Climate Change Vulnerability Report Summary

This document summarizes the findings of the City of Benicia Climate Change Vulnerability and Risk Report. The summary is designed for members of the Technical Advisory Committee (TAC) and Community Advisory Group (CAG) to quickly review the key takeaways from the full report. Adaptation strategies will be explained in a subsequent report.

Time for Action

Despite local and worldwide efforts to reduce carbon emissions, climate change is already happening. The impacts on the Bay Area are expected to grow in scale and in scope over the years ahead. To address these changes, Benicia is proactively planning for the challenges of a changing climate by conducting this Climate Change Vulnerability Assessment and creating an Adaptation Plan that will identify actionable adaptation measures that are sustainable, equitable, economically viable, cost effective, and where feasible, able to be integrated into existing and future City plans. This plan will help Benicia prepare for and become a more resilient city that can manage the risks of today, as well as those of tomorrow. The time to act is now, policies and infrastructure put in place today will impact the development of Benicia and its resilience to a changing climate for years to come.

This Vulnerability and Risk Report Summary begins with a brief overview of current and future climatic conditions, and a summary of key sector level vulnerabilities. This work is funded through the California Coastal Conservancy's Climate Ready Grant Program (Round 1).

Benicia Climate Adaptation Goals

These goals were developed with input from the TAC and CAG. They currently serve as aspirational goals, the implementation of which will extend beyond the life of this project.

1. Protect the beauty and functionality of the many assets that support Benicia's high quality of life, including historic districts and buildings, the shoreline, wetlands, marshes and shoreline recreational features.
2. Support all of Benicia's residents and businesses where they live and work in the face of climate change vulnerability, and help them to plan for and recover quickly from climate-related emergencies.
3. Incorporate planning for climate change, vulnerability and adaptation in all City functions, including planning, public works, parks and recreation, and emergency preparedness.
4. Revise local land use plans, development regulations and building codes to aid and protect future development projects in the face of climate change.
5. Serve as a regional leader and model in planning for climate change and adaptation, and cooperate with regional agencies and neighboring jurisdictions in planning for regional readiness and resilience.
6. Educate the public on the need for personal disaster preparedness, adaptation and investment in resilient infrastructure.
7. Use public art to illustrate issues and educate the public regarding climate change, vulnerability and adaptation.

Our Climate is Changing

Current Hazards

Benicia currently experiences natural hazards that threaten residents, businesses, and infrastructure. Existing stressors include earthquakes, storm surge, flooding, wildfires, landslides, extreme temperatures, and drought. Some of these existing stressors are projected to be exacerbated by climate

change, such as sea level rise, flooding and extreme temperatures.

A Range of Futures

The Intergovernmental Panel on Climate Change (IPCC), a scientific body established by the United Nations, regularly reviews, assesses, and summarizes the current state of knowledge on global climate change. The IPCC recognizes that all of their four future climate scenarios are "equally likely" and so, while all scenarios show an upward trend in global greenhouse gas emissions and measurable changes in climate, it is uncertain whether the lower emissions scenarios or the higher emissions scenarios will come to pass. Therefore, this report identifies that climate change projections vary. The projections used in this report are averages from many data sets and show a range of plausible future conditions. Neither end of the projection range is considered more likely to occur than the other because it is unknown how future policies will impact the rate of greenhouse gas emissions.

Benicia specific climate change projections were created using downscaled climate change data (i.e., a strategy for generating locally relevant data from global climate models) from publicly accessible data sets and tools (data sources noted below). The downscaled data shows that the greatest changes could occur to sea level rise and extreme temperatures and so, those climate stressors were selected for evaluation in this assessment.

Temperatures are Rising

Over the next 30 or so years, temperatures in Benicia are projected to climb. While the average temperature will only increase by a few degrees, Benicia may experience up to two months (54-66 days) of temperatures over 92°F. Historically, temperatures have only reached this threshold on the hottest five percent of days (18 days) per year. Looking out to the end-of-century time frame, these temperatures may occur even more frequently—62 to 101 days per year.

Building on the ART Project

The City of Benicia project is modeled after the San Francisco Bay Conservation and Development Commission's (BCDC) Adapting to Rising Tides (ART) project. During the ART project, BCDC, with support from the National Oceanic and Atmospheric Administration Coastal Services Center (NOAA CSC), undertook a detailed sea level rise vulnerability assessment project in Alameda County.

The ART project developed and piloted a process for conducting vulnerability assessments by bringing together a broad suite of stakeholders and experts to collectively gain a better understanding of how climate change will affect the ecosystems, infrastructure, and economy of Alameda County.

The City of Benicia is using the tools and framework developed for the ART project as much as feasible. Due to the differing scales of analysis (city vs. region) and project timeline, the tools have been customized for a local planning effort.

For more information on the ART project, please see http://www.adaptingtorisingtides.org/.

Table 1 displays annual temperature statistics. In order to avoid idiosyncrasies in the weather of any given year, the results display the average of a 49 year time frame. Temperature projections are derived from the World Climate Research Programme's Fifth Coupled Model Intercomparison Project (CMIP5). CMIP5 averages the projections of many climate models under different future greenhouse gas emissions scenarios. ICF used the CMIP Climate Data Processing Tool, soon to be available on the US Department of Transportation (DOT) website, to process the model outputs into variables that are more useful for planning and engineering.

Table 1: Range of Projected Changes in Temperature

Variable	Baseline (1950-1999) *Observed Value*	Mid-century (2046-2065) *Modeled Value*	End-of-century (2080-2099) *Modeled Value*
Average Annual Mean Temperature	59 °F	62 – 63 °F	63 – 67 °F
Hottest Temperature of the Year	102 °F	107 – 108 °F	108 – 112 °F
Average Number of Days per Year above 92.4°F **(95% of days in Benicia have historically fallen below this temperature)**	18 days	54 – 66 days	62 – 101 days
Maximum Number of Consecutive Days per Year above 92.4°F	5 days	12 – 15 days	13 – 32 days
Average Summer Temperatures	84 ° F	88 – 89 ° F	89 – 93 ° F
Highest 4-Day Average Summer Temperature	98 ° F	102 – 104 ° F	103 – 107 ° F

Sea Levels are Rising and Costal Areas are Flooding

Sea levels have risen in the past and are projected to rise at an accelerated rate due to climate change. For Benicia and other coastal communities, without intervention, this will lead to flooding of critical structures, infrastructure, and natural habitats.

