City of Alameda
Climate Action and Resiliency Plan

Task 1 Report on Existing Conditions and Future Goals

August 30, 2018
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1.0 Executive Summary

This report represents an important step in the City of Alameda’s efforts to update its 2008 Climate Action Plan (CAP). The updated CAP, called the Climate Action and Resiliency Plan, will propose future greenhouse gas (GHG) reduction targets and incorporate strategies to adapt to climate change impacts. The CAP update will build on the results of significant work to date; identify and fill key gaps; establish goals and priorities for future action; and recommend cost-effective strategies, policies, and programs to reduce GHG emissions and increase the City’s resilience to climate impacts.

Eastern Research Group, Inc. (ERG), developed this report to describe existing conditions in Alameda and work conducted to date, identify gaps, and recommend next steps to inform the development of the CAP update. It serves as a baseline that the City can use to track progress toward CAP update implementation, and it synthesizes studies and plans in a single location to facilitate future updates. In addition, this report includes information that ERG obtained consultation with City of Alameda staff, the Green Working Team, Alameda Municipal Power (AMP), and the CAP update Task Force. 1 Informed by this review and consultation, ERG proposes draft GHG reduction targets and resiliency goals as a starting point for robust stakeholder input and community-wide engagement.

1.1 GHG Emissions, Reduction Strategies, and Targets

ERG reviewed and summarized the following documents, studies, and plans related to GHG emissions and reductions to provide a basis for the CAP update:

- 2008 CAP (CoA, 2008)
- 2015 GHG emissions inventory (CoA, 2017a)
- Transportation-related plans: 2009 Pedestrian Plan (CoA, 2009a) and Bicycle Master Plan (CoA, 2010a)
- AMP energy efficiency efforts (AMP, 2018)
- Zero Waste Implementation Plan (CoA, 2010b)

Using the studies and plans, as well as input from City staff and stakeholders, ERG will investigate and possibly update the 2030 and 2050 projections in the City’s GHG emissions inventory. In addition, ERG will conduct a gap analysis to determine the potential shortfall in GHG reductions as compared to the preliminary GHG reduction targets for 2030.

ERG will also collect input from City staff and stakeholders on additional GHG reduction measures that may be considered for analysis and addition to the CAP update. Next, ERG will propose a list of the highest-priority measures for City and stakeholder consideration. Priority will be based on criteria such as GHG emissions reduction potential, estimated range of potential implementation costs, and other factors to be determined. Upon receiving additional input from the City and stakeholders, ERG will analyze in detail the selected mitigation measures, potential costs, and GHG reduction impact of implementing them as part of the CAP update.

The Alameda City Council adopted the City’s current GHG reduction target of “25% below 2005 levels by 2020” in February 2008. GHG reductions from “planned City actions” are estimated to fall short of the 2020 goals by 31,300 metric tons of carbon dioxide equivalent (MTCO2e) (CoA, 2017a). Through the CAP update, the City will establish future GHG reduction goals. ERG examined GHG reduction targets

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1 Future analysis related to GHG reductions and resilience planning will incorporate results of a citywide survey conducted in summer 2018.
established by the state of California and other jurisdictions to help Alameda set additional and interim year GHG reduction targets. To be “ambitious,” the City’s targets should be consistent with the state target; to be “visionary, the City could set a more aggressive target. Therefore, the City and its stakeholders could initially consider the following GHG reduction targets:

- **Ambitious:**
  - 40 percent below 2005 levels by 2030
  - 80 percent below 2005 levels or “carbon neutral” by 2050
- **Visionary**
  - At least 50 percent below 2005 levels by 2030
  - Carbon neutral by 2040 (as an interim “stepping stone” to being fossil free)
  - Fossil free by 2050

ERG will complete the GHG reduction analysis—including the trajectory showing the impact of the various GHG reduction “portfolios”—and present the results to stakeholders for input and decisions regarding which set of reductions achieve the desired reduction target. ERG will carry out this iterative process over the next six months and incorporate significant stakeholder input.

### 1.2 Resilience

The primary resilience goal for Alameda is to increase its resilience to climate change and ensure a sustainable and healthy economy, society, and environment. This will be accomplished by defining hazard-specific goals and determining adaptation actions needed to achieve them.

Several vulnerability or hazard assessments have been conducted for Alameda in the past decade. The most notable assessments include the following:

- *ART Oakland/Alameda Resilience Study* (2016)
- *City of Alameda Local Hazard Mitigation Plan (LHMP)* (2016)
- *City of Alameda Sea Level Rise Hazard Assessment* (2016)

These assessments provide the foundation for more detailed adaptation planning in Alameda. All the assessments identify similar key hazards facing Alameda and the vulnerability of assets and systems to these hazards. Key vulnerabilities include:

- Sea level rise and associated coastal flooding and permanent inundation.
- Inland flooding due to rising groundwater levels and an overwhelmed stormwater management system.
- Reliance on transportation systems and utilities that are at high risk from sea level rise.
- Earthquake risk and the potential for sea level rise to exacerbate the risk of liquefaction as groundwater levels rise.
- Other climate hazards that are lower priority but still pose a threat to Alameda, including extreme heat events, drought, and wildfire smoke.

The ART Alameda County Project has produced the most detailed vulnerability assessment, covering the three key components of exposure, sensitivity, and adaptive capacity. Although the *Sea Level Rise Hazard Assessment* included a detailed review of specific assets’ exposure in Alameda, it did not discuss...
sensitivity or adaptive capacity. Table 1-1 shows key gaps and recommended next steps for adaptation planning.

Table 1-1. Key Gaps and Next Steps for Vulnerability Assessment in Alameda

<table>
<thead>
<tr>
<th>Key Gap</th>
<th>Next Steps</th>
</tr>
</thead>
<tbody>
<tr>
<td>Existing Alameda-specific sea level rise assessment covered nine</td>
<td>Complete assessment for all neighborhoods in Alameda.</td>
</tr>
<tr>
<td>neighborhoods but not the entire city.</td>
<td></td>
</tr>
<tr>
<td>Existing Alameda-specific sea level rise assessment only included</td>
<td>Evaluate sensitivity and adaptive capacity for Alameda assets and incorporate water depth into the assessment.</td>
</tr>
<tr>
<td>exposure and did not consider inundation depth.</td>
<td></td>
</tr>
<tr>
<td>Countywide vulnerability assessment did not include many specific</td>
<td>Use the ART framework to assess Alameda-specific assets where appropriate.</td>
</tr>
<tr>
<td>assets in the City of Alameda.</td>
<td></td>
</tr>
<tr>
<td>Countywide vulnerability assessment was completed in 2012 using</td>
<td>Review 2012 vulnerability assessment results and verify the findings are still accurate given new projections.</td>
</tr>
<tr>
<td>outdated inundation maps.</td>
<td></td>
</tr>
<tr>
<td>Existing hazard and vulnerability assessments do not consider the</td>
<td>Complete vulnerability assessment of inland assets to flooding (exposure, sensitivity, and adaptive capacity).</td>
</tr>
<tr>
<td>vulnerability of inland assets to flooding if stormwater management</td>
<td></td>
</tr>
<tr>
<td>fails.</td>
<td></td>
</tr>
<tr>
<td>City has minimal understanding of the potential impact of sea level</td>
<td>Review relevant studies, develop a conceptual model, and recommend actions to conduct a more detailed modeling effort.</td>
</tr>
<tr>
<td>rise on groundwater levels and implications for inland flooding.</td>
<td></td>
</tr>
<tr>
<td>Alameda storm drain modeling considered 10-year and 25-year storm</td>
<td>Consider implications of more intense precipitation events in the future and provide recommendations for updating the storm drain modeling.</td>
</tr>
<tr>
<td>estimates but did not project changes in storm intensity.</td>
<td></td>
</tr>
<tr>
<td>Existing assessment of overlapping sea level rise/earthquake risk was</td>
<td>Translate findings of assessment to Alameda assets as appropriate and develop maps to highlight areas of high risk.</td>
</tr>
<tr>
<td>broad (Bay Area) and not specific to Alameda.</td>
<td></td>
</tr>
<tr>
<td>No vulnerability assessment has considered the risk posed to residents</td>
<td>Conduct a basic vulnerability assessment to understand how heat events may impact Alameda.</td>
</tr>
<tr>
<td>by an increase in extreme heat events.</td>
<td></td>
</tr>
</tbody>
</table>

1.3 GHG Reduction + Adaptation = Resilience to Climate Change

There is a strong scientific relationship between GHG emissions and sea level rise; future sea level can vary depending on GHG emission scenarios, as shown in Figure 1-1. Addressing this linkage in the CAP update will make the plan robust and responsive and acknowledge co-benefits such as the following:

- Green infrastructure, green roofs, and tree plantings reduce GHG emissions (via carbon sequestration), mitigate flooding and heat impacts, and improve water quality.
- Reducing reliance on single-occupancy vehicle trips by promoting other forms of transportation (bicycles, ferries) reduces GHG emissions and reliance on flood-prone transportation routes (e.g., Webster and Posey Tubes).
- Land use planning that encourages development near transit hubs reduces GHG emissions via fewer vehicle miles traveled (VMT) and could also locate new development away from areas at high risk of sea level rise.

- Nature-based shoreline stabilization methods, such as living shorelines, can reduce coastal flooding impacts while increasing biodiversity, improving water quality, sequestering carbon, and reducing GHG emissions.

Figure 1.1. Relationship Between GHG Emissions Pathways and Projected Sea Level Rise
The red line corresponds to representative concentration pathway (RCP) 8.5 and the blue line corresponds to RCP 2.6. RCPs represent different emission scenarios used for climate modeling. Screenshot from IPCC Fifth Assessment Report (IPCC, 2014)
2.0 Introduction

The City of Alameda has already begun to see the impacts associated with climate change, including rising seas, higher temperatures, and more extreme weather events. As an island, the City is particularly vulnerable to these impacts and is proactively trying to both mitigate the potential for climate change through GHG reduction efforts and to increase its resilience to climate change impacts by implementing adaptation strategies. Efforts to address GHG emissions date back to February 2008, when the Alameda City Council approved the CAP and established a GHG reduction goal of 25 percent by 2020 compared to a 2005 baseline. The City has made progress toward this goal but still has work to do. The original CAP did not include recommendations for implementing climate change adaptations, and the City is committed to pushing forward on that front as part of the CAP update.

The City is developing a new Climate Action and Resiliency Plan that meets or exceeds California’s GHG reduction goals and increases the resilience of the City, its assets, and its residents to the impacts of climate change. The CAP update will integrate and use other City plans to help institutionalize adaptation and GHG reduction throughout all City planning activities.

Alameda has already made substantial progress in addressing GHG emissions and is committed to be a leader in reducing emissions and preparing the City for climate change impacts. As such, the CAP update will build upon previous efforts and provide actionable recommendations for the City to meet GHG reduction targets and adaptation goals.

2.1 Purpose

The first step in updating the CAP is gaining a comprehensive understanding of the efforts made in Alameda and regionally to estimate GHG emissions, establish strategies for GHG reduction, and evaluate the vulnerability of the City and its assets to climate change. This report describes the existing conditions in Alameda and work conducted to date, identifies gaps, and recommends next steps to inform the CAP update. Furthermore, this report can serve as a baseline against which to track progress toward implementation of the CAP update, and it also synthesizes studies and plans in a single location to facilitate future updates to the CAP.

