Chapter 5. Community Land Use

Community land use describes the services and facilities, such as job centers, residences, schools, and hospitals, that together make up neighborhoods and reflect and support the way that people live. The ART project assessment of community land use considers the vulnerability and risk of people - where they live and work - the property they may own or rely on, and the key services and facilities that support and maintain the social and economic interactions that tie communities together.

Understanding the vulnerability and risk of a broad and varied asset category such as community land use to climate change impacts is both necessary and challenging. It is critical to the process of developing adaptation strategies for the residents, properties, employees, facilities, and services of a region. Developing robust, multi-objective adaptation approaches that address cross-sectoral and cross-jurisdictional issues are necessary to truly build community resilience.

Careful consideration must be given when analyzing the vulnerability and risk to community land use assets. The consequences of sea level rise for individual residents, neighborhoods, and communities as a whole, and even the region can be significant and far-reaching. While the resilience of all types of community land uses is important, particular consideration must be given to residential uses. Unlike office buildings or industrial sites, it can be exceedingly difficult to either relocate or reconstruct the complex social network and individual ties that can develop in a residential neighborhood. The proximity of families to schools, access to known and reliable services and facilities, and the close personal relationships often forged between and among neighbors are features of neighborhoods that cannot easily be recreated, and once lost are not easily rebuilt.

The assessment described in this report, and the findings discussed in this chapter and others, will be used to develop strategies to address community vulnerability and risk to sea level rise and storm events in the ART project area. Developing successful adaptation strategies for community land use will depend on a firm understanding of how sensitive communities are to potential sea level rise and storm events; the inherent adaptive capacity of the land uses, facilities, and services the community relies on; and the potential consequences to a neighborhood, community, and even the region, if an impact were to occur. Therefore, this community land use assessment includes an evaluation of exposure, sensitivity, adaptive capacity, and consequences (see Introduction for definitions) for the following:

- Residents
- Employees
- Property values
- Community facilities and services

Four categories of community facilities and services are considered. These include the facilities responsible for **emergency and disaster response**, such as hospitals, police and fire stations, and shelter-in-place locations (schools and churches); facilities that provide **services to at-risk populations**, such as health clinics, homeless shelters, and food banks; facilities with **vulnerable**, **less mobile populations**, such as senior housing, jails, long-term care facilities, and childcare centers; and **animal facilities**, such as shelters. Other facilities and services critical to communities, such as park and recreation areas, water and energy utilities, and ground transportation, are considered in other sections of this report. Figure 1 shows a selection of these facilities and services in the ART project area.



Figure 1. Map of selected community facilities and services in the ART project area.

The community land use exposure analysis for the ART project was conducted in collaboration with the Pacific Institute¹. Pacific Institute staff completed a technical analysis and provided a report on the exposure to sea level rise and storm events of the residents, employees, property values, and community services and facilities in the ART project area. A summary of the Pacific Institute's exposure findings is provided below, and the complete report, which includes an analysis of population and household demographics as well as social vulnerability in the ART project area, is provided in Appendix D.

Following the exposure analysis is a discussion of the sensitivity and adaptive capacity of the community land uses found in the ART project area. Taken together, exposure, sensitivity and adaptive capacity informs an understanding of vulnerability - the degree of susceptibility, or inability to accommodate adverse impacts of climate change (see Introduction for a detailed description of vulnerability). Each of these components is critical to understanding vulnerability. For example, a community facility that is exposed to storm event impacts, such as flooding, may not be vulnerable if it is not physically damaged and/or can continue to maintain its primary function. On the other hand, homes exposed to the same flood that are damaged and no longer livable without rehabilitation are themselves vulnerable, and can cause the neighborhood and community where they are located to be vulnerable.

Developing adaptation response strategies that address identified vulnerabilities requires consideration of the magnitude of the consequences, if a sea level rise impact were to occur. Community land use, as defined here, is a very broad and varied asset category. A generalized, high level discussion of the consequences of sea level rise and storm event impacts on community land use in the ART project area is provided. A more detailed and specific analysis of the consequences on such a critical asset category such as community land use is warranted; however, the ART project's multi-sector/multi-jurisdiction adaptation planning approach makes this level of analysis especially challenging. Further evaluation of consequences for the individual cities or regional entities responsible for managing community land use assets in the project area would be beneficial, and can be guided by the information presented herein.

Exposure

Exposure is the extent to which an asset experiences a specific climate impact such as storm event flooding, tidal inundation, or elevated groundwater. The exposure of residents, employees, property value, and community facilities and services in the ART project area was evaluated for two sea level rise projections and three Bay water levels. The two sea level rise projections, 16 inches (40 cm) and 55 inches (140 cm), correlate approximately to mid- and endof-century. These projections were coupled with three Bay water levels: the highest average daily high tide represented by mean higher high water (MHHW), hereafter "high tide" or "daily high tide;" the 100-year extreme water level, also known as the 100-year stillwater elevation (100-year SWEL), hereafter "100-year storm" or "storm event;" and the 100-year extreme water level coupled with wind-driven waves, hereafter "storm event with wind waves" or "wind waves." These water levels were selected because they represent a reasonable range of potential Bay conditions that will affect flooding and inundation along the shoreline. For more information about sea level rise projections and Bay water levels evaluated see Chapters 1 and 2.

The data sources, methods, and results of the exposure analysis are summarized below. For information on the ART project exposure analysis see Appendix C, for the data and methods used by the Pacific Institute see Appendix D.

¹ The Pacific Institute (www.pacinst.org) is a tax-exempt 501(c)(3) organization established in 1987 with offices located in the City of Oakland.

Exposure in the ART Project Area

Residents

The presence of residential housing units within areas potentially exposed to tidal inundation, storm event flooding and rising groundwater levels is of particular concern. Past experience with coastal flooding hazards, such as significant winter storms, hurricanes and tsunamis has demonstrated that residential neighborhoods are not only extremely vulnerable to these events, but also tend to be the slowest to recover and have the greatest difficulty in doing so.

The ART project analysis is based on an estimation of the residential population exposed to the two sea level rise projections and three Bay water levels. This analysis estimates the number of residents that could potentially experience a climate impact such as tidal inundation or storm event flooding. Careful consideration must be given to both the analysis and interpretation of residential exposure, as fully understanding the impact of inundation or flooding cannot be achieved without understanding the other components of vulnerability and risk (i.e., sensitivity, adaptive capacity, and consequences, each of which is discussed later in this section).

In the year 2000, there were more than 786,874 residents in the ART project area, representing more than half of Alameda County's total population of 1,443,741. US Census data at the census block level from the year 2000² was used to estimate the exposure of residents in the ART project area to sea level rise and storm events. The percentage area of all census blocks exposed was calculated, and then the population within the exposed area was estimated and summed.

The number of residents that would be exposed to flooding in the ART project area ranges from 2,000 with 16 inches of sea level rise at high tide, to 123,000³ with 55 inches of sea level rise during a storm event with wind waves. Further analysis was conducted on the demographics of residents and households potentially exposed with a focus on characteristics that increase vulnerability. A description of the methods used and the results of this analysis can be found in the Pacific Institute report (see Appendix D), and an interpretation of this analysis is presented in a white paper on equity and sea level rise completed for the ART project⁴.

Employees

Sea level rise and storm events disrupt not only the lives of residents, but also the lives of the people whose jobs are in exposed areas and the economic health of both individuals and the region. As of June 2011, the ART project area provided employment to a total of nearly 310,000 people. The exposure analysis of employees in the ART project area was conducted by California Employment Development Department, Labor Market Information Division, Statewide Information Services Group (EDD-LMID), using data on business establishments⁵ from the Quarterly Census of Employment and Wages from June 2011. Because this data was not publicly available, ART project staff provided EDD-LMID staff with exposure data for the ART project area, and EDD-LMID staff produced aggregate exposure calculations for employees in each city. An analysis of the storm event with wind waves scenarios was not conducted. The exposure of employees in the ART project area ranges from approximately 1,000

³ These figures reflect year 2000 population rather than projected for mid- and end-of-century populations. The population exposed is therefore an estimate, and will differ based on future conditions, including population growth in the ART project area.

² 2000 Census was used because the population data from the 2010 Census was aggregated based on new geographic boundaries that are not compatible with the 2000 Census.

⁴ Addressing Social Vulnerability and Equity in Climate Change Adaptation Planning. June 2012.

Available at http://www.adaptingtorisingtides.org/equity/. ⁵ The terms "business establishment" and "employer" are sometimes used interchangeably. However, an employer can have multiple geographic locations (e.g., a restaurant chain), while a business establishment is a single, particular location.

employees exposed to the daily high tide with 16 inches of sea level rise, to over 68,500 employees exposed to storm event flooding with 55 inches of sea level rise (see Table 1).

Property Value

Two evaluations were conducted for property in the ART project area: the *replacement costs of buildings and their contents* were evaluated using FEMA's HAZUS model, and the *value of land and improvements* was evaluated using data from the Assessor's Office. The HAZUS model uses a database that contains the value of buildings and their contents based on information from a number of sources. Values are provided for residential, commercial, industrial, agricultural, religious, governmental, and educational land uses in each census block. HAZUS uses a statistical model to estimate rebuilding or replacement costs based on square footage, number of stories, building material, and other variables. The Alameda County Assessor's Office provided data on the value of land and improvements such as buildings. This data included a parcel boundary GIS file and the property database, which contained information about land and property values. The county maintains this information for the purpose of levying taxes.

According to FEMA's HAZUS model, the total replacement cost of buildings and their contents in the ART project area is roughly \$45 billion. The Alameda County Assessor's Office estimates property value at nearly \$87 billion dollars. An exposure analysis was conducted for replacement costs as well as assessed property values to estimate, from two different perspectives, the monetary value that may be exposed to damage or loss due to sea level rise.