For this project, the ICF Team used the California Ocean Protection Council (OPC) 2013 sea level rise planning guidance projections. Benicia utilized publicly available sea level rise mapping tools (the National Oceanic and Atmospheric Administration (NOAA) Digital Coast Sea Level Rise Viewer[1] and Climate Central's Surging Seas Tool[2]) to visualize the following three sea level rise scenarios:

- 12 inches (low, mid-century projection)
- 24 inches (high, mid-century projection and the low end-of-century projection)
- 60 inches (high end-of-century projection)

To visualize impacts on natural habitats (e.g., marshes), the ICF Team used the Blue Point Conservation Science's Future San Francisco Bay Tidal Marshes: A Climate-Smart Planning Tool.[3]

To determine the effect of storms on coastal flooding, a FEMA study of average water level depths during storm events of various return intervals (e.g., 1-, 2-, 5-, 10-, 25-, 100-year) within the San Francisco Bay was used to identify current flood levels[4]. To combine the sea level rise mapping data and the storm depth data, the ICF Team used an approach called "total water levels". Total water levels

[1] http://coast.noaa.gov/digitalcoast/tools/slr
[2] http://sealevel.climatecentral.org/
[3] http://data.prbo.org/apps/sfbslr/
[4] FEMA CCAMP San Francisco Bay Area Coastal Study, http://www.r9map.org/Pages/San-Francisco-Coastal-Bay-Study.aspx

allows for the simultaneous consideration of changes in short-term, storm-related flooding as well as long-term permanent inundation due to sea level rise. The inundation scenarios represented by the total water levels are identified in the map legends in Figures 1, 2 and 3.

It should be noted that the elevation data used in the mapping may omit fine features affecting flooding connectivity (e.g. seawalls, ditches), meaning that the sea level rise maps may overstate the extent of flooding in certain locations. For example, the Benicia Wastewater Treatment Plant is protected by a flood wall that is not represented in the sea level rise model.