2.2 Process

ERG reviewed a wide variety of plans, reports, and other information as part of this synthesis of existing information. Table 2-1 lists the documents we reviewed and summarized, along with their relevance to adaptation/resilience and GHG emissions/reductions.
### Table 2-1. Documents Reviewed and Synthesized

<table>
<thead>
<tr>
<th>Document Title</th>
<th>Date</th>
<th>Relevant Topics Addressed</th>
</tr>
</thead>
<tbody>
<tr>
<td>City of Alameda Local Action Plan for Climate Protection</td>
<td>February 2008</td>
<td></td>
</tr>
<tr>
<td>City of Alameda 2010 Community-Wide Greenhouse Gas Emissions Inventory</td>
<td>April 2013</td>
<td>✓</td>
</tr>
<tr>
<td>City of Alameda 2015 Community-Wide Greenhouse Gas Inventory and Projections to 2020 Goal</td>
<td>November 2017</td>
<td>✓</td>
</tr>
<tr>
<td>City of Alameda Transportation Choices Plan</td>
<td>January 2018</td>
<td>✓</td>
</tr>
<tr>
<td>City of Alameda 1990 Bicycle Master Plan (updated November 2010)</td>
<td>November 2010</td>
<td>✓</td>
</tr>
<tr>
<td>City of Alameda Pedestrian Plan (component of the City’s Transportation Master Plan)</td>
<td>January 2008</td>
<td>✓</td>
</tr>
<tr>
<td>Alameda Economic Development Strategic Plan</td>
<td>June 2008</td>
<td>✓ ✓</td>
</tr>
<tr>
<td>City of Alameda Framework for Green Infrastructure Plan Development</td>
<td>June 2017</td>
<td>✓ ✓</td>
</tr>
<tr>
<td>Zero Waste Implementation Plan Update, Final Draft</td>
<td>March 2018</td>
<td>✓</td>
</tr>
<tr>
<td>Alameda Municipal Power Energy Efficiency Program Report for FY2017</td>
<td>February 2018</td>
<td>✓</td>
</tr>
<tr>
<td>City of Alameda Local Hazard Mitigation Plan</td>
<td>2016</td>
<td>✓</td>
</tr>
<tr>
<td>ART Alameda County Project: Vulnerability and Risk Report</td>
<td>2012</td>
<td>✓</td>
</tr>
<tr>
<td>ART Oakland/Alameda Resilience Study</td>
<td>2016</td>
<td>✓</td>
</tr>
<tr>
<td>City of Alameda Sea Level Rise Hazard Assessment</td>
<td>2017</td>
<td>✓</td>
</tr>
<tr>
<td>ABAG Stronger Housing, Safer Communities Report</td>
<td>2015</td>
<td>✓</td>
</tr>
<tr>
<td>Alameda Point Master Infrastructure Plan</td>
<td>2014</td>
<td>✓</td>
</tr>
<tr>
<td>San Francisco Estuary Institute (SFEI) Operational Landscape Units</td>
<td>2018</td>
<td>✓</td>
</tr>
</tbody>
</table>

* These plans are in development. ERG will align the adaptation and GHG reduction analysis with the outcomes from these plans.
3.0 Community Description: Existing Conditions

3.1 Project Area

The City of Alameda is in San Francisco Bay, approximately 7 miles east of San Francisco and just west of Oakland. The City is composed of Alameda Island and the western half of Bay Farm Island, for a total land area of 22.7 square miles. Before the settlement and development of California, Alameda was a peninsula covered in dense forest. The original landmass for both Alameda Island and Bay Farm Island comprises slightly more than half of the total land area at the core of the islands. The rest of the current landmass was built on fill material, including Alameda Point and many of the City’s coastal neighborhoods, such as the South Shore and East Shore neighborhoods, as well as substantial portions of Bay Farm Island.

Due to its location in San Francisco Bay, Alameda relies on connections to the mainland for critical services like transit and utilities. Residents rely on multiple modes of transportation; in 2015, an estimated 40.1 percent of commuters used transit options other than driving. Several bus routes, rail services, and ferries connect Alameda to Oakland and San Francisco. AMP provides electrical power, and the East Bay Municipal Utility District (EBMUD) provides drinking water and wastewater services.

3.2 Population and Housing Characteristics

The population in Alameda peaked in 1994 with 79,297 residents. Between 1994 and the 2010 Decennial Census, the population decreased by 5,485 residents to a total of 73,812 (-6.9 percent from 1994 to 2010). At the same time, the population of Alameda County more broadly increased by 12.8 percent. Recently, Alameda has seen a population increase, with an estimated 79,177 residents in 2017, living in 30,678 households (USCB, 2018). In 2013, the Association of Bay Area Governments (ABAG) projected that the Alameda population would reach 80,300 in 2020, reflecting growth of 8.8 percent from 2010 to 2020, driven largely by new residential development in former industrial areas and military installations, most notably Alameda Point and along the northern waterfront.

Housing in Alameda is characterized by residential properties with few multi-unit buildings. In 1973, the City passed initiative Measure A, prohibiting the construction of residential structures with more than two units. According to the “2012–2016 American Community Survey 5-Year Estimates,” the ratio of persons per household in Alameda is 2.48 (average for all household), consistent with previous 5-year estimates. ABAG’s 2020 population estimates are driven by the rate of new building construction because household size is not expected to change significantly.

The age distribution of Alameda residents did not change significantly between the 2000 and 2010 Census, and the City has an age distribution roughly similar to Alameda County more broadly, but with a higher proportion of residents older than 55 and a lower proportion under 15. According to the 2012–2016 5-year estimates, the age distribution has not substantially changed since the most recent complete Decennial Census in 2010.

Alameda residents are generally wealthier than Alameda County and the Bay Area as a whole. Median household income in 2016 was $83,048 (USCB, 2017), and 9.5 percent of all residents were living under the poverty level.
4.0 Establishing Goals and Setting Targets

Defining resilience goals in Alameda is an important step that considers the priority hazards, key assets, and unique characteristics of the City. Also, establishing a GHG emissions reduction target creates the interim and final goals for building an emissions reduction strategy (ICLEI, 2010) and enables policymakers to identify a set of policies, programs, and projects whose cumulative emissions reduction will achieve the reduction targets. The following sections provide information pertaining to existing resilience goals and GHG reduction targets.

4.1 Resilience Goals

Resilience goals are effective targets that can help the City identify and implement strategies, and then track the success of strategies based on progress toward goals. Although many municipalities have started to develop climate resilience plans with defined goals, the goals often lack specificity and do not provide sufficient detail to support identification and prioritization of adaptation strategies. The CAP update for Alameda will include clear hazard-specific goals that are coupled with metrics to help quantify the extent to which actions make progress toward a more resilient Alameda. At a higher level, Alameda has an overall vision to increase resilience to climate change, and each of the hazard-specific goals will be designed to collectively meet the larger vision. No specific goals have been defined at this time, but the overall vision for Alameda may be similar to the example shown at right.

The City should develop resilience goals that can be paired with quantitative metrics to track progress and help the public understand how different strategies are performing. To this end, ERG will define goals and metrics together to ensure the City can track performance and modify strategies (if necessary) as conditions and climate projections change moving forward.

4.1.1 Options from Other Communities

Although many municipalities have developed climate adaptation or resiliency plans, few include specific and actionable goals and methods to quantify progress. Goals are often defined as high-level visions that do a good job of framing the issues but lack detail, potentially making adaptation strategy implementation more difficult. For example, a city may define a high-level goal similar to the overarching goal shown above without including more detailed goals that help target strategy implementation to specific hazards.

To determine how resilience and adaptation are framed in existing climate adaptation plans, ERG reviewed other municipalities to identify goals and associated methods for measuring progress. The following cities were investigated:

- San Diego, California
- Vancouver, British Columbia
- San Francisco, California
- King County, Washington
- Surrey, British Columbia
- New York City, New York
- Chula Vista, California
- Goleta, California
- Laguna Woods, California
- Santa Barbara, California
- Sunnyvale, California
- Los Angeles, California
- Palo Alto, California
- Berkeley, California
4.1.2 Considerations for Alameda

The City of Alameda is committed to developing a climate adaptation plan that provides detailed and actionable guidance for both short- and long-term implementation. To that end, the CAP update will include detailed, hazard-specific goals in addition to any overarching goals or vision statements. Each goal will be paired with one or several metrics to help the City track progress. Examples are shown in Table 4-1.

Table 4-1. Examples of Goals and Associated Metrics for Alameda

<table>
<thead>
<tr>
<th>Climate Hazard</th>
<th>Resilience Goal</th>
<th>Metric</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sea level rise</td>
<td>Decrease the vulnerability of City assets to sea level rise in unprotected, coastal flood-prone areas.</td>
<td>Value of City assets within [xxx] sea level rise projection with <strong>no</strong> adaptation strategies implemented.</td>
</tr>
<tr>
<td></td>
<td>Develop a sustainable funding strategy to ensure short- and long-term implementation of adaptation strategies.</td>
<td>Federal and state dollars secured for coastal flood protection projects.</td>
</tr>
<tr>
<td></td>
<td>Reduce the frequency of disruptions to transportation networks from the impacts of sea level rise.</td>
<td>Percentage of critical transportation assets within [xxx] sea level rise projection with adaptation strategies implemented.</td>
</tr>
<tr>
<td>Overland flooding</td>
<td>Reduce the frequency of damage due to overland flooding and the cost to recover from flooding events.</td>
<td>Repair cost for infrastructure (transportation, utilities, etc.) impacted by flood events.</td>
</tr>
<tr>
<td></td>
<td>Encourage development of sustainable, nature-based strategies for managing stormwater.</td>
<td>Percentage or acreage of green infrastructure projects implemented per recommendations of <em>Green Infrastructure Plan</em>.</td>
</tr>
<tr>
<td>Extreme heat</td>
<td>Reduce the intensity of the urban heat island effect in Alameda.</td>
<td>Number of heat-related hospitalizations and mortalities.</td>
</tr>
</tbody>
</table>

4.2 GHG Reduction Targets

In February 2008, the Alameda City Council adopted the City’s current GHG reduction target of “25% below 2005 levels by 2020.” The City uses a 2005 base year, which is based on its initial GHG emissions inventory and assumed to approximate the state of California’s initial GHG reduction target of 1990 levels by 2020 (CoA, 2017a). The City’s 2015 GHG emissions, existing 2020 target, and emission projections are shown in Figure 4-1. According to this projection, GHG reductions from “planned City actions” are estimated to fall short of the 2020 goals by 31,300 MTCO₂e. The updated CAP will address this gap by adjusting for actions already implemented and adding future GHG control measures.
4.2.1 Options from Other Jurisdictions

Table 4-2 summarizes the GHG reduction targets established by the state of California, the City of Alameda, and other nearby and similar jurisdictions. Although the City is projected to undershoot its 2020 target by 9 percent (i.e., 64 percent of the total targeted reduction) (Figure 4-1), it is worth noting that many other local jurisdictions are also projected to miss their target. Ten municipalities in Alameda were polled and stated that their 2015 GHG inventories are on average about 75 percent of the 2015 interim target; they ranged from being 30 percent of the way to the 2015 interim target to exceeding it by 180 percent (Kitahara, 2018).

Table 4-2. Summary of Selected GHG Emissions Reduction Targets

<table>
<thead>
<tr>
<th>Target Year</th>
<th>Target</th>
<th>Jurisdiction</th>
</tr>
</thead>
<tbody>
<tr>
<td>2020</td>
<td>25% below 2005 level</td>
<td>Alameda</td>
</tr>
<tr>
<td></td>
<td>Achieve 1990 level</td>
<td>CA statewide</td>
</tr>
<tr>
<td></td>
<td>33% below 2000 level</td>
<td>Berkeley</td>
</tr>
<tr>
<td></td>
<td>36% below 2005 level</td>
<td>Oakland</td>
</tr>
<tr>
<td></td>
<td>30% below 1990 level</td>
<td>Santa Cruz</td>
</tr>
<tr>
<td>2025</td>
<td>40% below 1990 level</td>
<td>San Francisco</td>
</tr>
<tr>
<td></td>
<td>40% below 1990 level</td>
<td>CA statewide</td>
</tr>
<tr>
<td></td>
<td>80% below 1990 level</td>
<td>Palo Alto</td>
</tr>
<tr>
<td></td>
<td>50% below 2008 level</td>
<td>Seattle</td>
</tr>
<tr>
<td>2030</td>
<td>80% below 1990 level</td>
<td>CA statewide</td>
</tr>
<tr>
<td></td>
<td>80% below 2000 level</td>
<td>Berkeley</td>
</tr>
<tr>
<td></td>
<td>83% below 2005 level</td>
<td>Oakland</td>
</tr>
<tr>
<td></td>
<td>80% below 1990 level</td>
<td>Santa Cruz</td>
</tr>
<tr>
<td></td>
<td>Net zero GHG emissions</td>
<td>Seattle</td>
</tr>
</tbody>
</table>
4.2.2 Consideration for Alameda

An approach to establishing additional and interim year GHG reduction targets is to consider two sets of targets; one based on an “ambitious” target and one based on a “visionary” target. To be ambitious, the City’s targets should be consistent with the state target; to be visionary, the City could set a more aggressive target. Therefore, the City and its stakeholders could initially consider the following GHG reduction targets:

**Ambitious:**
- 40 percent below 2005 levels by 2030
- 80 percent below 2005 levels or “carbon neutral” by 2050

**Visionary:**
- At least 50 percent below 2005 levels by 2030
- Carbon neutral by 2040 (as an interim “stepping stone” to being fossil free)
- Fossil free by 2050

Carbon neutrality (i.e., having zero net carbon emissions) is achieved by balancing a measured amount of carbon released with an equivalent amount sequestered or offset, or buying enough carbon credit to make up the difference. Note that AMP is committed to achieving carbon-neutral energy generation by 2020.