Based on the HAZUS model, the replacement costs of buildings and contents in the ART project area ranges from \$323 million exposed to the daily high tide with 16 inches of sea level rise, to \$10.7 billion exposed to a storm event and wind waves with 55 inches of sea level rise (\$7.2 billion exposed to storm events and \$3.5 billion exposed to wind waves only). Based on the Assessor's data, the value of property exposed to sea level rise ranges from \$694 million exposed to storm events and \$4.5 billion exposed to wind waves only) exposed to a storm event and wind waves only and \$4.5 billion exposed to wind waves only and wind waves with 55 inches of sea level rise (see Table 1).

			16" SLR		55" SLR		
		Daily High Tide	Storm Event		Daily High Tide	Storm Event	
	Total	Exposed	Exposed	Exposed to wind waves only	Exposed	Exposed	Exposed to wind waves only
Residents	786,874						
Number		1,952	17,321	62,313	38,266	80,063	43,724
Percent		0%	2%	8%	5%	10%	6%
Employees	309,634						
Number		1,011	9,265		22,722	68,513	
Percent		0%	3%		7%	22%	
Replacement Costs (\$M) (HAZUS)	45,126						
Replacement costs		323	1,633	5,591	3,139	7,236	3,485
Percent		1%	4%	12%	7%	16%	8%
Assessed value (\$M)	86,591						
Assessed value		694	4,117	11,015	7,875	15,122	4,483
Percent		1%	5%	13%	9%	17%	5%

Table 1. Residents, Employees, and Property Values (in millions of dollars) exposed to 16 and 55 inches of sea level rise in the ART project area.

Community Facilities and Services

The ART project analyzed the exposure of four categories of community facilities and services: emergency and disaster response; facilities and services for at-risk populations; facilities housing vulnerable, less mobile populations; and animal facilities. The exposure analysis of these facilities and services (Table 2) was conducted using publicly available data from the following sources: California Community Care Licensing Division, FEMA HAZUS, Association of Bay Area Governments (ABAG), and the California Department of Public Health. Some sites – such as jails – were located through focused Internet searches rather than in a publicly available database. One of the terms, "health care facility," refers to many types of facilities, ranging from community health clinics to dialysis centers to administrative buildings for hospice care. Some locations appear more than once across the databases. For example, the same facility could provide senior housing and long term care, or the same property could house a daycare center or preschool – labeled as "childcare center" – and a K-12 school. These facilities serve different functions and populations, presenting different concerns in the event of flooding. For example, evacuating bed-ridden patients receiving long-term care poses a different evacuation challenge than evacuating healthy seniors. Therefore, such facilities are included in both categories under which they are listed, with a note indicating where overlap occurs in the *Exposure by City* section. Some facilities, such as schools, also serve as shelters during emergencies.

There are 37 emergency response facilities in the ART project area: ten hospitals, six police stations, and 21 fire stations. With 16 inches of sea level rise, none of these facilities are exposed to the daily high tide, but three fire stations are exposed to storm event flooding and an additional four facilities – also fire stations – are exposed to wind waves only. With 55 inches of sea level rise, four fire stations are exposed to the daily high tide. An additional three fire stations and one police station are exposed to storm events, and one additional fire station is exposed to wind waves only.

Just over 200 facilities in the ART project area serve at-risk populations. Two thirds of these are health care facilities, with the remainder comprised of homeless shelters, group homes, food banks, and jails. None of these facilities are exposed to the daily high tide with 16 inches of sea level rise, and only one – a health care facility – is exposed to storm events. Eleven additional health care facilities, two homeless shelters, and two food banks are exposed to wind waves only. With 55 inches of sea level rise, four health care facilities are exposed to the daily high tide. Fourteen facilities are exposed to storm events, and an additional seven are exposed to wind waves only.

Over 600 facilities in the ART project area serve vulnerable, less mobile populations. There are 159 senior housing facilities, 52 long-term care facilities, 253 childcare centers, and 172 schools (some of these locations provide multiple services; cross-listings are discussed in the Exposure by City section). With 16 inches of sea level rise, no facilities serving vulnerable, less mobile populations are exposed to the daily high tide. Seventeen are exposed to storm events, and 71 are exposed to wind waves only. With 55 inches of sea level rise, 38 facilities are exposed to the daily high tide, 87 are exposed to storm event flooding, and 35 are exposed to wind waves only.

There is one animal facility in the ART project area. This facility, an animal shelter in the City of Alameda, is exposed to all of the future climate scenarios evaluated, except for the daily high tide with 16 inches of sea level rise.

Table 2. Number of community facilities and services exposed to	16 and 55 inches of sea level rise in the
ART project area.	

			16" SLR			55" SLR		
		Daily High Tide	Storm	Event	Daily High Tide	Storm	i Event	
Type of facility	Total	Exposed	Exposed	Exposed to wind waves only	Exposed	Exposed	Exposed to wind waves only	
Emergency response	37	0	3	4	4	8	1	
Hospitals	10	0	0	0	0	0	0	
Police stations	6	0	0	0	0	1	0	
Fire stations	21	0	3	4	4	7	1	
Serving at-risk populations	218	0	1	15	4	13	7	
Health care facilities	144	0	1	11	4	9	5	
Homeless shelters	14	0	0	2	0	2	0	
Group homes	26	0	0	0	0	0	0	
Food banks	30	0	0	2	0	2	2	
Jails	4	0	0	0	0	0	0	
Serving vulnerable, less mobile populations	658	0	17	71	38	87	35	
Senior housing	159	0	5	25	9	30	15	
Long-term care	52	0	0	7	2	7	0	
Childcare centers	253	0	7	22	15	28	11	
Schools	194	0	5	17	12	22	9	
Animal Facilities	1	0	1	0	1	1	0	
Animal Shelters	1	0	1	0	1	1	0	
Total	914	0	22	90	47	109	43	

Exposure by City

The following discussion presents the results of the exposure analysis for each city in the ART project area. Summary tables of the number of residents, employees, property value, and community facilities and services exposed by city are provided. Note that the percent (of residents, employees, property value, etc.) presented is based on the portion of each city within the ART project area rather than based on city totals.

Alameda

The entire City of Alameda is within the ART project area, and a fairly large portion of residents is at risk of exposure to sea level rise (Table 3). While only 1,100 people, or 2% of the population, will be exposed to the daily high tide with 16 inches of sea level rise, over 10% will be exposed to storm event flooding, and over 40% will be exposed to wind waves. With 55 inches of sea level rise, exposure increases dramatically: 20% of the population would be exposed to the daily high tide, 45% to storm event flooding, and nearly 60% to wind waves. While the number of employees working in Alameda is much lower than the number of residents, there are similar trends in employee exposure. Only 18 employees, or 2%, would be exposed to the daily high tide with 16 inches of sea level rise, but 15% would be exposed to the daily high tide with 55 inches of sea level rise, and this increases to nearly half of all employees, if there is a storm event. Wind wave exposure was not analyzed.

According to HAZUS, replacement costs for buildings and their contents in the City of Alameda range from \$91 million exposed to the daily high tide with 16 inches of sea level rise, to \$2.9 billion exposed to storm events and wind waves with 55 inches of sea level rise (\$2.3 billion exposed to storm events and an additional \$550 million exposed to wind waves only). Using the Assessor's data, between \$370 million (daily high tide with 16 inches of sea level rise) and \$5.8 billion (\$4.6 billion exposed to storm events and \$1.2 billion exposed to wind waves only with 55 inches of sea level rise) is exposed.

Table 3. Residents, Employees, and Property Values (in millions of dollars) exposed to 16 and 55 inches of sea level rise in the City of Alameda.

			16" SLR		55" SLR			
		Daily High Tide	Storm	n Event Daily High Tide		Storm	Storm Event	
	City total*	Exposed	Exposed	Exposed to wind waves only	Exposed	Exposed	Exposed to wind waves only	
Residents	72,259							
Number		1,103	8,619	21,757	14,227	32,416	9,045	
Percent		2%	12%	30%	20%	45%	13%	
Employees	21,428							
Number		18	1,716		3,220	9,991		
Percent		0%	8%		15%	47%		
Replacement Costs (\$M) (HAZUS)	\$4,450							
Replacement costs		\$91	\$645	\$1,525	\$1,020	\$2,370	\$550	
Percent		2%	15%	34%	23%	53%	12%	
Assessed value (\$M)	\$8,877							
Assessed value		\$370	\$1,807	\$2,816	\$2,665	\$4,589	\$1,211	
Percent		4%	20%	32%	30%	52%	14%	

* Total is for portion of the city in the ART project area

There are six emergency response facilities in the City of Alameda – one police station, four fire stations, and one hospital (Table 4). With 16 inches of sea level rise, none of these facilities are exposed to the daily high tide, but Fire Station 4 is exposed to storm event flooding (Figure 2). With 55 inches of sea level rise, only Fire Station 4 is exposed to high tide inundation and storm event flooding.

There are six facilities serving at-risk populations: three health care facilities, two food banks, and one jail. There are no Figure 2. Fire Station 4 in the City of Alameda.



homeless shelters or group homes. Two health care facilities and one food bank are exposed to wind waves with 16 inches of sea level rise. These same facilities are exposed to storm event flooding with 55 inches of sea level rise, and an additional health care facility is exposed to wind waves only with 55 inches of sea level rise. The one jail is not exposed to any of the scenarios.

There are 76 facilities in Alameda serving vulnerable, less mobile populations such as seniors, the infirm, and children. Three long-term care facilities are cross-listed with other facilities (one health care facility, one hospital, and one senior housing facility), and nine schools are cross-listed with childcare facilities. None of the 76 facilities are exposed to the daily high tide with 16 inches of sea level rise, but several schools, childcare facilities, and senior housing facilities are exposed to storm event flooding. With 55 inches of sea level rise, over 25% of facilities are exposed to the daily high tide, and over half – including all of the long term care facilities and all but two senior housing facilities – are exposed to storm event flooding. Several more are exposed to wind waves only.

The one animal shelter in Alameda is exposed to all of the future climate scenarios evaluated except for the daily high tide with 16 inches of sea level rise.