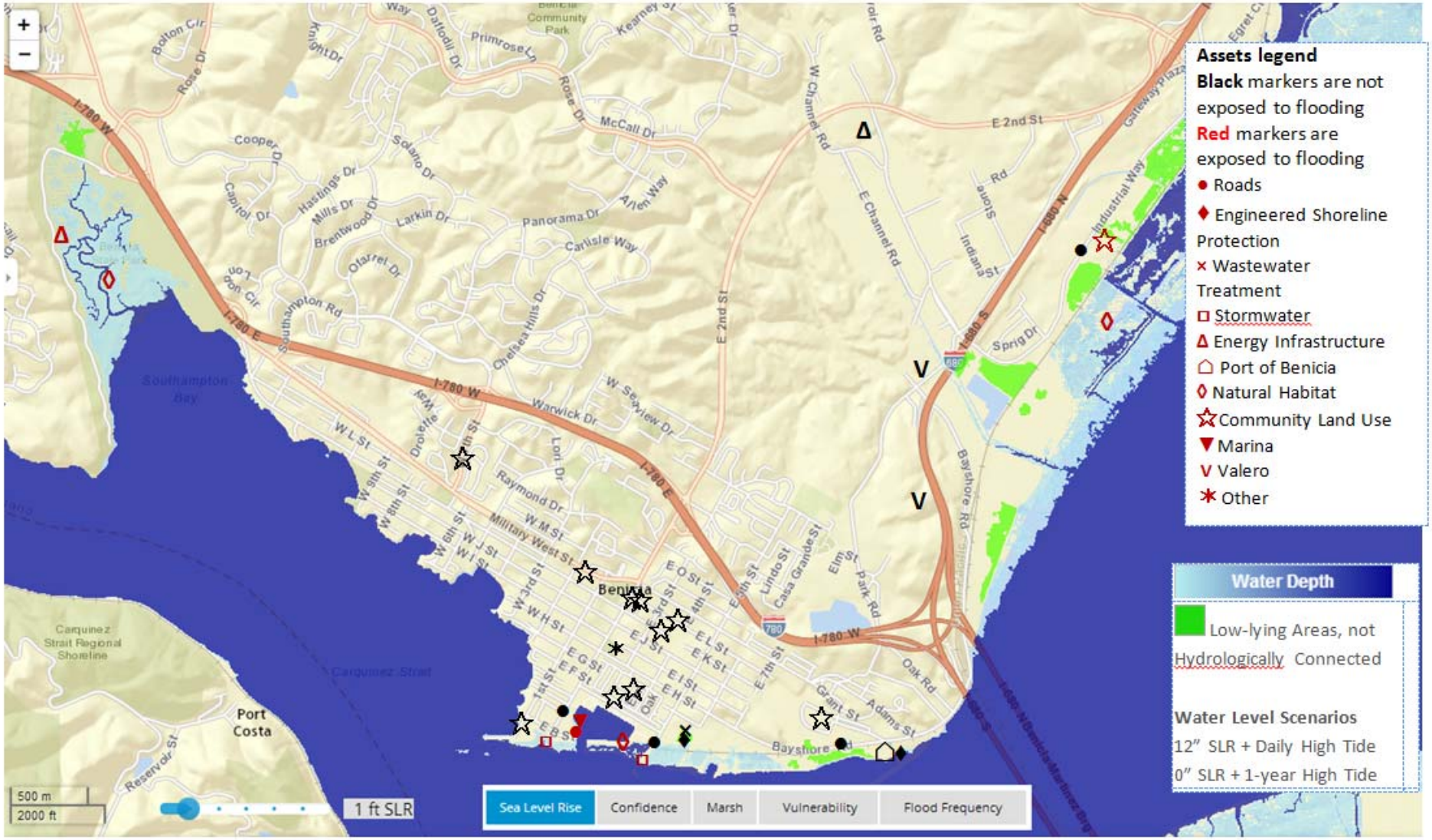


Figure 1: 12 Inches Total Water level

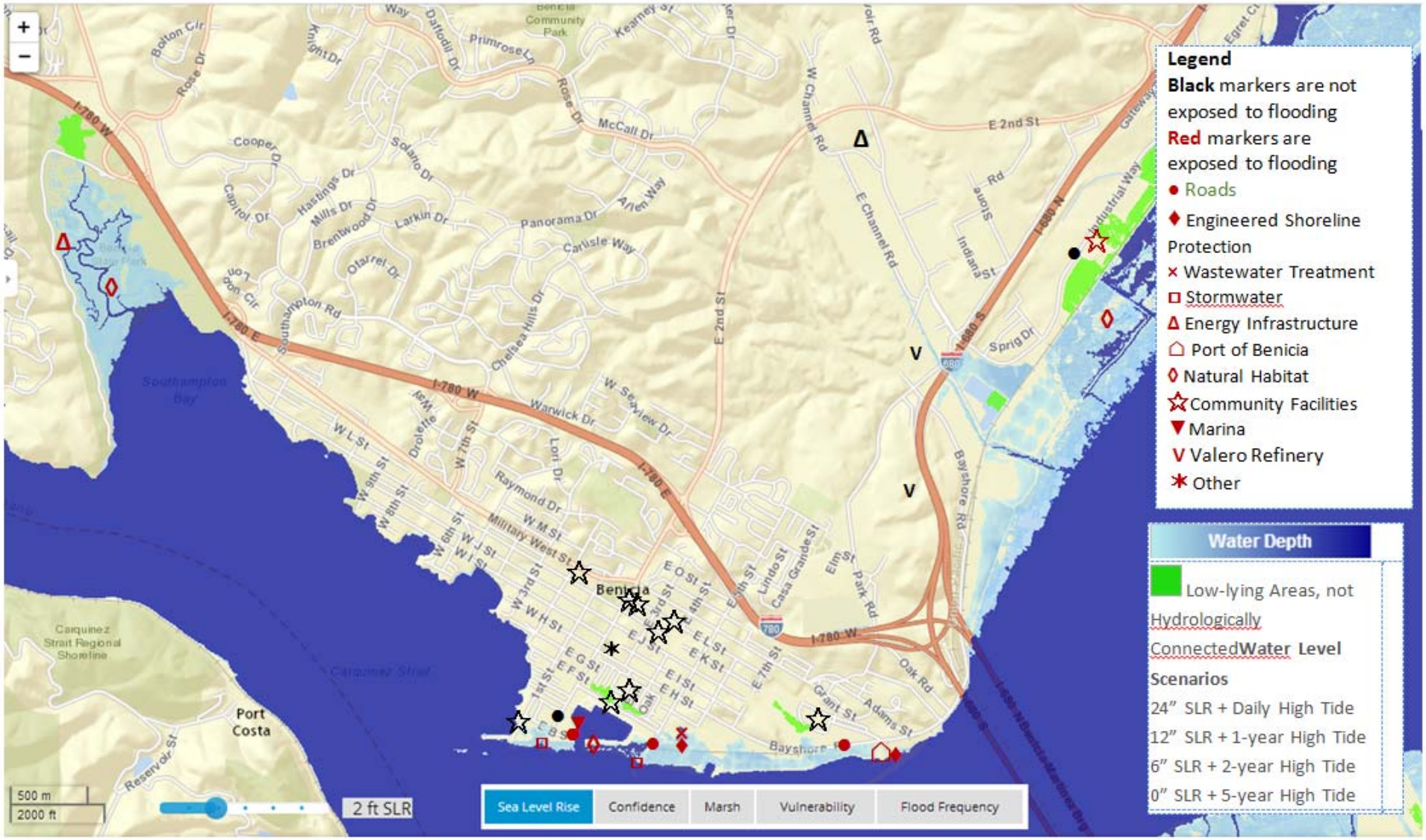


Figure 2: 24 Inches Total Water Level

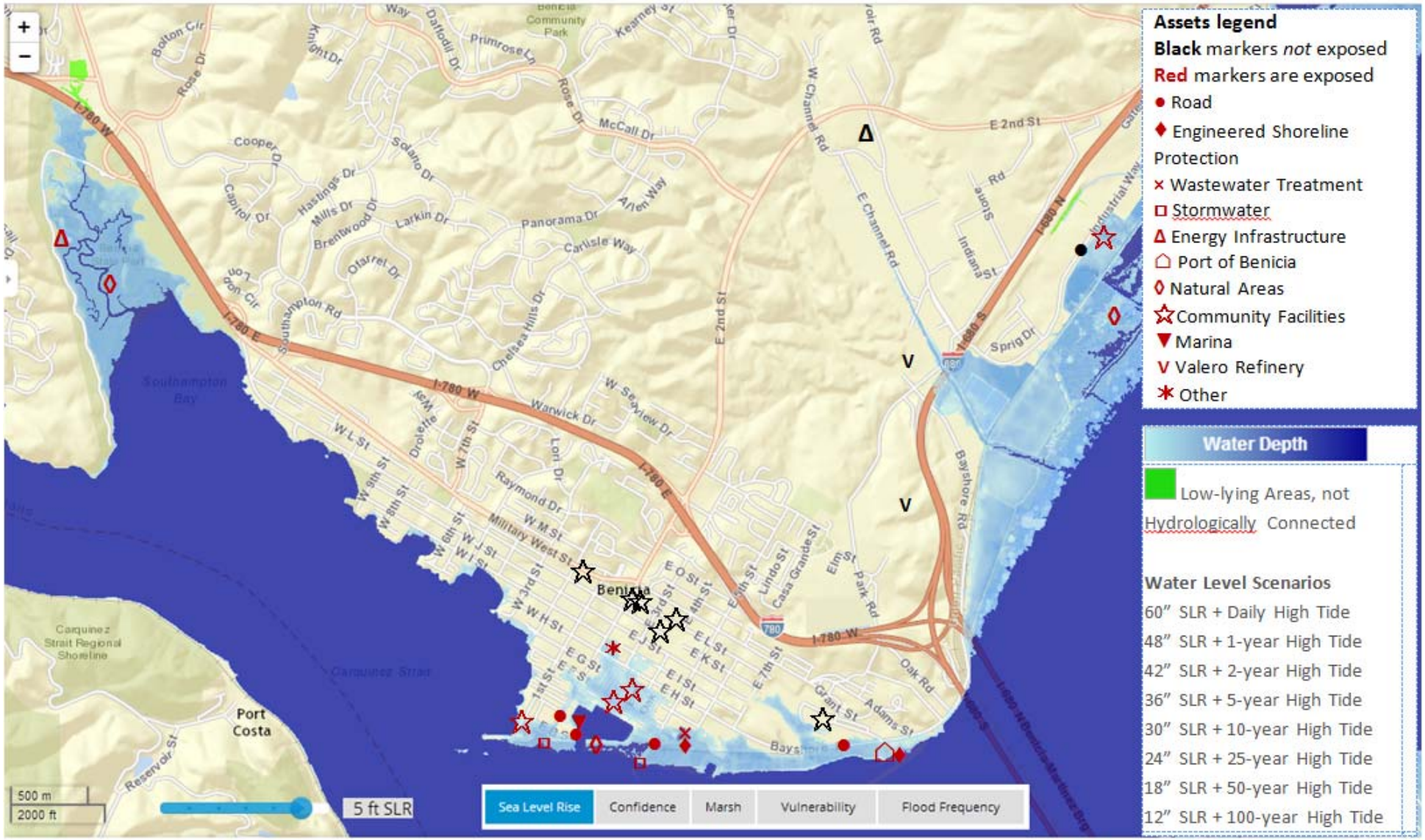


Figure 3: 60 Inches Total Water Level

What was Assessed?

