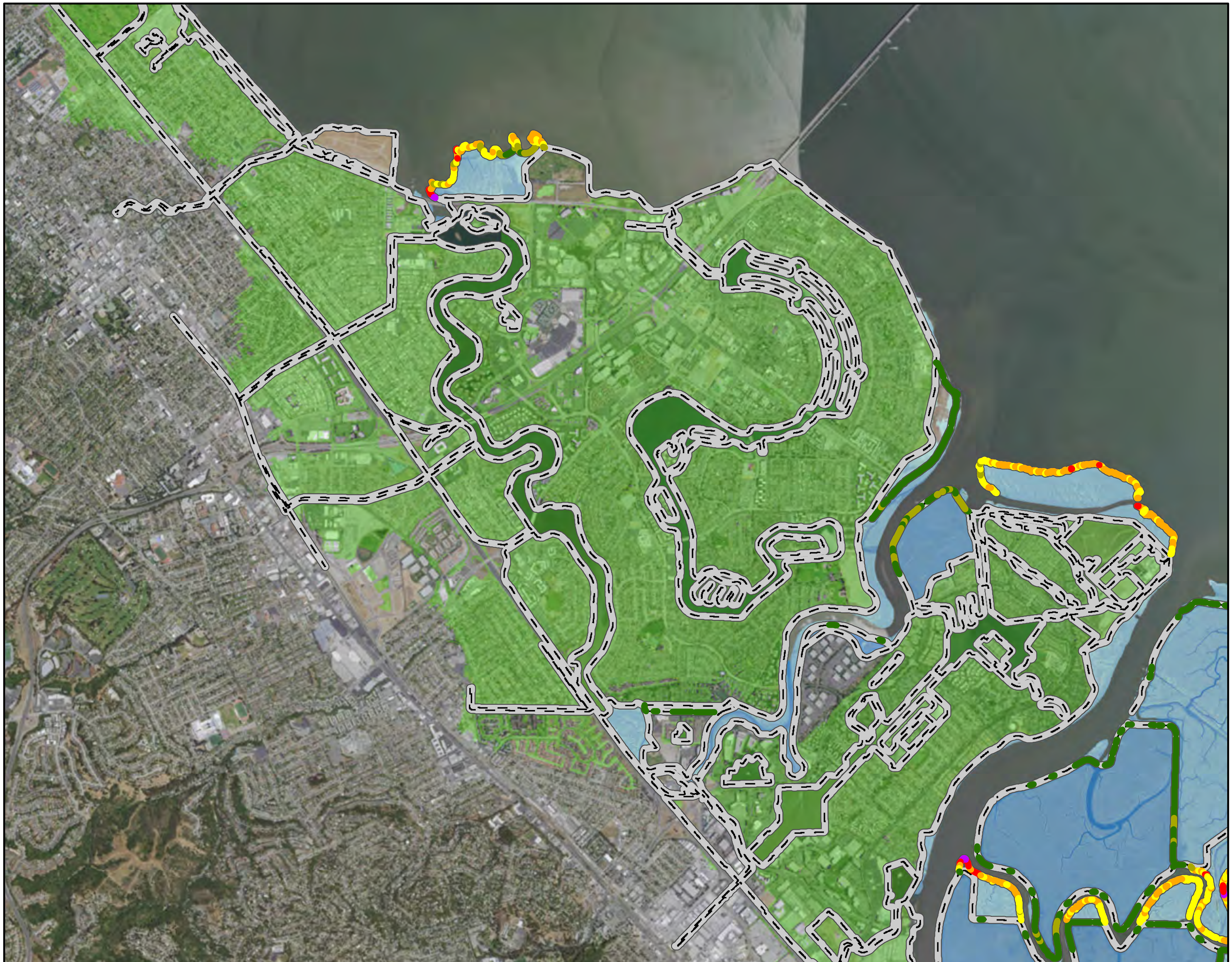

SAN MATEO COUNTY
Inundation Mapping

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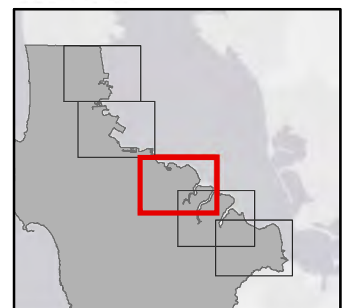

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SAN MATEO COUNTY
Inundation Mapping

MHHW + 24" SEA LEVEL RISE

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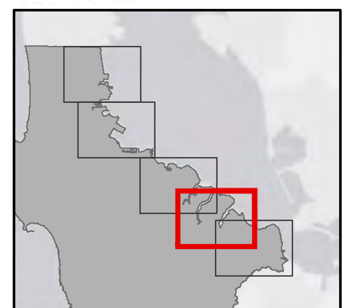
AECOM May, 2016



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SAN MATEO COUNTY
Inundation Mapping

MHHW + 24” SEA LEVEL RISE

SLR + STORM SURGE SCENARIOS LISTED BELOW COULD BE APPROXIMATED BY THE INUNDATION SHOWN ON THIS MAP.

0” SLR + 10-YEAR STORM SURGE
6” SLR + 2-YEAR STORM SURGE
12” SLR + 1-YEAR STORM SURGE

Shoreline Overtopping Potential

Depth in Feet

0 - 1
1 - 2
2 - 3
3 - 4
4 - 5
> 5

No Overtopping

Sea Level Rise Inundation

Depth in Feet

0 - 2
2 - 4
4 - 6
6 - 8
8 - 10
10 - 12
12 - 14
14 - 16
16+

Disconnected Areas > 1 Acre

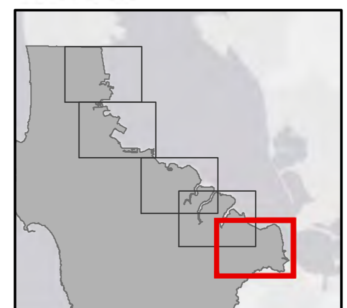
0 0.2 0.4 0.6 0.8 Miles

0 1,000 2,000 3,000 4,000 Feet

N

Projection:
Universal Transverse Mercator NAD83 Zone 10N

AECOM May, 2016



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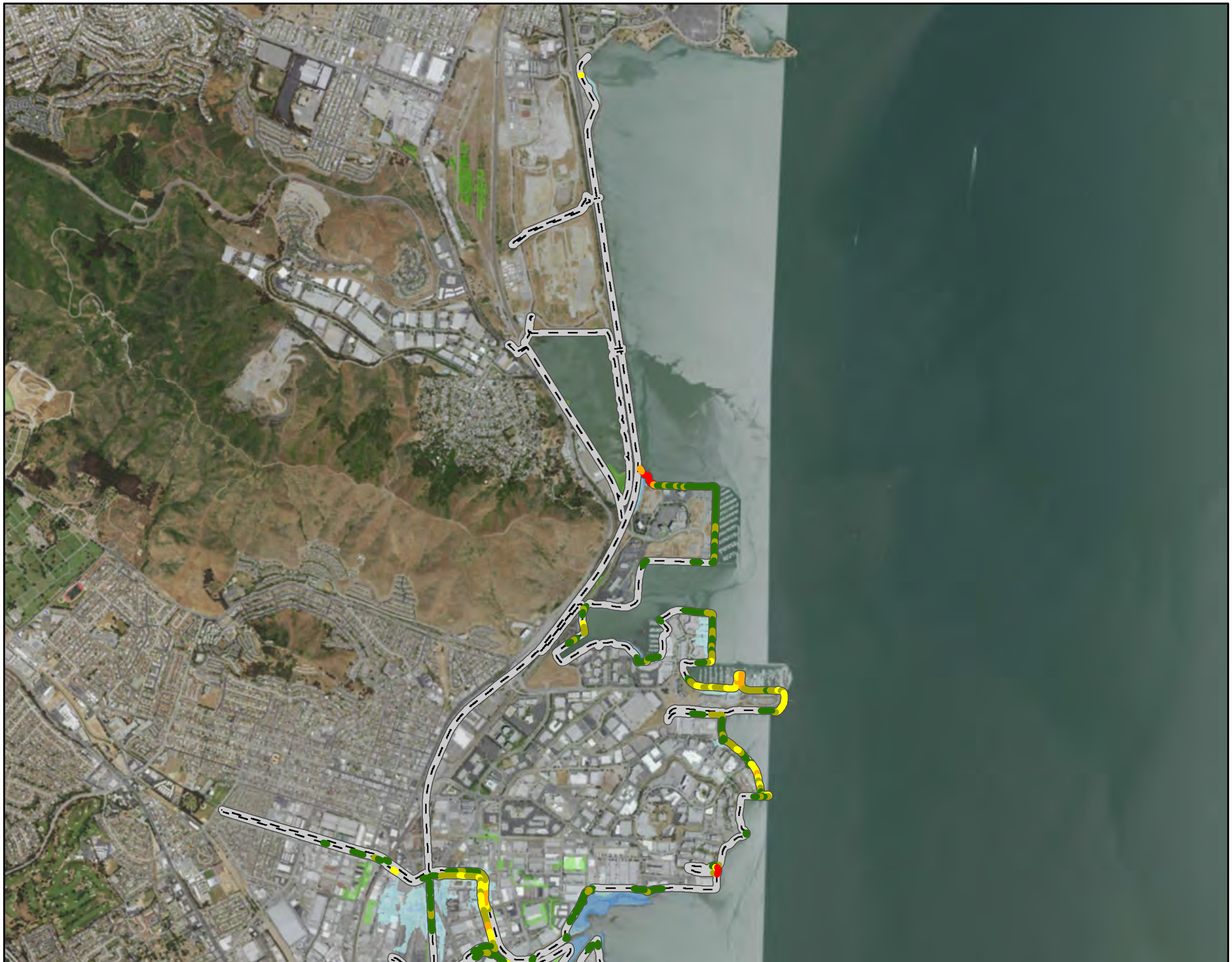


SAN MATEO COUNTY
Inundation Mapping

MHHW + 36" SEA LEVEL RISE

SLR + STORM SURGE SCENARIOS LISTED BELOW COULD BE APPROXIMATED BY THE INUNDATION SHOWN ON THIS MAP.

0" SLR + 50-YEAR STORM SURGE
6" SLR + 25-YEAR STORM SURGE
12" SLR + 10-YEAR STORM SURGE
18" SLR + 2-YEAR STORM SURGE
24" SLR + 1-YEAR STORM SURGE

Shoreline Overtopping Potential

Depth in Feet

- 0 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- 4 - 5
- > 5

No Overtopping

Sea Level Rise Inundation

Depth in Feet

- 0 - 2
- 2 - 4
- 4 - 6
- 6 - 8
- 8 - 10
- 10 - 12
- 12 - 14
- 14 - 16
- 16+

Disconnected Areas > 1 Acre

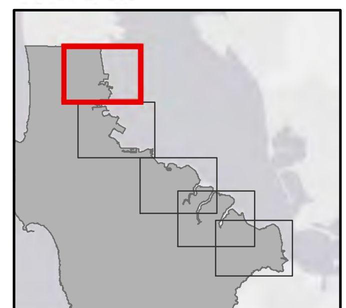
0 0.2 0.4 0.6 0.8 Miles

0 1,000 2,000 3,000 4,000 Feet

N

Projection:
Universal Transverse Mercator NAD83 Zone 10N

AECOM May, 2016



SAN MATEO COUNTY
Inundation Mapping

MHHW + 36" SEA LEVEL RISE

SLR + STORM SURGE SCENARIOS LISTED BELOW COULD BE APPROXIMATED BY THE INUNDATION SHOWN ON THIS MAP.

0" SLR + 50-YEAR STORM SURGE
6" SLR + 25-YEAR STORM SURGE
12" SLR + 10-YEAR STORM SURGE
18" SLR + 2-YEAR STORM SURGE
24" SLR + 1-YEAR STORM SURGE

Shoreline Overtopping Potential

Depth in Feet

0 - 1
1 - 2
2 - 3
3 - 4
4 - 5
> 5
No Overtopping

Sea Level Rise Inundation

Depth in Feet

0 - 2
2 - 4
4 - 6
6 - 8
8 - 10
10 - 12
12 - 14
14 - 16
16+
Disconnected Areas > 1 Acre

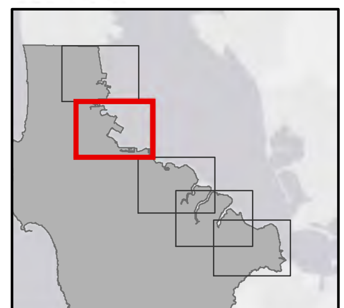
N

0 0.2 0.4 0.6 0.8 Miles

0 1,000 2,000 3,000 4,000 Feet

Projection:
Universal Transverse Mercator NAD83 Zone 10N

AECOM May, 2016



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SAN MATEO COUNTY
Inundation Mapping

MHHW + 36" SEA LEVEL RISE

SLR + STORM SURGE SCENARIOS LISTED BELOW COULD BE APPROXIMATED BY THE INUNDATION SHOWN ON THIS MAP.

0" SLR + 50-YEAR STORM SURGE
6" SLR + 25-YEAR STORM SURGE
12" SLR + 10-YEAR STORM SURGE
18" SLR + 2-YEAR STORM SURGE
24" SLR + 1-YEAR STORM SURGE

Shoreline Overtopping Potential

Depth in Feet

- 0 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- 4 - 5
- > 5

No Overtopping

Sea Level Rise Inundation

Depth in Feet

- 0 - 2
- 2 - 4
- 4 - 6
- 6 - 8
- 8 - 10
- 10 - 12
- 12 - 14
- 14 - 16
- 16+

Disconnected Areas > 1 Acre

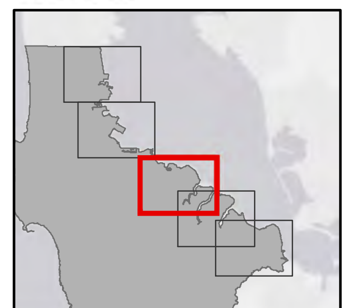
N

0 0.2 0.4 0.6 0.8 Miles

0 1,000 2,000 3,000 4,000 Feet

Projection:
Universal Transverse Mercator NAD83 Zone 10N

AECOM May, 2016



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SAN MATEO COUNTY
Inundation Mapping

MHHW + 36" SEA LEVEL RISE

SLR + STORM SURGE SCENARIOS LISTED BELOW COULD BE APPROXIMATED BY THE INUNDATION SHOWN ON THIS MAP.

0" SLR + 50-YEAR STORM SURGE
6" SLR + 25-YEAR STORM SURGE
12" SLR + 10-YEAR STORM SURGE
18" SLR + 2-YEAR STORM SURGE
24" SLR + 1-YEAR STORM SURGE

Shoreline Overtopping Potential

Depth in Feet

0 - 1
1 - 2
2 - 3
3 - 4
4 - 5
> 5

No Overtopping

Sea Level Rise Inundation

Depth in Feet

0 - 2
2 - 4
4 - 6
6 - 8
8 - 10
10 - 12
12 - 14
14 - 16
16+

Disconnected Areas > 1 Acre

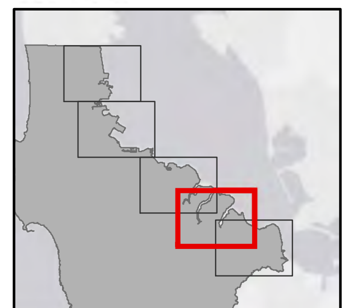
0 0.2 0.4 0.6 0.8 Miles

0 1,000 2,000 3,000 4,000 Feet

N

Projection:
Universal Transverse Mercator NAD83 Zone 10N

AECOM May, 2016



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SAN MATEO COUNTY
Inundation Mapping

MHHW + 36" SEA LEVEL RISE

SLR + STORM SURGE SCENARIOS LISTED BELOW COULD BE APPROXIMATED BY THE INUNDATION SHOWN ON THIS MAP.

0" SLR + 50-YEAR STORM SURGE
6" SLR + 25-YEAR STORM SURGE
12" SLR + 10-YEAR STORM SURGE
18" SLR + 2-YEAR STORM SURGE
24" SLR + 1-YEAR STORM SURGE

Shoreline Overtopping Potential

Depth in Feet

- 0 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- 4 - 5
- > 5
- No Overtopping

Sea Level Rise Inundation

Depth in Feet

- 0 - 2
- 2 - 4
- 4 - 6
- 6 - 8
- 8 - 10
- 10 - 12
- 12 - 14
- 14 - 16
- 16+
- Disconnected Areas > 1 Acre

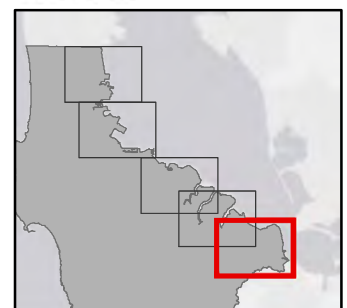
0 0.2 0.4 0.6 0.8 Miles

0 1,000 2,000 3,000 4,000 Feet

N

Projection:
Universal Transverse Mercator NAD83 Zone 10N

AECOM May, 2016



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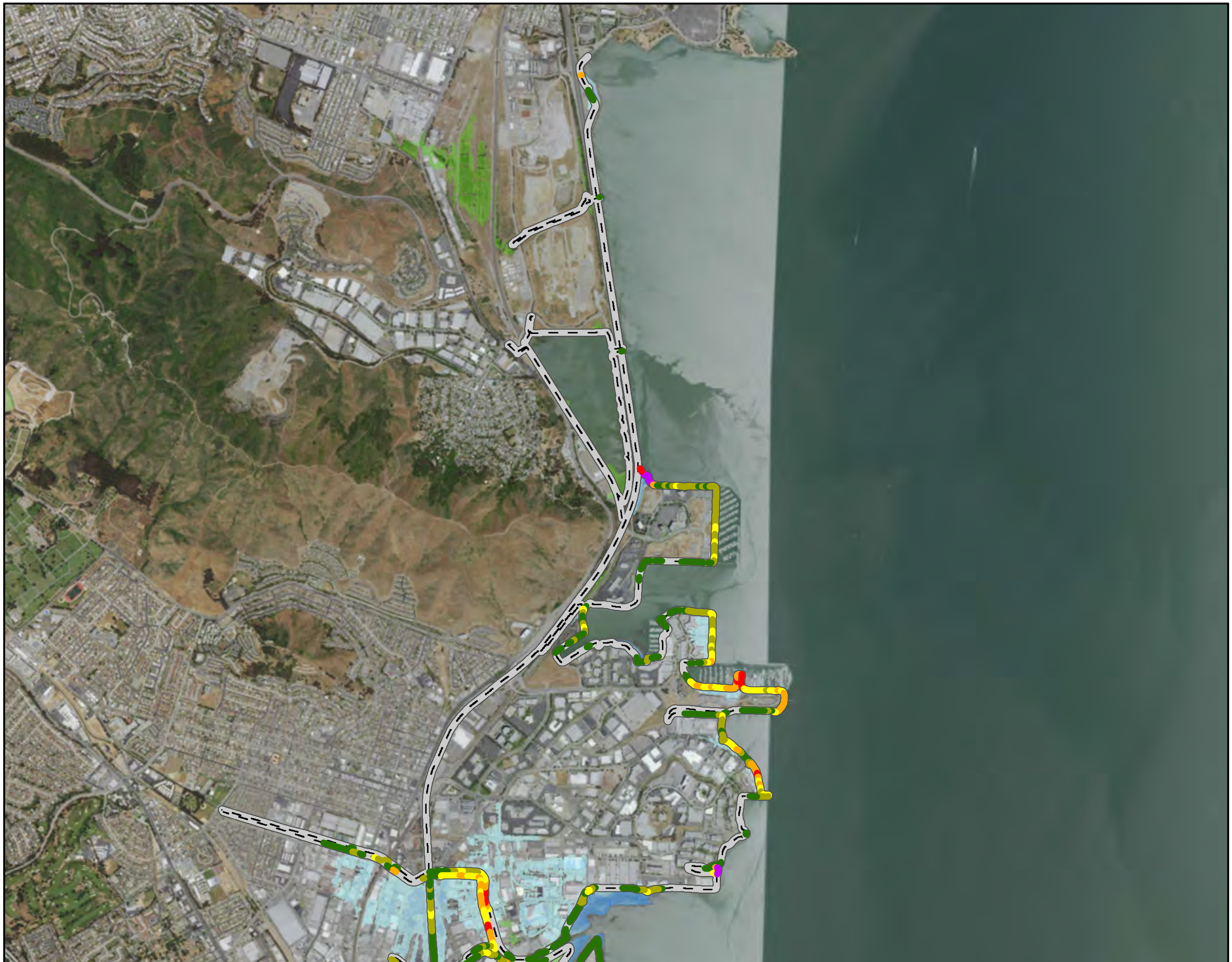


SAN MATEO COUNTY
Inundation Mapping

MHHW + 48" SEA LEVEL RISE

SLR + STORM SURGE SCENARIOS LISTED BELOW COULD BE APPROXIMATED BY THE INUNDATION SHOWN ON THIS MAP.

6" SLR + 100-YEAR STORM SURGE
12" SLR + 50-YEAR STORM SURGE
18" SLR + 25-YEAR STORM SURGE
24" SLR + 5-YEAR STORM SURGE
36" SLR + 1-YEAR STORM SURGE

Shoreline Overtopping Potential

Depth in Feet

0 - 1
1 - 2
2 - 3
3 - 4
4 - 5
> 5
No Overtopping

Sea Level Rise Inundation

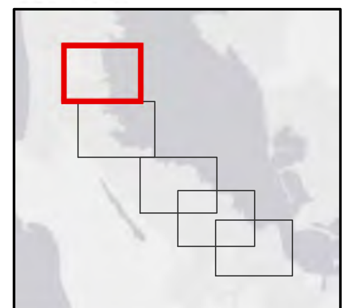
Depth in Feet

0 - 2
2 - 4
4 - 6
6 - 8
8 - 10
10 - 12
12 - 14
14 - 16
16+
Disconnected Areas > 1 Acre

0 0.2 0.4 0.6 0.8 Miles
0 1,000 2,000 3,000 4,000 Feet
N

Projection:
Universal Transverse Mercator NAD83 Zone 10N

AECOM May, 2016



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SAN MATEO COUNTY
Inundation Mapping

MHHW + 48" SEA LEVEL RISE

SLR + STORM SURGE SCENARIOS LISTED BELOW COULD BE APPROXIMATED BY THE INUNDATION SHOWN ON THIS MAP.