			16" SLR			55" SLR	
		Daily High Tide	Storm	Event	Daily High Tide	Storm	Event
Type of facility	City total*	Exposed	Exposed	Exposed to wind waves only	Exposed	Exposed	Exposed to wind waves only
Emergency	e	0	1	0	1	1	1
response	0	0	•	U		•	•
Hospitals	1	0	0	0	0	0	0
Police stations	1	0	0	0	0	0	0
Fire stations	4	0	1	0	1	1	1
Serving at-risk populations	6	0	0	3	0	3	1
Health care facilities	3	0	0	2	0	2	1
Homeless shelters	0						
Group homes	0						
Food banks	2	0	0	1	0	1	0
Jails	1	0	0	0	0	0	0
Serving vulnerable, less mobile populations	76	0	12	28	21	40	7
Senior housing	13	0	3	8	6	11	2
Long-term care	7	0	0	7	2	7	0
Childcare centers	30	0	5	6	8	11	3
Schools	26	0	4	7	5	11	2
Animal Facilities	1	0	1	0	1	1	0
Animal Shelters	1	0	1	0	1	1	0
Total	89	0	14	31	23	45	9

Table 4. Number of community facilities and services exposed to 16 and 55 inches of sea level rise in the City of Alameda.

Emeryville

There are nearly 7,000 people in the ART project area in the City of Emeryville. Of these, fewer than 150 will be exposed to the daily high tide or storm event flooding with 16 or 55 inches of sea level rise (Table 5). However, approximately 700 people will be exposed to wind waves with 16 inches of sea level rise, and nearly 2,000 will be exposed to wind waves with 55 inches of sea level rise. Over 18,000 people work in the ART project area in Emeryville, reflecting the commercial and industrial nature of this city. None of these employees are exposed to the daily high tide or storm event flooding with 16 inches of sea level rise; exposure to wind waves was not analyzed. With 55 inches of sea level rise, relatively few employees would be exposed to the daily high tide, but nearly 4,000, or 20% of employees would be exposed to storm event flooding, and an even higher percentage can be assumed to be exposed to wind waves.

The HAZUS replacement costs range from \$4 million exposed to the daily high tide with 16 inches of sea level rise, to \$316 million exposed to storm events and wind waves with 55 inches of sea level rise (\$69 million exposed to storm events and \$247 million exposed to wind waves only). Using the Assessor's data, between \$86 million (daily high tide with 16 inches of sea level rise) and \$1.3 billion (\$726 million exposed to storm events and \$545 million exposed to wind waves only with 55 inches of sea level rise) is exposed.

			16" SLR			55" SLR		
		Daily High Tide	Storm	Event	Daily High Tide	Storm	ו Event	
	Total*	Exposed	Exposed	Exposed to wind waves only	Exposed	Exposed	Exposed to wind waves only	
Residents	6,882							
Number		29	56	662	96	138	1,771	
Percent		0%	1%	10%	1%	2%	26%	
Employees	18,349							
Number		0	0		108	3,740		
Percent		0%	0%		1%	20%		
Replacement Costs (\$M) (HAZUS)	910							
Replacement costs		4	6	106	11	69	247	
Percent		0%	1%	12%	1%	8%	27%	
Assessed value (\$M)	3,512							
Assessed value		86	89	615	112	726	545	
Percent		2%	3%	18%	3%	21%	16%	

Table 5. Residents, Employees, and Property Values (in millions of dollars) exposed to 16 and 55 inches of sea level rise in the ART project area in Emeryville.

* Total is for portion of the city in the ART project area

There are three emergency response facilities in the ART project area in Emeryville – two fire stations and a police station (Table 6). The police station and one fire station are located on Powell Street, west of I-80/I-580. They are not exposed to the daily high tide or storm event flooding with 16 inches of sea level rise, but the fire station is exposed to wind waves. With 55 inches of sea level rise, the police station is exposed to storm event flooding and wind waves, and the fire station is exposed to high tide inundation and storm event flooding. The other fire station, on Hollis Street, is not exposed to any of the scenarios evaluated.

Three facilities in the ART project area in Emeryville serve at-risk populations, all of which are health care facilities. Two of these facilities are exposed to wind waves with 16 inches of sea level rise and storm event flooding with 55 inches of sea level rise. All three facilities are exposed to wind waves with 55 inches of sea level rise. There are nine facilities in the area that serve vulnerable, less mobile populations – one senior housing facility, four childcare centers, and four schools. One location houses both a childcare center and a school. The senior housing facility is exposed to wind waves with 55 inches of sea level rise only; no other facilities are exposed to any of the scenarios evaluated.

Table 6. Number of community facilities and services exposed to 16 and 55 inches of sea level rise in the ART project area in Emeryville.

			16" SLR		55" SLR			
		Daily High Tide	Storm	Event	Daily High Tide	Storm	Event	
Type of facility	City total*	Exposed	Exposed	Exposed to wind waves only	Exposed	Exposed	Exposed to wind waves only	
Emergency response	3	0	0	1	1	2	0	
Hospitals	0							
Police stations	1	0	0	0	0	1	0	
Fire stations	2	0	0	1	1	1	0	
Serving at-risk populations	3	0	0	2	0	2	1	
Health care facilities	3	0	0	2	0	2	1	
Homeless shelters	0							
Group homes	0							
Food banks	0							
Jails	0							
Serving vulnerable, less mobile populations	9	0	0	0	0	0	1	
Senior housing	1	0	0	0	0	0	1	
Long-term care	0							
Childcare centers	4	0	0	0	0	0	0	
Schools	4	0	0	0	0	0	0	
Animal Facilities	0	0	0	0	0	0	0	
Animal Shelters	0							
Total	15	0	0	3	1	4	2	

Hayward

Approximately 140,000 Hayward residents live in the ART project area. Relatively few would be exposed to the daily high tide with 16 or 55 inches of sea level rise, or storm event flooding with 16 inches (Table 7). Slightly fewer then 5,000 residents would be exposed to 16 inches of sea level rise during a storm event with wind waves. Over 5,000 residents would be exposed to storm event flooding with 55 inches, and over 10,000 are exposed to wind waves with 55 inches of sea level rise. Approximately 60,000 people work in the ART project area in Hayward. With 16 inches of sea level rise, none of these employees would be exposed to the daily high tide, and approximately 700 would be exposed to storm events. With 55 inches of sea level rise, approximately 2,500 and 10,000 would be exposed to flooding from the daily high tide and storm events, respectively. Exposure to wind waves was not analyzed.

The replacement value of property in the ART project area in Hayward is approximately \$8 billion according to the HAZUS model, and property values are just over \$16 billion using the Assessor's data. Based on HAZUS, replacement costs range from \$75 million exposed to the daily high tide with 16 inches of sea level rise, to \$1.5 billion exposed to storm events and wind waves with 55 inches of sea level rise (\$1.1 billion exposed to storm events and \$340 million exposed to wind waves only). Using the Assessor's data, property values exposed range from \$48 million exposed to the daily high tide with 16 inches of sea level rise, to \$3.2 billion exposed to storm events and \$748 million exposed to wind waves only).

			16" SLR		55" SLR		
		Daily High Tide	Storm Event		Daily High Tide	Storm Event	
	City total*	Exposed	Exposed	Exposed to wind waves only	Exposed	Exposed	Exposed to wind waves only
Residents	140,030						
Number		82	167	4,832	187	5,250	5,287
Percent		0%	0%	3%	0%	4%	4%
Employees	60,310						
Number		0	740		2,525	9,662	
Percent		0%	1%		4%	16%	
Replacement Costs (\$M) (HAZUS)	\$8,110						
Replacement costs		\$75	\$258	\$694	\$373	\$1,120	\$340
Percent		1%	3%	9%	5%	14%	4%
Assessed value (\$M)	\$16,315						
Assessed value		\$48	\$743	\$1,727	\$1,203	\$2,466	\$748
Percent		0%	5%	11%	7%	15%	5%

Table 7. Residents, Employees, and Property Values (in millions of dollars) exposed to 16 and 55 inches of sea level rise in the ART project area in Hayward.

* Total is for portion of the city in the ART project area

There are six emergency response facilities in the ART project area in Hayward: two hospitals, two police stations, and two fire stations (Table 8). These facilities are not exposed to any of the scenarios evaluated. Forty-six facilities serve at-risk populations: 32 health care facilities, two homeless shelters, four group homes, seven food banks, and one jail, which is co-located with one of the police stations. Of these facilities, two health care facilities are exposed to wind waves with 16 inches of sea level rise, and with 55 inches of sea level rise these same facilities are exposed to the daily high tide and storm event flooding. One hundred thirty five facilities serve

vulnerable, less mobile populations: 46 senior housing facilities, 16 long-term care facilities, 34 childcare centers, and 39 schools. Fourteen long-term care facilities are co-located with a health care or senior housing facility, and 14 locations house schools and childcare centers. Only five of the 135 facilities are exposed to wind waves with 16 inches of sea level rise, and to storm event flooding with 55 inches of sea level rise. An additional three are exposed to wind waves with 55 inches of sea level rise.

Table 8. Number of community facilities and services exposed to 16 and 55 inches of sea level rise in the ART project area in Hayward.

		16" SLR			55" SLR			
		Daily High Tide	Storm	Event	Daily High Tide	Storm	Event	
Type of facility	City total*	Exposed	Exposed	Exposed to wind waves only	Exposed	Exposed	Exposed to wind waves only	
Emergency response	6	0	0	0	0	0	0	
Hospitals	2	0	0	0	0	0	0	
Police stations	2	0	0	0	0	0	0	
Fire stations	2	0	0	0	0	0	0	
Serving at-risk populations	46	0	0	2	2	2	0	
Health care facilities	32	0	0	2	2	2	0	
Homeless shelters	2	0	0	0	0	0	0	
Group homes	4	0	0	0	0	0	0	
Food banks	7	0	0	0	0	0	0	
Jails	1	0	0	0	0	0	0	
Serving vulnerable, less mobile populations	135	0	0	5	0	5	3	
Senior housing	46	0	0	3	0	3	2	
Long-term care	16	0	0	0	0	0	0	
Childcare centers	34	0	0	1	0	1	1	
Schools	39	0	0	1	0	1	0	
Animal Facilities	0	0	0	0	0	0	0	
Animal Shelters	0							
Total	187	0	0	7	2	7	3	

Oakland

There are approximately 400,000 residents living in the ART project area in Oakland. Very few are exposed to the daily high tide with 16 inches of sea level rise, and approximately 6,000, or two percent, are exposed to wind waves (Table 9). Roughly the same amount are exposed to storm event flooding with 55 inches of sea level rise, and nearly 15,000, or four percent, are exposed to wind waves. Approximately 150,000 people work in Oakland. With 16 inches of sea level rise, fewer than 1,000 employees are exposed to the daily high tide, and approximately 4,000, or two percent, are exposed to storm event flooding. With 55 inches of sea level rise, over 12,000 employees, or eight percent, are exposed to storm event flooding, and over 32,000, or 21%, are exposed to wind waves.