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Although the state target for 2030 is relative to 1990 emission levels, the International Council for Local Environmental Initiatives does not recommend adjusting a 2005 baseline to 1990 due to the inaccuracies in doing so without creating an emissions inventory for 1990. However, Alameda’s population in 1990 (73,888) was approximately 3.6 percent greater than the population in 2005 (71,247); therefore, a 40 percent reduction target relative to 2005 could be slightly more aggressive (greater) than the same target relative to 1990, if based solely on population change.
5.0 Status of Climate Resilience: Synthesis

The City of Alameda has already taken several important steps toward developing a climate-resilient future. It adopted the 2008 CAP, incorporated sustainability into recent municipal plans such as the TCP and the forthcoming Green Infrastructure Plan, considered multiple climate threats and potential hazard mitigation strategies in the LHMP, and commissioned an analysis of the exposure of City assets to sea level rise. Regionally, two major studies related to adaptation have been undertaken in the past six years, and the City is now positioned to synchronize these related pieces—hazard mitigation, climate mitigation, and climate adaptation (or resilience)—into a holistic, cohesive strategy for action. This synthesis report focuses on the status of Alameda’s climate resilience and:

- Describes existing conditions in Alameda and the region to serve as a baseline against which to measure progress toward resilience goals.
- Summarizes findings from existing vulnerability and hazard mitigation assessments and documents any priorities already identified, actions taken, or actions underway.
- Identifies gaps.
- Develops a foundation for the risk assessment and adaptation strategies.

The synthesis also focuses on the key threats that the City previously identified: sea level rise, inland flooding, earthquakes, drought, extreme heat events, and poor air quality due to wildfires. To varying degrees, the City’s vulnerability to each of these threats has been described in past vulnerability and hazard risk assessments, most notably the Adapting to Rising Tides (ART) Alameda County Project (BCDC, 2012), ART Oakland/Alameda Resilience Study (BCDC, 2016), and the City of Alameda Sea Level Rise Hazard Assessment (CoA, 2017b). Vulnerability assessments consider exposure, sensitivity, and adaptive capacity; together, they indicate the seriousness of these threats. The likelihood that these threats will occur can be estimated based on historical observations and future projections, while their social and economic consequences can be estimated for each of the City’s assets or sectors. The combination of likelihood and consequence comprises the risk that the City and its residents face by the threats of concern. At this point in the City’s climate adaptation planning process, vulnerability has been largely assessed; the risk assessment and adaptation strategies to avoid or mitigate those risks will be addressed in the CAP update. The text box below describes the general process for development of the City’s adaptation plan, adopted from the ART Approach.

| 1. **Scope and Organize:** |
| Define what to address in the project. Convene stakeholders. Draft project goals and metrics. |
| 2. **Choose an Approach:** |
| Plan out the assessment method. Select climate scenarios. |
| 3. **Conduct Assessment:** |
| Conduct the vulnerability assessment (exposure, sensitivity, adaptive capacity). |
| 4. **Summarize Findings:** |
| Summarize assessment findings. |
| 5. **Identify Issues:** |
| Summarize asset-specific issues, assess risk, and identify key planning issues. Refine project goals. |
| 6. **Develop and Evaluate Responses:** |
| Develop adaptation strategies for key assets, issues, and vulnerabilities. Evaluate adaptation responses against resilience goals and metrics. |
| 7. **Advance Options:** |
| Share outcomes. Explore options and develop recommendations. |
This synthesis reviews previous plans and studies to identify the status of climate vulnerability and resilience planning in Alameda. Recommendations from previous planning and assessment efforts provide a valuable starting point for developing and prioritizing strategies across a range of asset categories and sectors in the City. The synthesis identifies gaps in existing assessments and—to the extent possible—addresses them to move forward with the risk assessment and prioritize adaptation strategies. It is critical to ensure the completeness of a vulnerability assessment, which should include the following components: exposure, sensitivity, and adaptive capacity. A vulnerability assessment should consider each key threat individually and all threats collectively across all sectors to identify areas at highest risk and to identify adaptation strategies with high potential to address multiple impacts and produce co-benefits. The text box below defines these terms.

### Key Terms Used in This Synthesis:

**Vulnerability** consists of the following components:

- **Exposure:** The presence of people, ecosystems, or assets in places and settings that could be adversely affected. (Adapted from *IPCC Fifth Assessment Report: Annex II*)
- **Sensitivity:** The degree to which people, ecosystems, or assets are affected by climate change. (Adapted from *IPCC Fifth Assessment Report: Annex II*)
- **Adaptive capacity:** The ability of people, ecosystems, or assets to adjust to adverse effects. (Adapted from *IPCC Fifth Assessment Report: Annex II*)

**Risk** is the threat posed by a negative impact or hazard event. It is the combination of likelihood and consequence.

**Adaptation response** is a combination of three key elements: 1) a key vulnerability directly linked to the outcome of the risk assessment, 2) one or more actions that could be taken to address the key vulnerability, and 3) implementation options to guide each action or set of actions. (Adapted from *The ART Approach White Paper*)

**Resilience** is the capacity of systems or assets to absorb disturbances and adapt to stress and change in a manner that retains function and structure. (Adapted from *IPCC Fifth Assessment Report: Annex II*)

**Adaptation** refers to actions that adjust to actual or expected climate change impacts, thereby increasing resilience to these impacts. (Adapted from *IPCC Fifth Assessment Report: Annex II*)

The City of Alameda is using the ART Approach as the framework for the CAP update. This synthesis serves as the “scope and organize” step of the ART Approach, and it also makes substantial progress into the “conduct assessment” step by identifying relevant and applicable work already completed to avoid redundant efforts.

### 5.1 Hazards and Impacts in Alameda and the Bay Area Region

#### 5.1.1 Overview

Alameda and the surrounding Bay Area region face six priority threats that the Alameda CAP update will focus on: sea level rise, flooding, earthquakes, drought, extreme heat, and wildfire smoke. Several of these have overlapping drivers and impacts. For example, sea level rise can directly cause coastal flooding, but it also impacts groundwater levels and the functioning of the City’s stormwater system,
thereby leading to flooding in inland portions of the City. To facilitate a coherent presentation of existing conditions in Alameda, this synthesis is organized into the following sections, based on priority threats and their impacts:

1. Sea level rise and coastal flooding
2. Inland flooding from surface water runoff and rising groundwater
3. Earthquakes
4. Drought
5. Extreme heat
6. Wildfires

Table 5-1. Summary of Projections for Priority Hazards in Alameda

<table>
<thead>
<tr>
<th>Hazard</th>
<th>Year</th>
<th>Projection</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sea level rise</td>
<td>2030</td>
<td>0.5 – 0.8 feet (H++ = 1.0 feet)</td>
<td>CA OPC^b</td>
</tr>
<tr>
<td></td>
<td>2050</td>
<td>1.1 – 1.9 feet (H++ = 2.7 feet)</td>
<td>CA OPC</td>
</tr>
<tr>
<td></td>
<td>2100</td>
<td>2.4 – 6.9 feet (H++ = 10.2 feet)</td>
<td>CA OPC</td>
</tr>
<tr>
<td>Extreme precipitation</td>
<td>2035</td>
<td>4.8 – 14.5% more intense (defined as inches/hr)</td>
<td>EPA</td>
</tr>
<tr>
<td></td>
<td>2060</td>
<td>9.3 – 28.3% more intense</td>
<td>EPA</td>
</tr>
<tr>
<td>Heat events</td>
<td>2050</td>
<td>+4 extreme heat days (&gt;90.4°F)</td>
<td>Cal-Adapt</td>
</tr>
<tr>
<td></td>
<td>2099</td>
<td>+8 extreme heat days +55 warm nights (&gt;62.6°F)</td>
<td>Cal-Adapt</td>
</tr>
<tr>
<td>Earthquakes</td>
<td>Next 30 years</td>
<td>72% chance of M6.7^c or greater in Bay Area</td>
<td>ABAG</td>
</tr>
<tr>
<td></td>
<td>Next 50 years</td>
<td>28% chance of M6.7 or greater on Hayward Fault</td>
<td>ABAG</td>
</tr>
</tbody>
</table>

^a Range represents the “Low Risk Aversion” to “High Risk Aversion” projections with the “Extreme Risk Aversion” or H++ projection in parentheses. A more detailed table of sea level rise projections from the most recent State of California Sea-Level Rise Guidance is included in Section 5.1.2.

^b OPC = Ocean Protection Council

^c M = magnitude; MMI = modified Mercalli intensity

Based on the findings of previous assessments in Alameda, sea level rise and flooding are the threats of greatest concern because of their likelihood and the major consequences associated with them. Multiple factors drive flooding in Alameda, including sea level rise, and it can be one of the costliest issues the city faces. The other climate-related threats included here are also of concern but given the relatively minor risk associated with them (as defined by the 2016 LHMP, which focused on occurrence and potential consequences), they will not receive as much attention in the CAP update (CoA, 2016). However, there is substantial opportunity to better understand these threats and identify adaptation strategies to address them, and the CAP update will include actionable guidance targeted at each of the threats listed above.

In addition to seal level rise and flooding, the greatest concern for Alameda is earthquakes. Although the CAP update will ostensibly focus on climate threats, there are numerous opportunities to also identify adaptation strategies that could increase resilience to earthquakes. Furthermore, there is a relationship between sea level rise and earthquakes, as highlighted in several reports by ABAG and the San Francisco Bay Conservation and Development Commission (BCDC), including the Stronger Housing, Safer Communities report released in 2015. These studies identified the potential for sea level rise to
compound the effects of liquefaction potential\(^3\) — earthquake frequency is unlikely to change, but the impacts could be much larger if more land is susceptible to liquefaction as a result of rising seas.

The Alameda CAP update builds on past studies; to avoid duplication, it is therefore necessary to extract key information from these documents before taking next steps. A major part of updating the CAP is identifying where and how climate-related impacts are already being experienced, because these impacts are of immediate concern and likely to get worse. Several vulnerability and risk assessments have been conducted with varying levels of technical detail. This synthesis identifies gaps in these previous assessments that need to be filled during the risk assessment process. It also extracts findings, recommendations, and actionable guidance to provide a common starting point for developing adaptation strategies and actions moving forward. The text box at right shows some of the sources reviewed for this synthesis. The Vulnerability and Risk Report (2012) developed as part of the ART Alameda County Project is the most comprehensive existing assessment of vulnerability and risk. It assesses exposure, sensitivity, and adaptive capacity for 14 key asset groups and sectors (BCDC, 2012). This synthesis will not present the findings of the Vulnerability and Risk Report in detail but will identify what information already exists; these findings will serve as the starting point for the risk assessment activities conducted for the CAP update.

5.1.2 Sea Level Rise and Coastal Flooding

Several iterations of sea level inundation mapping have occurred in the Bay Area, primarily conducted by BCDC and partner entities. BCDC completed its most recent mapping effort in 2017 and produced new inundation maps for a range of different sea level rise projections. Several previous efforts, including the ART Alameda County Project and the LHMP, used older inundation maps, while others, including the City of Alameda Sea Level Rise Hazard Assessment, used the more recent maps. The various maps are relatively consistent thanks to a constant baseline that the National Research Council (NRC) developed for sea level rise projections in 2012 (NRC, 2012) and the more recent State of California Sea-Level Rise Guidance: 2018 Update (OPC, 2018).

Observations and Projections

Globally, sea levels have risen roughly 7 to 8 inches since 1900, and nearly 3 inches of that rise has occurred since 1993 (USGCRP, 2017). The same is true in California, with observed sea level rise of 7 inches since 1900 in San Francisco (CAEPA, 2018). At the National Oceanic and Atmospheric Administration (NOAA) tide gauge in Alameda, sea level has risen at an average of +0.03 inches per year from 1939 to 2016, with rates increasing to nearly +0.1 inches per year from 1993 to 2010 (CAEPA, 2018). When considering sea level rise projections and their potential impact, it is important to understand the height of king tides, the two to four highest tides of the year, which are primarily driven by astronomical

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\(^3\) The U.S. Geological Survey defines liquefaction as “a process by which water-saturated sediment temporarily loses strength and acts as a fluid” (USGS, n.d.)
conditions. Sea level rise projections and inundation maps often reference king tides and other extreme tides—higher events driven by a combination of astronomical conditions, water temperature, and storms—because they are very useful targets for planning. Historically, the 10 highest king tides recorded by NOAA in Alameda over the past 75 years measured 8.6 feet to 9.5 feet above the North American Vertical Datum of 1988, roughly equivalent to mean sea level. King tides generally occur in the winter months (November–February) when storm frequency and severity are typically highest (CoA, 2016). Along with flooding associated with individual events such as El Niño, king tides can cause flooding on city streets. For example, the 1997–1998 El Niño event left 2 feet of standing water on Main Street (CoA, 2016).

Sea level rise has a very wide range of impacts, as highlighted in the text box to the left. It is important to distinguish between inundation and flooding when considering sea level rise projections and potential impacts. The Alameda CAP update will use BCDC’s 2017 inundation maps from the ART Sea Level Rise Analysis and Mapping Project (BCDC, 2017). This project distinguished permanent inundation (inundation at daily high tide levels) from temporary flooding (event-based flooding driven by storms or extreme high tides) (BCDC, 2017). Regular and predictable temporary flooding can also occur during king tides on a semi-annual basis.