With assistance from the TAC and CAG, Benicia identified important community features and areas to focus on in the vulnerability assessment as summarized in Table 2.

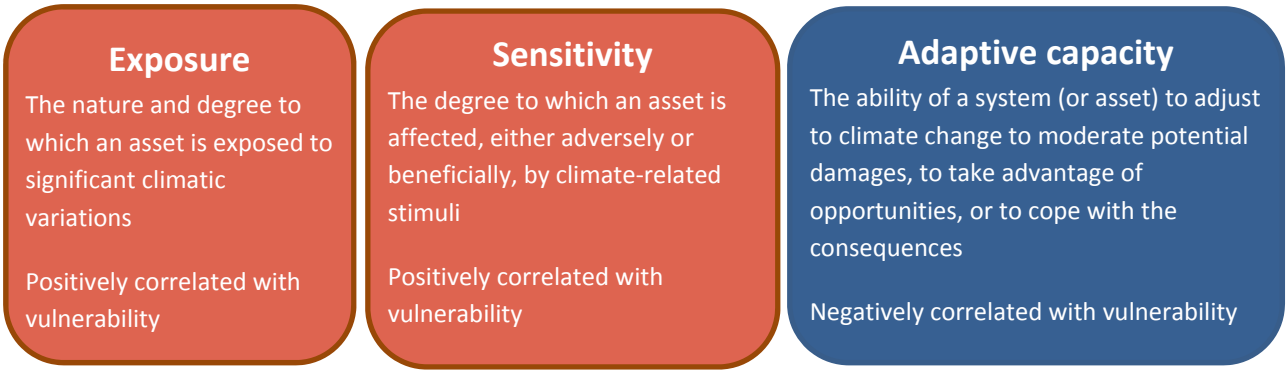
Table 2: Sectors and Assets included in Vulnerability Assessment

Sector	Assets
Community Land Use	• Downtown commercial areas • Portside Village townhomes • Benicia Industrial Park • Benicia Public Schools • Police Station (200 East L Street) • Fire Station (150 Military West) • Benicia Community Center (370 E L St) • City Hall • Fitzgerald Field • Benicia Marina
Transportation	• East 2nd Street/East B Street • East 5th Street • Bayshore Road • Industrial Way • Bay Trail*
Port of Benicia	• Port property at large • Engineered shoreline protection structures
Wastewater	• Benicia Wastewater Treatment Plant (WWTP), including flood walls
Stormwater	• Stormwater outfalls at East 2nd Street* and East 5th Street*
Natural Areas	• Benicia State Park (marsh and estuary) • Marsh in front of Benicia Industrial Park • Marsh in front of Benicia Marina
Energy and Pipeline Infrastructure	• PG&E infrastructure

**Vulnerability assessment results for these assets are limited due to insufficient data or no participation from the asset owners/managers. Results tend to be more generalized based on the professional opinion of the ICF Team.*

Vulnerability and Risk Assessment Framework

Vulnerability is made up of three main components: exposure, sensitivity, and adaptive capacity. To evaluate each of these components, the ICF Team first identified how and where the climate in Benicia might change, asset locations (exposure), the assets' potential sensitivities to future climate events



(sensitivity), and the assets ability to adapt to those changes in climate (adaptive capacity). Exposure was evaluated using the climate data discussed earlier. The evaluation of sensitivity and adaptive capacity depend largely on input from the asset managers through participation in the TAC/CAG workshops and through responses to an online survey developed first by BCDC and modified for Benicia; expert judgment of the consultant team was used to fill in remaining gaps.

Asset sensitivity is broken down into three main categories, as follows:

- **Physical and Functional Sensitivities:** Describes existing conditions or design features/materials that make an asset more sensitive to temperature and sea level rise.
- **Management Sensitivities**: Describes governance and management challenges, such as cross agency collaboration and funding constraints.
- **Informational Sensitivities:** Describes challenges to obtaining the information and data sets necessary to sufficiently understand vulnerability and risk. As discovered in previous projects, "these challenges were not only barriers to fully understanding the issues, but were themselves causes of vulnerability and risk."[5]

One element of risk is consequence. Consequence explains how damage to an asset would impact natural and human systems.[3] The ICF Team gathered information on consequence from the asset owner/manager surveys as well as academic literature. In this report, consequence includes the following three elements:

- **Economy**: Impacts to jobs and incomes, the costs of operating businesses, City revenue streams (e.g., sales tax, property tax), property value, and funding opportunities.
- **Environment** : Impacts to the natural environment including habitat, species, water quality, and public health

[5] BCDC. Adapting to Rising Tides, Vulnerability and Risk Assessment Report. Chapter 3: Vulnerability and Risk Classification. Available at: http://www.adaptingtorisingtides.org/vulnerability-and-risk-assessment-report/

- **Equity**: Impacts that limit the ability for all members of Benicia's community to have equal opportunities and access to services and open space.

Key Vulnerabilities and Consequences

The following sector level summaries of vulnerability and consequence provide a high level overview of cross-cutting vulnerabilities identified at the systematic level rather than a detailed assessment of the vulnerability of each individual asset. It needs to be emphasized that within every sector there is variation in vulnerability between different assets (e.g., no two roads have the exact same vulnerability due to variations in location, maintenance, and use). The individual asset profiles (included in the full report) provide information on asset-specific vulnerability and consequence.

Community Facilities and Services

The Community Facilities and Services sector consists of the job centers, residences, schools, emergency facilities, recreation areas, and public buildings that together support and define neighborhoods.

Table 3 summarizes the total water levels at which individual assets will be exposed to flooding.

Table 3: Community Facilities and Services Exposure to Flooding and Sea Level Rise

Asset	Historic Reports of Flooding due to Inadequate Drainage	12 Inch Total Water Level (daily inundation at mid-century)	24 Inch Total Water Level (daily inundation at late mid-century to early end-of-century)	60Inch Total Water Level (daily inundation at end-of-century)	Not Projected to be Inundated this century
Benicia Marina	X	X	X	X	
Downtown Commercial Area				X	
Portside Village Townhomes	X			X	
Rancho Benicia Townhomes	X			X	
Benicia Industrial Park				X	
Fitzgerald Field	X			X	
Benicia Public Schools					X
Police Station					X
Fire Station					X
Benicia Community Center					X
City of Benicia Buildings					X

Although individual residences and businesses are not listed as exposed to sea level rise, Table 4 summarizes the potential population and economic impacts of sea level rise and storm surge flooding.