6" SLR + 100-YEAR STORM SURGE
12" SLR + 50-YEAR STORM SURGE
18" SLR + 25-YEAR STORM SURGE
24" SLR + 5-YEAR STORM SURGE
36" SLR + 1-YEAR STORM SURGE

Shoreline Overtopping Potential

Depth in Feet

- 0 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- 4 - 5
- > 5
- No Overtopping

Sea Level Rise Inundation

Depth in Feet

- 0 - 2
- 2 - 4
- 4 - 6
- 6 - 8
- 8 - 10
- 10 - 12
- 12 - 14
- 14 - 16
- 16+
- Disconnected Areas > 1 Acre

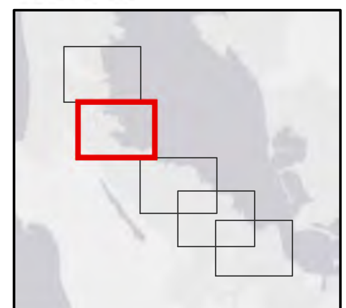
0 0.2 0.4 0.6 0.8 Miles

0 1,000 2,000 3,000 4,000 Feet

N

Projection:
Universal Transverse Mercator NAD83 Zone 10N

AECOM May, 2016



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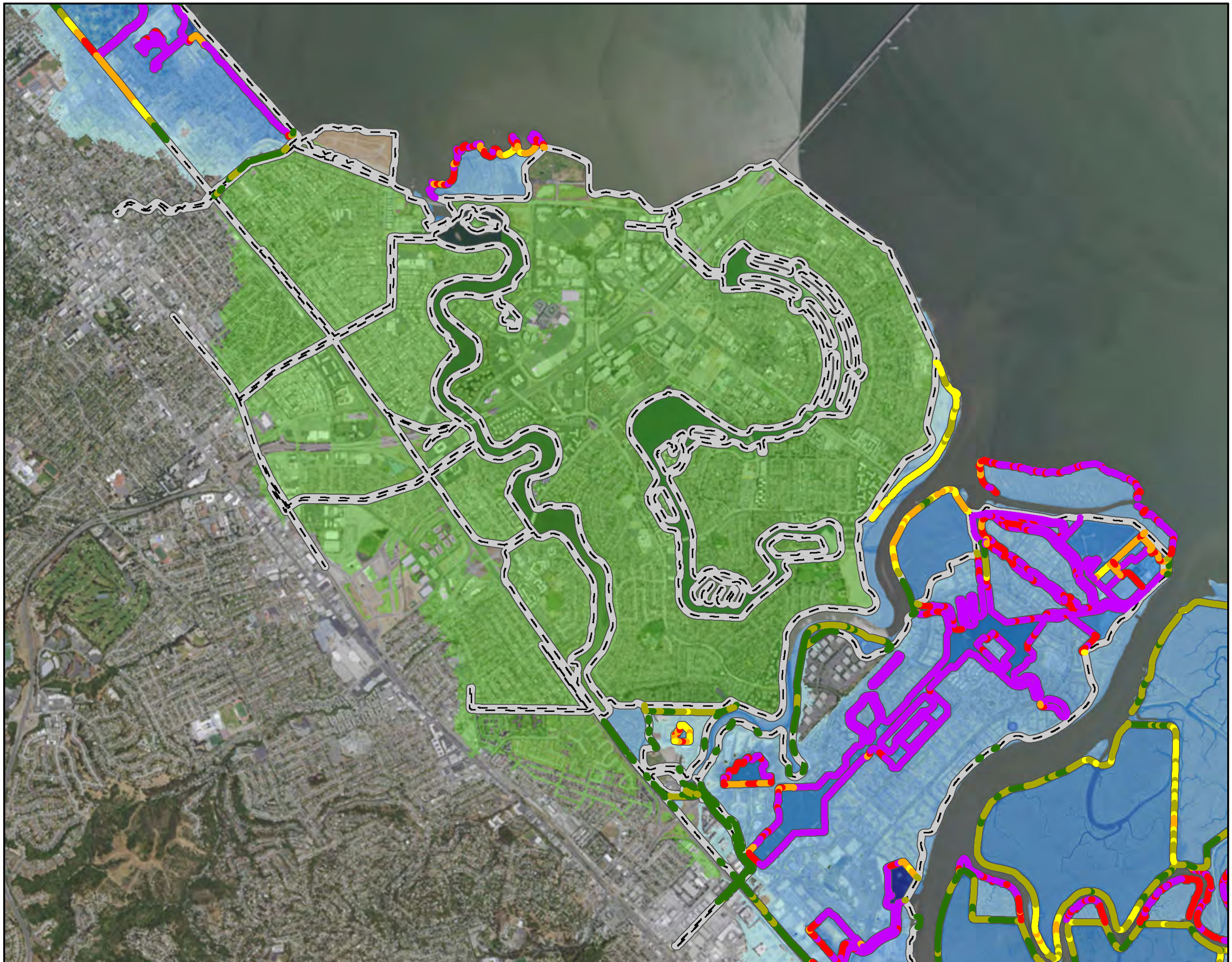


SAN MATEO COUNTY
Inundation Mapping

MHHW + 48" SEA LEVEL RISE

SLR + STORM SURGE SCENARIOS LISTED BELOW COULD BE APPROXIMATED BY THE INUNDATION SHOWN ON THIS MAP.

6" SLR + 100-YEAR STORM SURGE
12" SLR + 50-YEAR STORM SURGE
18" SLR + 25-YEAR STORM SURGE
24" SLR + 5-YEAR STORM SURGE
36" SLR + 1-YEAR STORM SURGE

Shoreline Overtopping Potential

Depth in Feet

- 0 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- 4 - 5
- > 5
- No Overtopping

Sea Level Rise Inundation

Depth in Feet

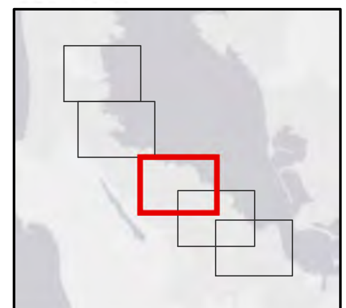
- 0 - 2
- 2 - 4
- 4 - 6
- 6 - 8
- 8 - 10
- 10 - 12
- 12 - 14
- 14 - 16
- 16+
- Disconnected Areas > 1 Acre

0 0.2 0.4 0.6 0.8 Miles

0 1,000 2,000 3,000 4,000 Feet

Projection:
Universal Transverse Mercator NAD83 Zone 10N

AECOM May, 2016



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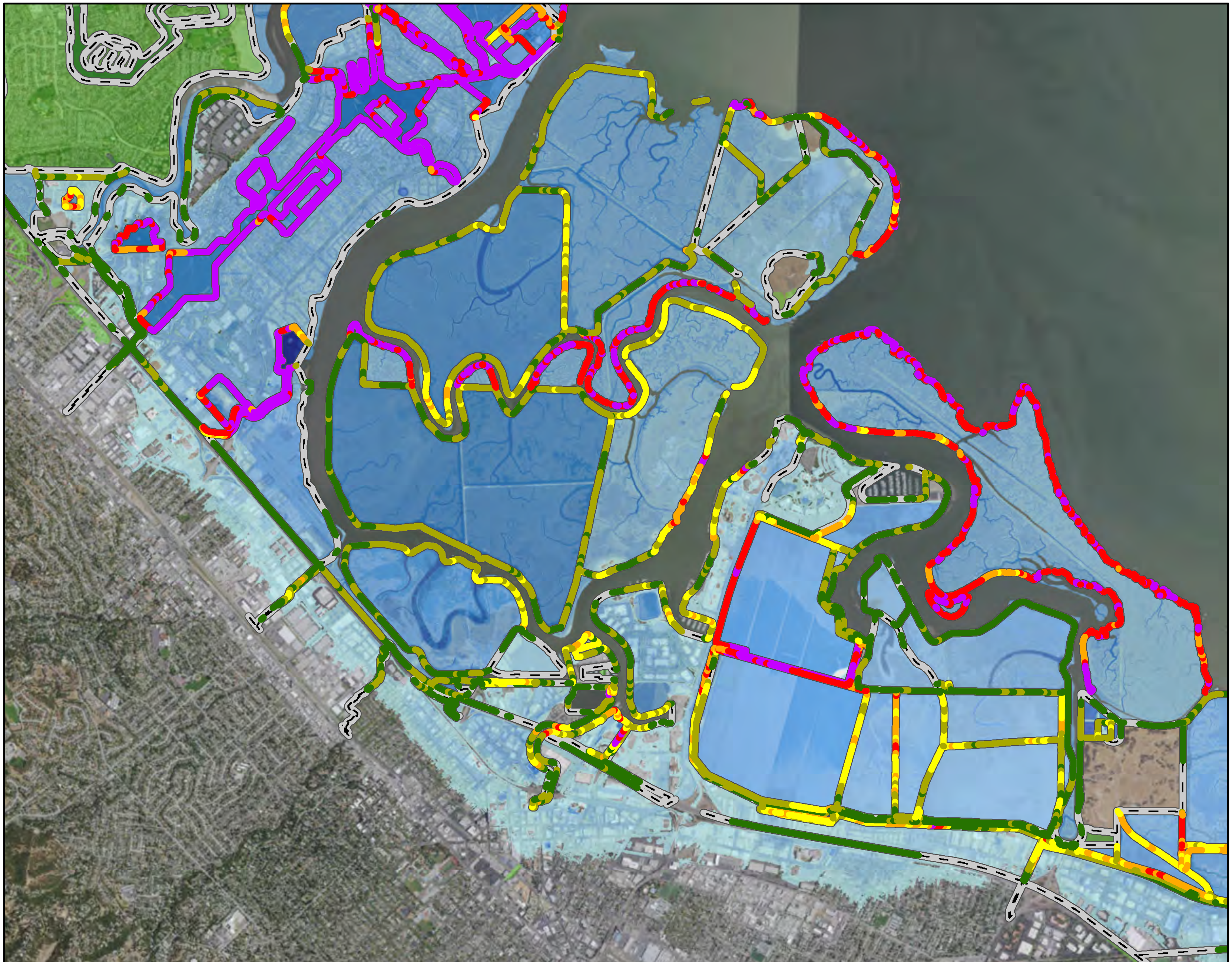


SAN MATEO COUNTY
Inundation Mapping

MHHW + 48” SEA LEVEL RISE

SLR + STORM SURGE SCENARIOS LISTED BELOW COULD BE APPROXIMATED BY THE INUNDATION SHOWN ON THIS MAP.

6” SLR + 100-YEAR STORM SURGE
12” SLR + 50-YEAR STORM SURGE
18” SLR + 25-YEAR STORM SURGE
24” SLR + 5-YEAR STORM SURGE
36” SLR + 1-YEAR STORM SURGE

Shoreline Overtopping Potential

Depth in Feet

- 0 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- 4 - 5
- > 5
- No Overtopping

Sea Level Rise Inundation

Depth in Feet

- 0 - 2
- 2 - 4
- 4 - 6
- 6 - 8
- 8 - 10
- 10 - 12
- 12 - 14
- 14 - 16
- 16+
- Disconnected Areas > 1 Acre

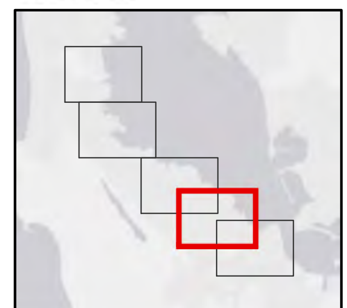
0 0.2 0.4 0.6 0.8 Miles

0 1,000 2,000 3,000 4,000 Feet

N

Projection:
Universal Transverse Mercator NAD83 Zone 10N

AECOM May, 2016



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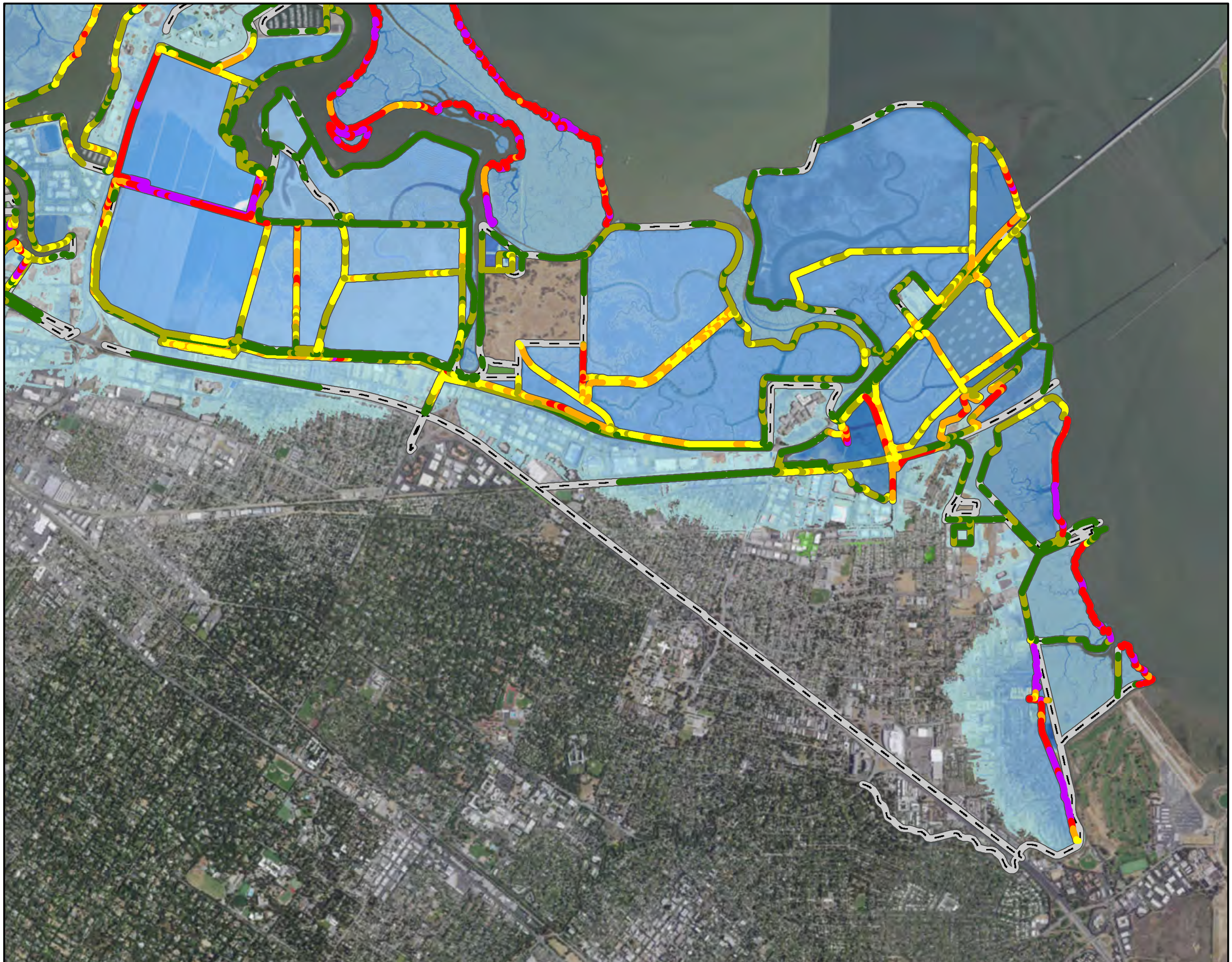


SAN MATEO COUNTY
Inundation Mapping

MHHW + 48" SEA LEVEL RISE

SLR + STORM SURGE SCENARIOS LISTED BELOW COULD BE APPROXIMATED BY THE INUNDATION SHOWN ON THIS MAP.

6" SLR + 100-YEAR STORM SURGE
12" SLR + 50-YEAR STORM SURGE
18" SLR + 25-YEAR STORM SURGE
24" SLR + 5-YEAR STORM SURGE
36" SLR + 1-YEAR STORM SURGE

Shoreline Overtopping Potential

Depth in Feet

0 - 1
1 - 2
2 - 3
3 - 4
4 - 5
> 5
No Overtopping

Sea Level Rise Inundation

Depth in Feet

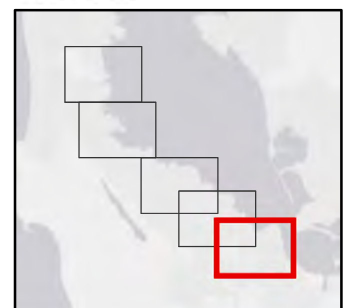
0 - 2
2 - 4
4 - 6
6 - 8
8 - 10
10 - 12
12 - 14
14 - 16
16+
Disconnected Areas > 1 Acre

0 0.2 0.4 0.6 0.8 Miles
0 1,000 2,000 3,000 4,000 Feet

N

Projection:
Universal Transverse Mercator NAD83 Zone 10N

AECOM May, 2016



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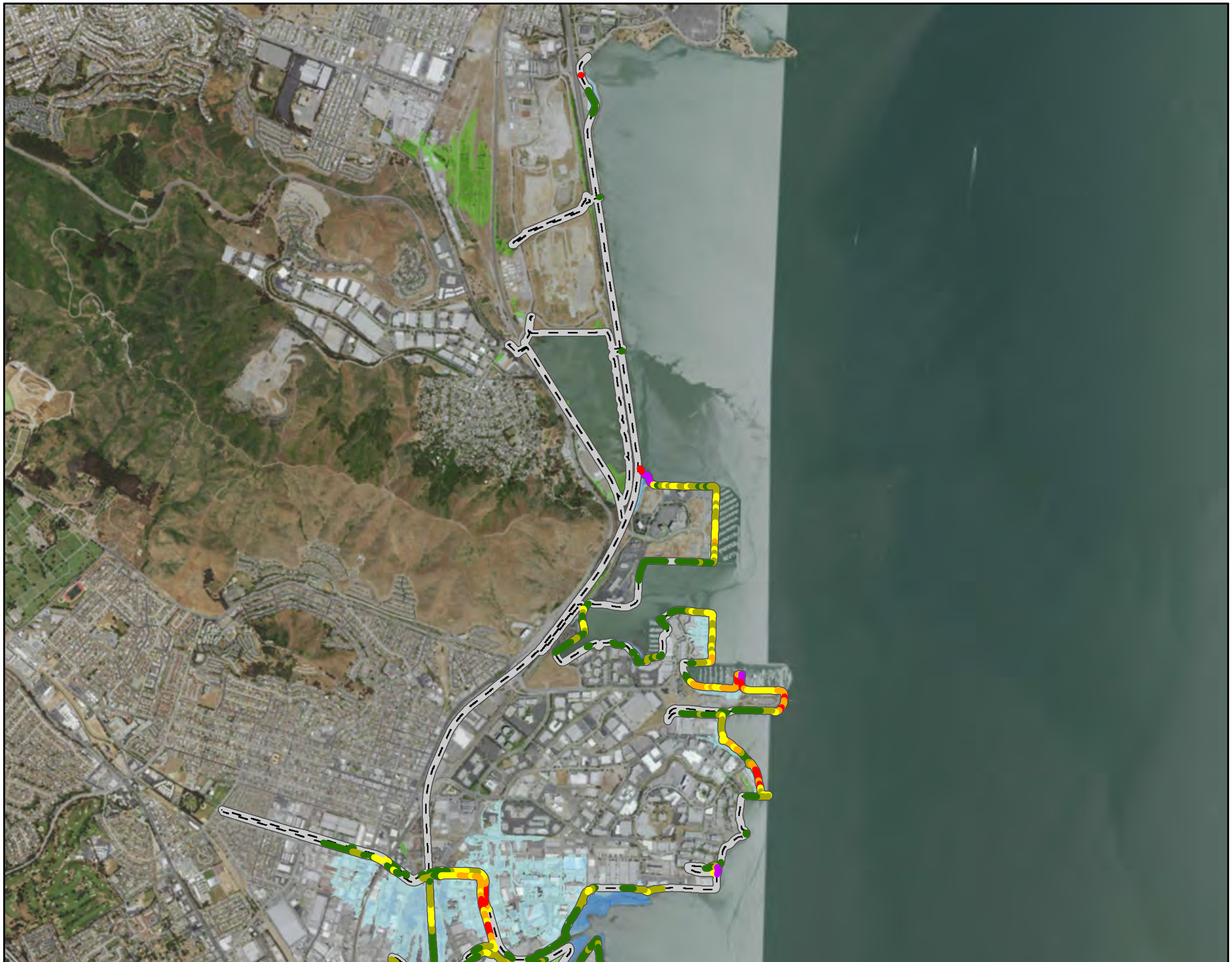


SAN MATEO COUNTY
Inundation Mapping

MHHW + 54" SEA LEVEL RISE

SLR + STORM SURGE SCENARIOS LISTED BELOW COULD BE APPROXIMATED BY THE INUNDATION SHOWN ON THIS MAP.

12" SLR + 100-YEAR STORM SURGE
18" SLR + 50-YEAR STORM SURGE
24" SLR + 25-YEAR STORM SURGE
30" SLR + 10-YEAR STORM SURGE
36" SLR + 2-YEAR STORM SURGE
42" SLR + 1-YEAR STORM SURGE

Shoreline Overtopping Potential

Depth in Feet

0 - 1
1 - 2
2 - 3
3 - 4
4 - 5
> 5
No Overtopping

Sea Level Rise Inundation

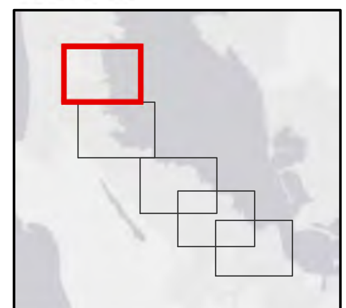
Depth in Feet

0 - 2
2 - 4
4 - 6
6 - 8
8 - 10
10 - 12
12 - 14
14 - 16
16+
Disconnected Areas > 1 Acre

0 0.2 0.4 0.6 0.8 Miles
0 1,000 2,000 3,000 4,000 Feet

Projection:
Universal Transverse Mercator NAD83 Zone 10N

AECOM May, 2016



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SAN MATEO COUNTY
Inundation Mapping

MHHW + 54” SEA LEVEL RISE

SLR + STORM SURGE SCENARIOS LISTED BELOW COULD BE APPROXIMATED BY THE INUNDATION SHOWN ON THIS MAP.

12” SLR + 100-YEAR STORM SURGE
18” SLR + 50-YEAR STORM SURGE
24” SLR + 25-YEAR STORM SURGE
30” SLR + 10-YEAR STORM SURGE
36” SLR + 2-YEAR STORM SURGE
42” SLR + 1-YEAR STORM SURGE

Shoreline Overtopping Potential

Depth in Feet

0 - 1
1 - 2
2 - 3
3 - 4
4 - 5
> 5

No Overtopping

Sea Level Rise Inundation

Depth in Feet

0 - 2
2 - 4
4 - 6
6 - 8
8 - 10
10 - 12
12 - 14
14 - 16
16+

Disconnected Areas > 1 Acre

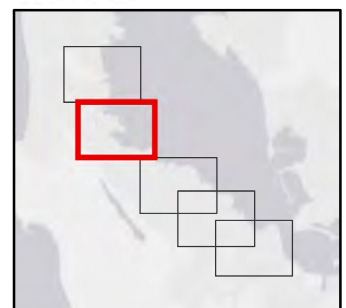
0 0.2 0.4 0.6 0.8 Miles

0 1,000 2,000 3,000 4,000 Feet

N

Projection:
Universal Transverse Mercator NAD83 Zone 10N

AECOM May, 2016



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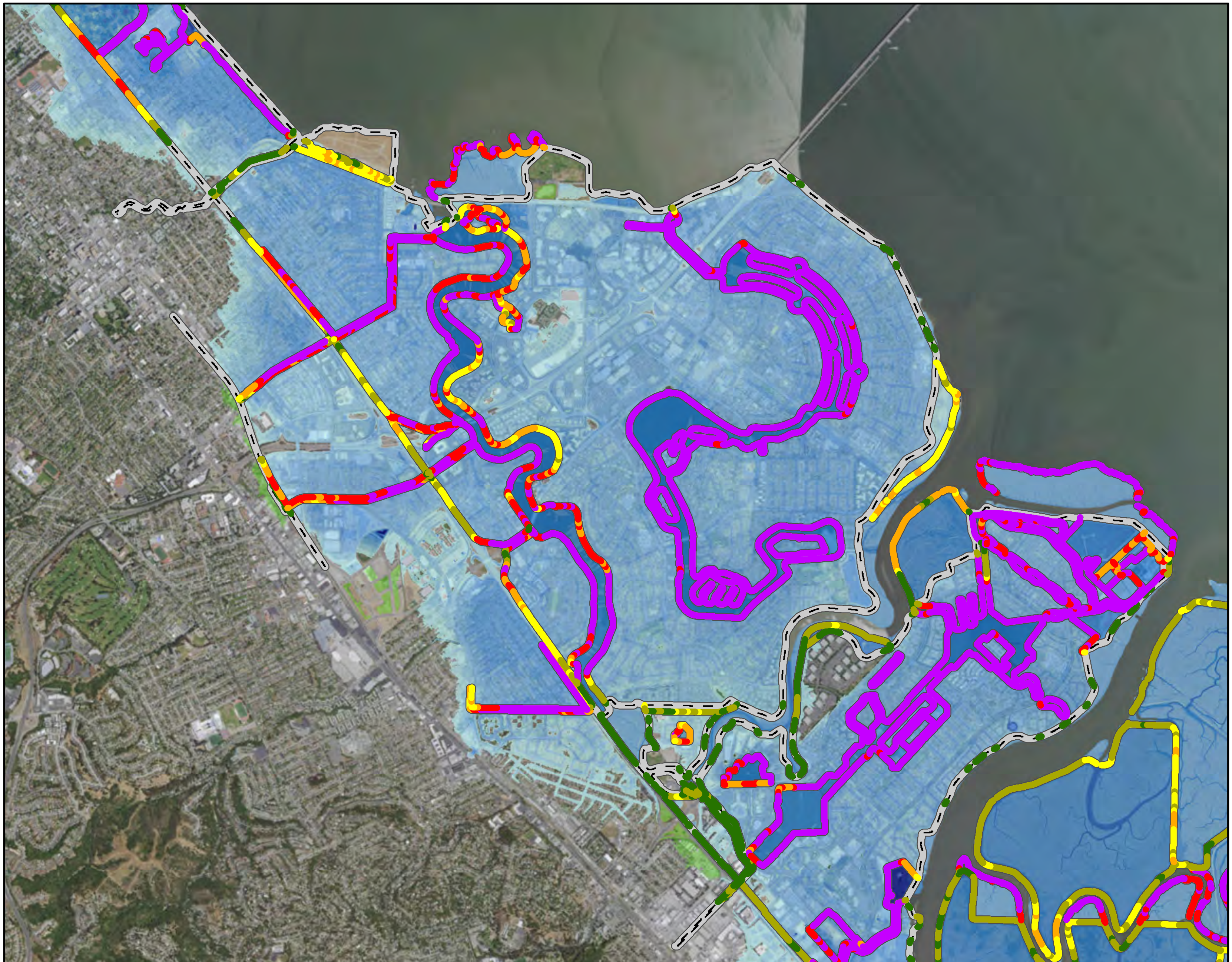

SAN MATEO COUNTY
Inundation Mapping

MHHW + 54” SEA LEVEL RISE

SLR + STORM SURGE SCENARIOS LISTED BELOW COULD BE APPROXIMATED BY THE INUNDATION SHOWN ON THIS MAP.