California has formally adopted several sea level projections, which BCDC used to produce the inundation maps. In 2013, the California Ocean Protection Council (OPC) formally adopted the NRC report *Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present, and Future* (NRC, 2012) as the best available science on sea level rise for the state. The NRC projections in Table 5-2 previously served as the underpinnings for inundation mapping and sea level rise analysis throughout California until the *Rising Seas in California* report (Griggs et al., 2017) defined new projections in 2017, and the OPC finalized its subsequent *State of California Sea-Level Rise Guidance* for projections in 2018, as shown in Table 5-3 (OPC, 2018).

**Table 5-2. Sea Level Rise Projections from the NRC (2012)**

<table>
<thead>
<tr>
<th>Year</th>
<th>Most Likely Projection (inches)</th>
<th>Rangea (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2030</td>
<td>6 ± 2</td>
<td>2 to 12</td>
</tr>
<tr>
<td>2050</td>
<td>11 ± 4</td>
<td>5 to 24</td>
</tr>
<tr>
<td>2100</td>
<td>36 ± 10</td>
<td>17 to 66</td>
</tr>
</tbody>
</table>

a The extreme limits on the range refer to model results from both low and very high emission scenarios and include significant additional land ice melt at the high extreme.
Table 5-3. California OPC Sea Level Rise (SLR) Projections in Feet (Adapted)

<table>
<thead>
<tr>
<th>Year</th>
<th>Likely Range (66% Chance)</th>
<th>1-in-20 Chance SLR Exceeds</th>
<th>1-in-200 Chance SLR Exceeds</th>
<th>H++ Single Scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td>2030</td>
<td>0.3 – 0.5</td>
<td>0.6</td>
<td>0.8</td>
<td>1.0</td>
</tr>
<tr>
<td>2050</td>
<td>0.6 – 1.1</td>
<td>1.4</td>
<td>1.9</td>
<td>2.7</td>
</tr>
<tr>
<td>2100</td>
<td>1.6 – 3.4</td>
<td>4.4</td>
<td>6.9</td>
<td>10.2</td>
</tr>
<tr>
<td>2150</td>
<td>2.8 – 5.8</td>
<td>5.7</td>
<td>13.0</td>
<td>21.9</td>
</tr>
</tbody>
</table>

a. All projections are for the high emissions (RCP 8.5) scenario. Projections for low emissions (RCP 2.6) can be found in the OPC sea level rise guidance. The low emissions scenario is considered extremely unlikely given current global emission trends.

b. OPC considers the top end of the “likely range” to be equivalent to a low risk aversion decision.

c. OPC considers the 1-in-200 chance to be equivalent to a medium-high risk aversion decision.

d. OPC considers the H++ single scenario to be equivalent to an extreme risk aversion decision.

e. Most climate models do not extend past 2100. There is greater uncertainty with these longer-range projections.

Overall, the new projections in the *State of California Sea-Level Rise Guidance* are consistent with the NRC’s 2012 projections; the “likely range” from the California guidance matches the “most likely projections” from the NRC report. The new guidance adds projections representing a 5 percent (1-in-20) and 0.5 percent (1-in-200) chance of sea level rise exceeding a certain value, as well as a single scenario model—the H++ scenario—that reflects the top end of potential sea level rise if ice caps melt at a much higher rate and to a greater degree than expected. These higher sea level rise levels are useful when determining flooding and inundation scenarios to use as a target during adaptation response development.

The ART Sea Level Rise Analysis and Mapping Project sought to produce new Bay Area inundation maps that had the flexibility to be robustly interpreted and applied as the underlying sea level rise projections continue to evolve, including for anticipated future changes to California’s official sea level rise planning guidance. BCDC’s most recent iteration of inundation mapping in 2017 leveraged the Federal Emergency Management Agency’s (FEMA’s) 2013 hydrodynamic modeling data, as well as topographic LiDAR data collected by the U.S. Geological Survey (USGS) and NOAA in 2016, as the basis for modeling (BCDC, 2017). BCDC developed inundation maps for a range of sea level rise scenarios while also considering king tide and extreme tide levels. As a result, maps exist up to a maximum of 108 inches of additional water level compared to current mean higher high water (MHHW); this corresponds roughly to the combination of 66 inches of sea level rise (permanent inundation) combined with a 100-year extreme tide event (temporary flooding). Alternatively, the inundation maps can be viewed as 108 inches of sea level rise inundation with no consideration of king tides or extreme tide events driven by storms.

Several other factors influence total water level, including El Niño, storm surge, waves, and rainfall/runoff. Climate models cannot predict changes in these conditions with great accuracy. The BCDC mapping effort addressed this by covering a range of possible extremes to account for uncertainty in the frequency and magnitude of these conditions. Additional information on factors that influence local water levels in addition to sea level rise is available in the ART Sea Level Rise Analysis and Mapping Project’s final report (Section 2.2) (BCDC, 2012). The new BCDC inundation maps include 10 sets of maps for each county representing a range of possible water levels associated with SLR and extreme tides of different historic recurrence intervals (e.g., 1-year, 5-year, 100-year). Figure 5-1 and Figure 5-2 below show the different scenarios BCDC/ART used to map inundation and how those scenarios correspond to different levels of sea level rise over MHHW and different extreme tide recurrence intervals. Additional details on the methods used for inundation mapping, including the data sources used (tide gauges, hydrodynamic models, topographic data, etc.) are available in the Sea Level Rise Analysis and Mapping Project’s final report (Section 3) (BCDC, 2017).
### Figure 5-1. ART Sea Level Rise and Mapping Project Scenarios (BCDC, 2017)

<table>
<thead>
<tr>
<th>Mapping Scenario</th>
<th>Reference Water Level</th>
<th>Applicable Range for Mapping Scenario (Reference ± 3 inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scenario 1</td>
<td>MHHW + 12&quot;</td>
<td>MHHW + 9 to 15&quot;</td>
</tr>
<tr>
<td>Scenario 2</td>
<td>MHHW + 24&quot;</td>
<td>MHHW + 21 to 27&quot;</td>
</tr>
<tr>
<td>Scenario 3</td>
<td>MHHW + 36&quot;</td>
<td>MHHW + 33 to 39&quot;</td>
</tr>
<tr>
<td>Scenario 4</td>
<td>MHHW + 48&quot;</td>
<td>MHHW + 45 to 51&quot;</td>
</tr>
<tr>
<td>Scenario 5</td>
<td>MHHW + 52&quot;</td>
<td>MHHW + 49 to 55&quot;</td>
</tr>
<tr>
<td>Scenario 6</td>
<td>MHHW + 66&quot;</td>
<td>MHHW + 63 to 69&quot;</td>
</tr>
<tr>
<td>Scenario 7</td>
<td>MHHW + 77&quot;</td>
<td>MHHW + 74 to 80&quot;</td>
</tr>
<tr>
<td>Scenario 8</td>
<td>MHHW + 84&quot;</td>
<td>MHHW + 81 to 87&quot;</td>
</tr>
<tr>
<td>Scenario 9</td>
<td>MHHW + 96&quot;</td>
<td>MHHW + 93 to 99&quot;</td>
</tr>
<tr>
<td>Scenario 10</td>
<td>MHHW + 108&quot;</td>
<td>MHHW + 105 to 111&quot;</td>
</tr>
</tbody>
</table>

MHHW = Mean Higher High Water
" = inches

### Figure 5-2. BCDC Sea Level Rise Mapping Scenarios and Relationships Between Sea Level Rise and Storm Surge (BCDC, 2017)

<table>
<thead>
<tr>
<th>Sea Level Rise Scenario</th>
<th>Daily Tide</th>
<th>Extreme Tide (Storm Surge)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>+SLR (in)</td>
<td>1yr</td>
</tr>
<tr>
<td>Existing Conditions</td>
<td>0</td>
<td>14</td>
</tr>
<tr>
<td>MHHW + 6&quot;</td>
<td>6</td>
<td>20</td>
</tr>
<tr>
<td>MHHW + 12&quot;</td>
<td>12</td>
<td>26</td>
</tr>
<tr>
<td>MHHW + 18&quot;</td>
<td>18</td>
<td>32</td>
</tr>
<tr>
<td>MHHW + 24&quot;</td>
<td>24</td>
<td>38</td>
</tr>
<tr>
<td>MHHW + 30&quot;</td>
<td>30</td>
<td>44</td>
</tr>
<tr>
<td>MHHW + 36&quot;</td>
<td>36</td>
<td>50</td>
</tr>
<tr>
<td>MHHW + 42&quot;</td>
<td>42</td>
<td>56</td>
</tr>
<tr>
<td>MHHW + 48&quot;</td>
<td>48</td>
<td>62</td>
</tr>
<tr>
<td>MHHW + 52&quot;</td>
<td>52</td>
<td>66</td>
</tr>
<tr>
<td>MHHW + 58&quot;</td>
<td>54</td>
<td>68</td>
</tr>
<tr>
<td>MHHW + 60&quot;</td>
<td>60</td>
<td>74</td>
</tr>
<tr>
<td>MHHW + 66&quot;</td>
<td>66</td>
<td>80</td>
</tr>
</tbody>
</table>

Note: Example Sea Level Rise Matrix shown is from Marin County.
in = inch(es)
MHHW = Mean Higher High Water
SLR = sea level rise
yr = year(s)
Vulnerability Assessment Summary

Table 5-4. Key Gaps and Next Steps for Sea Level Rise Vulnerability Assessment in Alameda

<table>
<thead>
<tr>
<th>Key Gap</th>
<th>Next Steps</th>
<th>Relevant Study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Existing Alameda-specific sea level rise assessment only included exposure and did not consider inundation depth.</td>
<td>Evaluate sensitivity and adaptive capacity for Alameda assets and incorporate water depth into the assessment.</td>
<td>City of Alameda Sea Level Rise Hazard Assessment (2017)</td>
</tr>
<tr>
<td>Countywide vulnerability assessment did not include many specific assets in the City of Alameda.</td>
<td>Use the ART framework to assess Alameda-specific assets where appropriate.</td>
<td>ART Alameda County Project: Vulnerability and Risk Report (2012)</td>
</tr>
<tr>
<td>Countywide vulnerability assessment was completed in 2012 using outdated inundation maps.</td>
<td>Review results of 2012 vulnerability assessment and verify the findings are still accurate given new projections.</td>
<td>ART Alameda County Project: Vulnerability and Risk Report (2012)</td>
</tr>
</tbody>
</table>

Several assessments of vulnerability to sea level rise and extreme tides have been conducted in the Bay Area broadly and in Alameda specifically. The ART Alameda County Project included the most comprehensive vulnerability assessment—examining exposure, sensitivity, and adaptive capacity—for a wide range of critical asset categories and sectors. Due to its relatively broad scope covering the entirety of Alameda County, the ART Alameda County Project: Vulnerability and Risk Report did not include a comprehensive assessment of assets specific to the City of Alameda (although it included many), but rather focused on asset categories more broadly. Furthermore, the vulnerability assessment was completed in 2012 using older sea level rise inundation maps that relied on somewhat outdated projections. Table 5-4 above shows key gaps in existing assessments.

More recently, the City of Alameda LHMP included a high-level assessment of the risk sea level rise poses to critical assets, using the NRC sea level rise projections from 2012 and a previous iteration of BCDC inundation maps. This high-level assessment did consider asset sensitivity to permanent inundation and temporary flooding, but only for general types of assets (e.g., buildings, utilities) and not for specific assets (CoA, 2016).

The City of Alameda Sea Level Rise Hazard Assessment was completed in 2017 using the most recent BCDC inundation maps and focusing on nine neighborhoods (see text box to the right). The City and other stakeholders collaborated to select these neighborhoods based on known hazards and local expertise (CoA, 2017b). In updating the CAP, the City will expand the analysis to cover neighborhoods excluded from the original assessment. The Sea Level Rise Hazard Assessment was also limited to an exposure analysis with no consideration of inundation depth, sensitivity, or adaptive capacity.

Neighborhoods Considered in City of Alameda Sea Level Rise Hazard Assessment (2017):
- Alameda Point
- Marina Village and Posey Tube
- South Shore Lagoons (4 neighborhoods defined)
- East End
- Eastshore
- Bay Farm
An important component of developing a climate adaptation plan for the City of Alameda is identifying the appropriate set of assets, services, and systems that should be the target of the risk assessment and adaptation strategy development. Table 5-5 summarizes the assets examined in previous assessments.