This analysis assumes static land use patterns and 2012 dollar values; most of the data is drawn from the 2010 Census data (for more information, please see the Climate Central Surging Seas Tool[6]).

Table 4: Project Area Exposure to Sea Level Rise

	12" Total Water Level (daily inundation at mid-century)	24" Total Water Level (daily inundation at late mid-century to early end-of-century)	60" Total Water Level (daily inundation at end-of-century)
Population	75	115	836
Property Value (Millions)	$31	$64	$213
Homes	41	62	515
Land (Acres, not including saltwater marsh)	50	118	402

Source: Climate Central Surging Seas Tool, http://sealevel.climatecentral.org/

Table 5 provides an overview of key vulnerabilities of the community facilities and services to extreme temperature and changes in total water levels.

Table 5: Community Facilities and Services Vulnerabilities

Exposure
• The number of high heat days (over 92.4°F) is projected to increase by 36-48 days by mid-century and 44-83 by end-of-century • The average summer temperature is projected to increase by 4-5°F by mid-century and 5-9°F by end-of-century • 515 homes are projected to be in the 2100 sea level rise inundation zone • Commercial centers are projected to be inundated on a daily basis by the end of the century; however, they will be impacted by storm events within the mid-century time frame • City services (e.g., fire, police, community center) are not projected to be exposed to sea level rise and storm surge
Sensitivity
Physical/Functional Sensitivities • Essential mechanical and electrical equipment in buildings are highly water and salt sensitive and are often located below-grade or on the ground floor. • Most buildings are constructed of water and heat sensitive materials such as wood and plaster. **Management Sensitivities** • Certain populations are especially sensitive to heat events and flooding. This includes children, the elderly, people without vehicles, those with pre-existing medical needs, renters, and those below the poverty line. • Communities of residents and businesses are informal networks that are easily severed during extreme weather events. Areas with strong social networks and may be less sensitive to extreme weather events. • Many emergency plans do not account for the impacts of sea level rise and extreme heat events. **Information Sensitivities**

[6] http://sealevel.climatecentral.org/ssrf/california

• Information on the location of residents with specific needs is not tracked and accessible for response during extreme weather events.
Adaptive Capacity (Select examples)
• **Redundancy:** Additional fire and police stations in Benicia can serve as back-up support in the event of weather-related emergency. • **Planned response:** While called by different names, a Continuity of Operations Plan specifies actions to take to preserve worker and workplace safety in the event of any number of scenarios. This plan would likely recommend temperatures at which it is unsafe to continue work or at which additional breaks are required, as well as instructions on shutting down and protecting equipment in the event of dangerous temperatures or flooding. • **Cooling centers:** The Benicia Community Center is one example of a location that could be used as a public cooling center which, during high heat events, could shelter and cool residents. A general protocol for implementing shelters is outlined in the Benicia Emergency Operations Plan[7], although the plan does not specifically indicate procedures for heat events. (See individual asset profiles for information on back-up cooling centers.)

The potential overarching consequences of extreme heat, sea level rise, and flooding affecting community facilities and services, as well as residents, include:

- **Decreased economic activity:** High heat may decrease leisure shopping as people try to stay indoors. However, if people do not have air conditioning at home, then they may seek out air conditioned businesses in order to cool themselves.
- **Loss of heat sensitive inventory:** Stores may have to dispose of portions of their inventory if it is exposed to high temperatures for too long. For example, produce may spoil faster under high temperatures.
- **Decreased air quality:** Increased temperatures can "cook up" local pollution levels (e.g., ground level ozone and secondary air pollutants). Poor air quality affects everyone but the very young, the elderly, and those with existing cardiopulmonary issues are particularly vulnerable.
- **Heat stroke:** High temperatures increase the risk of heat-related illness, such as heat stroke and heat cramps.
- **Infectious disease:** Warming temperatures open up new regions (such as the Bay Area) to the effects of insect carried infectious diseases such as Lyme disease and Valley Fever.
- **Reduced sales and property tax:** Damage to businesses would affect sales, and damage to residential and commercial properties could reduce property values and therefore reduce property tax revenue for the City of Benicia.
- **Increased insurance rates:** As flooding becomes more frequent, flood insurance rates could increase.
- **Loss of businesses and residents:** Damages to businesses could result in long lasting or permanent closure, limiting Benicia resident access to goods and reducing the quality of life. Damage to homes may cause residents to leave Benicia altogether.

[7] City of Benicia, California Emergency Operations Plan. 2007. Accessible at http://www.ci.benicia.ca.us/vertical/Sites/%7B3436CBED-6A58-4FEF-BFDF-5F9331215932%7D/uploads/%7BFFAF7365-1029-485A-B5FF-8ECD7951574C%7D.PDF.

- **Unsafe environments:** Mold-damaged homes and businesses could create unsafe living and working environments.
- **Loss of childcare:** School closures would affect parents' ability to work due to increased childcare demands.
- **Loss of recreation:** The flooding of Fitzgerald Field affects the ability of residents to play recreational baseball.
- **Loss of personal belongings:** Flooding can damage or destroy sensitive personal information and family heirlooms; these possessions may be irreplaceable.

Transportation

The project area is served by a network of local roadways, recreational trails, select bus routes, connections to major freeways, and rail lines. The transportation focus of the vulnerability assessment is on a subset of the local roads and recreational trails within the Project Area. These roads were selected based on their previous flooding damage as well as the access they provide to essential services in the City of Benicia. The assets include:

- **East B Street and East 2nd Street** – serve a residential neighborhood and provide spillover parking for 1st Street (a commercial district). Also provide access to the waterfront and commercial areas.
- **East 5th Street** – serves residential neighborhoods and provides access to the WWTP.
- **Bayshore Road** – provides access to the Port of Benicia and continues along Sulphur Springs Creek.
- **Industrial Way** – provides access to the Benicia Industrial Park, follows along Sulphur Springs Creek and abuts the natural marsh along the Suisun Bay.
- **Bay Trail** – a recreational biking and walking trail that circumnavigates the Bay on paved and unpaved paths and roads.

The sensitivity of the roadways to extreme heat and sea level rise is fairly consistent across the selected assets. This indicates that the findings are also applicable to other roadways within the City that may be exposed to climate change impacts.

Table 6 provides an overview of the total water levels at which select transportation assets will be exposed to flooding.