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18” SLR + 50-YEAR STORM SURGE
24” SLR + 25-YEAR STORM SURGE
30” SLR + 10-YEAR STORM SURGE
36” SLR + 2-YEAR STORM SURGE
42” SLR + 1-YEAR STORM SURGE

Shoreline Overtopping Potential

Depth in Feet

- 0 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- 4 - 5
- > 5
- No Overtopping

Sea Level Rise Inundation

Depth in Feet

- 0 - 2
- 2 - 4
- 4 - 6
- 6 - 8
- 8 - 10
- 10 - 12
- 12 - 14
- 14 - 16
- 16+
- Disconnected Areas > 1 Acre

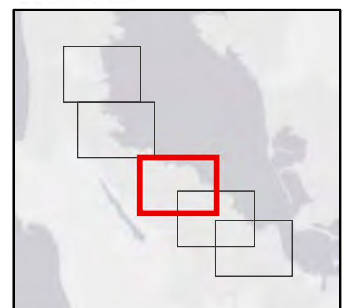
0 0.2 0.4 0.6 0.8 Miles

0 1,000 2,000 3,000 4,000 Feet

N

Projection:
Universal Transverse Mercator NAD83 Zone 10N

AECOM May, 2016



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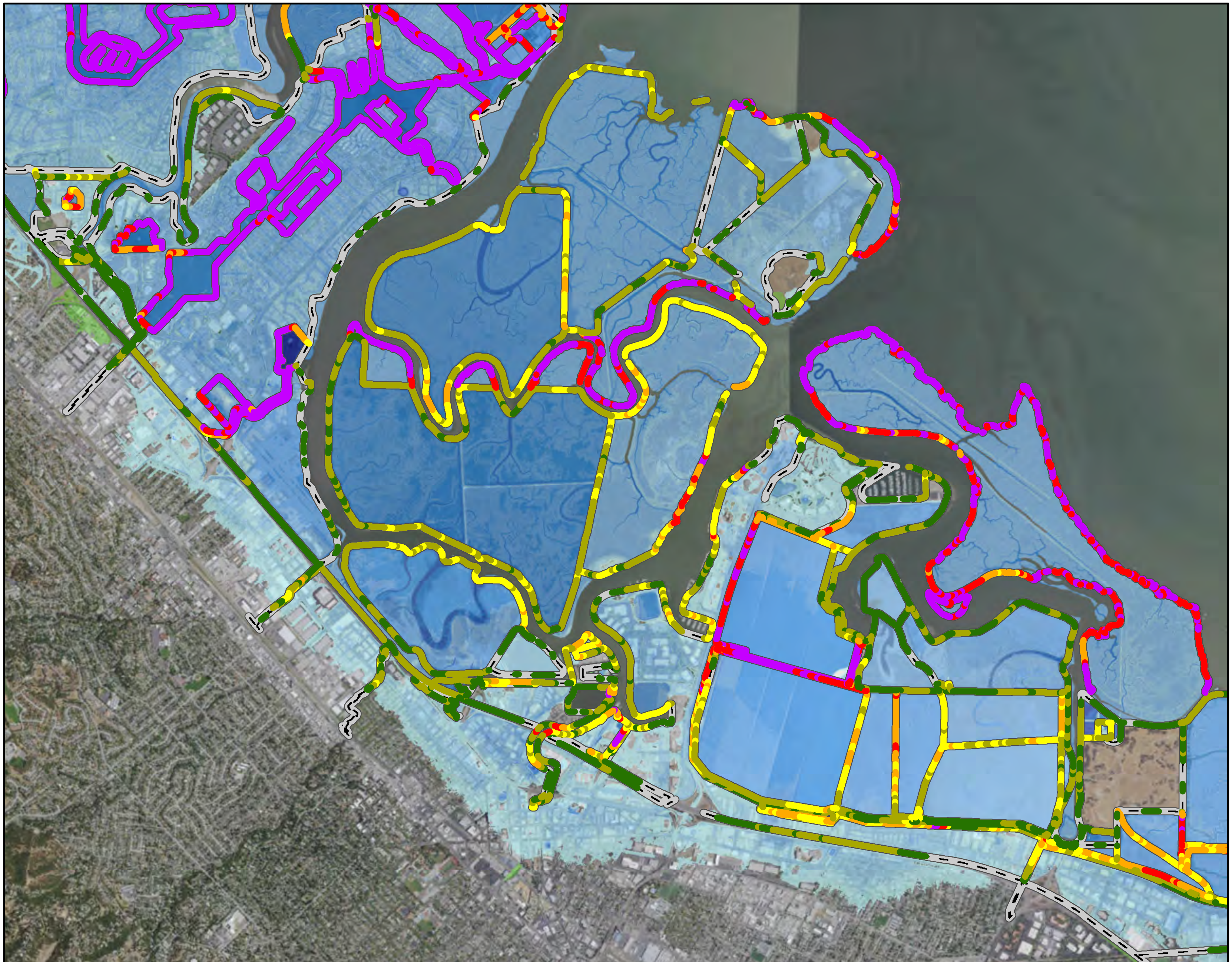


SAN MATEO COUNTY
Inundation Mapping

MHHW + 54" SEA LEVEL RISE

SLR + STORM SURGE SCENARIOS LISTED BELOW COULD BE APPROXIMATED BY THE INUNDATION SHOWN ON THIS MAP.

- 12" SLR + 100-YEAR STORM SURGE
- 18" SLR + 50-YEAR STORM SURGE
- 24" SLR + 25-YEAR STORM SURGE
- 30" SLR + 10-YEAR STORM SURGE
- 36" SLR + 2-YEAR STORM SURGE
- 42" SLR + 1-YEAR STORM SURGE

Shoreline Overtopping Potential

Depth in Feet

- 0 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- 4 - 5
- > 5
- No Overtopping

Sea Level Rise Inundation

Depth in Feet

- 0 - 2
- 2 - 4
- 4 - 6
- 6 - 8
- 8 - 10
- 10 - 12
- 12 - 14
- 14 - 16
- 16+
- Disconnected Areas > 1 Acre

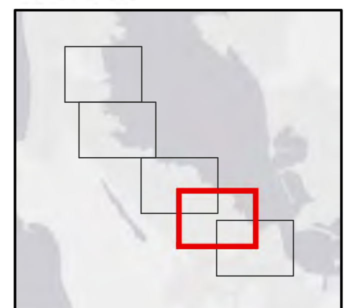
0 0.2 0.4 0.6 0.8 Miles

0 1,000 2,000 3,000 4,000 Feet

N

Projection:
Universal Transverse Mercator NAD83 Zone 10N

AECOM May, 2016



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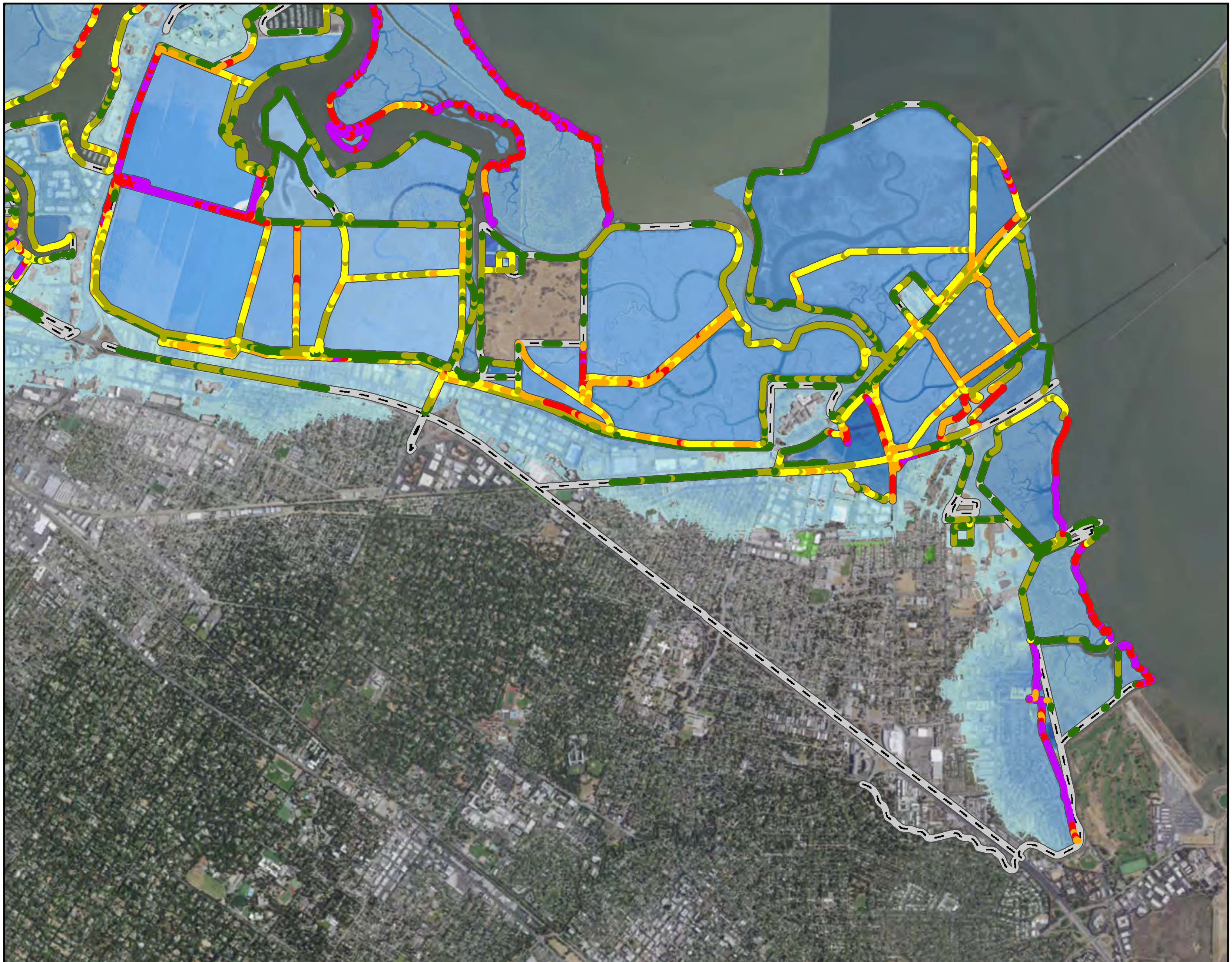


SAN MATEO COUNTY
Inundation Mapping

MHHW + 54” SEA LEVEL RISE

SLR + STORM SURGE SCENARIOS LISTED BELOW COULD BE APPROXIMATED BY THE INUNDATION SHOWN ON THIS MAP.

12” SLR + 100-YEAR STORM SURGE
18” SLR + 50-YEAR STORM SURGE
24” SLR + 25-YEAR STORM SURGE
30” SLR + 10-YEAR STORM SURGE
36” SLR + 2-YEAR STORM SURGE
42” SLR + 1-YEAR STORM SURGE

Shoreline Overtopping Potential

Depth in Feet

- 0 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- 4 - 5
- > 5

No Overtopping

Sea Level Rise Inundation

Depth in Feet

- 0 - 2
- 2 - 4
- 4 - 6
- 6 - 8
- 8 - 10
- 10 - 12
- 12 - 14
- 14 - 16
- 16+

Disconnected Areas > 1 Acre

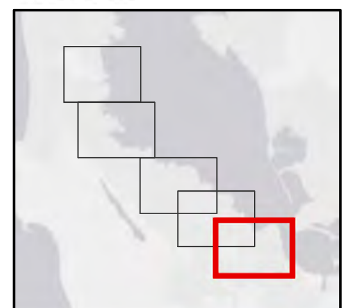
0 0.2 0.4 0.6 0.8 Miles

0 1,000 2,000 3,000 4,000 Feet

N

Projection:
Universal Transverse Mercator NAD83 Zone 10N

AECOM May, 2016



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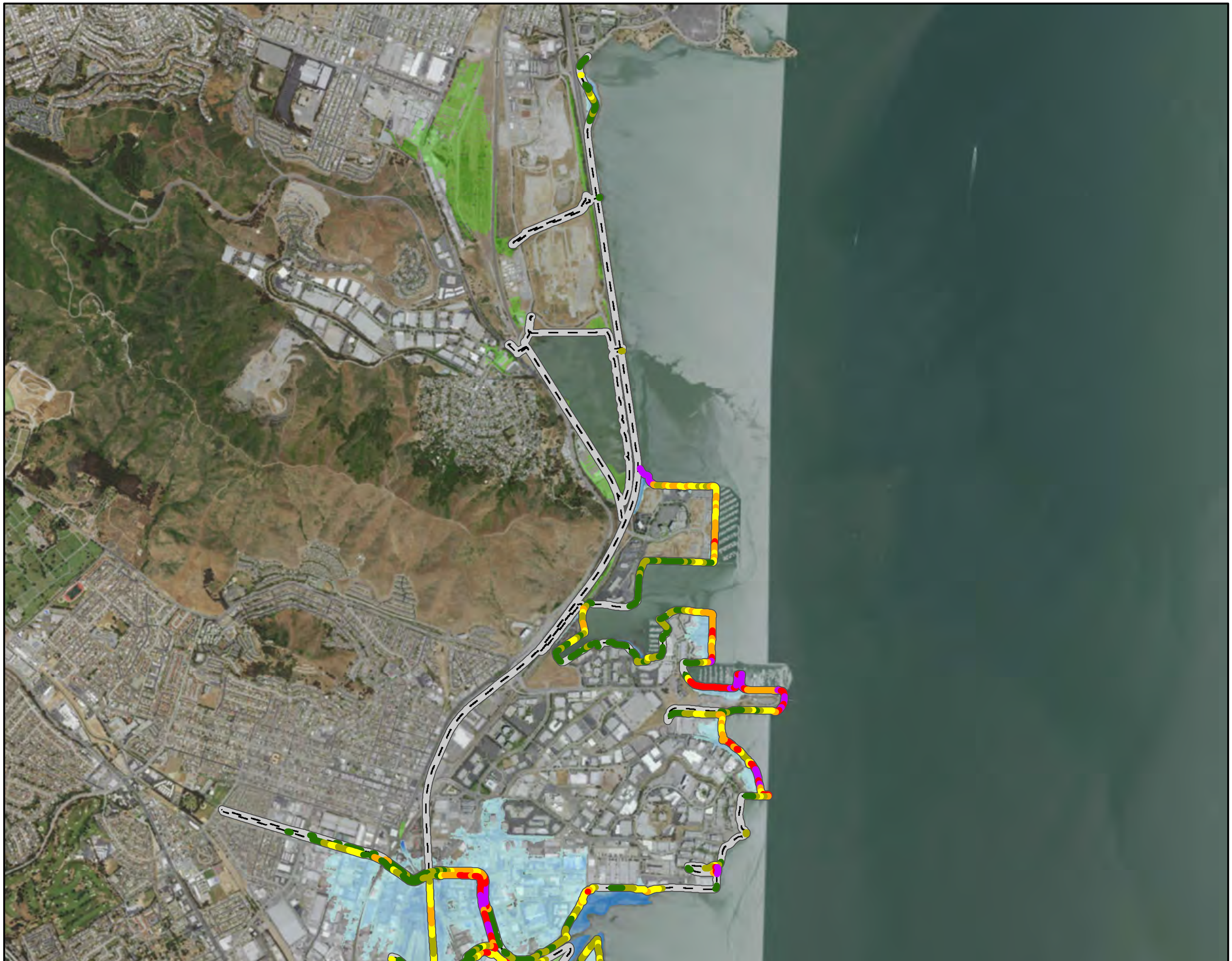
SAN MATEO COUNTY
Inundation Mapping



MHHW + 66" SEA LEVEL RISE

SLR + STORM SURGE SCENARIOS LISTED BELOW COULD BE APPROXIMATED BY THE INUNDATION SHOWN ON THIS MAP.

24" SLR + 100-YEAR STORM SURGE
30" SLR + 50-YEAR STORM SURGE
36" SLR + 25-YEAR STORM SURGE
42" SLR + 10-YEAR STORM SURGE
48" SLR + 2-YEAR STORM SURGE
54" SLR + 1-YEAR STORM SURGE

Shoreline Overtopping Potential

Depth in Feet

0 - 1
1 - 2
2 - 3
3 - 4
4 - 5
> 5
No Overtopping

Sea Level Rise Inundation

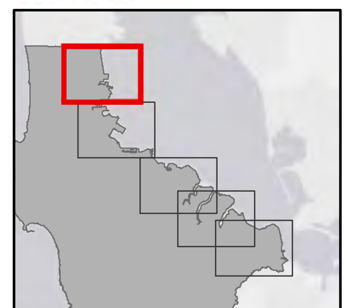
Depth in Feet

0 - 2
2 - 4
4 - 6
6 - 8
8 - 10
10 - 12
12 - 14
14 - 16
16+
Disconnected Areas > 1 Acre

0 0.2 0.4 0.6 0.8 Miles
0 1,000 2,000 3,000 4,000 Feet
N

Projection:
Universal Transverse Mercator NAD83 Zone 10N

AECOM May, 2016



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SAN MATEO COUNTY
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MHHW + 66” SEA LEVEL RISE

SLR + STORM SURGE SCENARIOS LISTED BELOW COULD BE APPROXIMATED BY THE INUNDATION SHOWN ON THIS MAP.

24” SLR + 100-YEAR STORM SURGE
30” SLR + 50-YEAR STORM SURGE
36” SLR + 25-YEAR STORM SURGE
42” SLR + 10-YEAR STORM SURGE
48” SLR + 2-YEAR STORM SURGE
54” SLR + 1-YEAR STORM SURGE

Shoreline Overtopping Potential

Depth in Feet

0 - 1
1 - 2
2 - 3
3 - 4
4 - 5
> 5
No Overtopping

Sea Level Rise Inundation

Depth in Feet

0 - 2
2 - 4
4 - 6
6 - 8
8 - 10
10 - 12
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16+
Disconnected Areas > 1 Acre

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0 1,000 2,000 3,000 4,000 Feet
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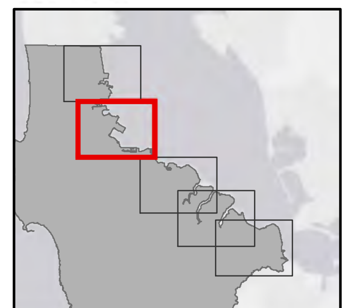
AECOM May, 2016



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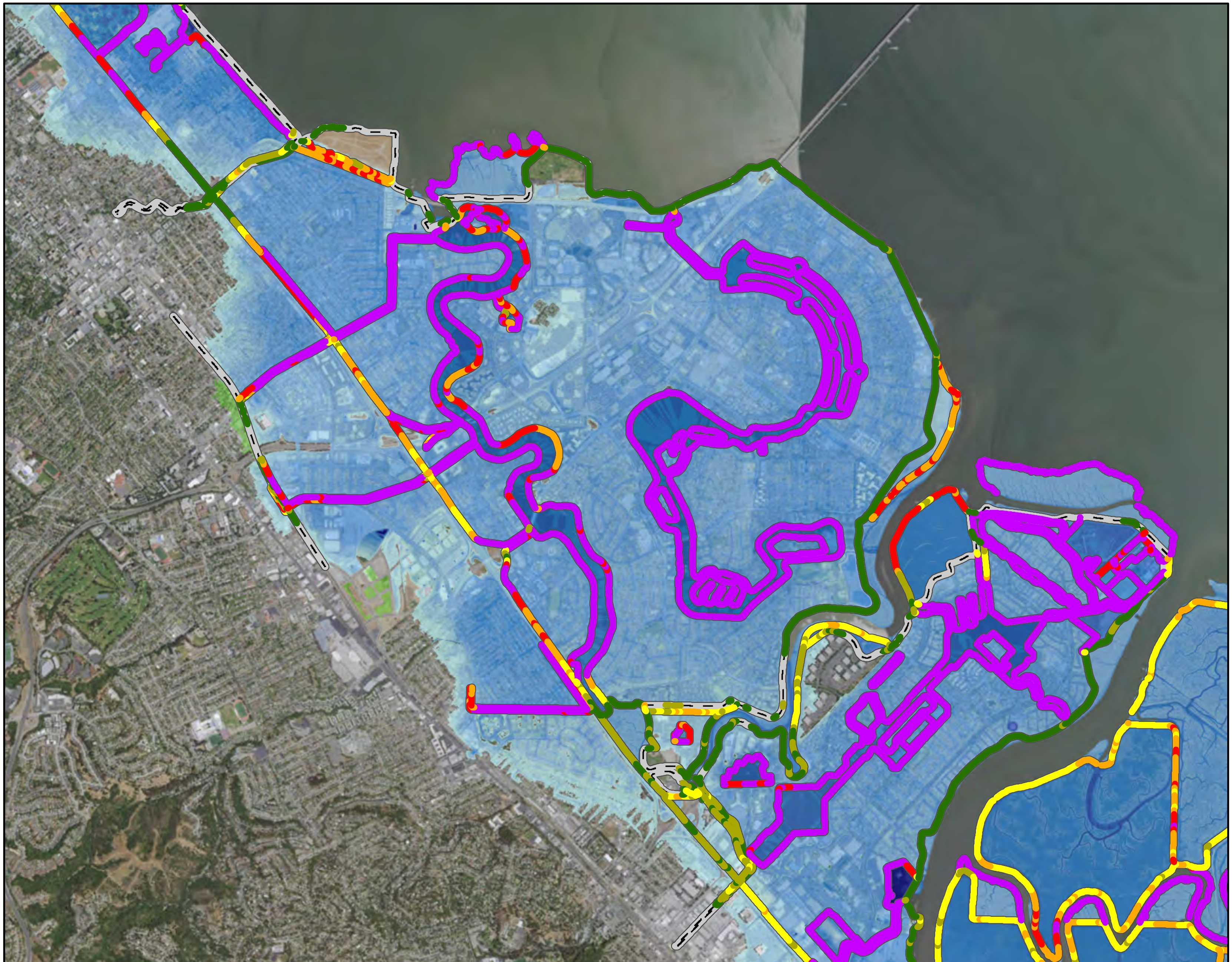

SAN MATEO COUNTY
Inundation Mapping

MHHW + 66” SEA LEVEL RISE

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- 30” SLR + 50-YEAR STORM SURGE
- 36” SLR + 25-YEAR STORM SURGE
- 42” SLR + 10-YEAR STORM SURGE
- 48” SLR + 2-YEAR STORM SURGE
- 54” SLR + 1-YEAR STORM SURGE

Shoreline Overtopping Potential

Depth in Feet

- 0 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- 4 - 5
- > 5
- No Overtopping

Sea Level Rise Inundation

Depth in Feet

- 0 - 2
- 2 - 4
- 4 - 6
- 6 - 8
- 8 - 10
- 10 - 12
- 12 - 14
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- 16+
- Disconnected Areas > 1 Acre

0 0.2 0.4 0.6 0.8 Miles

0 1,000 2,000 3,000 4,000 Feet

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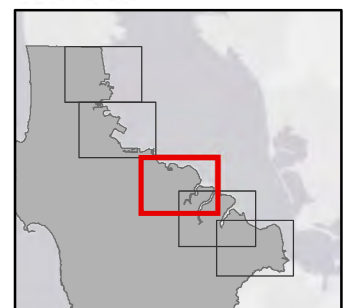
May, 2016