Table 5-5. Assets and Sectors Included in Previous Assessments

<table>
<thead>
<tr>
<th>Assessment or Plan</th>
<th>Assets and/or Sectors Assessed</th>
</tr>
</thead>
</table>
| ART Alameda County Project (2012) | 14 sectors or asset groups included in assessment:  
- Airports  
- Business and industry  
- Communities and housing  
- Contaminated lands  
- Critical services  
- Energy, pipelines, and telecommunications  
- Flood control and stormwater  
- Ground transportation  
- Hazardous materials  
- Natural areas  
- Parks and recreation  
- Seaport  
- Shoreline protection  
- Water management |
| ART Oakland/Alameda Resilience Study (2014) | Included both an asset-scale and sector-scale exposure analysis. The five sectors considered were:  
- Schools  
- Childcare facilities  
- Senior care facilities  
- Utilities  
- Communities  
Assets were selected based on a range of criteria. Multiple critical assets owned or operated by (or relevant to) the City of Alameda were evaluated:  
- Doolittle Drive  
- Harbor Bay Parkway  
- Bay Farm Island Brides (car and pedestrian/bike)  
- Harbor Bay Island Lagoon system  
- Harbor Bay Ferry Terminal |
| City of Alameda Local Hazard Mitigation Plan (2016) | Four main asset groups included in assessment:  
- Alameda’s building inventory  
- Alameda’s utility inventory (including stormwater and sewer assets)  
- Alameda’s transportation inventory  
- Alameda’s park and open space inventory |
| City of Alameda Sea Level Rise Hazard Assessment (2017) | Specific asset list developed in collaboration with the City of Alameda, with additional data from OpenStreetMap, Open Data, and BCDC. Assessed a range of asset types, including:  
- Critical facilities (fire, healthcare, schools, etc.)  
- Sewer and stormwater infrastructure  
- Transportation infrastructure (roads, railways, ferry terminals, etc.)  
- Community assets (parks, open spaces, museums)  
- Other facilities (hazardous waste storage, gas stations, etc.) |
Several criteria can be used as a starting point to ensure appropriate assets are considered without overwhelming the assessment. The graphic below shows examples of criteria that can help prioritize assets for the assessment.

**Exposure**

Assets and residents in the Bay Area are already being exposed to the impacts of sea level rise to a greater degree than in the past. Most notably, king tides that predictably occur two to four times a year currently lead to flooding in low-lying coastal areas around San Francisco Bay, including on some streets in Alameda (BCDC, 2017). Areas that are currently flooding at king tides are likely to be impacted more quickly and to a greater degree as water levels continue to rise. These are areas that should be targeted with early interventions to alleviate sea level rise impacts.

Assessments conducted to date in Alameda have reviewed asset exposure in detail, specifically the Sea Level Rise Hazard Assessment completed in 2017, but gaps need to be filled in the extent of exposure analysis to complete the assessment in all Alameda neighborhoods. The 2017 assessment also did not incorporate depth in its analysis, focusing only on the lateral extent of inundation, so there is limited understanding of how severely assets are exposed to sea level rise. However, the 2017 BCDC inundation maps do reflect both depth and inundation and can facilitate consideration of exposure to different inundation and/or temporary flooding depths. Table 5-6 presents the results of the Sea Level Rise Hazard Assessment, identifies the sea level rise level at which each neighborhood is impacted, and provides additional details on asset-specific exposure for each scenario.
<table>
<thead>
<tr>
<th>Neighborhood</th>
<th>Exposure</th>
<th>Threshold Sea Level Rise Levels</th>
<th>Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alameda Point</td>
<td>High</td>
<td>36 inches: buildings and assets affected; 66 inches: emergency access blocked</td>
<td>At 36 inches of sea level rise, Alameda Point would see inundation that moves beyond affecting isolated assets and streets to impacting buildings and city blocks. As water levels rise, an increasing number of educational, emergency, transportation, commercial, and recreational assets would be impacted. At 66 inches, floodwaters would block access to Fire Station 5 and inundate Main Street Ferry Terminal. At 96 inches, Alameda Point would be completely under water except for small areas of the former Naval Air Station.</td>
</tr>
<tr>
<td>Marina Village and Posey Tube</td>
<td>High</td>
<td>36 inches: Posey Tube entrance flooded; 48 inches: flooding of residential areas</td>
<td>At 36 inches of sea level rise, Marina Village and Posey Tube experience more significant impacts due to the complete inundation of the Posey Tube entrance, which would cut the City of Alameda off from Oakland and block one of the City’s main corridors for accessing the rest of East Bay. Increasing sea levels affect important commercial and recreational assets, such as the Marina Village Yacht Harbor facilities, the Oakland Yacht Club, and the Marina Village Shopping Center, all of which would be inundated partially or completely with 66 inches of sea level rise.</td>
</tr>
<tr>
<td>South Shore Lagoon 1</td>
<td>Medium</td>
<td>48 inches: buildings and assets affected; neighborhood access blocked</td>
<td>At 48 inches of sea level rise, South Shore Lagoon 1 would see significant asset exposure affecting community medical, recreational, and natural resource assets, such as Crown Bay Nursing Center, Robert Crown Memorial State Beach, and Robert W. Crown Marine Conservation Area, and access to the neighborhood south of the lagoon would be flooded. With higher water levels, these and other assets (e.g., transportation) would be inundated, making these assets inaccessible. At 77 inches, all roads would be flooded.</td>
</tr>
<tr>
<td>South Shore Lagoon 2</td>
<td>High</td>
<td>48 inches: buildings and assets affected; neighborhood access blocked; 77 inches: hospital partially flooded</td>
<td>At 48 inches, transportation assets such as the Grand Street Bridge would be affected, and access to the neighborhood south of the lagoon would be flooded. At 66 inches, important medical facilities that are critical care providers would be partially or fully inundated, such as the Southshore Convalescent Hospital, Bay View Nursing Center, and Alameda Care Center. At 77 inches, Alameda Hospital would partially flood.</td>
</tr>
<tr>
<td>South Shore Lagoon 3</td>
<td>Low</td>
<td>48 inches: buildings and assets affected; neighborhood access blocked</td>
<td>South Shore Lagoon 3 is not significantly affected by rising seas until water levels reach 48 inches, at which point some key roads such as Otis Drive and parts of Willow Street would be flooded, blocking access to and from the neighborhood. The next significant change in the extent of asset exposure occurs at 66 inches, when South Shore Lagoon 3 would be completely inundated.</td>
</tr>
<tr>
<td>Neighborhood</td>
<td>Exposure</td>
<td>Threshold Sea Level Rise Levels</td>
<td>Summary</td>
</tr>
<tr>
<td>---------------------</td>
<td>----------</td>
<td>-------------------------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>South Shore Lagoons 4 and 5</td>
<td>Medium</td>
<td>48 inches: Buildings and assets affected; neighborhood access blocked</td>
<td>With less than 48 inches of sea level rise, South Shore Lagoon 4 and 5 would experience erosion and/or flooding along the public walkway and boardwalk. At 48 inches, water would inundate neighborhoods as well as isolate important community and transportation assets, such as Otis Elementary School and Bay Farm Island Bridge. Rising water levels would flood an increasingly significant portion of the neighborhood, affecting residential areas and beachfront parcels.</td>
</tr>
<tr>
<td>East End</td>
<td>Medium</td>
<td>36 inches: neighborhoods experience flooding 48 inches: transportation and education assets flood</td>
<td>Up to 24 inches of sea level rise, asset exposure is limited to some homes along the shoreline and Towata Park. As water levels increase to 48 inches, the flooding affects several neighborhoods and community and transportation assets in nearby areas such as Otis Elementary School and Bay Farm Island Bridge. Higher sea level rise scenarios are marked by the expansion of flooding into East End.</td>
</tr>
<tr>
<td>Eastshore</td>
<td>Medium</td>
<td>36 inches: neighborhoods experience flooding 48 inches: Lincoln Middle School access blocked</td>
<td>At 36 inches of sea level rise, water would affect most of the streets north of Encinal Avenue, and homes along the shoreline would see impacts to their shore access due to erosion. At 48 inches, the residential area north of Lincoln Middle School would be almost entirely flooded, blocking access to the school. With an increase in sea levels to 66 inches, most of Eastshore would be inundated.</td>
</tr>
<tr>
<td>Bay Farm</td>
<td>High</td>
<td>36 inches: road access to and from neighborhood blocked; buildings and assets affected [52 inches]: fire Station 4 access blocked</td>
<td>When water levels reach 36 inches, sea level rise poses significant exposure risk to homes and streets as well as access to some commercial, educational, and recreational assets in the Bay Farm neighborhood. An increasingly significant portion of the neighborhood would be inundated; at 52 inches, floodwaters would further encroach into neighborhoods, affecting the homes located in these areas as well as access to critical citywide assets such as Fire Station 4. At 96 inches, most of the neighborhood would be flooded.</td>
</tr>
</tbody>
</table>

a Exposure levels developed in this assessment aligned with the FEMA Calculated Priority Risk Index methodology. See the City of Alameda Sea Level Rise Hazard Assessment, Appendix A, for more details (CoA, 2017b).
b Sea level rise levels shown here correspond to the scenarios BCDC used for inundation mapping in the 2017 Sea Level Rise Analysis and Mapping Project.
The ART Alameda County Project and the ART Oakland/Alameda Resilience Study both looked at asset exposure as well, but the City of Alameda Sea Level Rise Hazard Assessment’s detailed exposure analysis is more comprehensive. However, the Oakland/Alameda Resilience Study specifically focused on Bay Farm Island and produced a detailed assessment of that area’s vulnerability to coastal flooding (BCDC, 2016). The text box to the right highlights some of the critical vulnerabilities that specific assets and neighborhoods on Bay Farm Island face. The Oakland/Alameda Resilience Study identified several high-priority targets for adaptation, specifically for Doolittle Drive, the Veteran’s Court Seawall, and the Harbor Bay Island Lagoon System.

Sensitivity
Several existing assessments or plans provide information on asset sensitivity—defined as the degree to which climate change impacts people, assets, or ecosystems—but additional analysis is required to ensure a comprehensive evaluation. Existing studies and their limitations include the following:

- **ART Alameda County Project: Vulnerability and Risk Report** (2012): This is the most detailed analysis of asset sensitivity for Alameda, but it used older sea level rise scenarios.
- **ART Oakland/Alameda Resilience Study** (2014) and **Bay Farm Island Technical Study** (2014): These are more detailed assessments of asset sensitivity for Bay Farm Island specifically and didn’t include an assessment of Alameda Island.
- **City of Alameda LHMP** (2016): This plan provides a high-level overview of the potential impacts of priority hazards (sea level rise, flooding, earthquakes) on general asset groups (buildings, utilities, transportation) but does not consider asset-specific sensitivity, or adaptive capacity.

The following section summarizes the findings of the abovementioned assessments that examined sensitivity. Conducting a comprehensive vulnerability assessment for specific assets in Alameda will require additional analyses, using the results of previous assessments as a starting point.

In general, the potential impacts of sea level rise may include coastal flooding associated with shoreline overtopping, inland flooding associated with rising groundwater levels, coastal erosion in unprotected areas, and undermining of and damage to existing structures (e.g., bridge abutments) (CoA, 2016). The San Francisco Bay shoreline was historically composed of significant amounts of wetlands and open bays that have been filled or converted to developed land. Substantial portions of Alameda are built atop infill, potentially increasing the susceptibility of these areas to subsidence, especially as groundwater levels rise due to rising sea levels (BCDC, 2017).

**Impacts of Sea Level Rise on Bay Farm Island – Results of Oakland/Alameda Resilience Study:**

- Floodwater has the potential to overtop the shoreline along Doolittle Drive and result in flooding of low-lying areas.
- Water could block Doolittle Drive, the Harbor Bay Parkway, Ron Cowan Parkway, and the approach to the Bay Farm Island Bridge; this could completely cut off Bay Farm Island from Oakland (mainland) and Alameda Island.
- The Harbor Bay Island Lagoon System could also be threatened, given it is isolated from the ocean by a narrow isthmus of land that is not a formal engineered levee.
Asset sensitivity makes an important distinction between temporary flooding and permanent inundation—each condition has its own unique set of impacts. The text box to the left describes potential impacts from flooding as defined by the LHMP. In general, the LHMP found that flooding is likely to be a temporary condition driven by tide cycles as well as storm intensity and duration, with flooding likely to be shallow in most cases (approximately 2 feet or less). The location of flooding is of particular importance when analyzing the sensitivity of critical services to sea level rise, as damage or destruction of key transportation corridors can impact emergency services.

Previous ART projects in the region and locally conducted more detailed assessments of asset sensitivity than the City of Alameda LHMP. Using the ART framework, the *Oakland/Alameda Resilience Study* (which focused on Bay Farm Island and the area surrounding the Oakland Coliseum) developed profile sheets that presented sector- and asset-specific information. These profile sheets defined vulnerabilities for the following categories: governance, information, physical, and functional. The study also defined vulnerabilities using the ART Assessment Questions, and its framework can serve as the foundation for similar detailed analysis of assets and asset groups for the rest of Alameda.