The replacement costs of property in the ART project area in Oakland are approximately \$22 billion according to the HAZUS model, and property values are \$38 billion using the Assessor's data. Based on HAZUS, replacement costs range from \$104 million exposed to the daily high tide with 16 inches of sea level rise, to \$2.9 billion exposed to storm events and wind waves with 55 inches of sea level rise (\$1.9 billion exposed to storm events and \$1 billion exposed to wind waves only). Using the Assessor's data, the property value exposed ranges from \$182 million for the daily high tide with 16 inches of sea level rise, to \$3 billion exposed to storm events and wind waves and wind waves with 55 inches of sea level rise (\$2.4 billion exposed to storm events and \$621 million exposed to wind waves only).

			16" SLR		55" SLR		
		Daily High Tide	Storm	Event	Daily High Tide	Storm Event	
	City total*	Exposed	Exposed	Exposed to wind waves only	Exposed	Exposed	Exposed to wind waves only
Residents	399,484						
Number		16	233	5,732	1,370	5,840	8,991
Percent		0%	0%	1%	0%	2%	2%
Employees	151,962						
Number		993	3,599		12,486	32,431	
Percent		1%	2%		8%	21%	
Replacement Costs (\$M) (HAZUS)	22,176						
Replacement costs		104	256	1,664	678	1,960	1,010
Percent		1%	1%	8%	3%	9%	5%
Assessed value (\$M)	38,171						
Assessed value		182	375	2,028	1,158	2,396	621
Percent		0%	1%	5%	3%	6%	2%

Table 9. Residents, Employees, and Property Values (in millions of dollars) exposed to 16 and 55 inches of sea level rise in the ART project area in Oakland.

* Total is for portion of the city in the ART project area

There are thirteen emergency response facilities in the ART project area in Oakland: four hospitals, one police station and eight fire stations (Table 10). Two fire stations are exposed to wind waves with 16 inches of sea level rise. With 55 inches of sea level rise, these same stations are exposed to storm event flooding, and one additional fire station is exposed to wind waves. None of the other facilities are exposed to any of the scenarios evaluated.

There are 133 facilities serving at-risk populations: 87 health care facilities, 12 homeless shelters, 19 group homes, 14 food banks, and one jail. With 16 inches of sea level rise, only one facility is

exposed to storm event flooding and seven are exposed to wind waves. With 55 inches of sea level rise, two are exposed to the daily high tide, seven are exposed to storm event flooding, and four additional facilities are exposed to wind waves only. Two hundred ninety three facilities serving vulnerable, less mobile populations are in the ART project area in Oakland: 45 senior housing facilities, 21 long-term care facilities, 146 childcare centers, and 81 schools. With 16 inches of sea level rise, only one is exposed to storm events and eight are exposed to wind waves only. With 55 inches of sea level rise, two facilities are exposed to the daily high tide, nine are exposed to storm event flooding, and an additional 12 are exposed to wind waves only.

Several facilities in Oakland provide multiple services to the community. For example, all of the hospitals are also listed as other types of health care facilities, and five senior housing facilities and seven long-term care facilities are cross-listed. Thirteen schools are co-located with childcare centers or other services, and a number of food banks are located at the same address as homeless shelters or health care facilities.

Table 10. Number of community facilities and services exposed to 16 and 55 inches of sea level rise in the ART project area in Oakland.

			16" SLR		55" SLR			
		Daily High Tide	Storm	Event	Daily High Tide	Storm	Event	
Type of facility	City total*	Exposed	Exposed	Exposed to wind waves only	Exposed	Exposed	Exposed to wind waves only	
Emergency response	13	0	0	2	0	2	1	
Hospitals	4	0	0	0	0	0	0	
Police stations	1	0	0	0	0	0	0	
Fire stations	8	0	0	2	0	2	1	
Serving at-risk populations	133	0	1	7	2	7	4	
Health care facilities	87	0	1	4	2	4	2	
Homeless shelters	12	0	0	2	0	2	0	
Group homes	19	0	0	0	0	0	0	
Food banks	14	0	0	1	0	1	2	
Jails	1	0	0	0	0	0	0	
Serving vulnerable, less mobile populations	293	0	1	8	2	9	12	
Senior housing	45	0	0	0	0	0	3	
Long-term care	21	0	0	0	0	0	0	
Childcare centers	146	0	0	6	0	6	4	
Schools	81	0	1	2	2	3	5	
Animal Facilities	0	0	0	0	0	0	0	
Animal Shelters	0							
Total	439	0	2	17	4	18	17	

San Leandro

Nearly 80,000 people live in the ART project area in San Leandro. With 16 inches of sea level rise, a few hundred are exposed to the daily high tide, over 3,000 are exposed to storm event flooding, and over 9,000, or 12%, are exposed to wind waves (Table 11). With 55 inches of sea level rise, over 4,000 are exposed to the daily high tide, nearly 10,000 are exposed to storm event flooding, and over 15,000, or 20%, are exposed to wind waves. There are approximately 35,000 people who work in the ART project area in San Leandro. No employees are exposed to the daily high tide with 16 inches of sea level rise, but over 2,000, or seven percent, are exposed to storm event flooding. Roughly the same number are exposed to the daily high tide with 55 inches of sea level rise, and nearly 8,000, or 21%, are exposed to storm event flooding. Exposure to wind waves was not analyzed.

According to the HAZUS model, there are approximately \$5 billion of replacement costs in the ART project area in San Leandro. Between \$23 million (daily high tide with 16 inches of sea level rise) and \$1.1 billion (\$668 million exposed to storm events and \$472 million exposed to wind waves only with 55 inches of sea level rise) of replacement costs are exposed to the scenarios analyzed. The assessed value of property is nearly \$10 billion, of which \$8 million (daily high tide with 16 inches of sea level rise) to \$2 billion (\$1.6 billion exposed to storm events and \$415 million exposed to wind waves only with 55 inches of sea level rise) is exposed.

			16" SLR		55" SLR		
		Daily High Tide	Storm	Storm Event		Storm Event	
	City total*	Exposed	Exposed	Exposed to wind waves only	Exposed	Exposed	Exposed to wind waves only
Residents	79,452						
Number		356	3,220	6,227	4,246	9,732	5,734
Percent		0%	4%	8%	5%	12%	7%
Employees	35,690						
Number		0	2,494		2,984	7,673	
Percent		0%	7%		8%	21%	
Replacement Costs (\$M) (HAZUS)	5,218						
Replacement costs		23	227	510	316	668	472
Percent		0%	4%	10%	6%	13%	9%
Assessed value (\$M)	9,890						
Assessed value		8	464	1,097	802	1,607	415
Percent		0%	5%	11%	8%	16%	4%

Table 11. Residents, Employees, and Property Values (in millions of dollars) exposed to 16 and 55 inches of sea level rise in the ART project area in San Leandro.

* Total is for portion of the city in the ART project area

There are three hospitals, one police station, and three fire stations in the ART project area in San Leandro (Table 12). One fire station is exposed to all of the sea level rise scenarios except for the daily high tide with 16 inches of sea level rise. There are 23 facilities serving at-risk populations: 16 health care facilities, two group homes, four food banks, and one jail, which is co-located with the police station. Of these, only one health care facility is exposed to the most extreme scenario, wind waves with 55 inches of sea level rise. Eighty-one facilities serve vulnerable, less mobile populations: 23 senior housing facilities, eight long-term care facilities, 26 childcare centers, and 24 schools. Two long-term care facilities are co-located with other health care facilities, and seven locations house schools and childcare centers. Two facilities are exposed to storm event flooding with 16 inches of sea level rise, and an additional six are exposed to wind waves only. With 55 inches of sea level rise, two facilities are exposed to the daily high tide, eight are exposed to storm event flooding, and four additional facilities are exposed to wind waves only.

Table 12. Number of community facilities and services exposed to 16 and 55 inches of sea level rise inthe ART project area in San Leandro.

		16" SLR			55" SLR		
		Daily High Tide	Storm Event		Daily High Tide	Storm Event	
Type of facility	City total*	Exposed	Exposed	Exposed to wind waves only	Exposed	Exposed	Exposed to wind waves only
Emergency response	7	0	1	0	1	1	0
Hospitals	3	0	0	0	0	0	0
Police stations	1	0	0	0	0	0	0
Fire stations	3	0	1	0	1	1	0
Serving at-risk populations	23	0	0	0	0	0	1
Health care facilities	16	0	0	0	0	0	1
Homeless shelters	0						
Group homes	2	0	0	0	0	0	0
Food banks	4	0	0	0	0	0	0
Jails	1	0	0	0	0	0	0
Serving vulnerable, less mobile populations	81	0	2	6	2	8	4
Senior housing	23	0	2	2	2	4	1
Long-term care	8	0	0	0	0	0	0
Childcare centers**	26	0	0	2	0	2	1
Schools***	24	0	0	2	0	2	2
Animal Facilities	0	0	0	0	0	0	0
Animal Shelters	0						
Total	111	0	3	6	3	9	5

San Lorenzo

Approximately 22,000 people live in the ART project area in San Lorenzo. Very few are exposed to the daily high tide or storm event flooding with 16 inches of sea level rise, or the daily high tide with 55 inches of sea level rise (Table 13). Nearly 3,000 people are exposed to wind waves with 16 inches and storm event flooding with 55 inches of sea level rise. Over 5,000 people, or 24%, are exposed to wind waves with 55 inches of sea level rise. Of the roughly 2,500 people working in San Lorenzo, only 20 are exposed to storm event flooding with 55 inches of sea level rise, the most extreme scenario analyzed for this group of people.