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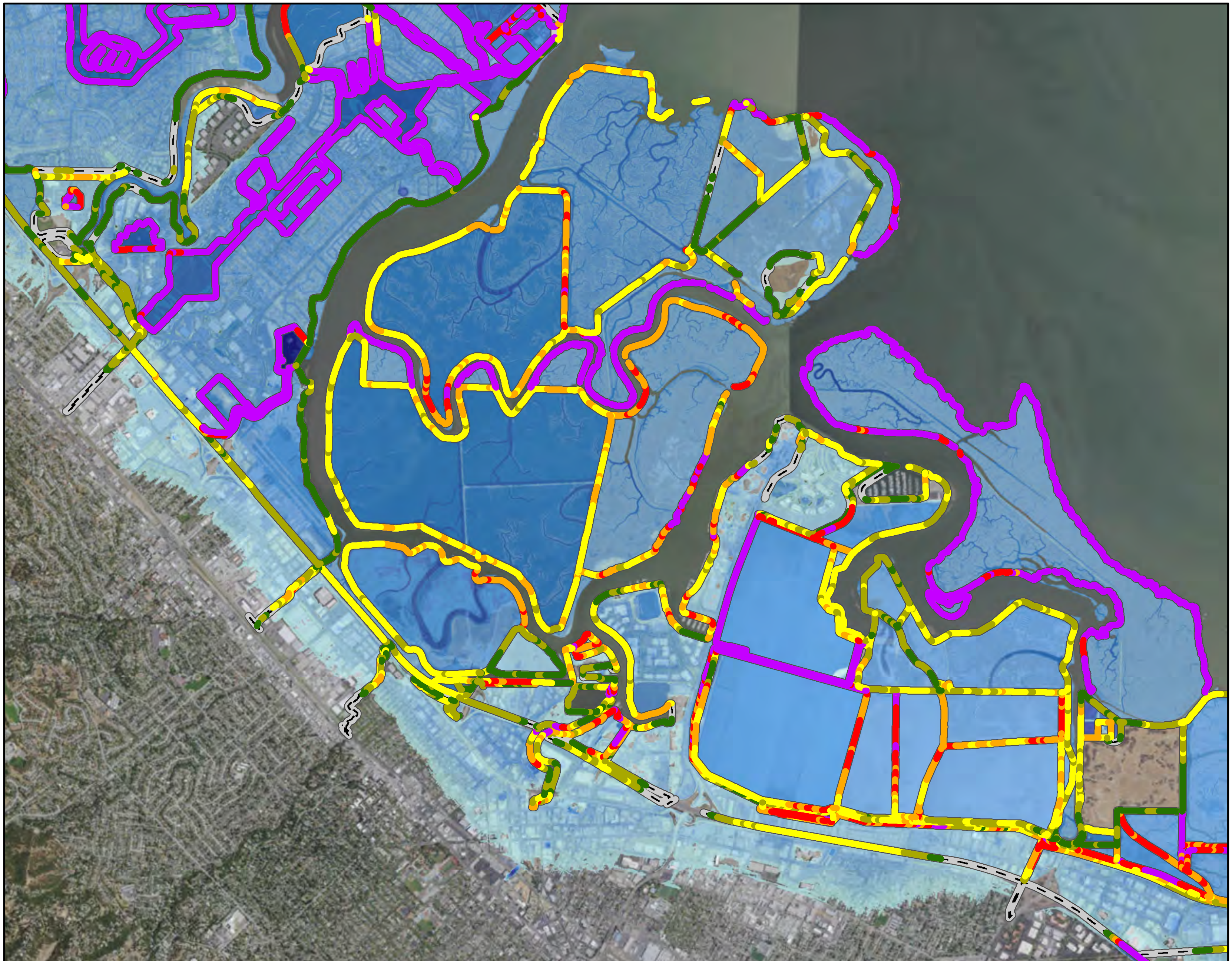


SAN MATEO COUNTY
Inundation Mapping

MHHW + 66" SEA LEVEL RISE

SLR + STORM SURGE SCENARIOS LISTED BELOW COULD BE APPROXIMATED BY THE INUNDATION SHOWN ON THIS MAP.

24" SLR + 100-YEAR STORM SURGE
30" SLR + 50-YEAR STORM SURGE
36" SLR + 25-YEAR STORM SURGE
42" SLR + 10-YEAR STORM SURGE
48" SLR + 2-YEAR STORM SURGE
54" SLR + 1-YEAR STORM SURGE

Shoreline Overtopping Potential

Depth in Feet

0 - 1
1 - 2
2 - 3
3 - 4
4 - 5
> 5
No Overtopping

Sea Level Rise Inundation

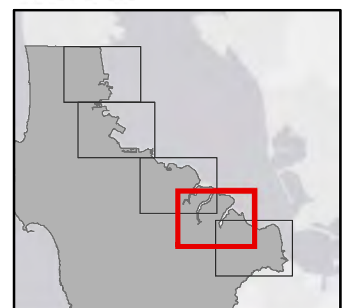
Depth in Feet

0 - 2
2 - 4
4 - 6
6 - 8
8 - 10
10 - 12
12 - 14
14 - 16
16+
Disconnected Areas > 1 Acre

0 0.2 0.4 0.6 0.8 Miles
0 1,000 2,000 3,000 4,000 Feet

Projection:
Universal Transverse Mercator NAD83 Zone 10N

AECOM May, 2016



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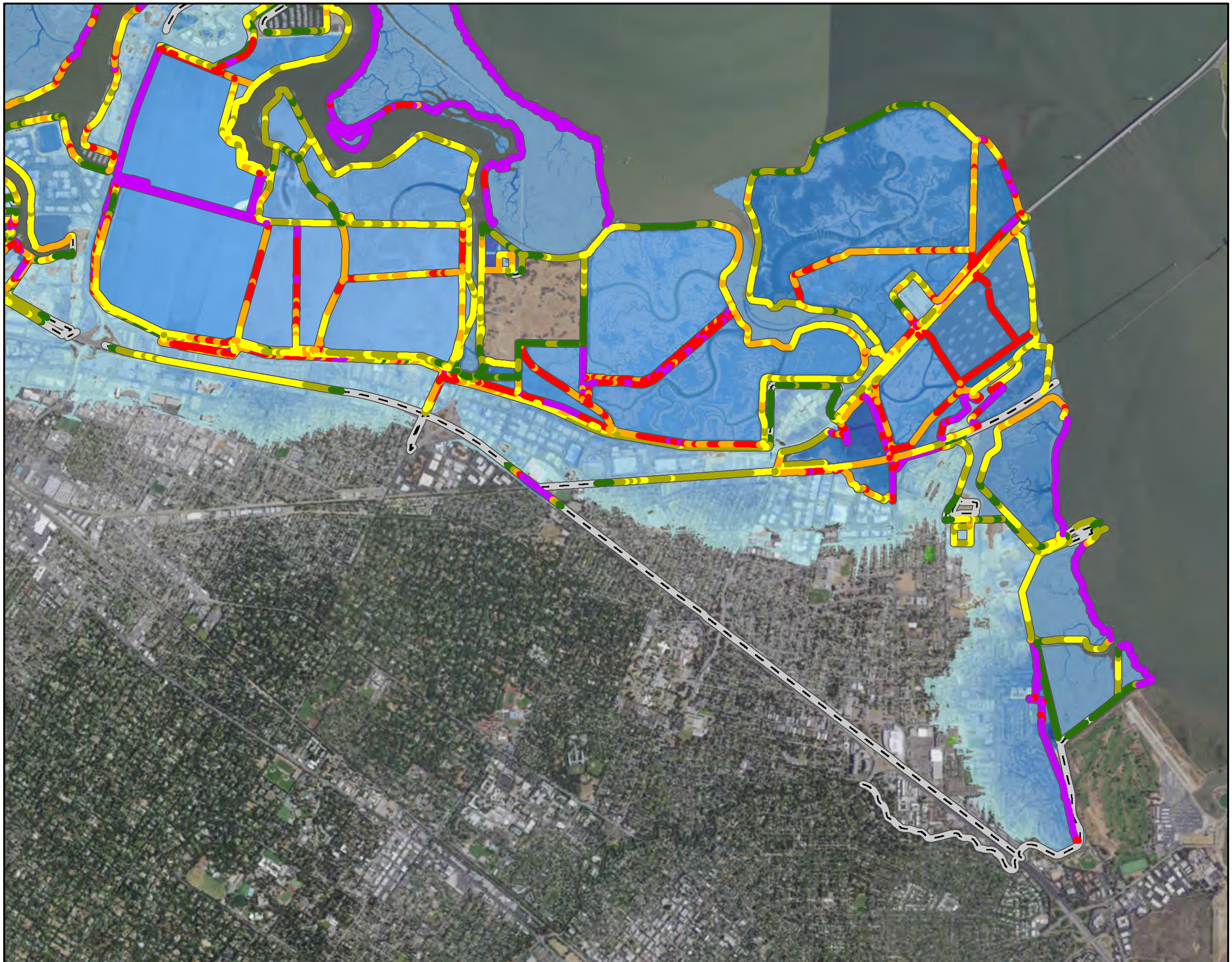


SAN MATEO COUNTY
Inundation Mapping

MHHW + 66" SEA LEVEL RISE

SLR + STORM SURGE SCENARIOS LISTED BELOW COULD BE APPROXIMATED BY THE INUNDATION SHOWN ON THIS MAP.

24" SLR + 100-YEAR STORM SURGE
30" SLR + 50-YEAR STORM SURGE
36" SLR + 25-YEAR STORM SURGE
42" SLR + 10-YEAR STORM SURGE
48" SLR + 2-YEAR STORM SURGE
54" SLR + 1-YEAR STORM SURGE

Shoreline Overtopping Potential

Depth in Feet

0 - 1
1 - 2
2 - 3
3 - 4
4 - 5
> 5
No Overtopping

Sea Level Rise Inundation

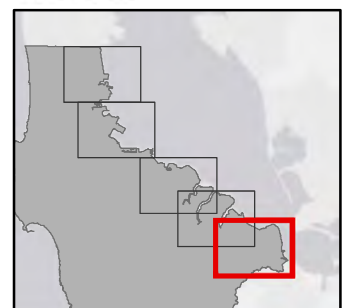
Depth in Feet

0 - 2
2 - 4
4 - 6
6 - 8
8 - 10
10 - 12
12 - 14
14 - 16
16+
Disconnected Areas > 1 Acre

0 0.2 0.4 0.6 0.8 Miles
0 1,000 2,000 3,000 4,000 Feet
N

Projection:
Universal Transverse Mercator NAD83 Zone 10N

AECOM May, 2016



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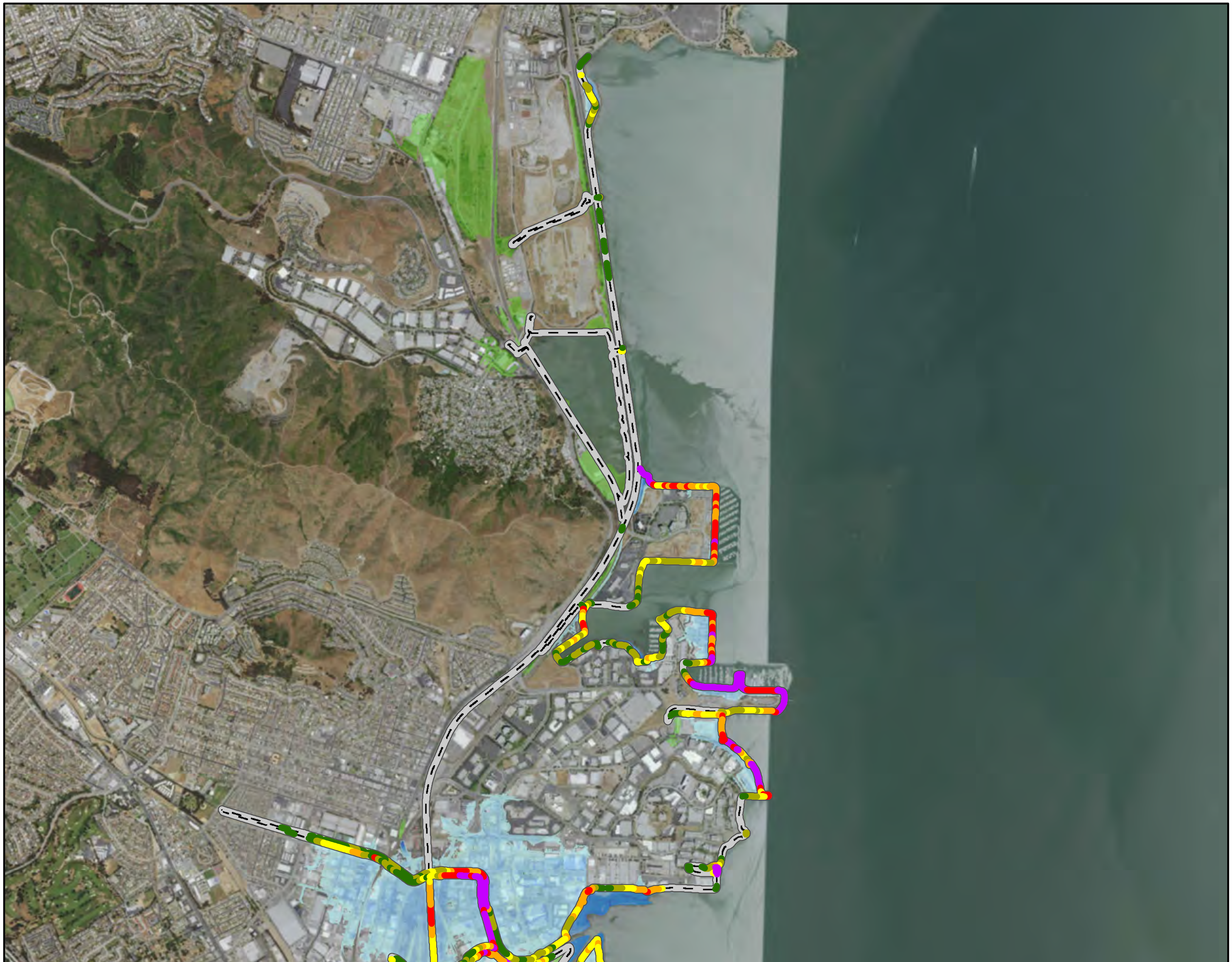


SAN MATEO COUNTY
Inundation Mapping

MHHW + 78" WATER LEVEL

SLR + STORM SURGE SCENARIOS LISTED BELOW COULD BE APPROXIMATED BY THE INUNDATION SHOWN ON THIS MAP.

36"SLR + 100-YEAR STORM SURGE
42"SLR + 50-YEAR STORM SURGE
48"SLR + 25-YEAR STORM SURGE
54"SLR + 10-YEAR STORM SURGE
60"SLR + 2-YEAR STORM SURGE
66"SLR + 1-YEAR STORM SURGE

Shoreline Overtopping Potential

Depth in Feet

- 0 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- 4 - 5
- > 5
- No Overtopping

Sea Level Rise Inundation

Depth in Feet

- 0 - 2
- 2 - 4
- 4 - 6
- 6 - 8
- 8 - 10
- 10 - 12
- 12 - 14
- 14 - 16
- 16+
- Disconnected Areas > 1 Acre

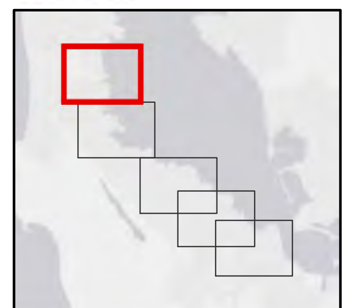
N

0 0.2 0.4 0.6 0.8 Miles

0 1,000 2,000 3,000 4,000 Feet

Projection:
Universal Transverse Mercator NAD83 Zone 10N

AECOM May, 2016



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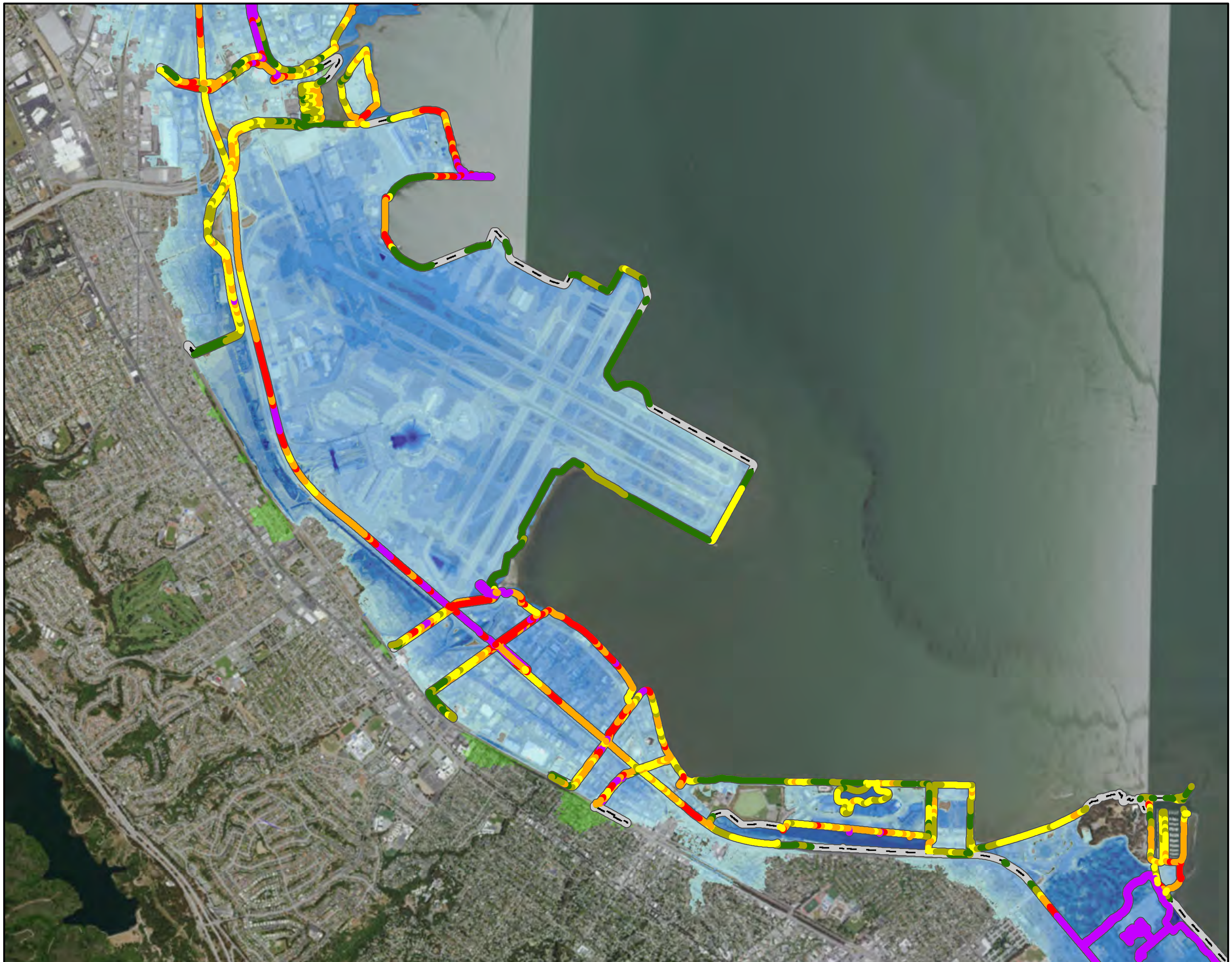


SAN MATEO COUNTY
Inundation Mapping

MHHW + 78" WATER LEVEL

SLR + STORM SURGE SCENARIOS LISTED BELOW COULD BE APPROXIMATED BY THE INUNDATION SHOWN ON THIS MAP.

36"SLR + 100-YEAR STORM SURGE
42"SLR + 50-YEAR STORM SURGE
48"SLR + 25-YEAR STORM SURGE
54"SLR + 10-YEAR STORM SURGE
60"SLR + 2-YEAR STORM SURGE
66"SLR + 1-YEAR STORM SURGE

Shoreline Overtopping Potential

Depth in Feet

0 - 1
1 - 2
2 - 3
3 - 4
4 - 5
> 5
No Overtopping

Sea Level Rise Inundation

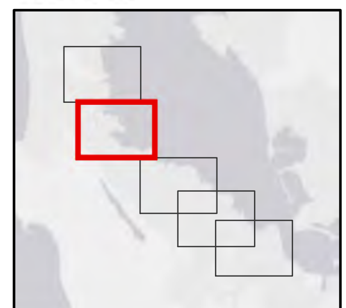
Depth in Feet

0 - 2
2 - 4
4 - 6
6 - 8
8 - 10
10 - 12
12 - 14
14 - 16
16+
Disconnected Areas > 1 Acre

0 0.2 0.4 0.6 0.8 Miles
0 1,000 2,000 3,000 4,000 Feet
N

Projection:
Universal Transverse Mercator NAD83 Zone 10N

AECOM May, 2016



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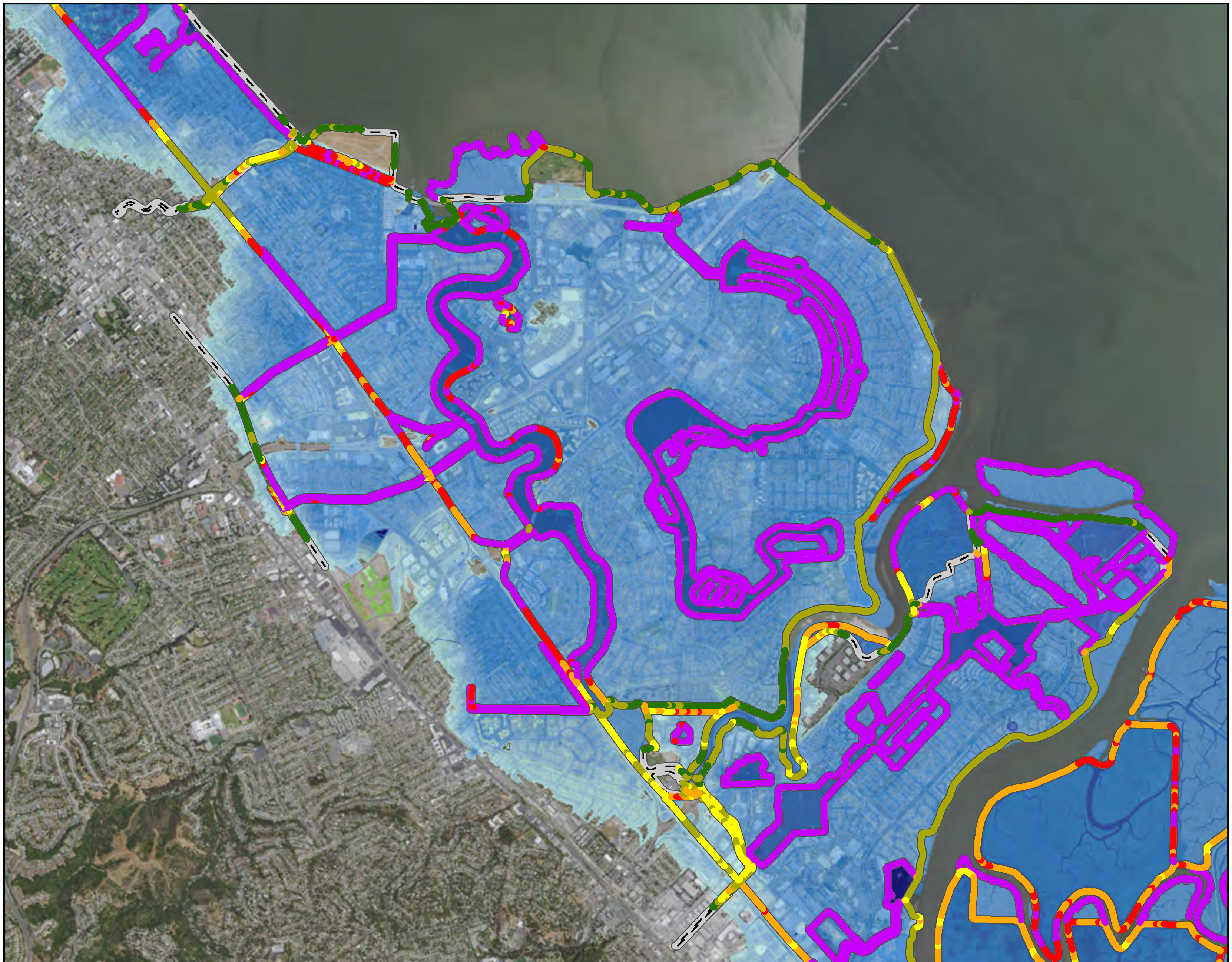


SAN MATEO COUNTY
Inundation Mapping

MHHW + 78" WATER LEVEL

SLR + STORM SURGE SCENARIOS LISTED BELOW COULD BE APPROXIMATED BY THE INUNDATION SHOWN ON THIS MAP.