### Adaptive Capacity

A full vulnerability assessment evaluates adaptive capacity, or the ability of assets, systems, or people to adjust to an adverse impact. The most complete assessment of the adaptive capacity of Alameda’s assets and systems is the ART Alameda County Project, which analyzed 14 critical sectors. The ART *Oakland/Alameda Resilience Study* also considered adaptive capacity when developing asset-specific profile sheets.

Table 5-7 summarizes the results of the ART *Alameda County Project: Vulnerability and Risk Report* for both sensitivity and adaptive capacity. These project results will serve as the foundation for a more detailed assessment of the vulnerability of specific assets in the City of Alameda.

#### Table 5-7. Summary of ART Alameda County Project: Vulnerability and Risk Report Results (BCDC, 2012)\(^a\)

<table>
<thead>
<tr>
<th>Sector</th>
<th>Sensitivity</th>
<th>Adaptive Capacity</th>
</tr>
</thead>
</table>
| Business and Industry    | • Residential neighborhoods are sensitive to inundation, flooding, and elevated groundwater levels.  
                             • Most buildings are not designed or constructed to withstand sea level rise impacts.  
                             • Underground components are sensitive to flooding and rising groundwater levels. | • Wood structures and buildings with drywall have limited adaptive capacity and may require demolition and replacement if impacted by sea level rise.  
                             • Underground components can be improved but may require retrofits or replacement. |
<p>| Contaminated Lands       | • Sediment-bound contaminants (e.g., PCBs) could be mobilized due to sea level rise and flooding. | • Many contaminated sites are regulated, increasing their adaptive capacity.        |</p>
<table>
<thead>
<tr>
<th>Sector</th>
<th>Sensitivity</th>
<th>Adaptive Capacity</th>
</tr>
</thead>
</table>
| Sector                                      | **Rising groundwater and infiltration of water during high tides could mobilize other contaminants contained in soil.**  
|                                             | **Leaking underground storage tanks are sensitive to rising groundwater and saltwater intrusion.**  
|                                             | **Alameda Point Superfund site includes a contaminated groundwater plume that could expand if groundwater rises.**                                                                                                                                                                                                                           | **capacity due to extensive monitoring and guidelines for contaminated lands.**  
|                                             |                                                                                                                                                                                                                                                                                                                                             | **Remedial efforts increase adaptive capacity at managed sites.**  
|                                             |                                                                                                                                                                                                                                                                                                                                             | **Some contaminated sites can be removed (e.g., underground storage tanks), while others are remediated in place.**                                                                                                                                                                                                                           |
| Critical Services                           | **Emergency facilities often contain highly sensitive equipment due to their use (e.g., specialized equipment).**  
|                                             | **Emergency facilities are critical during disasters but can also be cut off due to sea level rise, flooding, and other hazards.**                                                                                                                                                                                                                                                                           | **Emergency facilities have inherent adaptive capacity due to the services they provide.**  
|                                             |                                                                                                                                                                                                                                                                                                                                             | **Generally, there is redundancy in critical services (e.g., multiple fire stations, healthcare facilities).**  
|                                             |                                                                                                                                                                                                                                                                                                                                             | **Many emergency facilities have equipment to respond to disasters (e.g., portable pumps).**                                                                                                                                                                                                                                                        |
| Energy, Pipelines, and Telecommunications    | **Equipment at power plants and substations can be critically damaged due to flooding, especially from seawater that can corrode critical equipment.**  
|                                             | **Aboveground infrastructure is not sensitive to flooding, but buried components are at high risk.**  
|                                             | **Saltwater intrusion can damage buried infrastructure such as natural gas pipelines.**  
|                                             | **Increased liquefaction risk from rising groundwater levels poses a major threat to buried infrastructure that could be damaged heavily during earthquakes.**                                                                                                                                                                                   | **Regulations on management of buried and aboveground energy infrastructure (e.g., natural gas pipelines) requires corrosion control and other protections that increase adaptive capacity.**  
|                                             |                                                                                                                                                                                                                                                                                                                                             | **Entities managing critical energy infrastructure often have detailed asset management plans that help them proactively address potential impacts.**  
|                                             |                                                                                                                                                                                                                                                                                                                                             | **Onsite protection measures at many energy facilities provide adaptive capacity to rising sea levels and flooding.**                                                                                                                                                                                                                           |
| Flood Control and Stormwater                | **Stormwater management systems have relatively high sensitivity to inundation, flooding, and saltwater levels given their direct contact with the Bay and their critical function.**  
|                                             | **Rising sea levels increase the chance that stormwater systems are overwhelmed during precipitation events.**  
|                                             | **Corrosion of critical buried stormwater infrastructure can lead to failures.**  
|                                             | **Stormwater systems often use electrical equipment at pump stations that could be damaged by flooding.**                                                                                                                                                                                                                                  | **Stormwater systems are composed of many components that can be upgraded, replaced, or potentially relocated to reduce the potential threat posed by rising water levels (sea level and groundwater).**  
|                                             |                                                                                                                                                                                                                                                                                                                                             | **Addition of pumps can decrease the load on the stormwater system and increase resilience to sea level rise and precipitation events.**  
|                                             |                                                                                                                                                                                                                                                                                                                                             | **Replacement of gravity-fed stormwater systems with pump stations can reduce the risk of an overwhelmed system due to blocked outfalls.**  
|                                             |                                                                                                                                                                                                                                                                                                                                             | **Implementation of green infrastructure and low impact**                                                                                                                                                                                                                                                                           |
### Sector

<table>
<thead>
<tr>
<th>Sensitivity</th>
<th>Adaptive Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>development practices can greatly reduce the risk posed by inundation and temporary flooding.</td>
<td></td>
</tr>
</tbody>
</table>

#### Ground Transportation

- The location of many roads and other transit assets near the shoreline make them highly sensitive to sea level rise and associated shoreline overtopping.
- Tunnels are used heavily in Alameda County and in some cases (including the Alameda Tube entrances) have access ramps that are below grade.
- Roadway access to ferry terminals are often in low-lying areas and therefore very sensitive to sea level rise.

- There is limited redundancy in major transit systems in Alameda County; therefore, adaptive capacity for rail systems is particularly low.
- The abundance of transit-dependent communities within Alameda County prevents retrofits or replacement of many critical transit networks and roadways that cannot be shut down.

#### Hazardous Materials

- Floods can hazardous materials to release from containers or uncontained waste to mobilize.

- Implementation of flood control measures at individual facilities can increase adaptive capacity.
- Regulations regarding hazardous waste require careful management that increases adaptive capacity.

#### Parks and Recreation

- Many parks and recreational areas in Alameda County are located on the shoreline and are therefore sensitive to sea level rise.
- Developed trails (including pedestrian and bike paths) can be damaged by flood events and lost to permanent inundation.

- Parks and recreational areas that include substantial natural land tend to have greater adaptive capacity because they allow water to percolate into soils or recede naturally.
- Many parks can be closed temporarily when flooding occurs, and retrofits or proactive planning can decrease the need for repairs after a flood event.

#### Shoreline Protection

- Engineered flood protection structures are not sensitive to sea level rise if designed for projected future sea levels.
- Flood protection designed without considering future sea level is at high risk of impacts from shoreline overtopping that can damage structures.
- Structural integrity can be compromised due to sea level rise and flooding, as larger and more frequent storms erode embankments or footings.
- Natural shorelines can be overwhelmed due to inundation or frequent floods, reducing their ability to attenuate storm event flooding.

- Structures designed with consideration of future sea level rise have greater adaptive capacity.
- Structures can be designed to be amended or upgraded to accommodate higher water levels.
- Structures that are regularly maintained or that include permit authorizations can be regularly improved.

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*This table presents a subset of the sectors analyzed in the ART Alameda County Project. The project findings are much more extensive and constitute the most comprehensive vulnerability assessment for the City of Alameda.*
Findings and Recommendations

The previous assessments and plans related to sea level rise and associated impacts have produced a wide range of findings and recommendations, including identification of information gaps, prioritization of hazards and assets, and specific adaptation or hazard mitigation strategies to consider for implementation. The 2016 LHMP also provides a list of completed hazard mitigation strategies, primarily since the 2010 LHMP, that can help Alameda identify existing interventions to support prioritization of future adaptation actions. For example, an Emergency Alert System (Nixle 360) was established to send voice messages to targeted geographic areas. This strategy addresses several potential hazards and provides a platform for the City to send information to residents based on their exposure to a threat, but it should be revisited and expanded to meet new, advancing technological needs and capabilities.

Table 5-8 presents example findings from the Oakland/Alameda study for the schools asset group. The City of Alameda can build upon this study’s findings and recommendations when updating the CAP. Similar findings are presented in the Oakland/Alameda study for the other asset groups and specific assets listed above in Table 5-5. The Oakland/Alameda study identified several adaptation responses for each of the vulnerabilities defined for each asset or asset group. The responses defined during this previous effort can be used to target pilot projects and “early-track” implementation in Alameda. The text box to the right shows key high-priority targets for adaptation identified during the Oakland/Alameda Resilience Study and related Bay Farm Island Technical Memorandum.

### Critical Assets to Consider for Early Implementation of Adaptation Actions
- Doolittle Drive
- Harbor Bay Island Lagoon system
- Veteran’s Court Seawall
- Bay Farm Island tide gate structure

5.1.3 Inland Flooding from Surface Water Runoff and Rising Groundwater

Observations and Projections

It is difficult to separate the impacts of sea level rise from other flooding sources because of Alameda’s location, but inland flooding in portions of the city that are not directly impacted by sea level rise and shoreline overtopping is a special concern. Surface water runoff and rising groundwater—which is exacerbated by sea level rise—can cause inland flooding during heavy precipitation events. Alameda struggles frequently with overwhelmed or blocked stormwater infrastructure, as summarized in the 2016 LHMP and several assessments related to the stormwater system. The City is very flat, especially along the coast, where it is primarily constructed on infill areas. The flat topography prevents the use of a gravity stormwater system, necessitating pump stations to manage stormwater (CoA, 2016). Furthermore, seawater during high tides currently covers stormwater outfalls, and mud deposition can block outfalls, requiring additional pump stations and lift stations to move water out under pressure.
Table 5-8. Example of Findings from *Oakland/Alameda Resilience Study*

<table>
<thead>
<tr>
<th>Key Issue(s)</th>
<th><strong>Schools</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>● The construction and function of schools makes them vulnerable to sea level rise impacts, including flooding.</td>
</tr>
<tr>
<td></td>
<td>● Young children are more difficult to evacuate in an emergency.</td>
</tr>
<tr>
<td></td>
<td>● Lack of resources may preclude schools from investing in building improvements or future relocation plans.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Vulnerabilities</th>
<th><strong>Schools</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Informational:</td>
<td>● Lack of evaluations for earthquake safety.</td>
</tr>
<tr>
<td>Governance:</td>
<td>● Older schools may not meet current earthquake standards.</td>
</tr>
<tr>
<td></td>
<td>● Central database on school condition is lacking.</td>
</tr>
<tr>
<td>Functional:</td>
<td>● Overcrowding.</td>
</tr>
<tr>
<td></td>
<td>● Heavy reliance on other systems that could be impacted (roads, transit, electricity, water, etc.).</td>
</tr>
<tr>
<td>Physical:</td>
<td>● Ability of staff to access schools is critical to their function.</td>
</tr>
<tr>
<td></td>
<td>● Most schools are built at-grade and vulnerable to flooding.</td>
</tr>
<tr>
<td></td>
<td>● Older schools are vulnerable to earthquake impacts.</td>
</tr>
<tr>
<td></td>
<td>● Contents of schools (bookshelves, equipment, etc.) makes them more at risk of damage from earthquake shaking.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Consequences</th>
<th><strong>Schools</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>● Schools provide important functions in communities and can also be a place of shelter during emergencies.</td>
</tr>
<tr>
<td></td>
<td>● Damage to schools can disrupt education and place additional financial burden on districts.</td>
</tr>
<tr>
<td></td>
<td>● Schools that service transit-dependent or low-income communities are especially vulnerable because of their demographic makeup.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Example Adaptation Responses</th>
<th><strong>Schools</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>● Reduce dependency on school buildings that are vulnerable to sea level rise by building alternative facilities or increasing the capacity of existing schools in areas not at risk from sea level rise.</td>
</tr>
<tr>
<td></td>
<td>● Conduct vulnerability and risk assessments of individual schools and develop site-specific strategies to reduce service disruptions or closures.</td>
</tr>
</tbody>
</table>

* Information summarized from ART *Oakland/Alameda Resilience Study*, Appendix A: “Profile Sheets and Adaptation Responses.”
The City completed a *Storm Drain Master Plan*, completed in 2008 and most recently updated in 2017, and has conducted several assessments of the stormwater system (see text box to the right). These assessments identify potential flooding locations where stormwater infrastructure could be overwhelmed due to the combination of surface water runoff and sea level rise. Analyses included both the 10-year storm event and 25-year storm event using current storm intensity estimates, but they did not project future changes in storm intensity; however, the analyses did consider changing ocean water levels (CoA, 2008b; CoA, 2009b).