Table 6: Transportation Exposure to Total Water Levels

Asset	Currently Floods due to Inadequate Drainage	12 Inch Total Water Level (daily inundation at mid-century)	24 Inch Total Water Level (daily inundation at late mid-century to early end-of-century)	60 Inch Total Water Level (daily inundation at end-of-century)
East 2nd St./East B St.	**X**		**X**	**X**
East 5th St.	**X**		**X**	**X**
Bayshore Road			**X**	**X**
Industrial Way			**X**	**X**
Bay Trail	**X**	**X**	**X**	**X**
Union Pacific	**Unknown**		**X**	**X**

Table 7 provides an overview of key vulnerabilities of the transportation sector to extreme temperature and changes in total water levels.

Table 7: Key Transportation Sector Vulnerabilities

Exposure
• The number of high heat days (over 92.4°F) is projected to increase by 36-48 days by mid-century and 44-83 by end-of century • The average summer temperature is projected to increase by 4-5°F by mid-century and 5-9°F by end-of-century • Many of the transportation assets currently flood during extreme high tide events (in part due to local drainage issues) • All transportation assets are projected to be partially exposed to daily inundation by mid-century
Sensitivity
Physical/Functional Sensitivities • Roadways located at grade, making them susceptible to flooding • Ancillary support (e.g., stop lights) may be sensitive to salt water flooding • Asphalt mix may soften and rut in extreme temperatures • Closed roadways could interfere with emergency response/evacuation procedures **Management Sensitivities** • The number of agencies involved in allocating funding for roadway repairs and improvements complicates the planning and implementation process • There is a lack of financing to plan for the impacts of sea level rise and high heat events on transportation assets • Planning needs to be coordinated between transportation agencies and the surrounding land owners and stakeholders • Roadway repair workers are sensitive to high heat work environments and may require additional breaks until temperatures cool **Information Sensitivities**

• There is a lack of detailed, easily accessible transportation data (e.g., cost, elevations, construction date, settlement measurements)
Adaptive Capacity (Select examples)
• **Redundancy:** Through traffic may be able to use alternate routes, but access to specific residences and businesses is dependent on the operability of specific roads • **Routine Repair:** Existing routine repair schedules and staff can be quickly dispatched to respond to physical damage • **Lifespan and Cost:** The relatively short lifespan and low cost of roadway overlays provides opportunities for rehabilitation projects to include adaptive measures. However, significant structural changes (e.g., raising the roadway) would significantly increase costs.

Extreme heat, sea level rise, and storm surge impacts on the transportation sector may have the following consequences:

- **Increased roadway repairs**: Increased roadway repairs would lead to temporary, localized increases in dust and air pollution. Repairs could also require detours, increasing traffic and decreasing access to the Project Area. However, most roadway repairs can be conducted at night to minimize these affects.
- **Higher construction costs**: More frequent repairs and transitions to less temperature sensitive materials could increase the cost of construction and roadway repairs.
- **Disruptions:** More frequent and serious disruptions to traffic flow could have economic and social consequences. The disruption of truck access to the port, disruption of access to Benicia Industrial Park businesses and access to the Marina could affect the City's economic development, as well as people's access to their homes, places of employment, and shopping locations. There may also be disruptions to the access road to the waste water treatment plant.
- **Maintenance costs:** Some of the common damage from moisture includes surface defects, surface deformations, and cracking. Repairing this damage could increase City maintenance costs.
- **Safety**: Flooded residential roadways may affect the ability of emergency personnel to evacuate those in need, particularly the elderly, and low-income households.
- **Public agency coordination**: Planning transportation requires significant interagency coordination, between different levels of government (local, county, regional, state, federal), and different types of agencies (funding, operating, regulatory). The necessity of coordination will only increase with sea level rise affects.

Port of Benicia

The Port of Benicia is privately owned and operated by AMPORTS; however, the underlying land is owned by the City of Benicia. AMPORTS' lease on the land will sunset in 2032. The ports major imports include automobiles and one major export is oil from the Valero Benicia Refinery.

Table 8 provides an overview of key vulnerabilities of the Port of Benicia to extreme temperature and changes in total water levels.

Table 8: Key Port of Benicia Vulnerabilities

Exposure
• The number of high heat days (over 92.4°F) is projected to increase by 36-48 days by mid-century and 44-83 days by end-of century • The average summer temperature is projected to increase by 4-5°F by mid-century and 5-9°F by end of century • Currently protected from flooding by levees; however, water traveling up Sulphur Springs Creek may flood the port property
Sensitivity (select examples)
Physical/Functional Sensitivities • Mechanical equipment is sensitive to flooding and high heat conditions • Paved areas sensitive to high heat and flooding • Shoreline protection, back-up power, and sump pumps reduce the properties sensitivity **Management Sensitivities** • The port is surrounded by other assets with which it will have to coordinate to address flooding issues. These include the Valero refinery, Union Pacific, local roads, and Sulphur Springs Creek • The port is privately owned but the land is leased from the City, which will require coordination on adaptation strategies • Temperature sensitive cargo is sensitive to extreme heat days • Port employees are sensitive to high heat work environments and may require additional breaks until temperatures cool **Information Sensitivities** • Additional information is needed on the temperature design thresholds of port equipment
Adaptive Capacity
• **Redundancy:** The port has some excess storage capacity that could be used in the event of flooding within their standard storage areas • **Planned response:** The port has protocols in place to manage flooding events, thus providing for a faster response and reopening of the property

If the port were to be affected by sea level rise, storm surge, or high temperatures, the following consequences may impact the port and the City of Benicia:

- **Loss of business:** Business may shift to other ports of call if there are issues at the port. This could reduce economic prosperity and potentially lead to a loss of jobs within Benicia.
- **Higher operating costs:** Higher temperatures could result in higher energy consumption and increased costs for refrigerated warehouses or "reefer slots" (electrical plug-ins for containers with on-board cooling units). Electricity outage during extreme heat events can spoil refrigerated goods.
- **Coordination:** The leased structure of the port land will require coordination between the City and AMPORTS to determine an appropriate path towards resiliency.
- **Temporary closure:** Past flooding events have resulted in short duration (approximately one day) closures of the port.

Wastewater

The City of Benicia Wastewater Treatment Plant (WWTP) treats residential, commercial, and industrial sewage in the city (except process waste from the Valero Benicia Refinery) before discharging it in the

Carquinez Strait. The WWTP is located on East 5th Street and was built in 1958. In 2000, the City completed a $20 million upgrade of the WWTP, including the construction of a five foot seawall which protects the WWTP from coastal storms.

Table 9 provides an overview of key vulnerabilities of the WWTP to extreme temperature and changes in total water levels.