- 36"SLR + 100-YEAR STORM SURGE
- 42"SLR + 50-YEAR STORM SURGE
- 48"SLR + 25-YEAR STORM SURGE
- 54"SLR + 10-YEAR STORM SURGE
- 60"SLR + 2-YEAR STORM SURGE
- 66"SLR + 1-YEAR STORM SURGE

Shoreline Overtopping Potential

Depth in Feet

- 0 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- 4 - 5
- > 5

No Overtopping

Sea Level Rise Inundation

Depth in Feet

- 0 - 2
- 2 - 4
- 4 - 6
- 6 - 8
- 8 - 10
- 10 - 12
- 12 - 14
- 14 - 16
- 16+

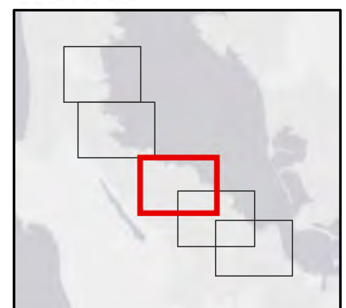
Disconnected Areas > 1 Acre

0 0.2 0.4 0.6 0.8 Miles

0 1,000 2,000 3,000 4,000 Feet

Projection:
Universal Transverse Mercator NAD83 Zone 10N

AECOM May, 2016



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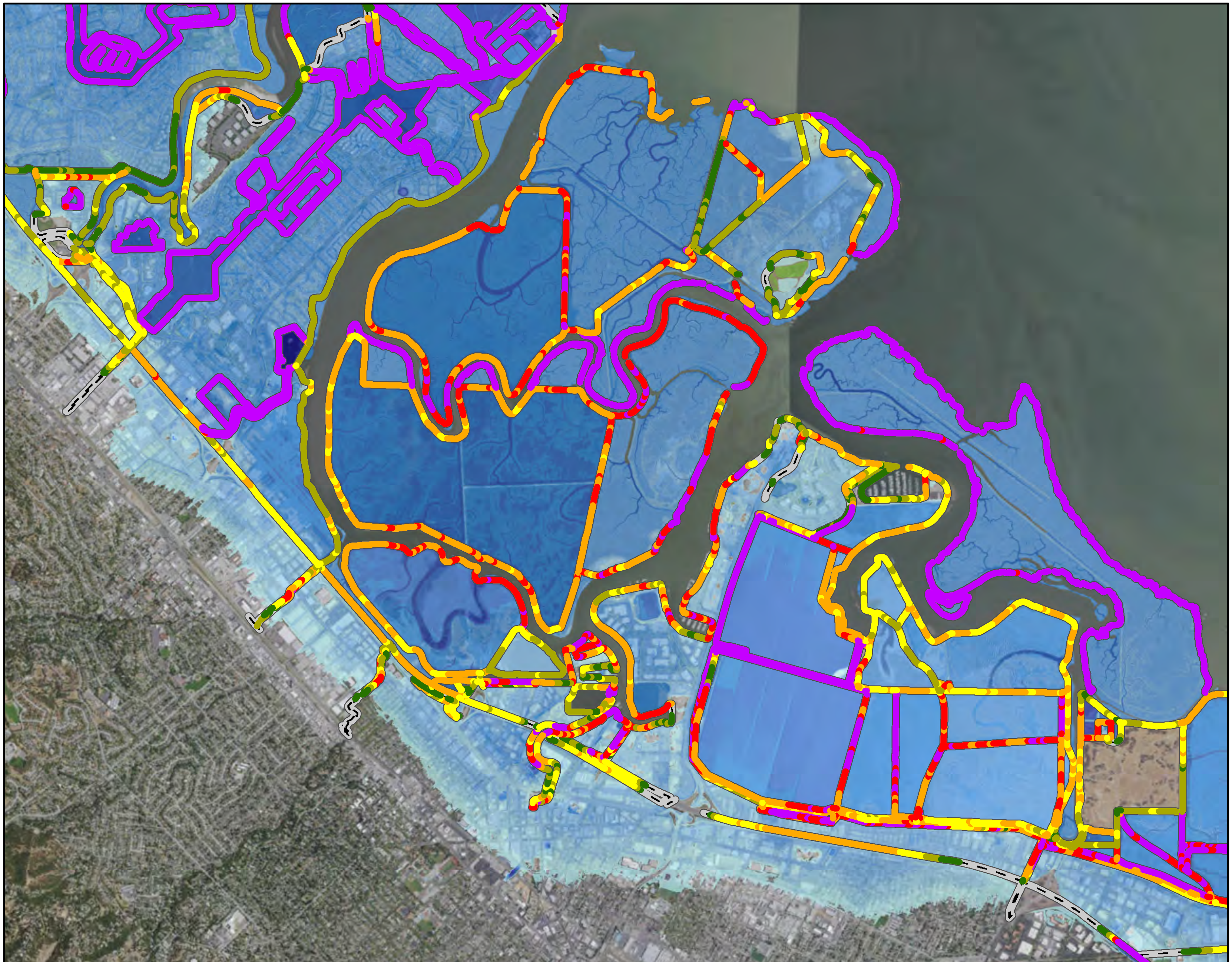


SAN MATEO COUNTY
Inundation Mapping

MHHW + 78” WATER LEVEL

SLR + STORM SURGE SCENARIOS LISTED BELOW COULD BE APPROXIMATED BY THE INUNDATION SHOWN ON THIS MAP.

36”SLR + 100-YEAR STORM SURGE
42”SLR + 50-YEAR STORM SURGE
48”SLR + 25-YEAR STORM SURGE
54”SLR + 10-YEAR STORM SURGE
60”SLR + 2-YEAR STORM SURGE
66”SLR + 1-YEAR STORM SURGE

Shoreline Overtopping Potential

Depth in Feet

0 - 1
1 - 2
2 - 3
3 - 4
4 - 5
> 5

No Overtopping

Sea Level Rise Inundation

Depth in Feet

0 - 2
2 - 4
4 - 6
6 - 8
8 - 10
10 - 12
12 - 14
14 - 16
16+

Disconnected Areas > 1 Acre

0 0.2 0.4 0.6 0.8 Miles

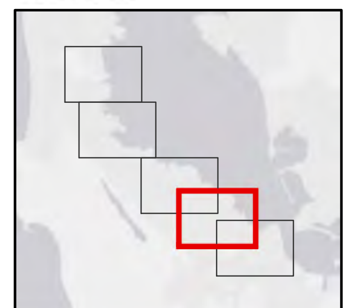
0 1,000 2,000 3,000 4,000 Feet

N

Projection:
Universal Transverse Mercator NAD83 Zone 10N

AECOM

May, 2016



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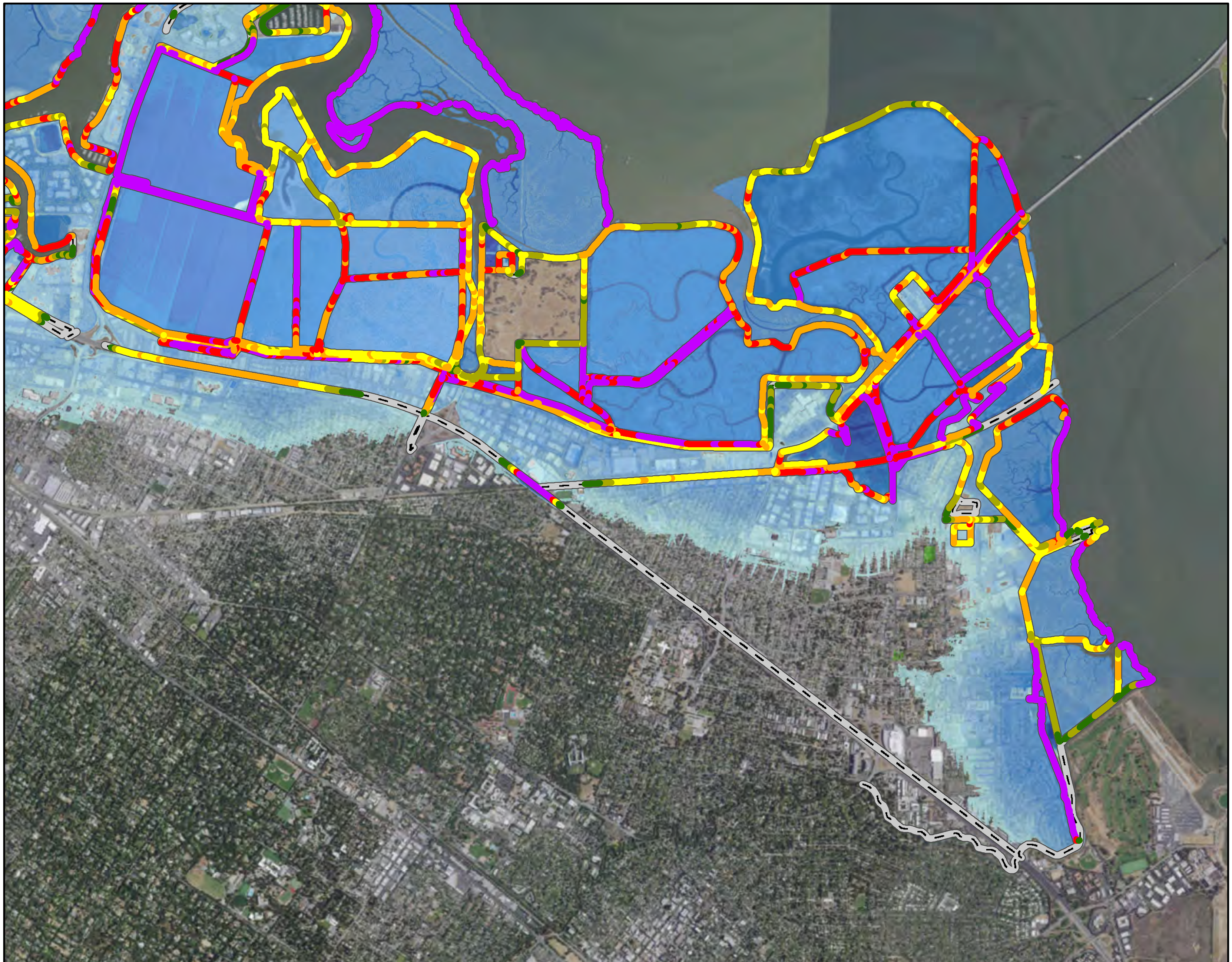


SAN MATEO COUNTY

Inundation Mapping

MHHW + 78" WATER LEVEL

SLR + STORM SURGE SCENARIOS LISTED BELOW COULD BE APPROXIMATED BY THE INUNDATION SHOWN ON THIS MAP.

36"SLR + 100-YEAR STORM SURGE
42"SLR + 50-YEAR STORM SURGE
48"SLR + 25-YEAR STORM SURGE
54"SLR + 10-YEAR STORM SURGE
60"SLR + 2-YEAR STORM SURGE
66"SLR + 1-YEAR STORM SURGE

Shoreline Overtopping Potential

Depth in Feet

0 - 1
1 - 2
2 - 3
3 - 4
4 - 5
> 5

No Overtopping

Sea Level Rise Inundation

Depth in Feet

0 - 2
2 - 4
4 - 6
6 - 8
8 - 10
10 - 12
12 - 14
14 - 16
16+

Disconnected Areas > 1 Acre

0 0.2 0.4 0.6 0.8 Miles

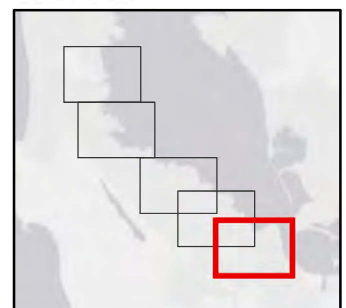
0 1,000 2,000 3,000 4,000 Feet

N

Projection:
Universal Transverse Mercator NAD83 Zone 10N

AECOM

May, 2016



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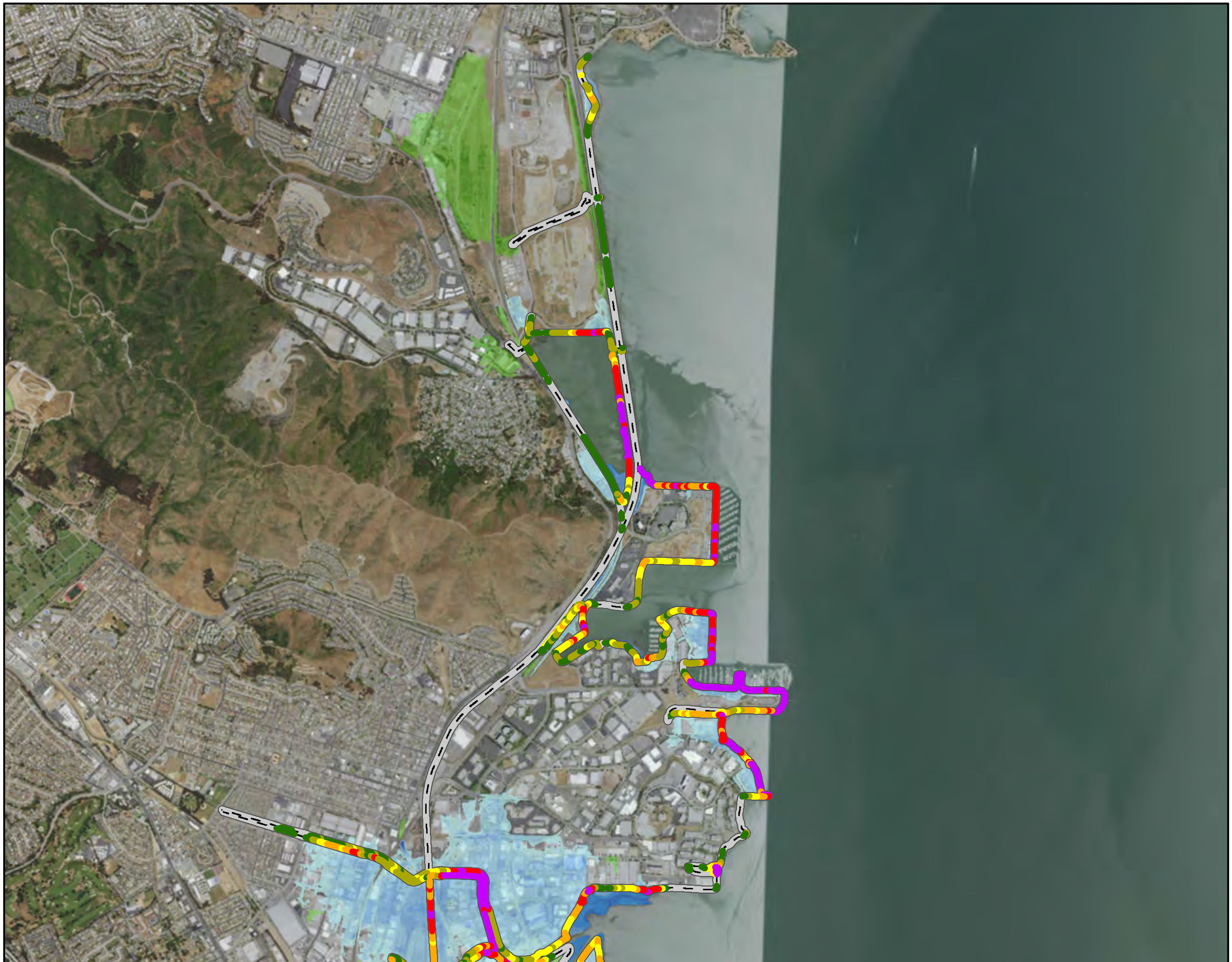


SAN MATEO COUNTY
Inundation Mapping

MHHW + 84" WATER LEVEL

SLR + STORM SURGE SCENARIOS LISTED BELOW COULD BE APPROXIMATED BY THE INUNDATION SHOWN ON THIS MAP.

- 42"SLR + 100-YEAR STORM SURGE
- 48"SLR + 50-YEAR STORM SURGE
- 54"SLR + 25-YEAR STORM SURGE
- 60"SLR + 10-YEAR STORM SURGE
- 66"SLR + 2-YEAR STORM SURGE

Shoreline Overtopping Potential

Depth in Feet

- 0 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- 4 - 5
- > 5
- No Overtopping

Sea Level Rise Inundation

Depth in Feet

- 0 - 2
- 2 - 4
- 4 - 6
- 6 - 8
- 8 - 10
- 10 - 12
- 12 - 14
- 14 - 16
- 16+
- Disconnected Areas > 1 Acre

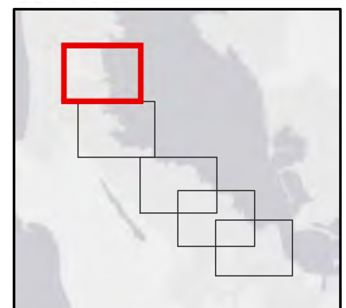
0 0.2 0.4 0.6 0.8 Miles

0 1,000 2,000 3,000 4,000 Feet

N

Projection:
Universal Transverse Mercator NAD83 Zone 10N

AECOM May, 2016



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SAN MATEO COUNTY
Inundation Mapping

MHHW + 84” WATER LEVEL

SLR + STORM SURGE SCENARIOS LISTED BELOW COULD BE APPROXIMATED BY THE INUNDATION SHOWN ON THIS MAP.

42”SLR + 100-YEAR STORM SURGE
48”SLR + 50-YEAR STORM SURGE
54”SLR + 25-YEAR STORM SURGE
60”SLR + 10-YEAR STORM SURGE
66”SLR + 2-YEAR STORM SURGE

Shoreline Overtopping Potential

Depth in Feet

0 - 1
1 - 2
2 - 3
3 - 4
4 - 5
> 5
No Overtopping

Sea Level Rise Inundation

Depth in Feet

0 - 2
2 - 4
4 - 6
6 - 8
8 - 10
10 - 12
12 - 14
14 - 16
16+
Disconnected Areas > 1 Acre

0 0.2 0.4 0.6 0.8 Miles
0 1,000 2,000 3,000 4,000 Feet
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Projection:
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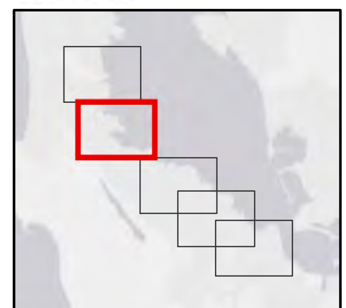
AECOM May, 2016



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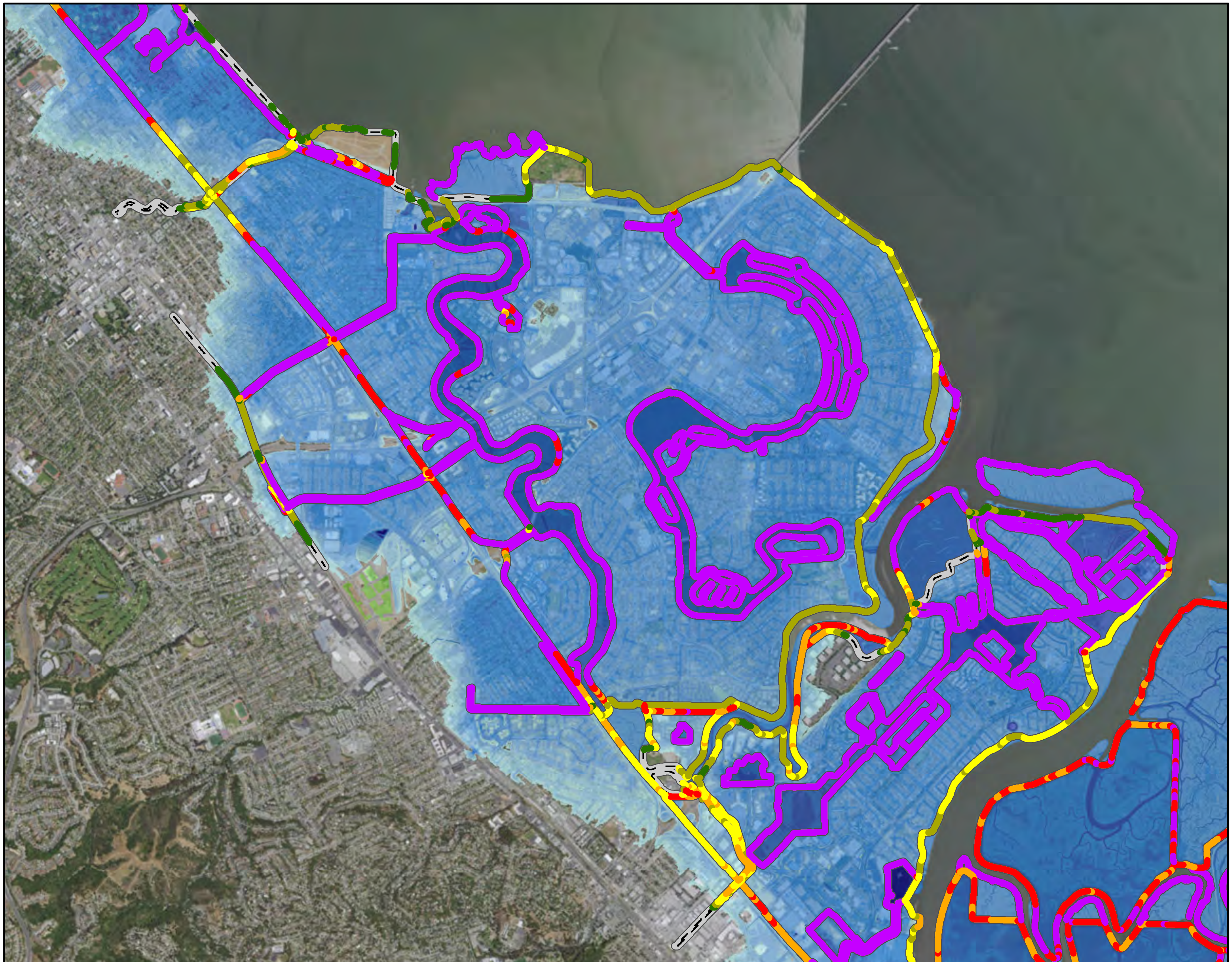


SAN MATEO COUNTY
Inundation Mapping

MHHW + 84" WATER LEVEL

SLR + STORM SURGE SCENARIOS LISTED BELOW COULD BE APPROXIMATED BY THE INUNDATION SHOWN ON THIS MAP.