In 2018, FEMA approved and officially adopted new Flood Insurance Rate Maps (FIRMs) based on modeling completed in 2015. These updated maps include a larger 100-year and 500-year floodplain area, approximately XX units greater than the previous maps from 2009.4

There has been little analysis of the potential impact of rising groundwater on flooding in Alameda. Due to the complexities of subsurface hydrology and the lack of quantitative data on groundwater in the City, conducting a detailed analysis of the potential impact of sea level rise on groundwater levels would be difficult. The text box below lists several such studies that have been conducted in specific locations. These could provide valuable information as Alameda considers groundwater in developing its adaptation strategies. However, without substantial groundwater monitoring data in Alameda, the types of comprehensive analyses conducted elsewhere cannot be conducted in the City. Despite this limitation, Alameda can consider sea level rise impacts on groundwater levels and subsequent surface flooding during the CAP update.

---

**Example Studies of the Relationship Between Sea Level Rise and Groundwater Levels**


- Conceptual Groundwater Model of Sea Level Rise in the Humboldt Bay Eureka-Arcata Coastal Plain – California State Coastal Conservancy and Coastal Ecosystems Institute of Northern California (2014)


---

4 **Question to City**: Is this information readily available from the City’s own floodplain modeling? If not, ERG can determine the change in area from the 2009 FEMA maps to the new 2015 ones.
Several sources of information on the current and projected storm intensity in Alameda and the Bay Area region could be used when assessing Alameda’s vulnerability to flooding from storm-driven surface water runoff. To date, no specific studies have been completed that explicitly consider potential future changes in storm intensity due to climate change. The graphic below depicts the projected changes in storm intensity from current levels. These projections are based on an ensemble approach that the U.S. Environmental Protection Agency (EPA) used for water resources planning, with model projections provided at the scale of a 30 x 30-mile grid (USEPA, 2016). The City can incorporate the projected intensities into a vulnerability assessment and consider them when developing adaptation responses.

### Table 5-9. Key Gaps and Next Steps for Flood Vulnerability Assessment in Alameda

<table>
<thead>
<tr>
<th>Key Gap</th>
<th>Next Steps</th>
<th>Relevant Study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Existing hazard and vulnerability assessments do not consider the</td>
<td>Assess inland assets’ vulnerability to flooding (exposure, sensitivity and</td>
<td>N/A</td>
</tr>
<tr>
<td>vulnerability of inland assets to flooding if stormwater management fails.</td>
<td>adaptive capacity).</td>
<td></td>
</tr>
<tr>
<td>City has minimal understanding of the potential impact of sea level rise</td>
<td>Review relevant studies, develop a conceptual model, and recommend</td>
<td>N/A</td>
</tr>
<tr>
<td>on groundwater levels and implications for inland flooding.</td>
<td>actions to conduct a more detailed modeling effort.</td>
<td></td>
</tr>
<tr>
<td>Alameda storm drain modeling considered 10-year and 25-year storm</td>
<td>Consider implications of more intense precipitation events in the future</td>
<td>Storm Drain Flooding Analysis (2008)</td>
</tr>
<tr>
<td>estimates but did not project changes in storm intensity.</td>
<td>and provide recommendations for updating the storm drain modeling.</td>
<td></td>
</tr>
</tbody>
</table>

As highlighted above, the City of Alameda has conducted several assessments specific to the stormwater system, including modeling flooding potential for 10-year and 25-year storm events, and for 18 inches and 55 inches of sea level rise on top of the current 25-year storm event. These assessment results were included in the 2016 LHMP’s hazard assessment, which explicitly considered stormwater assets and included the maps of storm-drain-related flooding potential from the City’s previous analysis. However, none of these assessments conducted a detailed evaluation of vulnerability to flooding for other assets if the stormwater system is overwhelmed. The results of the storm drain modeling can be used to assess...
the vulnerability of critical assets, communities, and residents to inland flooding, particularly when records of stormwater overflows and their resulting inland flooding are reviewed to identify low points in the City that may not appear on coastal inundation and FEMA floodplain maps.

**Exposure**

Although storm drain modeling efforts identified pumps and other assets that are likely to be overwhelmed during storm events or due to sea level rise, these previous analyses did not extrapolate the flooding potential to surrounding assets to determine what areas or assets might be exposed if the stormwater system is overwhelmed. Previous modeling efforts determined flood level above the street for point locations, providing the foundation for determining the exposure of surrounding assets to flooding. Figure 5-3 below shows an example of the results from the 2008 *Storm Drain Master Plan’s 25-year storm analysis* and highlights the information available when assessing other assets’ vulnerability to inland flooding. Portions of Alameda disconnected from the coast are likely to still experience flooding, especially as groundwater levels rise, and these portions of the City should be evaluated for their exposure to overland flooding events.

**Figure 5-3. Example of Storm Drain Modeling Results Identifying Flood Levels for 25-Year Storm**

**Sensitivity**

No detailed assessment of asset sensitivity to flooding has been completed for Alameda. Many of the findings from the assessments focused on sea level rise (described earlier in this synthesis) apply to inland flooding. The 2016 LHMP also included some generic information regarding the vulnerability of assets, as
well as the relative risk of individual buildings to hazards overall, but that evaluation did not discuss asset sensitivity in detail.

Modeling conducted to support the Storm Drain Master Plan and subsequent updates did evaluate the system’s functionality during a 25-year storm event at current intensity on top of 18 inches and 55 inches of sea level rise. These models indicated that 18 inches of sea level rise had little impact on the system during a 25-year storm event, but 55 inches of sea level rise presented major flooding difficulties without system optimization and upsizing. The model findings provide some information on stormwater assets’ sensitivity to flooding after sea level rise, but they do not extend into an analysis of other assets’ sensitivity to flooding caused by an overwhelmed stormwater system.

Adaptive Capacity
None of the assessments conducted to date specifically discuss the assets’ adaptive capacity to flooding caused by surface water runoff and rising groundwater. However, the findings of the ART Alameda County Project related to sea level rise and coastal flooding apply in some cases and could be extrapolated to interior portions of Alameda that are not directly impacted by sea level rise but may still experience flooding.

Findings and Recommendations
The most relevant findings from previous assessments come from the Storm Drain Master Plan and subsequent updates, specifically the 2011 Storm Drain Pump Station Assessment (CoA, 2011) and the 2017 Storm Drain Master Plan Capital Improvement Program (CIP) Update. Modeling efforts identified stormwater assets that are most at risk from climate change and recommended system upgrades to account for potential future changes in ocean level. Notably, the analyses used current storm intensity (10-year or 25-year depending on the modeling effort) but did not consider changes to the intensity of storm events. The Storm Drain Master Plan CIP Update includes recommended system renovations, including new pump stations and upsizing of existing assets.

5.1.4 Earthquakes
Although earthquakes are not a climate hazard, they are intimately related to other climate threats. ABAG has conducted extensive analysis of the overlap between sea level rise and earthquakes, including in the Stronger Housing, Safer Communities report released in 2015. Sea level rise results in higher groundwater levels that can saturate soils and sediment underlying developed land. This saturated soil is at much higher risk of liquefaction during an earthquake. As such, the City of Alameda is including earthquakes in its climate adaptation assessment and strategy development to ensure it identifies actions that could address this compounded risk.

Observations and Projections
Alameda is located within a high earthquake hazard zone, as defined by the USGS. The Hayward Fault is closest to Alameda and is more likely than other faults in California to result in major damage to the City. However, the fault type in and around Alameda has less potential to cause a very extreme earthquake of greater than M8.0.

The area has a history of observed earthquake activity and has experienced 20 strong earthquakes and one major earthquake in the Bay Area in the past 165 years, including the 1868 Hayward Fault quake and the 1906 San Andreas quake. Two historic earthquakes that caused major damage to Alameda occurred before the islands were expanded with man-made fill. The most recent strong earthquake to occur after the infilling of the islands was the 1989 Loma Prieta earthquake (M6.9). All areas of damage during that earthquake were on infill outside of the original islands’ shorelines (CoA, 2016).
In 2013, USGS and ABAG made the following projections of earthquake hazard for the Bay Area and Alameda:

- 72 percent chance over the next 30 years of an earthquake of M6.7 or higher in the Bay Area.
- 28 percent chance over the next 30 years of an earthquake of M6.7 or greater on the Hayward Fault.
- All scenarios combined—10 percent chance of MMI 8 to MMI 9 shaking in Alameda over the next 50 years.

Alameda is also highly susceptible to liquefaction, particularly in areas where development occurred on top of infill material. Liquefaction was documented at Alameda Point and the Harbor Bay Business Park during the 1989 Loma Prieta earthquake (CoA, 2016).

Several studies have attempted to connect sea level rise and earthquake risk, specifically by considering sea level rise’s impact on liquefaction potential in the Bay Area. Notably, the ABAG Stronger Houses, Safer Communities report included a detailed evaluation of the overlap between sea level rise inundation and earthquake liquefaction risk, as did the Bay Area Housing and Community Risk Assessment Report, a related effort.

### Vulnerability Assessment Summary

<table>
<thead>
<tr>
<th>Key Gap</th>
<th>Next Steps</th>
<th>Relevant Study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Existing assessment of overlapping sea level rise/earthquake risk was broad (Bay Area) and not specific to Alameda.</td>
<td>Translate findings of assessment to Alameda assets as appropriate and develop maps to highlight areas of high risk.</td>
<td>ABAG Stronger Housing, Safer Communities report (2015)</td>
</tr>
</tbody>
</table>

Several existing assessments have evaluated the vulnerability of communities and assets to earthquake risk. However, few have evaluated specifically how earthquake risk and climate hazards combine to influence asset vulnerability. Despite the substantial potential risk that earthquakes pose to Alameda, an adaptation plan for climate hazards should focus on this overlap. The ABAG Stronger Housing, Safer Communities report findings provide the best information on the potential impact of earthquakes to the Bay Area in concert with sea level rise. Other information sources, including the 2016 LHMP, ART Alameda County Project, and ART Oakland/Alameda Resilience Study, discuss the exposure and sensitivity of asset groups to earthquakes and suggest adaptation responses to the threat of earthquakes. These studies provide a valuable starting point when evaluating potential options to increase Alameda’s resilience to hazards overall and earthquakes specifically.

#### Exposure

The 2016 LHMP evaluated the assets’ exposure to liquefaction as part of the overall vulnerability assessment, using the USGS 2006 liquefaction map for the Bay Area; a new liquefaction map has not been produced since 2006. In general, areas of Alameda that are built on infill, including the majority of Bay Farm Island, Alameda Point, and most coastal areas on Alameda Island, are most susceptible to liquefaction.

Overall exposure to earthquakes is similar throughout Alameda due to its proximity to the Hayward Fault and to a lesser degree the San Andreas Fault. USGS recently completed the HayWired Earthquake
Scenario—an analysis of a “worst-case scenario” rupture on the Hayward Fault—to describe the potential impacts of a major earthquake on the Bay Area. In this scenario, the epicenter of the earthquake was located under Oakland, leading to major shaking in Alameda. Although the HayWired scenario provides information on the potential impacts of a M7.0 earthquake on the Bay Area, it did not analyze specific asset types. Figure 5-4 shows the study area’s liquefaction potential during the HayWired scenario.

Figure 5-4. Liquefaction Probability for USGS HayWired Scenario (M7.0 Earthquake)

An adaptation plan for the City of Alameda can build upon the ABAG Stronger Housing, Safer Communities report by considering its findings in light of the USGS HayWired scenario and analyzing the exposure of critical assets to potential liquefaction, which sea level rise could exacerbate.

Sensitivity
As highlighted in the 2016 LHMP, characteristics of Bay Farm Island and Alameda Island make coastal neighborhoods more susceptible to damage from earthquakes. Both islands have “central cores” of relatively stable higher ground surrounded by areas of man-made fill that are more sensitive to shaking and ground disturbances. Alameda’s sensitivity to earthquakes is also driven by its dependency on connections to the mainland that earthquakes could damage, including transportation infrastructure, utilities, commerce, and services.

Notably, the 2016 LHMP reports that an earthquake could result in Alameda needing to be fully self-sufficient for 72 hours or more if bridges and utility crossings are severely damaged. These assets are also
at high risk from sea level rise, highlighting the fact that many of the same assets are affected by multiple threats. These assets should be considered high-priority when identifying targets for adaptation action.