Table 9: Key Vulnerabilities of the WWTP

Exposure
• The number of high heat days (over 92.4°F) is projected to increase by 36-48 days by mid-century and 44-83 days by end-of century • The average summer temperature is projected to increase by 4-5°F by mid-century and 5-9°F by end of century • Flood walls will likely protect the WWTP from mid-century flooding but water is projected to travel up East 5th Street and circumnavigate the flood walls, resulting in daily inundation by the end of the century and earlier during extreme storm events (e.g. 50 to 100 year flood)
Sensitivity (select examples)
Physical/Functional Sensitivities • No heat sensitive elements have been identified at the WWTP • Mechanical equipment is sensitive to flooding. Existing pumps offer some capacity to remove water but they may be undersized for future events • The floodwall provides protection from shore side flooding but does not protect against landside water intrusion • The WWTP outfall may not operate properly with additional sea level rise • The wet weather relief system provides storage during rainfall and coastal flooding events to reduce excess load at the WWTP • The WWTP is a large, expensive, and complex system with little to no redundancy within each system • Rising sea levels could cause rise in groundwater levels around ageing sewer pipes resulting in groundwater intrusion into the pipes and thus loss in sewer pipe capacity **Management Sensitivities** • The existing commitment to monitoring sea level rise (reviewing literature at least every 5 years) and planning to adapt reduces the sensitivity of the WWTP **Information Sensitivities** • There is a need for additional information on the rate of change in groundwater levels and the impact it would have on increased total dissolved solids and flow to the WWTP
Adaptive Capacity (select examples)
• **Redundancy:** There are no other WWTPs that serve the City of Benicia • **Planned response:** The WWTP holds supply contracts with multiple companies, which helps to ensure the availability of treatment chemicals after an extreme weather event • **Expansion:** The WWTP is geographically constrained, which limits the adaptive measures that could be used to protect the property • **Pumps:** The WWTP has small pumps to remove flood water during storm events

If the WWTP were to be affected by sea level rise, storm surge, or extreme temperatures, the following consequences may affect the City:

- **Replacement and repair costs**: In general, wastewater treatment components have moderate to high capital replacement costs (e.g., sewer lines, sewer lifts, pump stations, stop gates, interceptors, outfall flow regulator, all electrical and mechanical components, filters), moderate to high operating and maintenance costs (e.g., treatment chemicals, power, staff), and, depending on the extent of the impact, would require significant financial resources to be returned to full function after damage.
- **Fines**: If the WWTP violates its discharge permit (e.g., if groundwater rise or coastal flooding overwhelmed the WWTP and led to the release of untreated sewage), they City could be fined. Fines vary depending on severity and duration of violation, ranging from several thousand to millions of dollars. The Bay Area Air Quality Management District may also levy similar fines.
- **Local Economy**: Failure of the wastewater system could not only affect residential communities and commercial enterprises, but also would adversely affect industrial facilities that require sewer service to operate. The overall economic consequences due to loss of industrial production and employment disruption could be quite significant depending on the duration and extent of the shutdown.
- **Community services**: Access to community services and facilities could be affected, leading to significant cumulative impacts.
- **Pathogens**: Disruption of sewer service or failure of particular wastewater system components could result in backups in the community collection system or sewer laterals that may result in overflows of raw sewage into basements and streets. The result may be exposure of the public to disease-causing microorganisms (pathogens), requiring decontamination, cleanup, and repair or rehabilitation of affected areas.
- **Recreation:** Overflows or discharges of treated or partially treated wastewater could result in limitations on the use of shoreline recreational resources such as the Marina and boat launches, as well as contact recreation such as swimming or boating in areas near the discharge location.
- **Aquatic Resources:** If sewage overflows occurs into the nearshore waters of the Bay at low tide when there is minimal dilution or mixing, the consequences could be significant for the Bay ecosystem. Pathogens, organic loading, nutrients, and toxics in untreated wastewater could cause a variety of adverse effects on the Bay's aquatic resources.

Stormwater

The City stormwater system is designed to minimize flooding from runoff which is generated when rain flows over land or impervious surfaces and does not infiltrate into the ground. Stormwater infrastructure consists of storm drains that collect urban runoff and underground pipes that carry water to the Bay.

While precipitation and associated stormwater can cause flooding directly, this assessment addresses only the affects from the interaction of sea level rise with the stormwater outfalls that discharge into the Bay. This section does not address the potential effects of precipitation based flooding because changes in the intensity of precipitation events are projected to be minimal within the City of Benicia; however,

extreme rainfall events may occur slightly more frequently (from the current five times per year to six times per year).

Table 10 provides an overview of key vulnerabilities of the stormwater outfalls to extreme temperature and changes in total water levels.

Table 10: Key Stormwater Vulnerabilities

Exposure
• Due to the sub-grade nature of the stormwater system, it will only experience minimal temperature fluctuations • The stormwater outfalls at East 2nd Street and East 5th Street (other outfalls were not assessed) are currently submerged during high tide and extreme storm events and will likely be permanently submerged by mid-century
Sensitivity (select examples)
Physical/Functional Sensitivities • No heat sensitive elements have been identified in the stormwater outfalls • Groundwater intrusion from degraded pipes and rising groundwater levels may decrease the stormwater system capacity • The gravity-fed outfalls are will not operate when submerged, resulting in flooding up the line • Sea level rise and storm surge driven erosion and scour may undermine the stormwater outfalls **Management Sensitivities** • The most recent Stormwater Management Plan was adopted in 2003 and only contained an implementation plan that ran through 2008; the City plans to update this document within the next 3 years. • The stormwater system and the WWTP are intrinsically liked (e.g., reducing versus managing wet weather flows) and will need to coordinate in response to climate change **Information Sensitivities** • There is a lack of detailed, easily accessible, and well-coordinated information on the current capacity, design, elevation, and condition of the stormwater system which is needed for site-specific vulnerability assessments • The location of cross-connections between the storm and sewer lines are unknown
Adaptive Capacity
• **Maintenance:** Routine maintenance of the stormwater system (e.g., cleaning out the pipes) allows for some monitoring and response as changes in climate occur

In the event of impact from sea level rise, storm surge, or extreme temperatures, the following consequences may occur:

- **Repair costs:** The submersion of the stormwater outfalls increases inland flooding which requires cleanup and costly repairs to structures and landscapes damaged by flooding.
- **Access:** Since the stormwater outfall inundation exacerbates inland flooding, an indirect economic consequence is the business or productivity that could be lost due to commercial buildings being inaccessible if they or the roads required to reach them are flooded. Additionally, residents would be affected if they do not have access to their homes or places of employment.