42"SLR + 100-YEAR STORM SURGE
48"SLR + 50-YEAR STORM SURGE
54"SLR + 25-YEAR STORM SURGE
60"SLR + 10-YEAR STORM SURGE
66"SLR + 2-YEAR STORM SURGE

Shoreline Overtopping Potential

Depth in Feet

- 0 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- 4 - 5
- > 5

No Overtopping

Sea Level Rise Inundation

Depth in Feet

- 0 - 2
- 2 - 4
- 4 - 6
- 6 - 8
- 8 - 10
- 10 - 12
- 12 - 14
- 14 - 16
- 16+

Disconnected Areas > 1 Acre

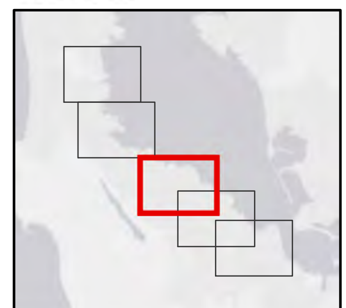
N

0 0.2 0.4 0.6 0.8 Miles

0 1,000 2,000 3,000 4,000 Feet

Projection:
Universal Transverse Mercator NAD83 Zone 10N

AECOM May, 2016



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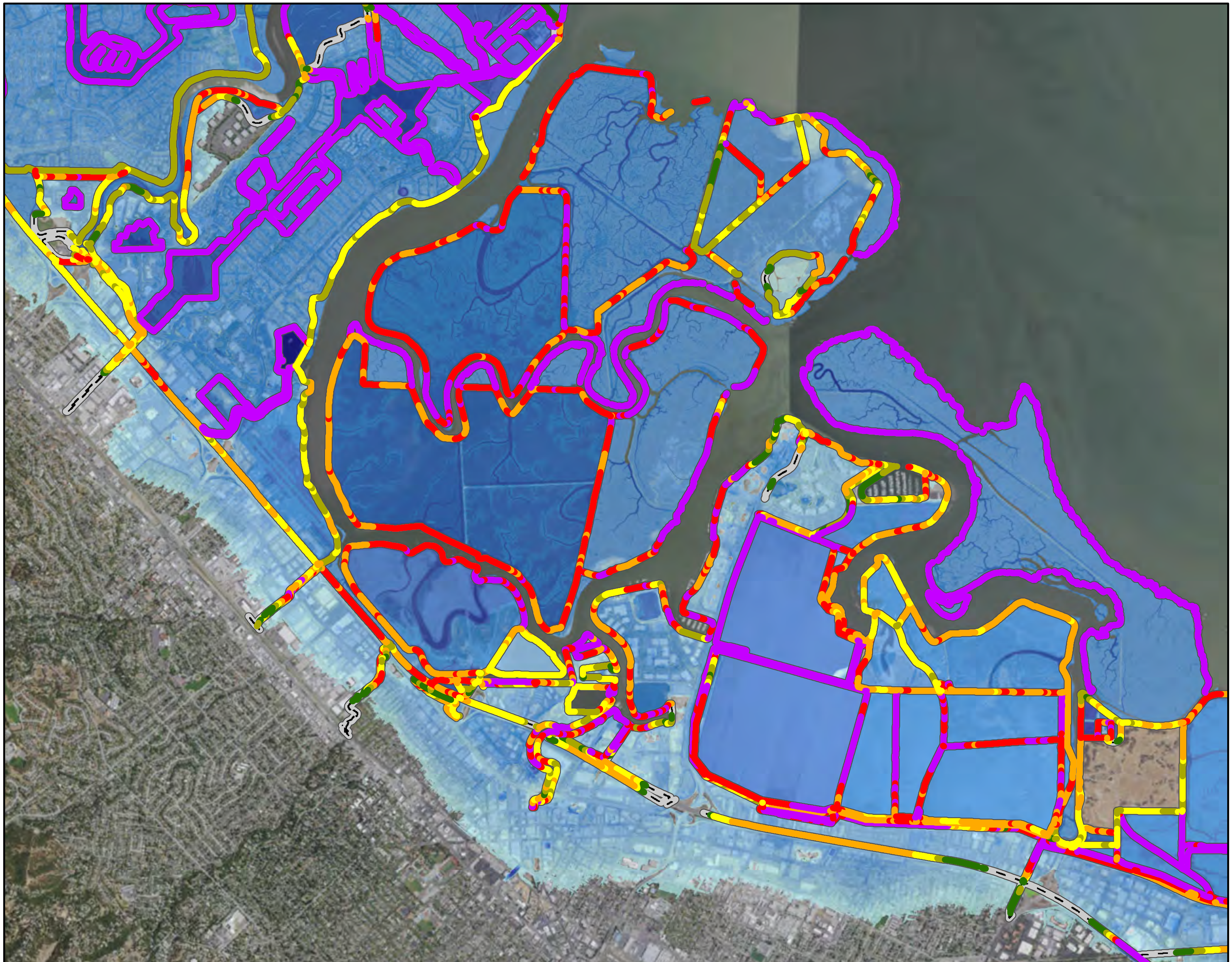


SAN MATEO COUNTY
Inundation Mapping

MHHW + 84" WATER LEVEL

SLR + STORM SURGE SCENARIOS LISTED BELOW COULD BE APPROXIMATED BY THE INUNDATION SHOWN ON THIS MAP.

42"SLR + 100-YEAR STORM SURGE
48"SLR + 50-YEAR STORM SURGE
54"SLR + 25-YEAR STORM SURGE
60"SLR + 10-YEAR STORM SURGE
66"SLR + 2-YEAR STORM SURGE

Shoreline Overtopping Potential

Depth in Feet

0 - 1
1 - 2
2 - 3
3 - 4
4 - 5
> 5
No Overtopping

Sea Level Rise Inundation

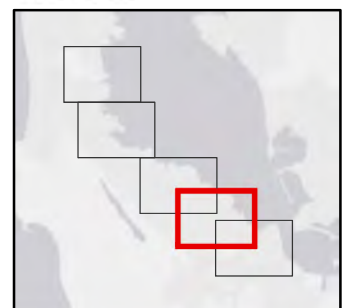
Depth in Feet

0 - 2
2 - 4
4 - 6
6 - 8
8 - 10
10 - 12
12 - 14
14 - 16
16+
Disconnected Areas > 1 Acre

0 0.2 0.4 0.6 0.8 Miles
0 1,000 2,000 3,000 4,000 Feet

Projection:
Universal Transverse Mercator NAD83 Zone 10N

AECOM May, 2016



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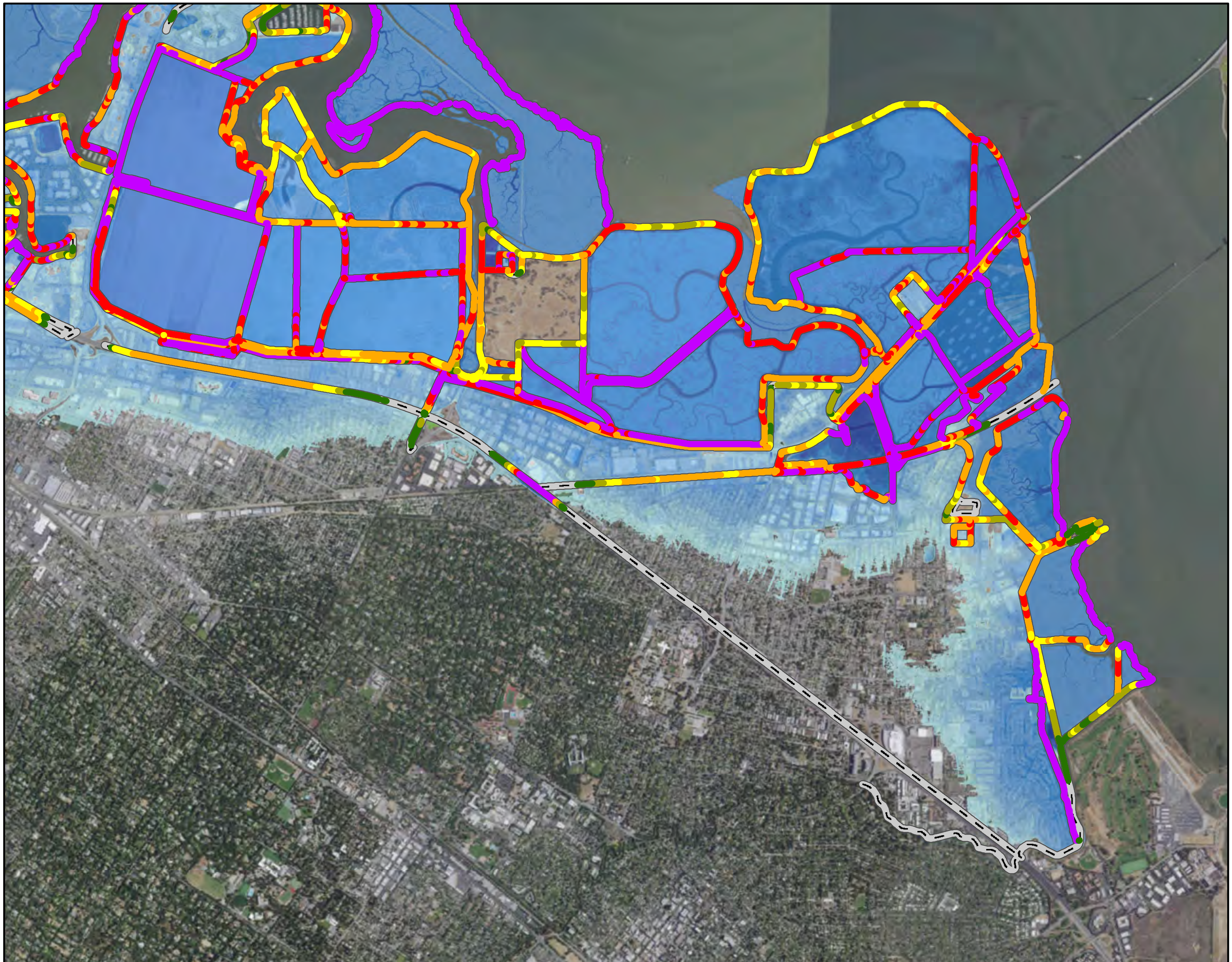


SAN MATEO COUNTY
Inundation Mapping

MHHW + 84" WATER LEVEL

SLR + STORM SURGE SCENARIOS LISTED BELOW COULD BE APPROXIMATED BY THE INUNDATION SHOWN ON THIS MAP.

42"SLR + 100-YEAR STORM SURGE
48"SLR + 50-YEAR STORM SURGE
54"SLR + 25-YEAR STORM SURGE
60"SLR + 10-YEAR STORM SURGE
66"SLR + 2-YEAR STORM SURGE

Shoreline Overtopping Potential

Depth in Feet

0 - 1
1 - 2
2 - 3
3 - 4
4 - 5
> 5

No Overtopping

Sea Level Rise Inundation

Depth in Feet

0 - 2
2 - 4
4 - 6
6 - 8
8 - 10
10 - 12
12 - 14
14 - 16
16+

Disconnected Areas > 1 Acre

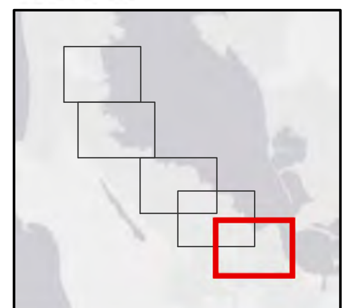
0 0.2 0.4 0.6 0.8 Miles

0 1,000 2,000 3,000 4,000 Feet

N

Projection:
Universal Transverse Mercator NAD83 Zone 10N

AECOM May, 2016



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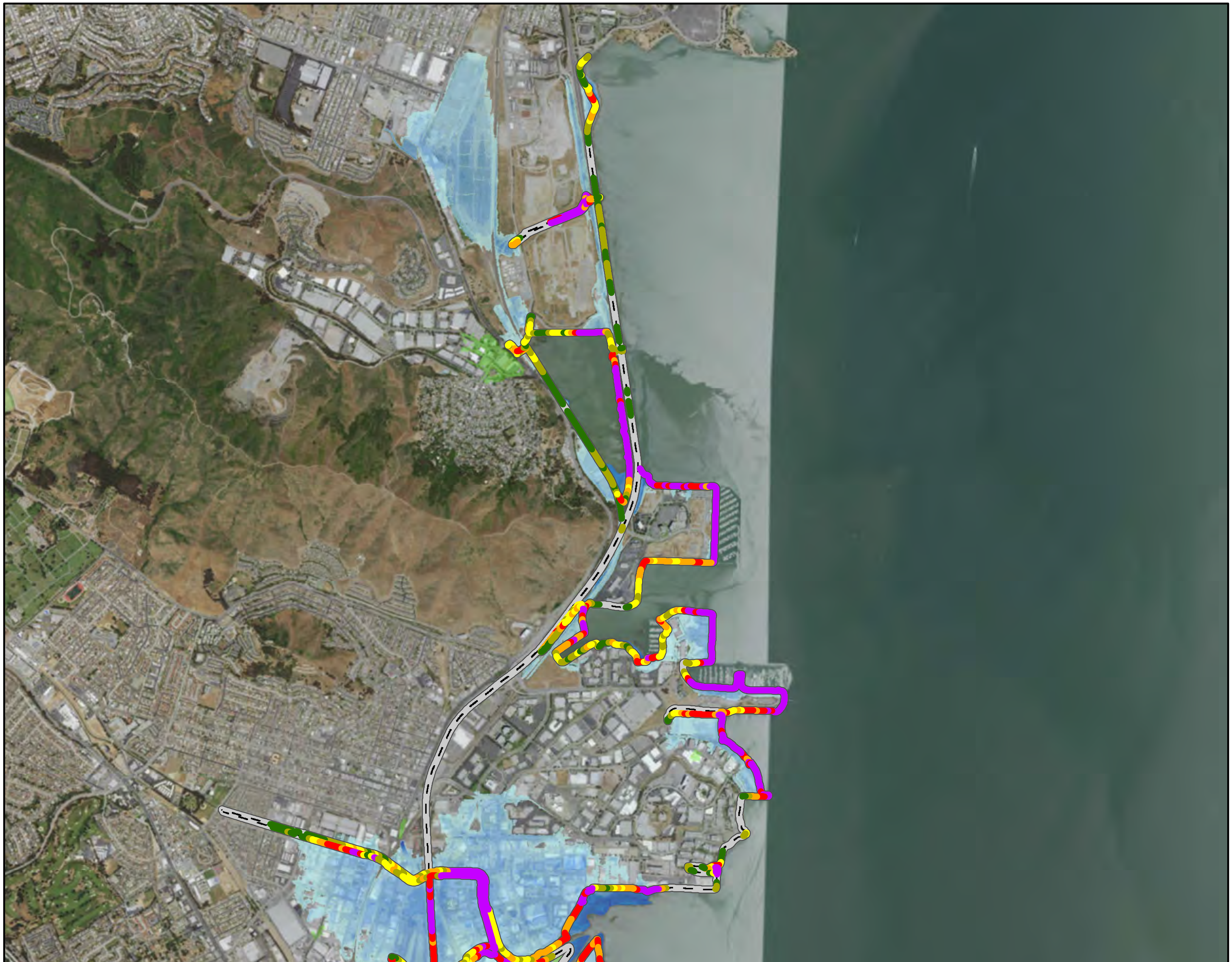


SAN MATEO COUNTY
Inundation Mapping

MHHW + 96" WATER LEVEL

SLR + STORM SURGE SCENARIOS LISTED BELOW COULD BE APPROXIMATED BY THE INUNDATION SHOWN ON THIS MAP.

54"SLR + 100-YEAR STORM SURGE
60"SLR + 50-YEAR STORM SURGE
66"SLR + 25-YEAR STORM SURGE

Shoreline Overtopping Potential

Depth in Feet

- 0 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- 4 - 5
- > 5
- No Overtopping

Sea Level Rise Inundation

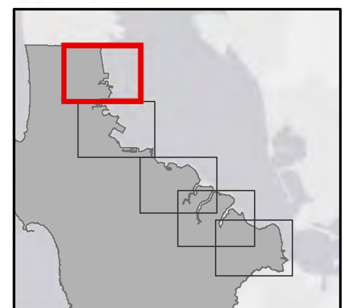
Depth in Feet

- 0 - 2
- 2 - 4
- 4 - 6
- 6 - 8
- 8 - 10
- 10 - 12
- 12 - 14
- 14 - 16
- 16+
- Disconnected Areas > 1 Acre

0 0.2 0.4 0.6 0.8 Miles
0 1,000 2,000 3,000 4,000 Feet
N

Projection:
Universal Transverse Mercator NAD83 Zone 10N

AECOM May, 2016



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SAN MATEO COUNTY
Inundation Mapping

MHHW + 96" WATER LEVEL

SLR + STORM SURGE SCENARIOS LISTED BELOW COULD BE APPROXIMATED BY THE INUNDATION SHOWN ON THIS MAP.

54"SLR + 100-YEAR STORM SURGE
60"SLR + 50-YEAR STORM SURGE
66"SLR + 25-YEAR STORM SURGE

Shoreline Overtopping Potential

Depth in Feet

0 - 1
1 - 2
2 - 3
3 - 4
4 - 5
> 5
No Overtopping

Sea Level Rise Inundation

Depth in Feet

0 - 2
2 - 4
4 - 6
6 - 8
8 - 10
10 - 12
12 - 14
14 - 16
16+
Disconnected Areas > 1 Acre

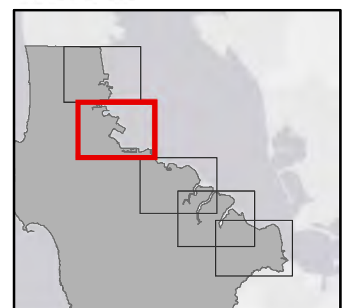
0 0.2 0.4 0.6 0.8 Miles

0 1,000 2,000 3,000 4,000 Feet

N

Projection:
Universal Transverse Mercator NAD83 Zone 10N

AECOM May, 2016



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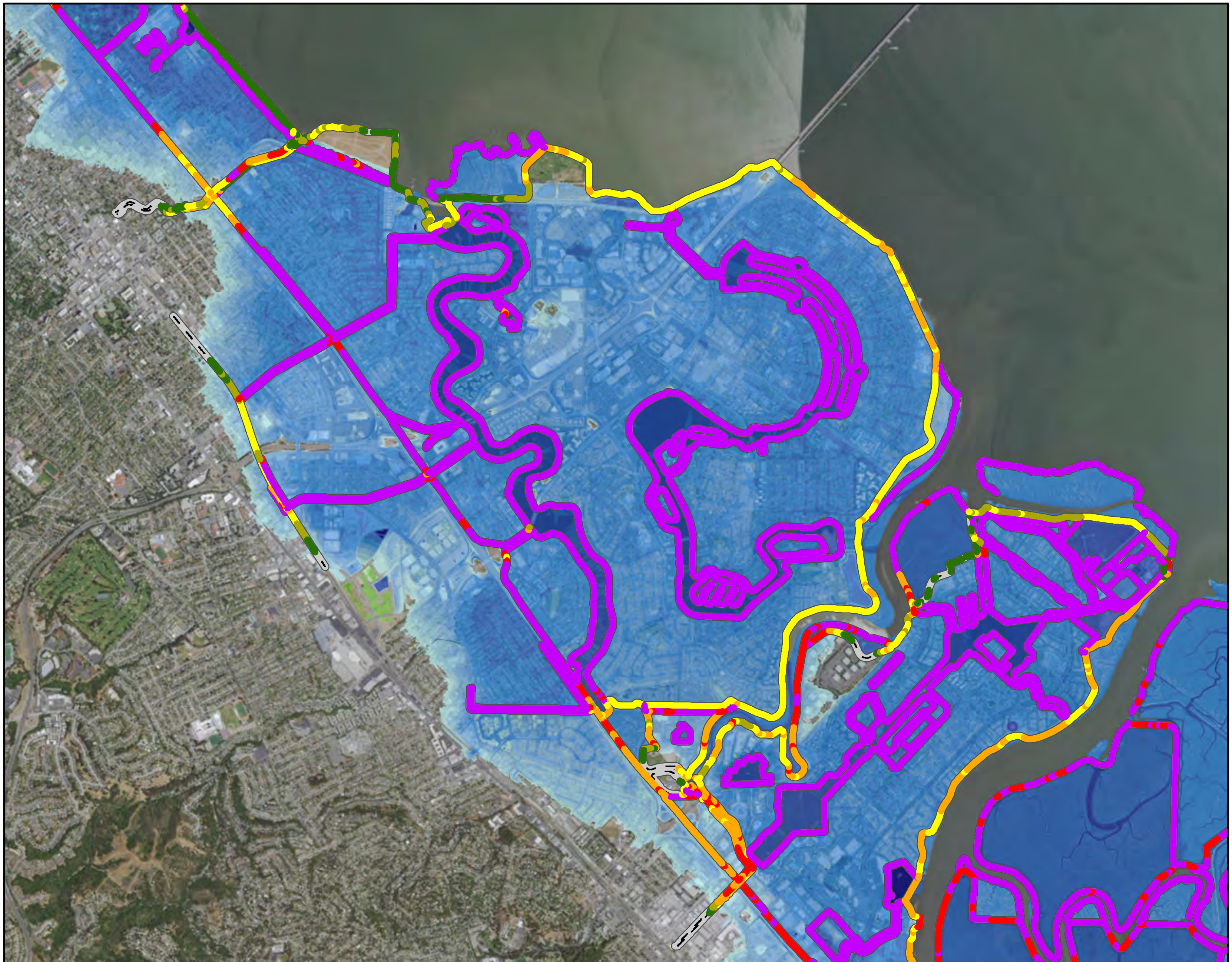


SAN MATEO COUNTY
Inundation Mapping

MHHW + 96” WATER LEVEL

SLR + STORM SURGE SCENARIOS LISTED BELOW COULD BE APPROXIMATED BY THE INUNDATION SHOWN ON THIS MAP.

54”SLR + 100-YEAR STORM SURGE
60”SLR + 50-YEAR STORM SURGE
66”SLR + 25-YEAR STORM SURGE

Shoreline Overtopping Potential

Depth in Feet

0 - 1
1 - 2
2 - 3
3 - 4
4 - 5
> 5

No Overtopping

Sea Level Rise Inundation

Depth in Feet

0 - 2
2 - 4
4 - 6
6 - 8
8 - 10
10 - 12
12 - 14
14 - 16
16+

Disconnected Areas > 1 Acre

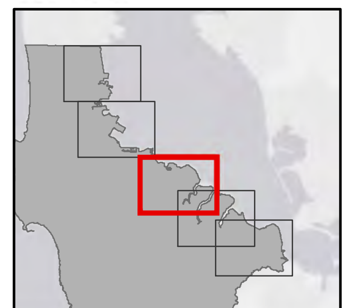
0 0.2 0.4 0.6 0.8 Miles

0 1,000 2,000 3,000 4,000 Feet

N

Projection:
Universal Transverse Mercator NAD83 Zone 10N

AECOM May, 2016



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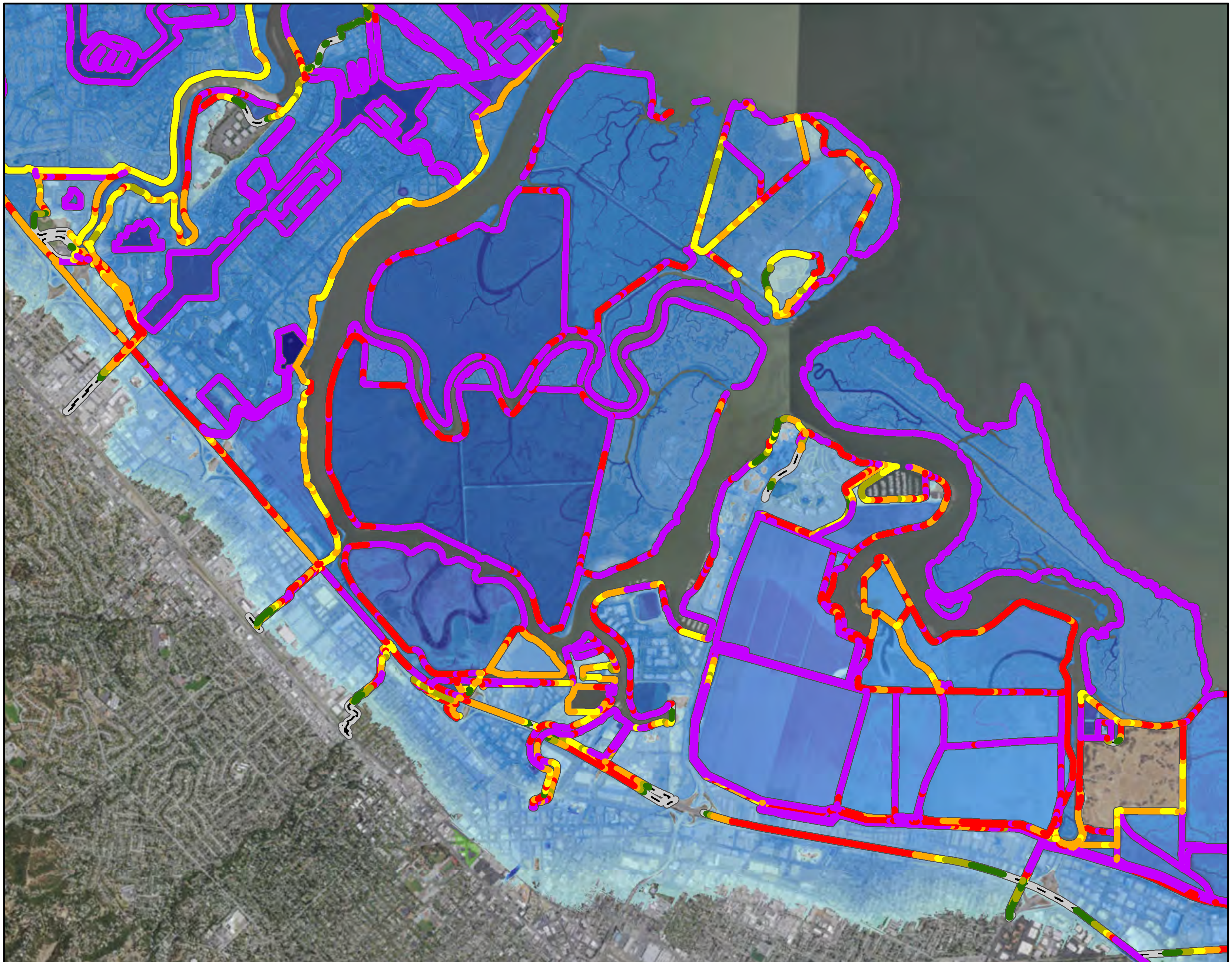


SAN MATEO COUNTY
Inundation Mapping

MHHW + 96" WATER LEVEL

SLR + STORM SURGE SCENARIOS LISTED BELOW COULD BE APPROXIMATED BY THE INUNDATION SHOWN ON THIS MAP.