According to the HAZUS model, there are \$1 billion of replacement costs in the ART project area in San Lorenzo, of which \$2 million (daily high tide with 16 inches of sea level rise) to \$282 million (\$172 million exposed to storm events and \$110 million exposed to wind waves only with 55 inches of sea level rise) are exposed to the various sea level rise scenarios analyzed. The assessed value of property in the area is approximately \$2.3 billion. Between \$1 million (daily high tide with 16 inches of sea level rise) and \$551 million (\$373 million exposed to storm events and \$178 million exposed to wind waves only with 55 inches of sea level rise) of this property value is exposed to sea level rise.

		16" SLR			55" SLR		
		Daily High Tide	Storm Event		Daily High Tide	Storm Event	
	City total*	Exposed	Exposed	Exposed to wind waves only	Exposed	Exposed	Exposed to wind waves only
Residents	21,898						
Number		13	177	2,451	200	2,950	2,387
Percent		0%	1%	11%	1%	14%	11%
Employees	2,685						
Number		0	0		7	20	
Percent		0%	0%		0%	1%	
Replacement Costs (\$M) (HAZUS)	1,004						
Replacement costs		2	22	133	27	172	110
Percent		0%	2%	13%	3%	17%	11%
Assessed value (\$M)	2,264						
Assessed value		1	49	304	76	373	178
Percent		0%	2%	13%	3%	16%	8%

Table 13. Residents, Employees, and Property Values (in millions of dollars) exposed to 16 and 55 inches of sea level rise in the ART project area in San Lorenzo.

* Total is for portion of the city in the ART project area

There are no emergency response facilities in the ART project area in San Lorenzo. None of the three facilities that serve at-risk populations – one health care facility and two food banks – are exposed to any of the scenarios analyzed. There are 30 facilities that serve vulnerable, less mobile populations: eight senior housing facilities, nine childcare centers and 13 schools (Table 14). Five of the facilities are co-located schools and childcare facilities. Of these 30 facilities, one is exposed to storm event flooding with 16 inches of sea level rise, and an additional five are exposed to wind waves only. With 55 inches of sea level rise, four are exposed to the daily high tide, six are exposed to storm event flooding, and two more are exposed to wind waves only.

Table 14. Number of community facilities and services exposed to 16 and 55 inches of sea level rise inthe ART project area in San Lorenzo.

		16" SLR			55" SLR		
		Daily High Tide	Storm	Event	Daily High Tide	Storm	i Event
Type of facility	City total*	Exposed	Exposed	Exposed to wind waves only	Exposed	Exposed	Exposed to wind waves only
Emergency response	0						
Hospitals	0						
Police stations	0						
Fire stations	0						
Serving at-risk populations	3	0	0	0	0	0	0
Health care facilities	1	0	0	0	0	0	0
Homeless shelters	0						
Group homes	0						
Food banks	2	0	0	0	0	0	0
Jails	0						
Serving vulnerable, less mobile populations	30	0	1	5	4	6	2
Senior housing	8	0	0	1	0	1	0
Long-term care	0						
Childcare centers**	9	0	1	4	4	5	2
Schools***	13	0	0	0	0	0	0
Animal Facilities	0	0	0	0	0	0	0
Animal Shelters	0						
Total	33	0	1	5	4	6	2

Union City

Nearly 67,000 people live in the ART project area in Union City. While only one percent is exposed to the daily high tide with 16 inches of sea level rise, nearly 5,000, or seven percent is exposed to storm event flooding, and over 25,000, or 38%, are exposed to wind waves (Table 15). With 55 inches of sea level rise nearly 18,000, or 27%, are exposed to the daily high tide; almost 40% are exposed to storm event flooding, and over 34,000, or 51%, are exposed to wind waves. Just over 19,000 people work in the ART project area in Union City. Of these, approximately 700, or four percent, are exposed to storm event flooding with 16 inches of sea level rise. With 55 inches of sea level rise, just over 1,000 employees, or six percent, are exposed to the daily high tide, and 4,500, or 24%, are exposed to storm event flooding. Employee exposure to wind waves was not analyzed.

According to the HAZUS model, there are 3.2 billion dollars of replacement costs in the ART project area in Union City, of which \$26 million (daily high tide with 16 inches of sea level rise) to \$1.6 billion dollars (\$1.2 billion exposed to storm event flooding, and an additional 380 million dollars exposed to wind waves with 55 inches of sea level rise) are exposed. The assessed value of property in the area is \$7.6 billion, with zero (daily high tide with 16 inches of sea level rise) to \$3.7 billion (\$3 billion exposed to storm event flooding and an additional \$766 million exposed to wind waves with 55 inches of sea level rise) exposed.

		16" SLR			55" SLR		
		Daily High Tide	Storm Event		Daily High Tide	Storm Event	
	ART project area total	Exposed	Exposed	Exposed to wind waves only	Exposed	Exposed	Exposed to wind waves only
Residents	66,869						
Number		353	4,849	20,652	17,940	25,722	8,441
Percent		1%	7%	31%	27%	39%	13%
Employees	19,210						
Number		0	716		1,197	4,562	
Percent		0%	4%		6%	24%	
Replacement Costs (\$M) (HAZUS)	3,259						
Replacement costs		26	220	940	716	1,200	380
Percent		1%	7%	29%	22%	37%	12%
Assessed value (\$M)	7,563						
Assessed value		0	589	2,428	1,859	2,964	766
Percent		0%	8%	32%	25%	39%	10%

Table 15. Residents, Employees, and Property Values (in millions of dollars) exposed to 16 and 55 inches of sea level rise in the ART project area in Union City.

* Total is for portion of the city in the ART project area

There are two emergency response facilities – both of which are fire stations – in the ART project area in Union City (Table 16). One station is exposed to storm event flooding with 16 inches of sea level rise, and another is exposed to wind waves only. With 55 inches of sea level rise, one is exposed to the daily high tide, and both are exposed to storm event flooding and wind waves. There are three facilities serving at-risk populations. One, a health care facility, is exposed to storm event flooding. There are 34 facilities serving vulnerable, less mobile populations: 23 senior housing facilities, four childcare centers, and seven schools. Two

locations have childcare centers and schools. Of the 34 facilities, one is exposed to storm event flooding with 16 inches of sea level rise, and 19, including 11 senior housing facilities, are exposed to wind waves only. With 55 inches of sea level rise, nine facilities are exposed to the daily high tide, including three childcare facilities and five schools. Nineteen are exposed to storm event flooding, and six are exposed to wind waves only.

Table 16. Number of community facilities and services exposed to 16 and 55 inches of sea level rise in the ART project area in Union City.

		16" SLR			55" SLR		
		Daily High Tide	Storm Event		Daily High Tide	Storm Event	
Type of facility	City total*	Exposed	Exposed	Exposed to wind waves only	Exposed	Exposed	Exposed to wind waves only
Emergency response	2	0	1	1	1	2	0
Hospitals	0						
Police stations	0						
Fire stations	2	0	1	1	1	2	0
Serving at-risk populations	4	0	0	1	0	1	0
Health care facilities	2	0	0	1	0	1	0
Homeless shelters	0						
Group homes	1	0	0	0	0	0	0
Food banks	1	0	0	0	0	0	0
Jails	0						
Serving vulnerable, less mobile populations	34	0	1	19	9	19	6
Senior housing	23	0	0	11	1	11	6
Long-term care	0						
Childcare centers**	4	0	1	3	3	3	0
Schools***	7	0	0	5	5	5	0
Animal Facilities	0	0	0	0	0	0	0
Animal Shelters	0						
Total	40	0	2	21	10	22	6

Sensitivity and Adaptive Capacity

Sensitivity refers to the degree to which an asset or entire system (e.g., a senior housing facility, or jobs within a city) would be physically or functionally impaired if exposed to a climate impact. Adaptive capacity is the ability for an asset or system to accommodate or adjust to a climate impact and maintain or quickly resume its primary function. This chapter addresses a very broad cross section of assets, ranging from private residences to facilities housing seniors who may have limited mobility, to police and fire stations that would be heavily relied on in a flood emergency. Because of the diversity across and within these categories, this section does not provide a detailed analysis of the sensitivity of every asset, or even every category, but rather provides an overview of how the ART project area's residents, employees, facilities, and services are sensitive to sea level rise, and describes where adaptive capacity exists.

Residents and Employees

The sensitivity and adaptive capacity of the people who live and work in the ART project area will depend on a number of factors, including economic status, level of education, health and physical mobility, ownership of a home or car, and proficiency in English. These factors can influence the degree to which individuals, households, neighborhoods and even communities are vulnerable. An analysis of demographic factors in the ART project area and their relationship to community vulnerability is discussed in detail in a companion piece to this report⁶.

Beyond these factors, individuals are often sensitive to, and have limited capacity to either adjust to or accommodate, a climate impact such as flooding. Having to leave one's home, even for a short period, can have a devastating effect on both individuals and families. For many, especially those in the Bay Area where available housing is expensive and difficult to find, losing housing even temporarily can be a significant hardship that is hard to overcome. Often there is limited capacity or opportunity to find adequate and affordable replacement housing that is near the jobs, schools, services, and facilities that individuals and households rely on.

Individuals that rent housing may be particularly sensitive, as they may not be able to influence the owners to improve the property to better withstand flooding, or to respond to a flood event if it does occur, for example by quickly drying and replacing damaged materials. Renters may also lack insurance that could provide assistance with replacing damaged personal items or providing an alternative place to live. In all cases, for both homeowners and renters alike, in addition to the burden of relocation, the loss of all or even a portion of one's personal belongings – including photos, birth certificates, financial documents, valuables, and other treasured items – can have significant and lasting impacts. Often these items cannot be replaced, and in many cases personal and financial documents are necessary to begin recovering and rebuilding after a flood event.