- **Emergency response:** Flooding could impede emergency response, important not only for immediate problems that could be caused by flooding, but also for related medical or other issues that require urgent attention.
- **Disease**: If floodwaters are not removed quickly, they could become breeding grounds for mosquitoes and other disease vectors.
- **Contaminants**: Flooding can cause the redistribution of contaminants that water picks up from the land surface. An impaired stormwater system would distribute contaminated runoff differently – rather than flowing directly to the Bay, pollutants could be deposited wherever the floodwaters flow.

Natural Habitats

Marshes provide ecosystem functions such as wave energy dissipation, flood protection, water filtration, and carbon sequestration, as well as ecological benefits and habitats. Arts Benicia is currently creating an educational public art display on the benefits of biofiltration (i.e., a pollution control technique that uses living material to capture and biologically degrade pollutants). This piece of art will be on display at the Benicia Waterfront.

The natural habitats in evaluated in this assessment includes:

- The Benicia State Recreation Area,
- The marsh along the Benicia Industrial Park, and
- The marsh adjacent to the Marina and the Waterfront Park area.

Table 11 provides an overview of key vulnerabilities of natural areas to extreme temperature and changes in total water levels.

Table 11: Key Natural Habitat Vulnerabilities

Exposure
• The number of high heat days (over 92.4°F) is projected to increase by 36-48 days by mid-century and 44-83 days by end-of century • The average summer temperature is projected to increase by 4-5°F by mid-century and 5-9°F by end of century • The low lying, natural areas are currently exposed to storm surge events and will be exposed to any changes in sea level
Sensitivity (select examples)
Physical/Functional Sensitivities • Tidal marshes will not keep up with sea level rise on their own due vertical accretion and they are constrained from shifting landward due to hardened infrastructure. This will result in a change in the type of habitats provided by mid-century and an extreme loss of marsh areas by end-of-century • Local plants and animals are sensitive to changes in extreme temperatures and migratory patterns will likely change **Management Sensitivities** • The natural areas are owned, managed, and permitted by a variety of agencies (e.g., CA State Parks, CA Fish and Wildlife, the City of Benicia, BCDC) which will have to coordinate in their

response to climate impacts • Existing funding levels are insufficient for planning and implementing large scale responses to climate change vulnerabilities
Adaptive Capacity
• While natural systems have some ability to self-repair, the anticipated changes in temperature and sea level rise will outpace their ability to respond

Loss of the marshes due to sea level rise, storm surge, or extreme temperatures could impact the community, economy, and species conservation in the following ways:

- **Shoreline protection:** The complete or partial loss of marsh systems would reduce the wave attenuation benefits of natural shoreline protection which could place shoreline residents and businesses at a greater risk of flooding.
- **Recreation:** The community may also face loss of aesthetics and opportunities for outdoor recreation, which may diminish the value of Benicia as a desirable place to live.
- **Habitat:** Downshifts (e.g., changes in classification from mid to low marsh) and loss of marsh habitat could impact plants and animals including several state-listed or federally threatened and endangered species that rely on tidal marsh for breeding, foraging, and high tide refugia.
- **Environmental quality:** Loss of tidal marsh could decrease the potential for carbon sequestration and water quality improvement.
- **Economic impact:** The reduction of shoreline protection would have a major economic impact on the Marina and the Benicia Industrial Park, where flooding could require increased maintenance, repair, and upgrade of expensive assets.

Energy and Pipeline Infrastructure

PG&E is currently the energy provider for the City of Benicia; however, Benicia recently joined Marin Clean Energy (MCE), which supplies customers with an electricity energy mix that includes 51 to 100 percent renewable sources. MCE optional services have not yet been rolled out to residents and businesses; even once it is, users will be able to elect to keep their existing PG&E account. Once MCE is fully operational, they will use PG&E's transmission infrastructure to provide clean energy to their users; therefore, this analysis focuses on the vulnerability of PG&E infrastructure.

PG&E representatives are aware that climate change poses risks to their infrastructure and are internally conducting vulnerability assessments. The City of Benicia is actively working with PG&E to coordinate on developing an appropriate response to climate change vulnerabilities. However, PG&E is sensitive to publicly sharing specifics on their systems vulnerabilities. Due to these concerns, this section only provides a summary of generic risks that heat and sea level rise pose to energy infrastructure, with a few specifics as permitted by PG&E.

Table 12 provides an overview of key vulnerabilities of energy infrastructure to extreme temperature and changes in total water levels.

Table 12: Key Energy Sector Vulnerabilities

Exposure
• The number of high heat days (over 92.4°F) is projected to increase by 36-48 days by mid-century and 44-83 days by end-of century • The average summer temperature is projected to increase by 4-5°F by mid-century and 5-9°F by end of century • Based on an analysis by PG&E, the two electrical substations in Benicia are not projected to be impacted by sea level rise within the mid-century timeframe. Exposure at end-of-century is unknown as PG&E does not include 2100 scenarios in its long-range planning
Sensitivity (select examples)
Physical/Functional Sensitivities • Transmission lines are sensitive to high temperatures which may cause line sag and decrease their transmission capacity • Older substations may be sensitive to extreme temperatures due to their design • Electrical components are sensitive to corrosion from saltwater **Management Sensitivities** • Increased temperatures will increase energy demand for cooling, thus adding additional stress to the grid • Coordination between public and private companies will be required to address changing demands and vulnerable infrastructure • Emergency operating procedures decrease sensitivity but may need to be updated to prepare for additional extreme heat days and more frequent flooding **Information Sensitivities** • Data sharing between MCE, PG&E, and the City will be required to inform an appropriate response to climate change vulnerabilities
Adaptive Capacity
• **Redundancy:** The electrical grid is highly redundant and loss of any one particular substation is unlikely to have an impact on the City of Benicia

In the event of an impact from sea level rise, storm surge, or extreme temperatures, the following consequences may occur:

- **Loss of power:** If power cannot be shifted, the areas served by affected substations would lose power until any damaged or moved equipment is repaired or replaced.
- **Long-term outages:** Sustained outages could result in a loss of productivity due to workplaces and schools being closed.
- **Loss of vital services:** Telecommunications components and pumps, which are vital during an emergency, could be forced out of service unless backup power is available.

Next Steps

Following the approval of this report, the City of Benicia and the ICF team will work with the asset owners/managers to confirm the identified vulnerabilities. This finalized information will then be used to inform the development of adaptation strategies, the team has already begun drafting proposed strategies, some of which were presented at the Public Workshop on November 20, 2014. These strategies may be designed to increase the resiliency of an individual asset or a suite of assets. The strategies will include physical changes, management changes, and information gathering and monitoring strategies.