54"SLR + 100-YEAR STORM SURGE
60"SLR + 50-YEAR STORM SURGE
66"SLR + 25-YEAR STORM SURGE

Shoreline Overtopping Potential

Depth in Feet

0 - 1
1 - 2
2 - 3
3 - 4
4 - 5
> 5

No Overtopping

Sea Level Rise Inundation

Depth in Feet

0 - 2
2 - 4
4 - 6
6 - 8
8 - 10
10 - 12
12 - 14
14 - 16
16+

Disconnected Areas > 1 Acre

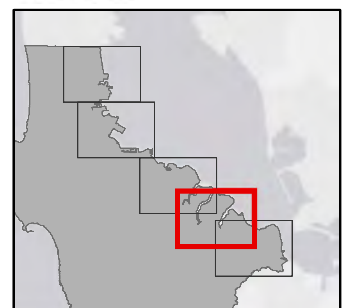
0 0.2 0.4 0.6 0.8 Miles

0 1,000 2,000 3,000 4,000 Feet

N

Projection:
Universal Transverse Mercator NAD83 Zone 10N

AECOM May, 2016



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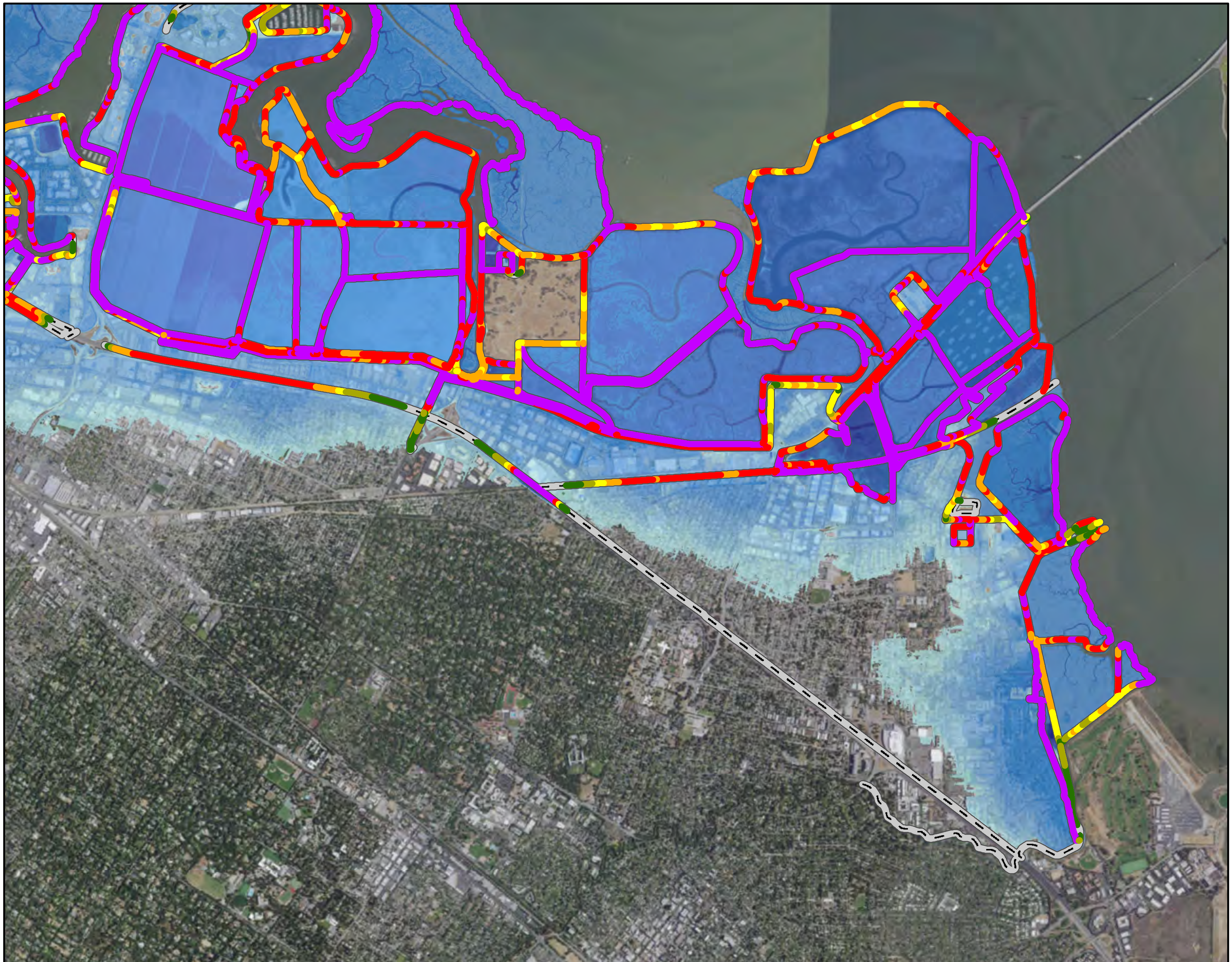

SAN MATEO COUNTY
Inundation Mapping

MHHW + 96" WATER LEVEL

SLR + STORM SURGE SCENARIOS LISTED BELOW COULD BE APPROXIMATED BY THE INUNDATION SHOWN ON THIS MAP.

54"SLR + 100-YEAR STORM SURGE
60"SLR + 50-YEAR STORM SURGE
66"SLR + 25-YEAR STORM SURGE

Shoreline Overtopping Potential

Depth in Feet

- 0 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- 4 - 5
- > 5

No Overtopping

Sea Level Rise Inundation

Depth in Feet

- 0 - 2
- 2 - 4
- 4 - 6
- 6 - 8
- 8 - 10
- 10 - 12
- 12 - 14
- 14 - 16
- 16+

Disconnected Areas > 1 Acre

0 0.2 0.4 0.6 0.8 Miles

0 1,000 2,000 3,000 4,000 Feet

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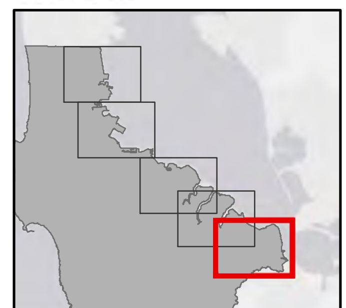
Projection:
Universal Transverse Mercator NAD83 Zone 10N

AECOM May, 2016



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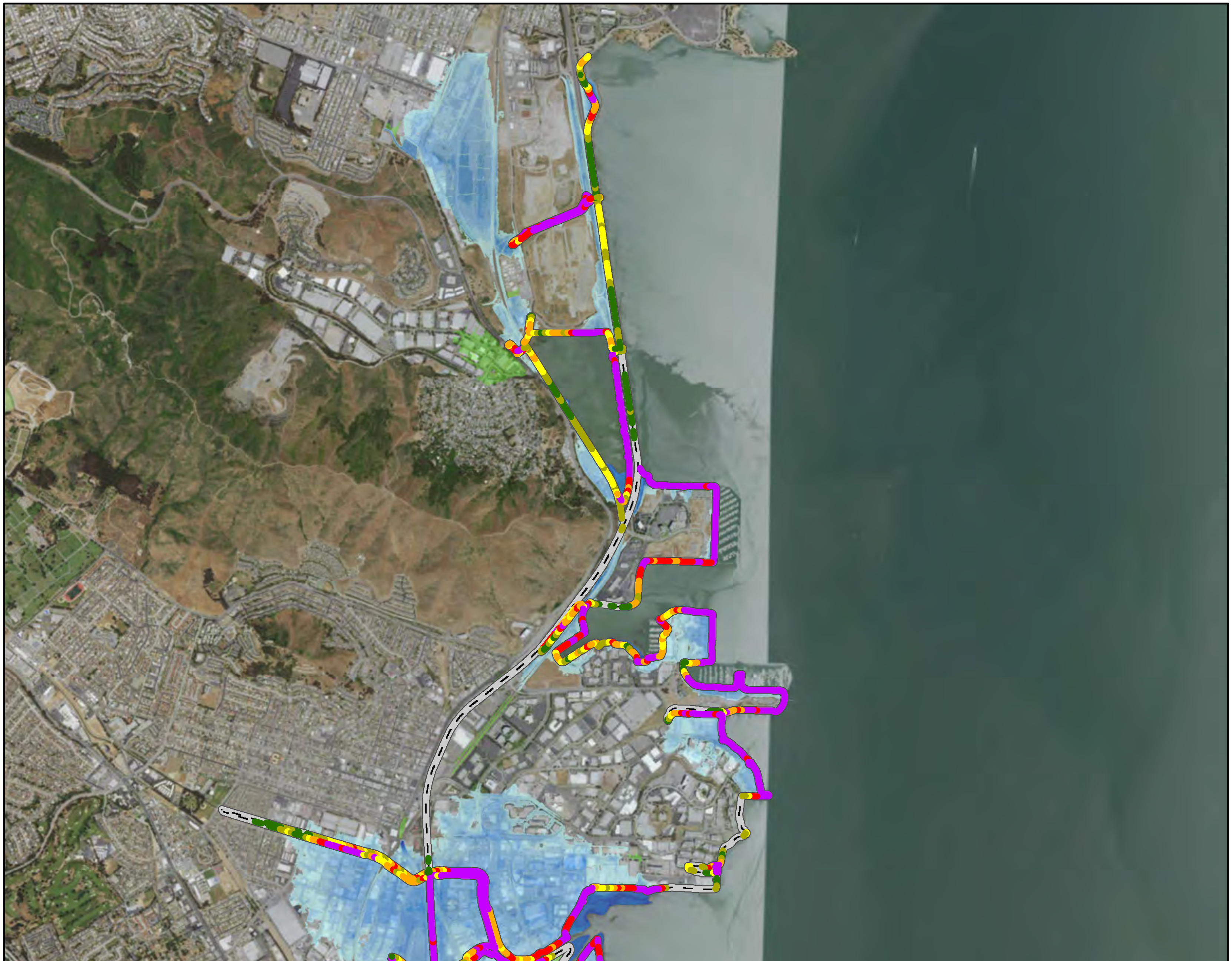


SAN MATEO COUNTY
Inundation Mapping

MHHW + 108" WATER LEVEL

SLR + STORM SURGE SCENARIOS LISTED BELOW COULD BE APPROXIMATED BY THE INUNDATION SHOWN ON THIS MAP.

66"SLR + 100-YEAR STORM SURGE

Shoreline Overtopping Potential

Depth in Feet

- 0 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- 4 - 5
- > 5
- No Overtopping

Sea Level Rise Inundation

Depth in Feet

- 0 - 2
- 2 - 4
- 4 - 6
- 6 - 8
- 8 - 10
- 10 - 12
- 12 - 14
- 14 - 16
- 16+
- Disconnected Areas > 1 Acre

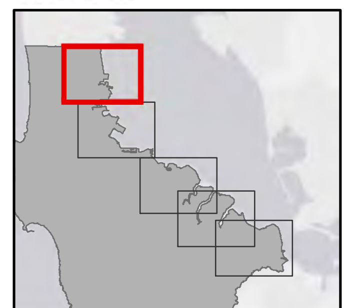
0 0.2 0.4 0.6 0.8 Miles

0 1,000 2,000 3,000 4,000 Feet

N

Projection:
Universal Transverse Mercator NAD83 Zone 10N

AECOM May, 2016



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SAN MATEO COUNTY
Inundation Mapping

MHHW + 108” WATER LEVEL

SLR + STORM SURGE SCENARIOS LISTED BELOW COULD BE APPROXIMATED BY THE INUNDATION SHOWN ON THIS MAP.

66”SLR + 100-YEAR STORM SURGE

Shoreline Overtopping Potential

Depth in Feet

- 0 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- 4 - 5
- > 5
- No Overtopping

Sea Level Rise Inundation

Depth in Feet

- 0 - 2
- 2 - 4
- 4 - 6
- 6 - 8
- 8 - 10
- 10 - 12
- 12 - 14
- 14 - 16
- 16+
- Disconnected Areas > 1 Acre

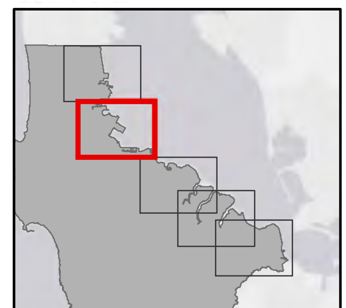
0 0.2 0.4 0.6 0.8 Miles

0 1,000 2,000 3,000 4,000 Feet

N

Projection:
Universal Transverse Mercator NAD83 Zone 10N

AECOM May, 2016



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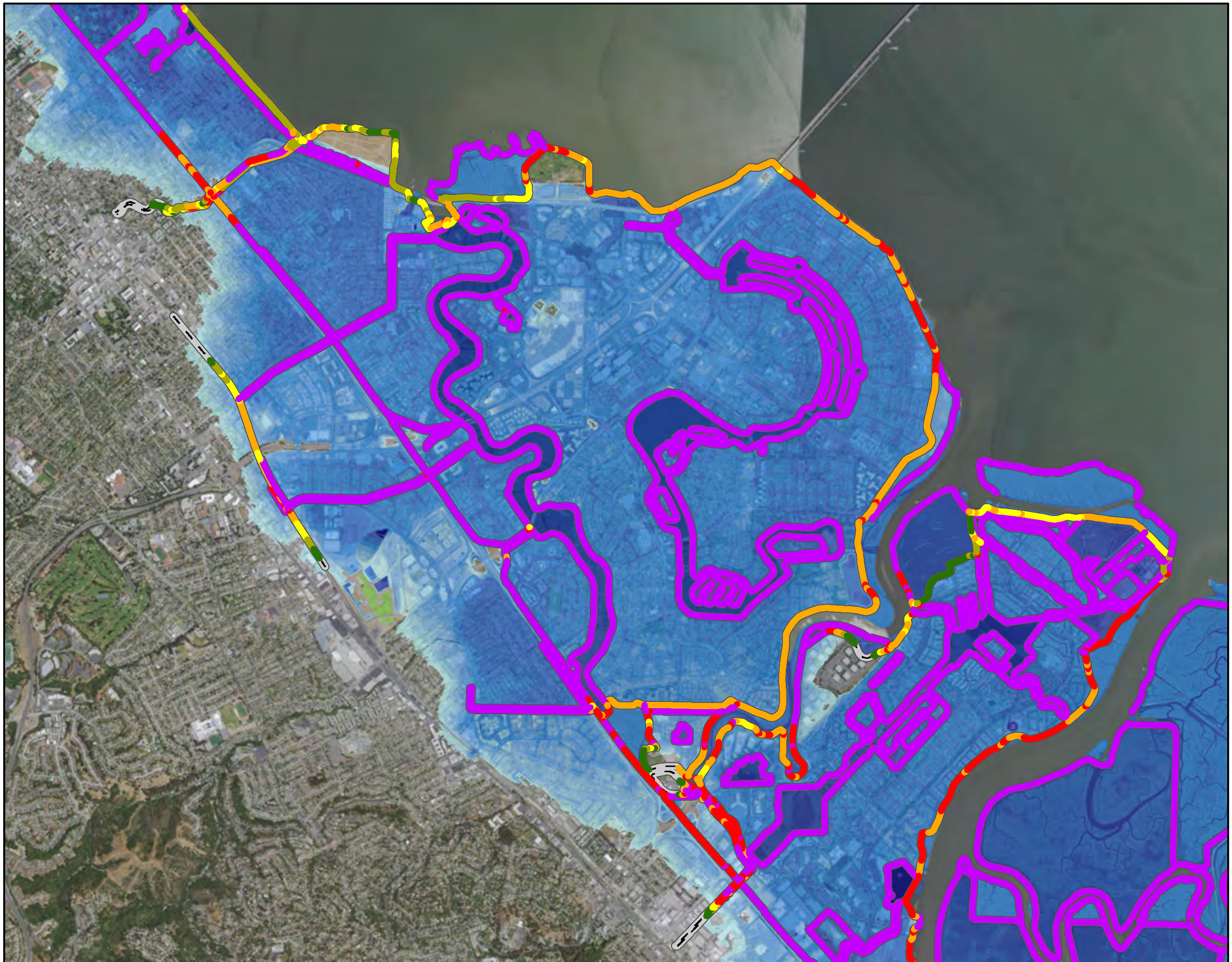
SAN MATEO COUNTY
Inundation Mapping



MHHW + 108" WATER LEVEL

SLR + STORM SURGE SCENARIOS LISTED BELOW COULD BE APPROXIMATED BY THE INUNDATION SHOWN ON THIS MAP.

66"SLR + 100-YEAR STORM SURGE

Shoreline Overtopping Potential

Depth in Feet

- 0 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- 4 - 5
- > 5

No Overtopping

Sea Level Rise Inundation

Depth in Feet

- 0 - 2
- 2 - 4
- 4 - 6
- 6 - 8
- 8 - 10
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- 12 - 14
- 14 - 16
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Disconnected Areas > 1 Acre

0 0.2 0.4 0.6 0.8 Miles

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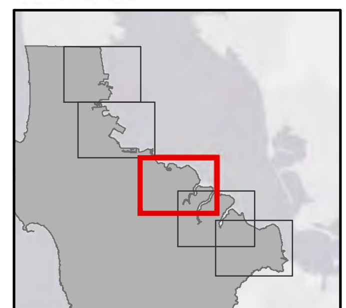

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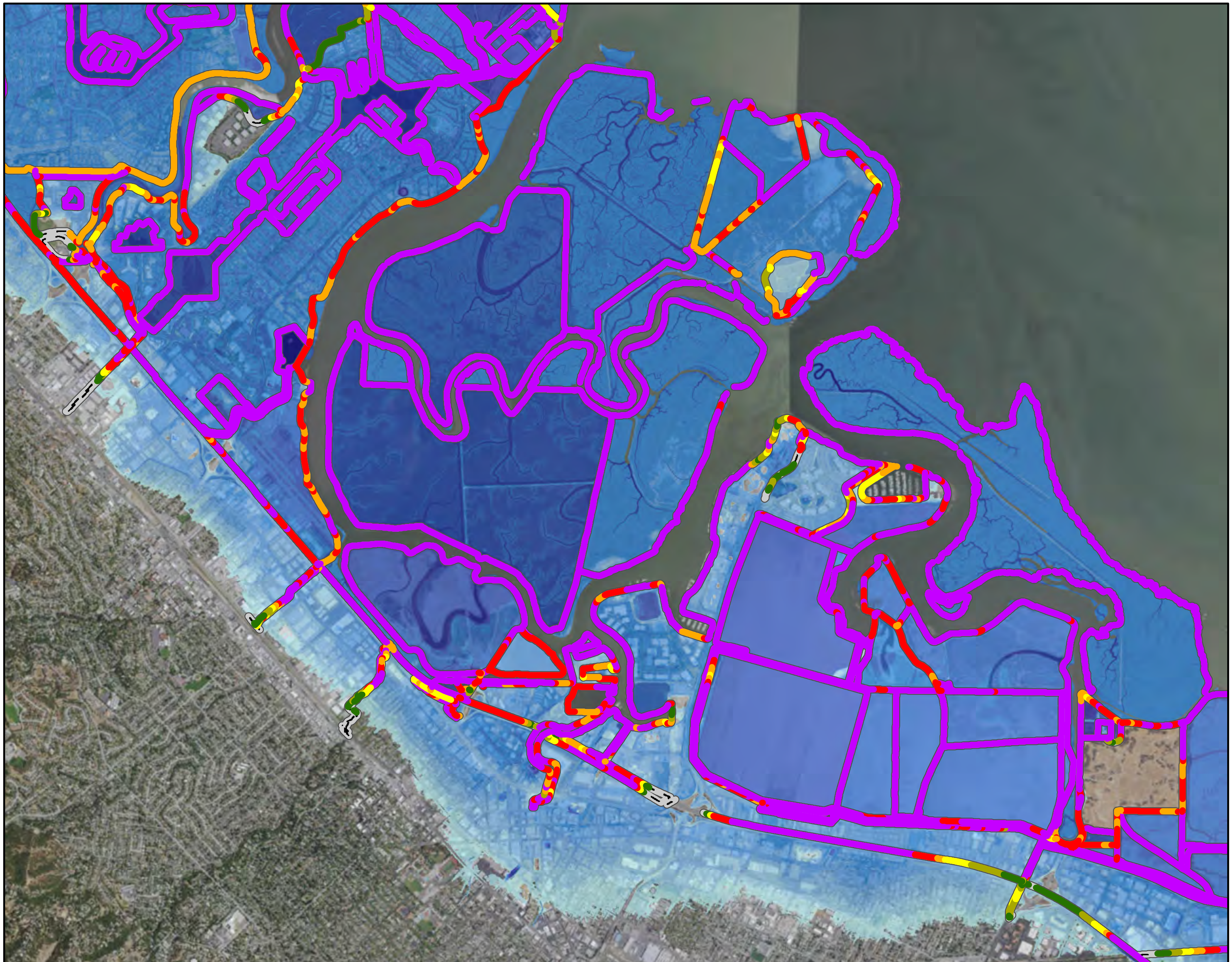

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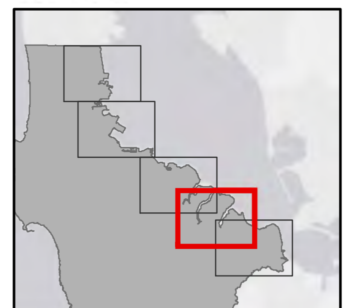