In addition to the individual and household vulnerabilities discussed above, the people, property, and places that make up the neighborhoods in the ART project area are collectively sensitive to sea level rise and storm events, and have varying capacities to accommodate or adjust to impacts if they were to occur.

Residential neighborhoods, in particular, are both physically and functionally sensitive to inundation, flooding, and elevated groundwater levels. In general, most buildings are not designed or constructed to withstand flooding or rising groundwater. For example, buildings

⁶ See "Addressing Social Vulnerability and Equity in Climate Change Adaptation Planning," available on the ART project website: http://www.adaptingtorisingtides.org/project-reports/.

with drywall are particularly sensitive as drywall wicks water upward, meaning damage can occur well above the actual level of flooding. In addition, drywall and other materials, such as plaster can become fragile if exposed to water for long periods of time, and even if dried, they cannot easily be decontaminated and generally must be demolished and replaced. Other common construction materials, such as wood, may not suffer structural damage from flooding, but mold and other organisms can flourish in the wet, post-flood environment. Wood structures must be thoroughly and fairly immediately dried out or they will decay, requiring demolition and replacement.

In addition to flooding due to extreme tides or storm events, higher groundwater levels that may result from rising sea level will affect residential and other buildings that have underground components. Sump pumps are often used in areas that already have high groundwater to keep basements and underground areas such as storage or parking areas dry and functioning. As groundwater levels rise, underground areas, which are already sensitive to flooding, will be at greater risk. There are opportunities for underground areas to be improved to accommodate or adjust to rising groundwater, for example by installing new or larger pumps, or elevating or removing items that could be damaged if wet. However, long duration high groundwater events, especially if combined with power outages that cause pumps to cease functioning or if there is overland flooding at the same time, can ultimately not be accommodated.

While there is some capacity for individual buildings within neighborhoods to accommodate or adjust to flooding impacts, often this capacity is limited to short duration or less severe events. For example, sandbags can provide some level of protection to buildings and other facilities, and in some cases personal property or valuables can be moved to upper floors. Adaptive capacity could be increased if buildings are constructed or reconstructed with flood resistant materials, or if lower floors are raised above projected flood levels. However, these are costly and time-consuming efforts for property owners, and from the perspective of city- or region-wide adaptive capacity, there is no way to ensure that building owners will take these steps without some form of financial or regulatory incentives.

If protecting buildings and neighborhoods from flooding is not an option, in the short-term residents can evacuate and stay in hotels or shelters, and some businesses may be able to rent space or have workers telecommute. These solutions may not be viable over the long term, as hotels and shelters do not provide real redundancy, and many businesses require specialized equipment or storage space that is not immediately available elsewhere. Over the long term, and in the event of large scale flooding, many of the options that increase individuals' and neighborhoods' adaptive capacity will not be sustainable, and there will need to be coordinated action to improve resilience.

In general, neighborhoods are greater than the sum of their parts. Beyond the physical characteristics and conditions of buildings that comprise a neighborhood are the social networks that define how a neighborhood functions. This function is dependent on the people that live and work there, the relationships among them, and the ties that connect them. In many ways, how a neighborhood functions can either impart resilience or be the cause of vulnerability. A neighborhood with a strong social network that is tied together by individual relationships will have a lower overall sensitivity and higher adaptive capacity than a neighborhood where residents either do not know each other, or are not invested in the overall community good. For example, a neighborhood where residents have strong connections and can rely on each other in an urgent or emergency situation will be less sensitive, and will be more likely to find ways to adjust to or accommodate a climate impact such as a flood event than those responding on their own.

Neighborhood networks and resources can be both informal and formal. An example of a formal neighborhood network is the Community Emergency Response Team (CERT), one of which is run by Alameda County, and several others by cities in the ART project area.⁷ The CERT program is a countrywide initiative that helps local agencies and other entities train citizens to respond to emergencies in their neighborhoods, particularly when official emergency responders are overwhelmed by a large-scale disaster. While training content and format differs from program to program, most include disaster medical operations, fire suppression, and HAZMAT awareness. Neighborhoods where individuals have been trained to respond to disasters will be better equipped to respond to an extreme tide or storm events, as will those with informal, social connections among neighbors. On the other hand, in a neighborhood without these resources and connections, each individual or household would be on their own to face the impact separately.

In addition, the social networks and ties that connect individuals in a neighborhood can themselves be sensitive and have limited adaptive capacity. For example, a storm event that floods a neighborhood and causes residents to be relocated to disparate locations, either temporarily or permanently, can sever even long-standing relationships, disrupting the social network that imparted collective strength and resilience. The capacity to reconnect or rebuild these ties will depend, ultimately, on the duration of the event, and the strength and will of the residents that return to the neighborhood.

Facilities and Services

Facilities that provide key community services will have similar physical sensitivities to those discussed above. The services these facilities provide will be sensitive to inundation, flooding, and elevated groundwater depending on the type of facility and the role it serves in the community. The different facilities will also have varying degrees of adaptive capacity. The ability to accommodate or adjust to an impact if it does occur will depend in part on the type of facility and service it provides to the community. These differences are described in more detail below.

Emergency Facilities

Emergency facilities will have similar physical sensitivities to flooding as other types of structures, but their functional sensitivities vary widely based on the nature of the facility. Many emergency facilities are large employers and sometimes shelter vulnerable populations, and therefore are sensitive in terms of the need to evacuate or safely shelter in place. These facilities also have two characteristics that can significantly increase their sensitivity: They usually contain highly sensitive, expensive, specialized equipment; and, they are critical in assisting others in the event of a disaster. Therefore, if exposed, these facilities are not only directly sensitive to potential physical damage or harm to people on-site, but are functionally sensitive in that their ability to serve the community as intended could be compromised.

An additional concern is that the function of an emergency facility can easily be compromised if access to and from it is disrupted. For example, patients must be able to get into hospitals, and fire and police vehicles must be able to leave stations to respond to emergencies. Therefore, the location and elevation of driveways and doorways is critical, as is the vulnerability of access roads. The facilities in the ART project area that are potentially exposed to flooding that have entrances at grade, critical equipment located on the first floor, or underground areas necessary to the function of the facility, will be sensitive to sea level rise impacts if they were to occur.

⁷ Alameda County: https://www.citizencorps.gov/cc/showCert.do?cert&id=44855; City of Alameda: http://www.cityofalamedaca.gov/City-Hall/CERT; Emeryville:

https://www.citizencorps.gov/cc/showCert.do?cert&id=43305; Hayward:

https://www.citizencorps.gov/cc/showCert.do?cert&id=44015; Oakland:

http://www.oaklandnet.com/fire/core/neighborhood.html

Emergency facilities do, however, have an inherent capacity to accommodate or adjust to impacts, which comes from the services these facilities provide. For example, fire stations are equipped to assist their communities with flooding and have access to portable pumps and power. In addition, as trained emergency responders, police and fire fighters should be individually prepared to safely evacuate if the stations are threatened. Where buildings have multiple stories, sensitive equipment may be able to be moved above the ground floor. In some cities, redundancy – that is, multiple hospitals and fire and police stations located within reasonable proximity – provides adaptive capacity. Even in cities with only one fire station or hospital, emergency responders are part of mutual aid agreements with other cities and their own county, and even other counties can be called upon to assist in the event of insufficient resources at the site of an emergency. For example, Union City contracts with the Alameda County Fire Department for fire services, but still owns and manages four fire stations. If one of Union City's facilities was out of service for an extended period of time, the city could coordinate with an adjacent city that is also affiliated with Alameda County Fire Department to provide coverage.

Beyond specific facilities that provide emergency response services on an ongoing basis, there are predetermined shelter-in-place locations identified in approved disaster plans. If there is an emergency in the ART project area, the Alameda County Emergency Operations Center, Alameda County Social Service Agency, and the affected cities would work with the American Red Cross to house displaced populations at local schools and other appropriate locations. Some of these shelter-in-place sites could, however, also be exposed to an extreme tide or storm event flooding. Because there are many sites identified across the county, though, and because they are not activated until the emergency occurs, there is probably adequate redundancy to sustain the overall function of temporarily housing displaced individuals.

At-risk populations

Facilities serving at-risk populations are particularly sensitive if people rely on them for shelter, for example facilities such as homeless shelters and group homes. In these cases, evacuation may be necessary and could result in the displacement of very vulnerable individuals. While temporary shelters may be available for residents and employees, some individuals – such as those with physical disabilities or special medical requirements – may not be able to be placed in these shelters, and alternative, appropriate facilities would need to be found. Facilities serving at-risk populations are often difficult to relocate due to the population served, the need to be located near transit, and the small operating budgets available to most organizations that run these types of shelters and homes. The capacity of facilities serving at-risk populations to a flood event will depend on the preparation of carefully considered disaster plans, the adequacy of access to the temporary facility, access to appropriate facilities to temporarily house these populations, and the availability of equipment and trained personnel to assist in emergency response activities.

Other types of facilities serving at-risk populations, such as food banks and health clinics, will have physical and functional sensitivities. Sea level rise and storm events could result in the loss of supplies and equipment that would be difficult to move in an emergency and to replace during the response. Temporary re-location would also pose a challenge because in addition to the need for special equipment and facilities, transportation options to these facilities and access to transit is critical. Access to these facilities is also important and if impaired, would reduce or eliminate the role that they serve within the community.

In addition, the increased need for these types of services that may arise during a flooding emergency could be an added stressor that increases their sensitivity. For example, in the event of a flood, health clinics must continue to provide their regular services (i.e., to existing patients)

while also preparing for and responding to a potentially large-scale disaster. Up to a point, health care systems have the capacity to bring in resources from other areas to assist them. However, this source of adaptive capacity could also be taxed if an emergency were to cause widespread impacts.

Vulnerable, less mobile populations

Facilities serving vulnerable, less mobile populations are sensitive largely because the people who live or regularly spend time in these facilities are themselves sensitive due to age (small children and the elderly), health, or other conditions and need assistance with daily, routine tasks. This causes additional challenges in responding to a flood event. For example, evacuating a senior housing facility could be complicated by large numbers of less mobile people who would need additional time, assistance, or equipment. Evacuating schools and childcare centers will require careful coordination so that there is adequate supervision of young people and safe locations identified where family members can be reunited.

Often, these types of facilities have some capacity to accommodate or adjust to emergency events such as flooding, as they generally have already prepared emergency response plans. Additional capacity can be gained by coordinating with emergency responders prior to emergencies to ensure that the location and number of people at each facility is known to emergency responders, keeping plans up to date, practicing evacuation procedures, having alternate, temporary shelter locations and meeting points pre-identified, and ensuring that there are upper floors within the facility where people or equipment could be housed during an emergency. Due to the sensitivity of these populations, a longer-term strategy may be to move these facilities out of areas threatened by sea level rise and storm events. While emergency preparedness and response is an adequate approach in the short-term, if these facilities or access to them were to confront frequent or severe flooding, such response strategies would likely be inadequate to protect populations that are as sensitive to disruption as those in vulnerable, less mobile populations.

Animal Facilities

Animal facilities share many of the same characteristics of the other facilities and services described above and have many of the same sensitivities, adaptive capacities, and need for advance preparedness and response planning. There are several categories that are often included when describing the vulnerabilities of animal facilities within communities. These categories include:

- Municipal and Non-Profit Animal Shelters
- Zoo, Wildlife and Marine Mammals
- Rescued Household Pets
- Evacuated Household Pets
- Lost and Abandoned Household Pets
- Livestock
- Research Animals
- Pet Shops, particularly those that sell exotic animals

Based on the data available regarding the types of facilities within the ART project area, there is one non-profit animal shelter located within the exposure zone. This animal shelter is located in the City of Alameda and is operated by the Friends of Alameda Animal Shelter (Figure 3). Data on the presence of pet shops, research animals, and livestock within the project area was not available. There are likely a number of household pets and possibly some backyard livestock within the project area.

Animal facilities are sensitive for a number of reasons. Animals are often extremely difficult to move and relocate for most households and facilities. Special equipment and personnel are often needed to safely move many animals and adequate relocation facilities are also necessary. For households with dogs and cats, even temporary displacement can be difficult, as hotels and rentals do not always allow pets. For those with horses, chickens, or other livestock, or exotic animals, temporary or permanent displacement poses additional challenges in looking for replacement housing. For these reasons, having pets can result in



people making poor choices regarding evacuation, and make them more sensitive to hazards, if, for example, they choose to stay in order to take care of animals that are difficult to move and relocate.

Zoos, animal shelters, research facilities, and pet shops confront many of the same challenges as households regarding moving and relocating the animals in their care, except on a larger and more complex scale. There are more animals to address, there are often exotic and large species in their care, and they may not have the staff available for a large-scale evacuation or the facilities to relocate to temporarily or permanently once the animals have been removed from the hazard zone. In 2007, a series of wildfires caused the evacuation of most staff and some animals (cheetahs, condors, snakes) within the San Diego Wild Animal Park. However, through various adaptation measures to increase adaptive capacity in a fire zone, such as fire proof buildings on-site and significant fire-breaks around the perimeter of the zoo, it was possible for the animals to be evacuated to locations on-site.

Animal facilities, such as animal shelters and their staff, may confront a dual challenge during a hazard: the need to evacuate and relocate their own facility and the animals currently in their care, and the need to assist in the evacuation and re-location of household pets. Animal shelters are often operated with few financial resources, and paid staff are often not adequate for even the day-to-day operations of most shelters. When confronting response to a hazard that includes a change in operation, reduced access to the facility, or temporary relocation, paid staff will not be adequate to deal with most hazards and volunteers will be necessary to respond. Providing for both a response for the facility and service to the community will be a significant challenge, as it has when such hazards have occurred in other parts of the country. In such cases, neighboring facilities have assisted, temporary facilities have been set up and outside agencies and volunteers have provided significant assistance.

In addition to local agencies, there are several national non-profit and federal agencies that provide assistance and staff to local animal facilities. In recognition of the serious nature of the issue and the need for better coordination and preparedness, the Pets Evacuation and Transportation Standards Act was passed by the House of Representatives in 2006 in the aftermath of Katrina and signed into law. The law requires that states seeking Federal Emergency Management Agency (FEMA) assistance must accommodate pets and service animals in their plans for evacuating residents from hazards and recovery from that hazard. Additionally, organizations such as the Humane Society of the United States and the United States Department of Agriculture provide trainings for communities and organizations on preparedness and response to hazards, and the Humane Society and other non-profit organizations has both paid staff and volunteers ready to assist in response.

In addition to the sensitivity of animals, households, and facilities, there is also a significant public health and safety risk if animals are not evacuated properly and become loose in the community. With respect to dogs and cats, the issues can include animal welfare and safety, predation and threats to wild and domestic species, biting and attacks, and the spread of disease. For exotic species, the danger to the environment and to the welfare of the animal may include an environment that is inhospitable for an animal who needs special care (heat lamps, treated water, special diet) or an animal that could create an imbalance in the native environment if allowed to hunt and reproduce.

Many of the sensitivities associated with animals and animal facilities within communities can be significantly reduced through developing preparedness and response plans for the pet and livestock owning households and animal facilities within each community. These plans must include strategies to avoid or minimize adverse impacts on animal welfare and public health and safety. The plans should include procedures for evacuating animals, including transportation, trained staff and volunteers and the proper tools (cages, leashes, tranquilizers if necessary); the potential sites for re-location, evacuation locations for household pets and livestock; and assistance in the recovery of the community's animal facilities. For the ART project area, the primary concerns will be household pets and some livestock, pet stores that have live animals in their care, and the Friends of Alameda Animal Shelter.

Summary

For most of the community services and facilities, a key to reducing sensitivity and increasing adaptive capacity is to plan ahead as neighborhoods and communities by developing preparedness and response strategies for the possible hazards that each community may confront, including earthquakes, storms and future climate hazards. This includes working together as part of a CERT or as an informal neighborhood collective, having household and neighborhood evacuation procedures and emergency supplies, and having certain members trained for the different roles that will be necessary, including moving the most vulnerable community members, first aid and assisting in animal evacuations. Although such preparedness and response strategies cannot eliminate sensitivity to hazards, these strategies can, in certain circumstances, significantly reduce this sensitivity and save lives.

In addition to developing preparedness and response strategies, the way that communities are designed and constructed can also reduce sensitivity and increase adaptive capacity. Building codes, construction materials, overlay zones, site design and other strategies can be developed to apply to areas and uses where exposure is likely and sensitivity is high.

Consequences

The potential consequences of sea level rise and storm events on the residents, employees, facilities, and services in the ART project area could be significant, not only for the communities in the study area but for the region. Due to the varied and diverse nature of the land uses, facilities, and services, and because a detailed understanding of consequences would require resources beyond those available to the current project, only a high-level discussion of consequences is provided. A full assessment of the potential magnitude of the consequences for the economy, society, environment, and governance structures that would occur if community land use, services, and facilities were affected by a climate impact will require a specific and

detailed evaluation of multiple factors, such as the severity of the impact on revenues and opportunities for financing operations, maintenance, and capital improvements; the demographics of the individuals and neighborhoods affected; the land uses and facilities affected, the types of natural resources affected and the services and benefits they provide; the regulatory and decision-making processes; and the type, extent, and severity of the effects on public health, safety, and welfare.

Economy

In addition to the obvious economic consequences of damage to residential, commercial, and government property, exposure to flooding can have additional, far-reaching economic impacts. If workplaces are forced to close, it can mean losses for the companies affected, as well as lost wages for workers and lost tax revenue. The threat of frequent flooding could even drive businesses out of an area permanently. In many parts of the Bay Area, including the ART project area, business and industrial parks where large numbers of employees work are located near the shoreline. Exposure of these job sites could disrupt jobs for thousands of workers, and property and business owners could face high costs to repair and replace damaged buildings, specialized equipment, and other items exposed to floodwaters.

Closed schools and other facilities housing vulnerable populations could mean time off of work and associated lost wages for parents and caretakers, and if alternative housing has to be found for individuals such as those living in group homes or long-term care facilities, it could drain the budgets that fund those facilities' operations. Further, if long-term evacuation is necessary, individuals, families, and businesses could choose to re-locate permanently outside of the community, with associated economic consequences for neighborhoods, employers, and cities. Additionally, while proper preparation will ultimately reduce economic consequences in the event of an impact, in the short term the resources expended in preparing for an impact will have their own economic consequences as individuals, businesses, and agencies make trade-offs within limited budgets.

Society

As addressed in depth in the ART project Equity White Paper and the discussion of the sensitivity and adaptive capacity above, the consequences of flooding for residents vary depending on the characteristics of the populations exposed. For most residents, being exposed to flooding will be very disruptive and could result not only in temporary displacement, but also the loss of belongings and personal and financial information that is hard to replace (such as birth certificates, passports, and living wills), high costs to repair damage and replace items, and the disruption of neighborhoods and lives, including lost time at school and work. Permanent displacement would increase the consequences beyond the individual scale and result in neighborhood and community scale impacts, such as the loss of neighborhood relationships and services. The flooding of small businesses and places where people work, or loss of access to these locations, could result in the temporary or permanent shutdown of operations and associated loss of livelihoods. Facilities serving at-risk populations face unique challenges in safely and properly evacuating and / or serving the population that relies on them. In the face of a climate impact, this population may become further marginalized and have greater difficulty recovering.

Figure 4. Flooding in San Anselmo in 1982 and 2005 damaged many local businesses. Photos are from New Years Eve flood, 2005.