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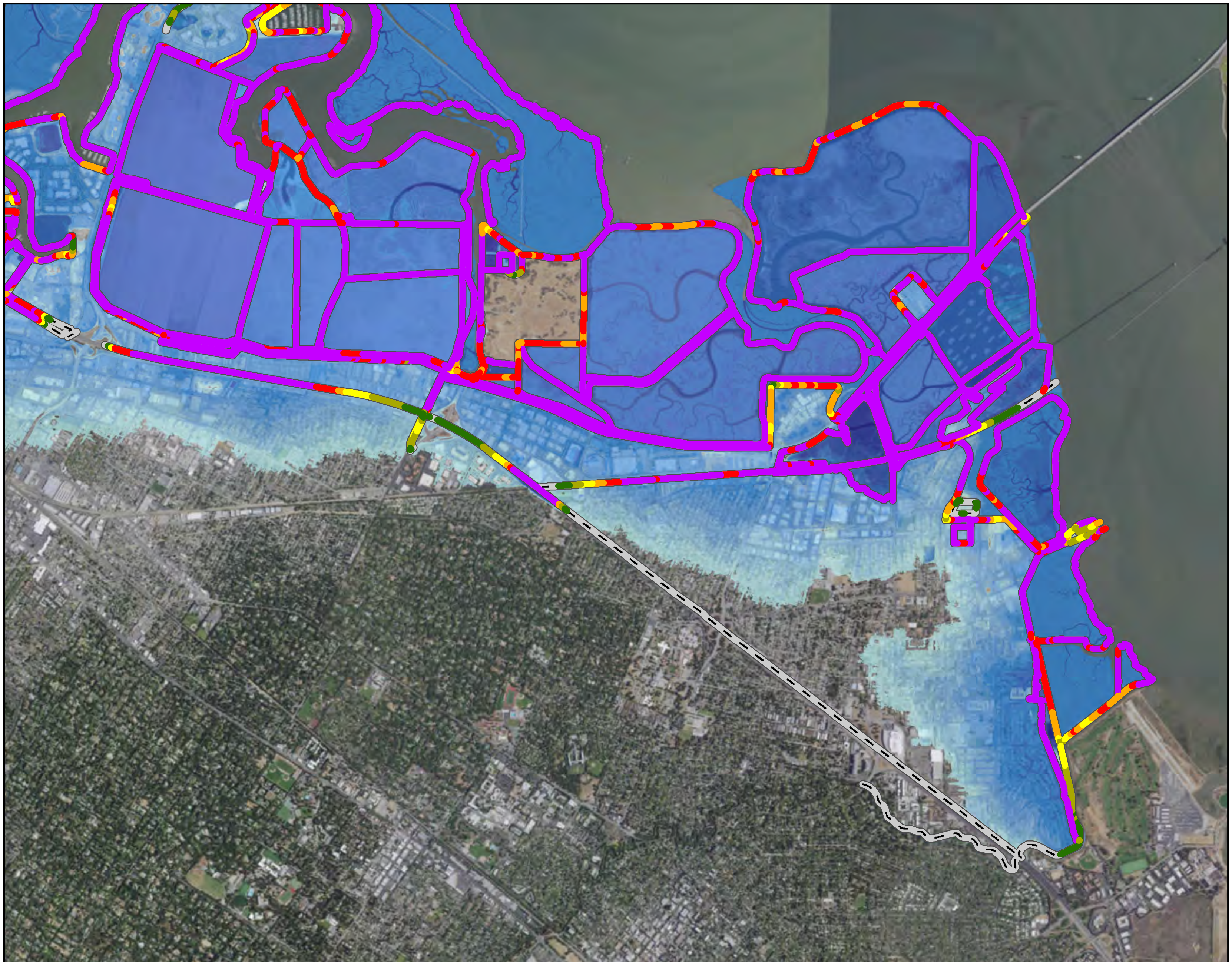

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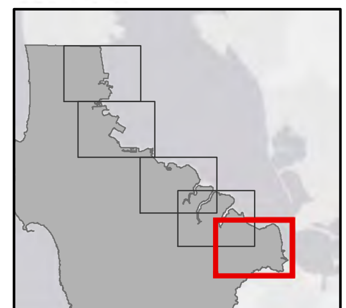

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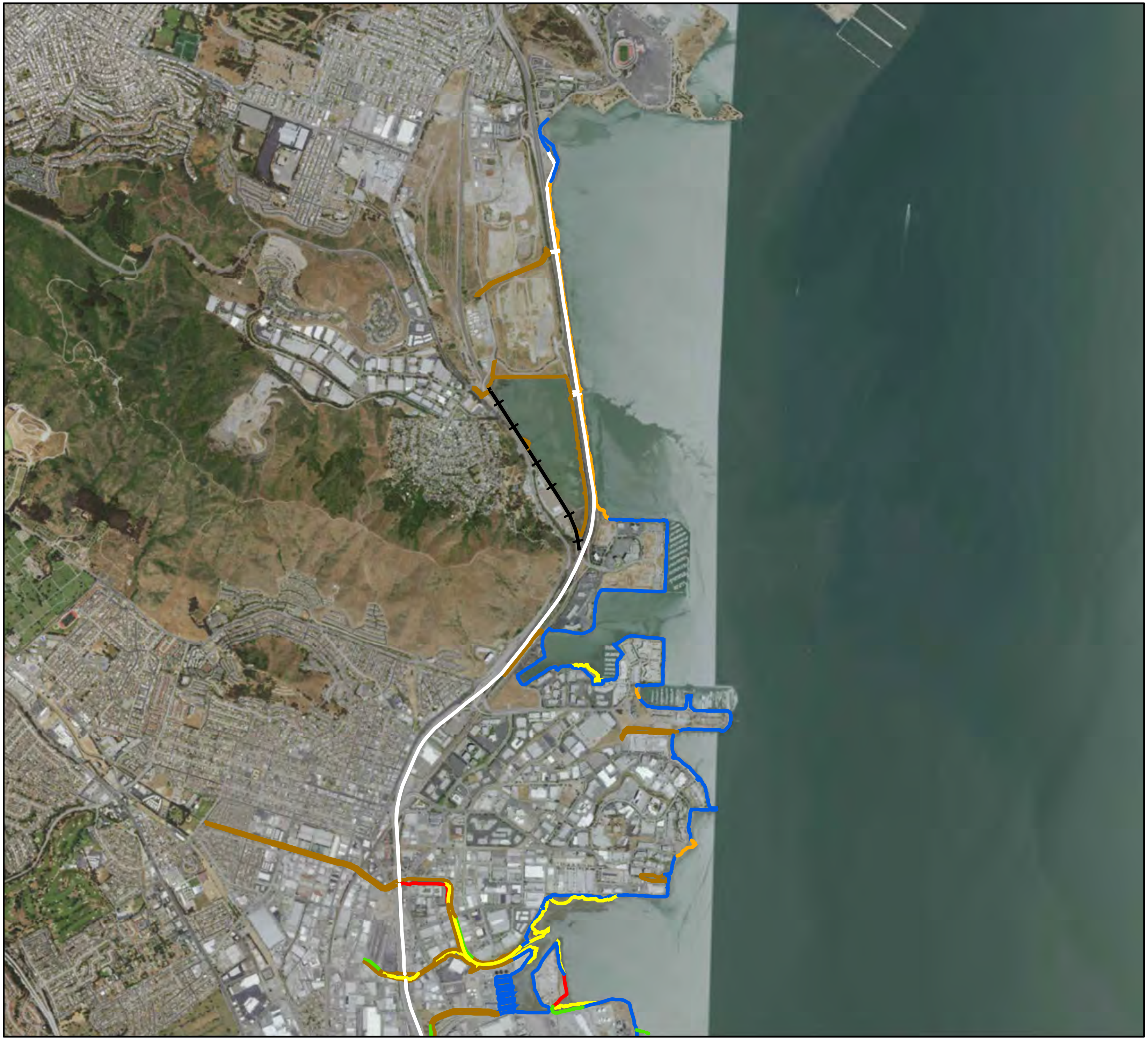
B

SHORELINE TYPE MAPS


Photo used under Creative Commons. Provided by Flickr user 'ElaineWithGreyCats'.



SAN MATEO COUNTY
Inundation Mapping

Shoreline Type

- Shoreline Protection Structure
- Engineered Flood Protection Structure
- Transportation Structure (Major Road)
- Transportation Structure (Rail)
- Embankment
- Non Engineered Berms
- Natural Shoreline: Wetland
- Natural Shoreline: Cliff or Bluff or Hill
- Tidegate

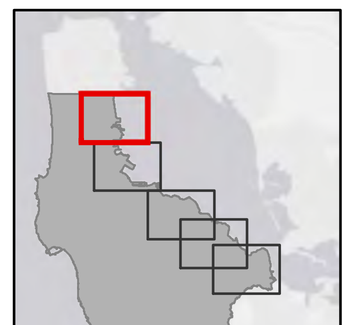
0 0.2 0.4 0.6 0.8 Miles

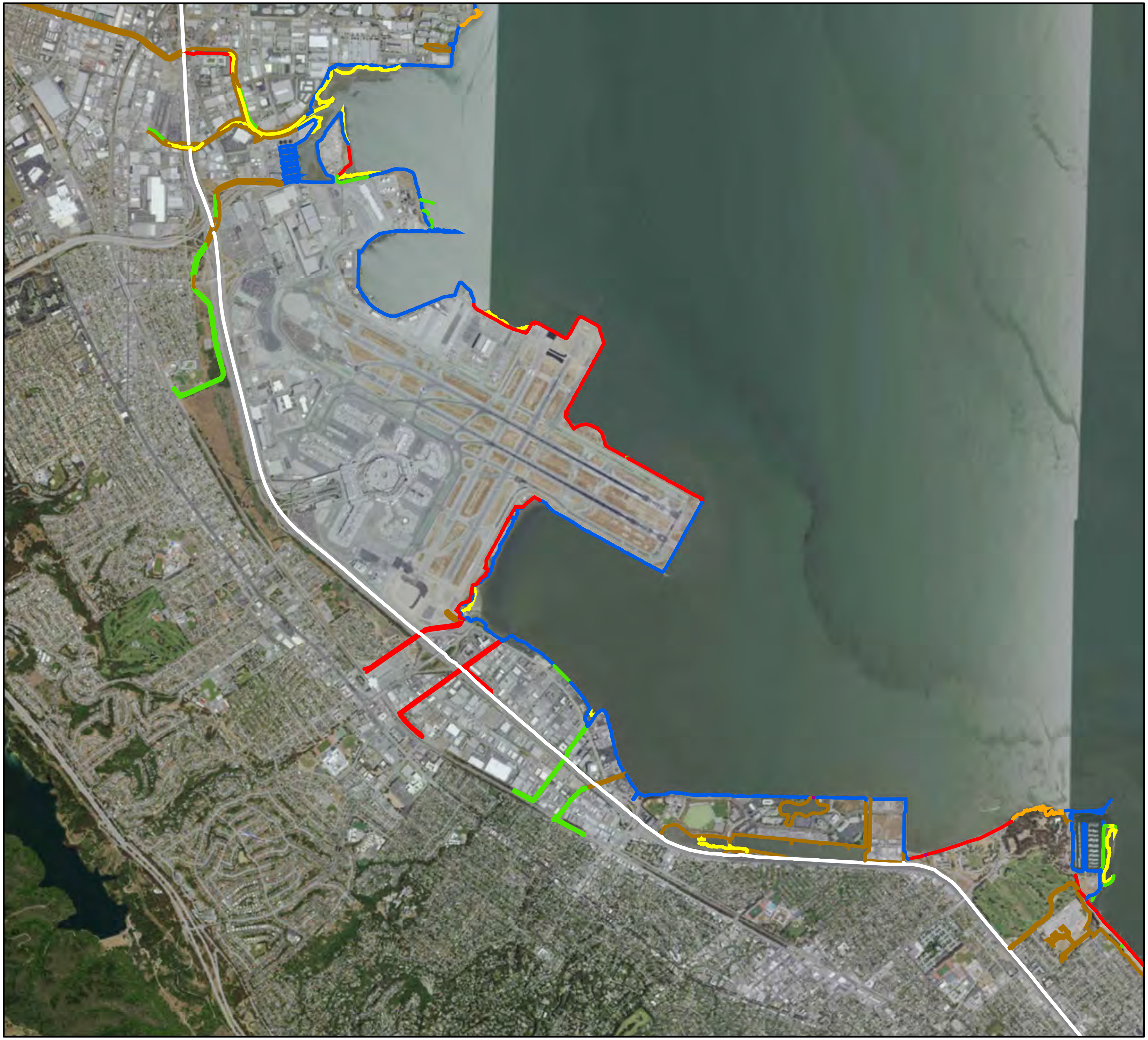
0 1,000 2,000 3,000 4,000 Feet

N

Projection:
Universal Transverse Mercator NAD83 Zone10N

AECOM May 2016





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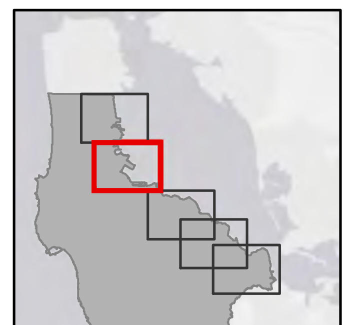

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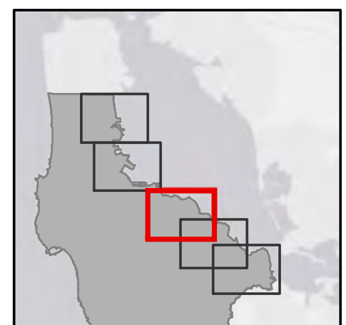

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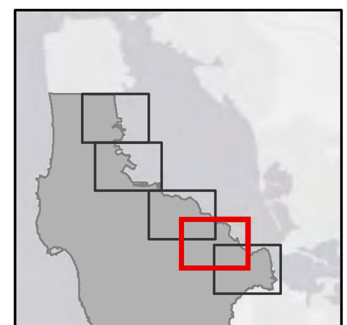

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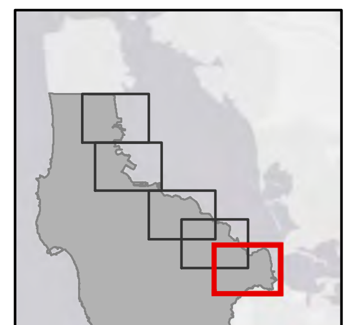
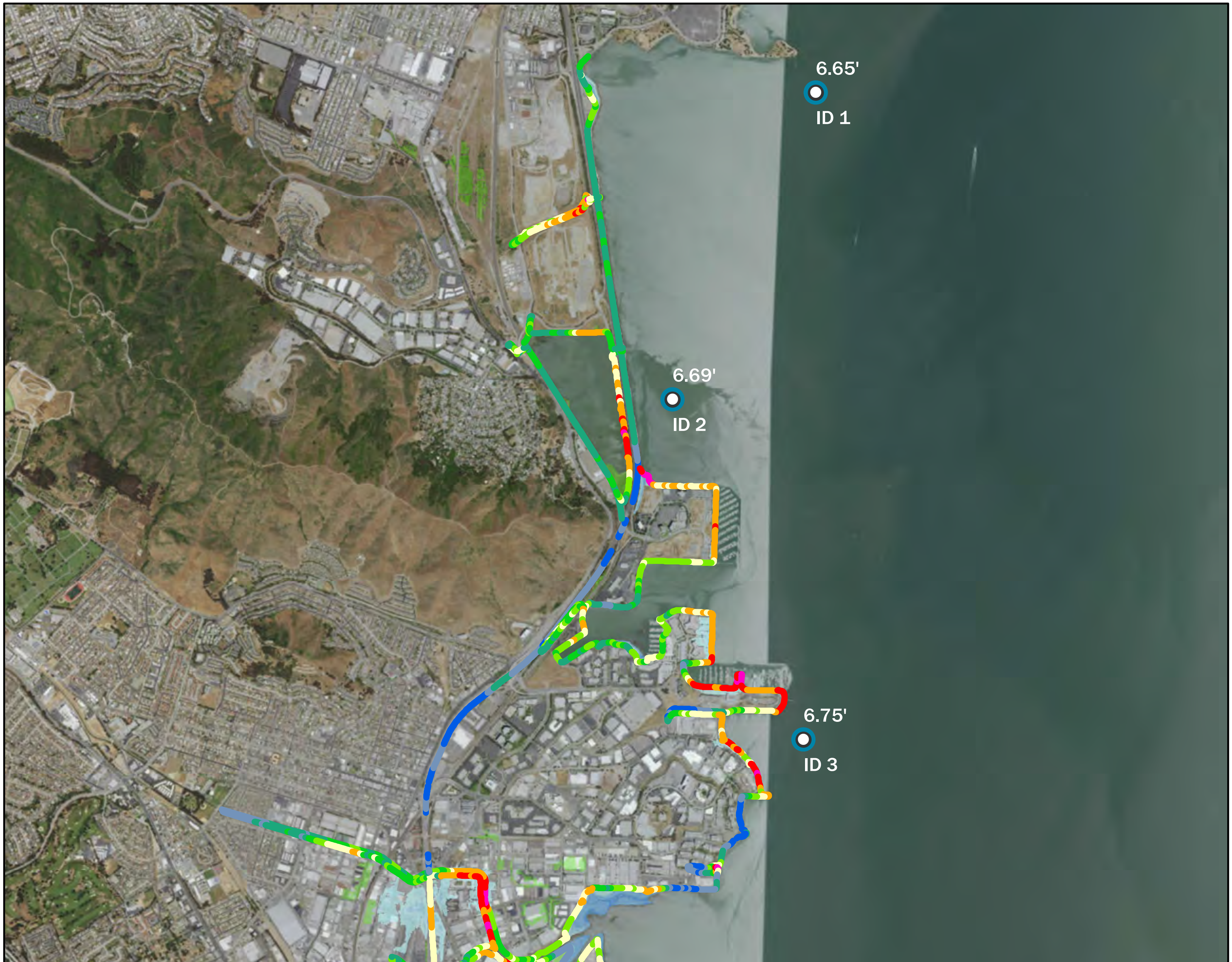


C

NORMALIZED SHORELINE MAPS



SAN MATEO COUNTY
Inundation Mapping

Normalized Shoreline Elevation relative to MHHW

- < 1.0
- 1.0 - 1.2
- 1.2 - 1.4
- 1.4 - 1.6
- 1.6 - 1.8
- 1.8 - 2.0
- 2.0 - 2.5
- 2.5 - 3.0
- > 3.0

MHHW Point Locations

MHHW (NAVD88)

MHHW + 36" Sea Level Rise

Depth in Feet

- 0 - 2
- 2 - 4
- 4 - 6
- 6 - 8
- 8 - 10
- 10 - 12
- 12 - 14
- 14 - 16
- 16+

Disconnected Areas > 1 Acre

0 0.2 0.4 0.6 0.8 Miles

0 1,000 2,000 3,000 4,000 Feet

N

Projection:
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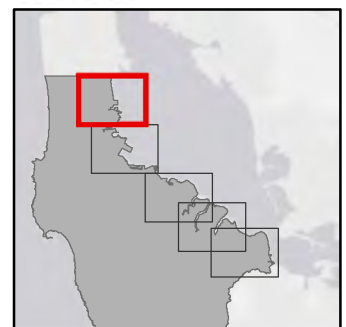
AECOM

May, 2016



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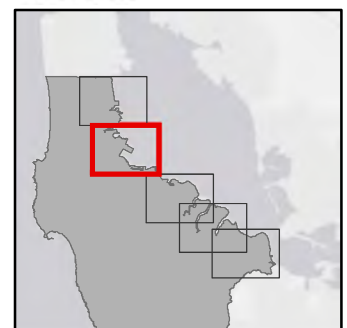

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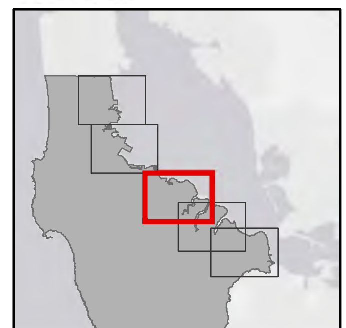

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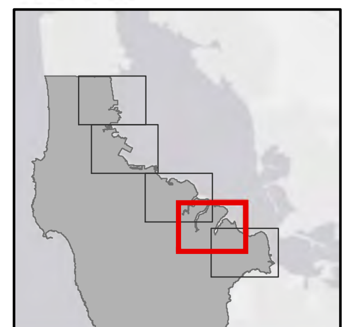

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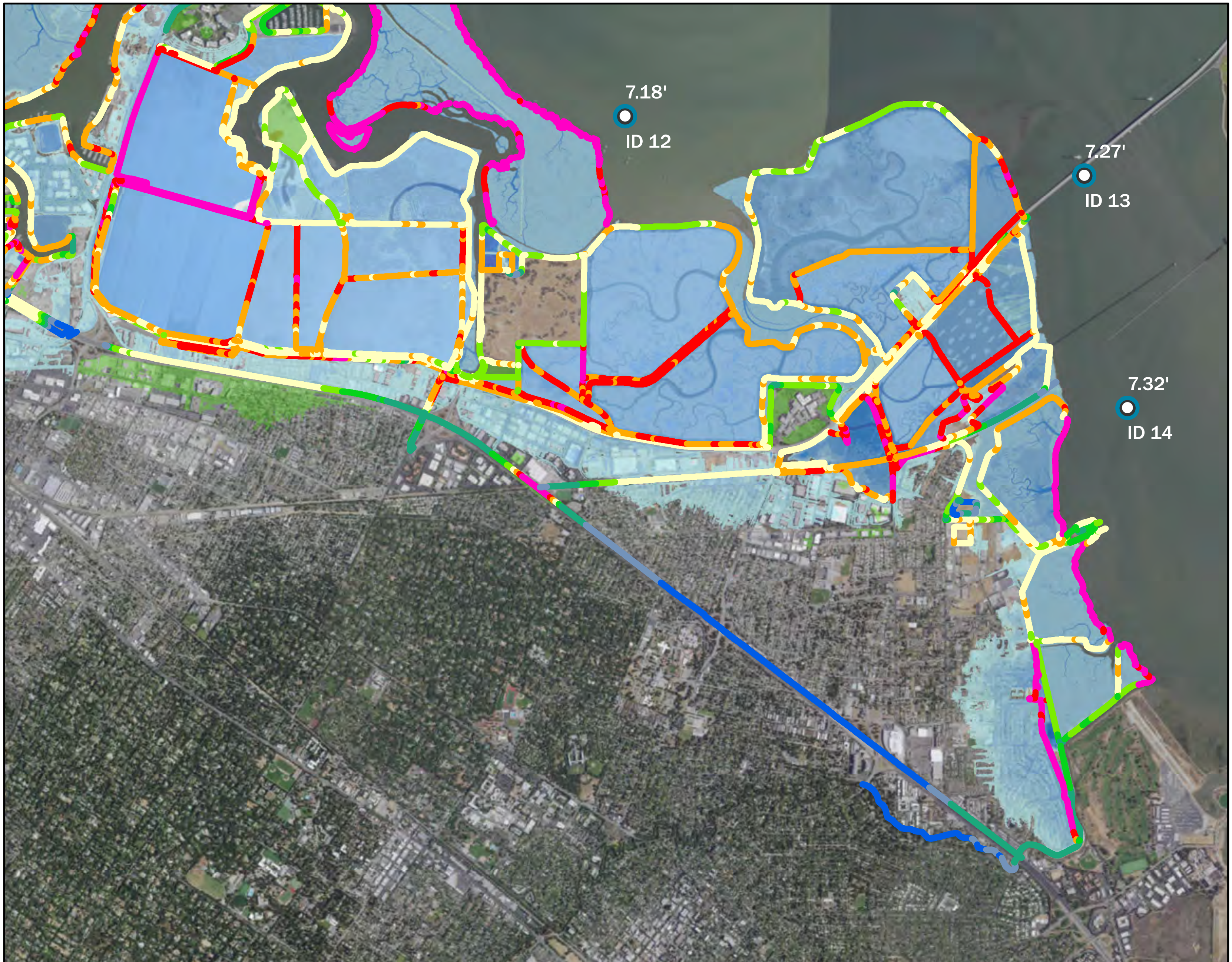

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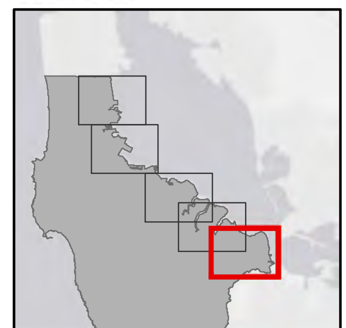
May, 2016



The inundation maps and the associated analyses provide a regional-scale illustration of inundation and coastal flooding due to specific sea level rise and storm surge scenarios, and are intended to improve sea level rise awareness and preparedness. The maps are not detailed to the parcel-scale and should not be used for navigation, permitting, regulatory, or other legal uses. Flooding due to sea level rise and storm surges is possible in areas outside of those predicted in these maps, and the maps do not guarantee the safety of an individual or structure. Nor do the maps model flooding from other sources, such as riverine or surface water flooding from rainfall-runoff events. The contributors and sponsors of this product do not assume liability for any injury, death, property damage, or other effects of flooding. The maps relied on a 1-meter digital elevation model created from LiDAR data collected in 2010 and additional survey data (where available). Although care was taken to capture all relevant topographic features and coastal structures that may impact coastal inundation, it is possible that structures may not be fully represented, especially those that are narrower than the 1-meter horizontal map scale. The maps are based on model outputs and do not account for all of the complex and dynamic San Francisco Bay processes or future conditions such as erosion, subsidence, future construction or shoreline protection upgrades, or other changes to San Francisco Bay or the region that may occur in response to sea level rise. More context about the maps and analyses, including a description of the data and methods used, are documented in the Sea Level Rise and Overtopping Analysis for San Mateo County's Bayshore Report (May 2016).