After a flood subsides, cleanup can require an enormous community effort, involving time and resources from property owners, residents, private and public agencies and organizations, and volunteers (Figure 4). Residents and workers may be able to return to their homes and places of work, but unless buildings are properly dried and cleaned, there may be health risks. For example, mold is common in flooded buildings, and it poses a serious health risk, particularly for people with asthma and certain chronic health conditions.

If police and fire stations, or access to them, were to be flooded, their ability to respond to an emergency would be compromised, making communities more sensitive and less able to adapt to climate impacts. Likewise, hospitals and health clinics exposed to flooding may be unable to care for patients. If schools and childcare centers

care for patients. If schools and childcare centers are flooded, in addition to the challenge of evacuating children safely, school may be canceled while buildings, equipment and supplies are restored, significantly affecting the education of the affected children and the community that schools provide, including the relationships with teachers and peers.

In the event that facilities that house vulnerable or at-risk populations, such as shelters and senior housing, need to be evacuated, it could create additional burdens for caretakers, whether family members, caseworkers, or professional staff. The exposure of jails could create security concerns, or even threaten the safety of those locked in cells if nobody is on site to evacuate them. There is one animal shelter in the ART project area, the Friends of Alameda Animal Shelter, and a number of households with pets, some with livestock, and possibly some pet stores, research facilities and interpretive centers **Figure 5.** Thousands of refrigerators waiting to be crushed at the Old Gentilly landfill outside New Orleans. Photo credit: Ed Kashi. http://www.onearth.org/article/rough-burial



that house animals. Without the proper preparedness and response for these households and facilities, animal welfare and public health and safety will be at risk.

Environment

It is difficult to evaluate the consequences of sea level rise and storm events on community land use, facilities, and services from an environmental perspective, since each of these facilities is so different in the role that it serves and its relationship to the environment. One environmental consequence of flood-damaged buildings is the enormous amount of debris that is released into the environment, as well as other, damaged material that has to be disposed of (Figure 5). In a severely damaged home, carpets, drywall and refrigerators, not to mention any damaged clothing, furniture, electronics, and other possessions, may have to be discarded. Depending on the overall community response and types of materials, these items could be recycled, taken to landfills, or discarded illegally, each with its own environmental impact.

Invasive species is another significant concern related to sea level and storm events, and floods and higher water can result in invasive species being introduced to sensitive habitats and introducing predation or competition with native species. Additionally, if animal facilities or households with pets or livestock are not properly evacuated, animals could escape and cause problems for wild species.

Another environmental consequence could occur if Bay water floods community facilities containing hazardous materials such as pharmaceuticals, or buildings housing other harmful substances. For example, some basic household items such as paint, garden pesticides or automobile oil are environmentally harmful if released into the Bay, adding to the pollutant load there.

Governance

The governance consequences are significant with respect to community land use, facilities, and services but they will also vary with the type of facility or portion of the community exposed to sea level rise and storm events. Each of the different categories of use and function within community land use, facilities, and services has its own governance structures, relevant regulations, and critical relationships that will have consequences on how sensitive that use and facility will be and what impacts that will have on the populations served by these facilities. For example, the redevelopment of certain areas will directly affect the number of people living and working in areas that may be exposed, and zoning laws will influence the sensitivity and adaptive capacity of new buildings and neighborhoods. The creation of disaster response plans will require the participation of many local agencies as well as individuals who need to be educated about the risks associated with sea level rise.

In order to better understand these relationships and the potential for governance to either increase or impair resilience, the ART project is currently evaluating governance and institutional arrangements for the project area. Once the evaluation is complete, it will better define the governance consequences associated with community land use, facilities, and services.

Key Findings

The population of the ART project area was nearly 800,000 in the year 2000, and over 300,000 people were employed in the area in 2011. While less than one percent of residents would be exposed to the daily high tide with 16 inches of sea level rise, over 15% would be exposed to the most extreme scenario of a storm event with wind waves with 55 inches of sea level rise. Individually, residents are sensitive to sea level rise and storm events, some to a greater degree than others depending upon age, health, income, vehicle ownership, pet ownership and other characteristics of these residents. Sea level rise and storm events can result in significant financial and personal hardships for residents. These include the loss of personal and financial information and belongings, the cost to repair or replace belongings and homes, temporary or

permanent relocation, increased insurance costs, if insured, the permanent loss of belongings and residency if not insured, and dislocation from jobs, schools and other important community services and ties. For these reasons, residential neighborhoods are particularly sensitive to hazards, including sea level rise and storm events. Near term strategies to increase adaptive capacity include either informal or formal emergency preparedness and response on both an individual and a neighborhood scale, reducing the items and living spaces below sea level in basements, obtaining either owner or renter insurance for property and personal belongings, improving drainage at the neighborhood scale, and knowing the agencies, services and facilities that will be critical in responding to a hazard such as a storm event. When sea level rise or storm frequency increases past a certain point in certain neighborhoods, many of these sources of adaptive capacity may be overwhelmed and more significant considerations will be necessary.

Less than one percent of workers in the ART project area would be exposed to the daily high tide with 16 inches of sea level rise, but 22% would be exposed to the most extreme scenario of wind waves with 55 inches of sea level rise. Employees, employers, and small business owners are vulnerable to sea level rise and storm events and the ability for individual business owners to protect their property is limited. While there are short-term solutions such as telecommuting (for some types of employment) and temporary relocation is possible, these approaches are not practical in the long run. Employees, employers, and small business owners have some adaptive capacity – sandbags and pumps can keep some degree of flooding at bay for a short period of time, emergency preparedness and response strategies can minimize impact, drainage can be improved, buildings can be designed or retrofitted to reduce impacts, and valuable possessions can be kept on upper floors where possible. However, none of these strategies would likely be sufficient to deal with frequent flooding or sea level rise in the longer term and the impacts to the employment, businesses, and the economy could include the relocation of businesses out of the subregion, the elimination of jobs, increased insurance costs, and increased maintenance, repair, and replacement costs.

Some buildings are more sensitive than others based on the materials used to build them and whether they are built at or above grade. Repairing damaged buildings and replacing damaged belongings and equipment is costly and takes significant time. The total property value in the ART project area, depending on how it is valued, is estimated at 45 billion dollars (replacement costs) and 86.6 billion dollars (assessed value). The percentage of property value exposed to each sea level rise scenario is fairly similar across the two valuation methods, ranging from one percent exposed to the daily high tide with 16 inches of sea level rise, to approximately 23% exposed to wind waves with 55 inches of sea level rise. While replacement costs and assessed value do not have inherent characteristics that make property more or less vulnerable to sea level rise, the value at risk could affect how cities and individuals choose to protect various assets, which in turn could affect the vulnerability of the people who rely on them.

Each of the community facilities serves a different role and population. In the ART project area, there are 35 emergency response facilities: 19 fire stations, ten hospitals, and six police stations. Most of these are not exposed to sea level rise, but some facilities are quite sensitive, due to the role they play in serving and sometimes sheltering vulnerable populations, the presence of specialized and sensitive equipment, and the possibility that access roads will be flooded. However, due to the very nature of these facilities, they should have fairly high adaptive capacity because personnel should be well trained to handle emergencies, and, in the case of fire stations at least, some equipment such as pumps, may be on hand. While the impairment of an emergency response facility could have serious consequences for the community relying on that facility, the existence of mutual aid agreements across the county should help to reduce the impact for police and fire stations, provided those service personnel are not overwhelmed. Hospitals will be much more sensitive and vulnerable due to the needs of patients, the role

played in emergency response, and the specialized and sensitive equipment contained in their facilities.

Just over 200 facilities serve at-risk populations, the majority of which are health care facilities (without on-site patients). None of these facilities are exposed to the daily high tide with 16 inches of sea level rise, and only one is exposed to storm event flooding. Fifteen are exposed to wind waves only. With 55 inches of sea level rise, only four are exposed to the daily high tide, 15 are exposed to storm event flooding, and an additional ten are exposed to wind waves, for a total of 25, or roughly ten percent, exposed to the most extreme scenario. These facilities are quite sensitive due to the population they serve – for example, a flooded homeless shelter dislocates people who likely have very little, if anything, to fall back on. Other facilities, such as jails, will be particularly challenging to evacuate because people residing there need special supervision. Therefore, while the exposure of these facilities over the entire ART project area is relatively low, they have high vulnerability because of their sensitivity.

There are over 650 facilities serving vulnerable, less mobile populations. While none of these facilities are exposed to the daily high tide with 16 inches of sea level rise, and only 13 are exposed to storm event flooding, 53 are exposed to storm event flooding with wind waves. Sixty-eight, approximately ten percent, of these facilities are exposed to the most extreme sea level rise scenario, storm event flooding and wind waves with 55 inches of sea level rise. These facilities are sensitive because many are full-time residences for vulnerable populations, such as seniors who may need more time to evacuate, and long-term care patients who are in fragile health. While schools and childcare facilities do not house children full-time, they nonetheless present evacuation challenges due to the care and supervision needed for young children. Adaptive capacity is also fairly low, since alternative locations for many of the people in the facilities are limited. Furthermore, there are some "clusters" of facilities – for example, senior housing in Oakland – which are exposed to sea level rise and would all need to be evacuated at once and could strain local resources. Therefore, although exposure is relatively low system-wide, these facilities have high vulnerability because of their sensitivity.

There is one animal shelter in the ART project area, which is exposed to all scenarios except for the daily high tide with 16 inches of sea level rise. It is also highly sensitive because of the difficulty of both evacuating and relocating the animals in their care in the event of flooding, and providing assistance to people who need to evacuate with their pets. Due to high exposure, high sensitivity, and low adaptive capacity because of the lack of redundancy, this facility is very vulnerable. In addition to the animal shelter, there are likely a large number of household pets, some livestock, several pet stores, and possibly some research facilities or interpretive centers that have animals in their care within the ART project area, but due to the availability of information, the locations and numbers are not known. These households and sites are all also highly sensitive due to the difficultly of evacuating and re-locating with animals and the potential for some of these animals to become loose in the community and pose a risk to the welfare of the animals and to public health and safety.