Regionally, ABAG has conducted assessments of the sensitivity of communities and assets to earthquakes that can serve as the foundation for a more specific evaluation of assets in Alameda.

**Adaptive Capacity**

To date, no assessments have evaluated the adaptive capacity of Alameda’s assets to the risk posed by the confluence of earthquakes and sea level rise. The ART Alameda County Project and ART *Oakland/Alameda Resilience Study* both provide information on asset vulnerability to earthquakes, including adaptive capacity. This information can be leveraged to develop adaptation strategies that address both climate hazards and earthquake risk.

**Findings and Recommendations**

The 2016 LHMP highlights progress Alameda has made toward increased resilience to earthquakes, most notably related to earthquake-induced fires. The City has a Class 01/1Y ranking, placing it in the top 0.2 percent of 48,000 fire agencies in California. This high ranking is due in part to systems that Alameda put in place to enhance 911, E911 wireless, and VoIP communications; computer-aided dispatch; geographic information systems; and an established incident management system.

Several studies and reports have identified strategies to increase resilience to earthquake risk, including the 2016 LHMP, the ART Alameda County Project, the ART *Oakland/Alameda Resilience Study*, and the ABAG *Stronger Housing, Safer Communities* report. Of these, the ABAG report provides the most detailed information on the overlap between climate threats and earthquakes, and it can serve as the starting point for identifying adaptation responses that increase resilience to both earthquakes and sea level rise.

5.1.5 **Drought**

EBMUD provides Alameda’s drinking water, which it collects from the Sierra Nevada Mountains. The source water system is shown in Figure 5-5.

EBMUD has a well-established drought management plan, which was most recently updated in the 2015 *Urban Water Management Plan*. This plan helps EBMUD ensure water supply by advocating water conservation, water recycling, and long-term water supply projects. It specifically considers climate change, with a *Climate Change Monitoring and Response Plan* released in 2014, building on an initial effort in 2008 to incorporate climate change into the long-term strategic plan.

Long-term drought conditions in California, especially from 2013 to 2015, have led water suppliers to incorporate climate change into planning activities. Although Alameda does not control its own water supply, it can influence water conservation practices and advocate for smart water use by residents and businesses, following guidelines and recommendations set by EBMUD and the state of California.

**Projections**

The 2016 LHMP identifies drought as a minimal risk to Alameda because water supplies are stable; thus, drought effects are not a major concern. However, climate change may affect that assessment, as highlighted by EBMUD’s emphasis on drought and water conservation. Given Alameda’s limited control over the drinking water supply, projections for future drought conditions are relevant only so far as they influence conservation practices in the City.
Cal-Adapt is developing long-term, downscaled drought projections for specific locations in California, which may be available in late 2018/early 2019. These projections will inform drought contingency plans for water suppliers and will provide further justification for water conservation efforts in Alameda.

**Vulnerability Assessment Summary**

Alameda has not conducted a specific assessment of asset vulnerability to drought, likely due to the lack of direct control it has over its water supply, and no comprehensive vulnerability assessment is necessary. EBMUD has conducted extensive analyses of the vulnerability of its water supply overall to the risks posed by increasingly severe and prolonged droughts. Alameda can leverage the findings of EBMUD assessments to identify strategies for reducing per capita water consumption.

**Exposure**

Alameda is not directly exposed to drought impacts because EBMUD provides its water supply. The City overall is indirectly exposed to drought and its impacts, but a specific assessment of individual community or asset exposure has not been conducted.

**Sensitivity**

Increasingly severe and prolonged droughts in California have impacted and will continue to impact assets and communities in Alameda. Given the indirect impacts of drought on the City, no detailed assessment of asset sensitivity to drought is necessary. The City can instead identify adaptation responses that include water conservation best practices to reduce the burden on EBMUD, based on recommendations from the EBMUD Urban Water Management Plan.
Adaptive Capacity
Alameda has the capacity to adapt to drought to the extent that residents, businesses, and City-managed properties can conserve water to reduce stress on the system overall. No assessment has been conducted to identify the adaptive capacity of specific assets (e.g., parks, open spaces, and City-owned buildings), but EBMUD provides the general framework for conserving water.

Findings and Recommendations
The City of Alameda has limited control over source water protection against drought. However, the EBMUD Urban Water Management Plan outlines strategies for water conservation systemwide to support long-term sustainability. The EBMUD recommendations will serve as the basis for water conservation strategies in Alameda.

5.1.6 Heat
Extreme heat events, including hot days, warm nights, and heat waves, are an issue that is expected to increase in severity and duration. An accounting of heat-related deaths in 2011 identified 622 deaths in California from 2000 to 2011, with 184 deaths in the particularly hot summer of 2006 (CEHTP, 2011). In 2017, six deaths in the Bay Area were attributed to a heat wave over Labor Day, although none were reported in Alameda. The 2016 LHMP reported no heat emergencies in Alameda or California at large between 1960 and 2008 based on information from the State of California Multi-Hazard Mitigation Plan.

Projections
Table 5-11 summarizes observed heat events—extreme heat days, warm nights, and heat waves—from the Cal-Adapt tool.

Table 5-11. Summary of Extreme Heat Projections from Cal-Adapt

<table>
<thead>
<tr>
<th>Projection</th>
<th>Scenario</th>
<th>Extreme Heat Days (&gt; 90.4°F)</th>
<th>Warm Nights (&gt; 62.6°F)</th>
<th>Heat Wave Days (&gt; 90.4°F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Historical</td>
<td>-</td>
<td>4</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>2050</td>
<td>RCP 4.5</td>
<td>9</td>
<td>26</td>
<td>18 (2070)</td>
</tr>
<tr>
<td></td>
<td>RCP 8.5</td>
<td>9</td>
<td>60</td>
<td>38</td>
</tr>
<tr>
<td>2099</td>
<td>RCP 4.5</td>
<td>12</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td></td>
<td>RCP 8.5</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Extreme heat is known to be a potential public health threat, particularly in low-income areas and for vulnerable populations, which include infants/children, the elderly, and people with compromised immune systems. Heat events have been linked to higher rates of illnesses such as asthma as well as acute issues associated with heat exhaustion and heat stroke.

The other main impact of extreme heat is on transportation infrastructure. Roadways are more susceptible to damage during extreme heat events due to pavement softening, and rail lines can buckle during heat waves as metal becomes more pliable.
Vulnerability Assessment Summary

Table 5-12. Key Gaps and Next Steps for Flood Vulnerability Assessment in Alameda

<table>
<thead>
<tr>
<th>Key Gap</th>
<th>Next Steps</th>
<th>Relevant Study</th>
</tr>
</thead>
<tbody>
<tr>
<td>No vulnerability assessment has considered the risk posed to residents by an increase in extreme heat events.</td>
<td>Conduct a basic vulnerability assessment to understand how heat events may impact Alameda.</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Caltrans conducted a vulnerability assessment in 2018 that describes the risk extreme heat events pose to transportation assets in California (Caltrans, 2018). The findings apply to Alameda, especially as heat events become more severe and prolonged due to climate change.

The City has not conducted a detailed evaluation of its residents’ vulnerability to extreme heat.

**Exposure**

No assessments have directly considered the exposure of specific assets, services, or sectors to extreme heat events. Similarly, no assessments have evaluated the extent to which an increase in extreme heat events is likely to impact Alameda’s residents. Generally speaking, extreme heat events occur at a wide scale, with the exception of local urban heat island effects. Therefore, the majority of Alameda residents would be exposed to these events if they increase in the future as projected. An assessment of Alameda’s exposure to extreme heat would focus on disadvantaged communities and other residents that may be highly vulnerable to the impacts, using information such as BCDC’s community vulnerability mapping effort, EPA’s EJSCREEN tool, and CalEnviroScreen to identify at-risk populations.

**Sensitivity**

The impacts from extreme heat events and heat waves include:

- Public health issues, especially for vulnerable communities (children, elderly, infirm, poor), such as heat stroke, dehydration, and asthma.
- Public health threats to outdoor employees (construction workers, public works department employees, etc.) and associated decreased productivity.
- Damage to transportation infrastructure, including buckled rail lines, pavement softening and expansion, and equipment failure.

Although there are no assessments of heat event impacts on Alameda specifically, there are detailed case studies that describe the impacts of extreme heat events and heat waves on transportation infrastructure. The City can leverage these case studies to assess the vulnerability of its transportation assets to extreme heat and identify adaptation strategies.

**Adaptive Capacity**

Alameda has not specifically assessed the adaptive capacity of its assets to extreme heat events but can apply other report findings and more general assessments to the City’s assets.

**Findings and Recommendations**

The 2016 LHMP recommended that future LHMP revisions should re-assess the risk that extreme heat poses as the climate changes. Recent heat waves give greater impetus to this recommendation. The risk assessment conducted as part of the CAP update can help serve this purpose.
5.1.7 Wildfire

The City of Alameda is interested in understanding the potential impact of wildfire smoke on public health, especially as wildfires increase in frequency and severity throughout California. There are no established projections for wildfire smoke; the few projections that exist focus on determining areas susceptible to wildfires themselves and not the downstream effects. The Bay Area Air Quality Management District provides air monitoring data for several constituents—including ozone and PM$_{2.5}$ (particulate matter with diameters that are 2.5 micrometers or less)—that can provide some evidence of smoke impacts, but no projections have been made.

**Projections**

There are no existing projections for wildfire smoke impacts due to climate change. Furthermore, the direct connection between climate change and wildfires is still uncertain. There is consensus that climate change will exacerbate the conditions that can lead to fires, but it is difficult to project wildfires because of interannual variability and other drivers. Despite the lack of specific projections for wildfires, projected increases in air temperature and the frequency and severity of droughts and extreme heat events are likely to result in an elevated risk of more intense, prolonged, and/or large-scale fires throughout California.

**Vulnerability Assessment Summary**

The City has not specifically assessed the potential vulnerability of its residents to wildfire smoke impacts. More general assessments may provide valuable information when determining potential adaptation responses. Focusing on at-risk populations can help target adaptation strategies where they may have the greatest impacts.

5.2 Gaps and Recommended Next Steps

The assessments and studies conducted to date and described throughout this synthesis substantially characterize the vulnerability of assets, ecosystems, and residents to climate change. Notable gaps need to be filled, but the existing analyses provide a strong foundation upon which to build an adaptation plan. The text box below provides key opportunities to expand these existing efforts.

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**Key Considerations for Alameda’s Vulnerability Assessment and Adaptation Strategies**

- Ensure the vulnerability assessment includes all neighborhoods in Alameda.
- Develop a greater understanding of the potential impact of inundation depth on vulnerability.
- Expand assessment to consider extreme heat.
- Pay special attention to transportation asset vulnerability to extreme heat events given the potential impacts on the transit systems and the importance of transit to Alameda residents.
- Ensure the vulnerability assessment considers vulnerable communities using the most recent demographic and socioeconomic data.
- Focus the vulnerability assessment and strategy development on key assets and those that are already impacted by climate change.
- Ensure consistency with existing efforts regionally and statewide, including the San Francisco Estuary Institute Operational Landscape Units Project and ART.
The ART Oakland/Alameda Resilience Study identified several “Key Planning Issues” that are highly relevant to Alameda and the development of an adaptation plan. These findings were consistent with those from the ART Alameda County Project and include the following:

- Access on and off Bay Farm Island and to/from Oakland International Airport is already limited due to the island’s geography; is vulnerable to future flooding and seismic events; and will affect the economy, public health and safety, and community function if disrupted.

- Housing, community members, and community facilities are vulnerable to current and future flooding as well as seismic events.

- Oakland International Airport is vulnerable to future flooding and seismic events within its facilities and through its dependence on other assets.
  - A specific concern is the flood risk that low-lying areas pose along Doolittle Drive.
  - This requires collaboration between multiple stakeholders, including the City of Alameda (Caltrans owns Doolittle Drive, but some low-lying portions are within city limits).

- Overarching: Permitting and regulatory issues along shoreline and with multiple owners and jurisdictions may delay or impede adaptation.

The next steps in the development of an adaptation plan are described below.

1. Proceed with the “Define” step in the ART process:
   - Collaborate with stakeholders to establish key planning issues for the study area; key issues draw from asset- and sector-specific profile sheets and assessment findings.
   - Key planning issues differ from asset-specific issues because individual asset managers cannot address the vulnerabilities that underpin them (i.e., they require more substantial collaboration across a larger group of stakeholders).

2. Establish framework and criteria for adaptation strategy development. Examples of criteria that could be used to characterize and prioritize strategies include those from the 2016 LHMP:
   - Goal and objective support: prioritize actions that support multiple goals/objectives.
   - Funding availability: prioritize actions with secured funding.
   - Hazards addressed: prioritize actions addressing the plan’s hazards of greatest concern (earthquake and flooding).
   - Public and political support: prioritize actions with public and political support.
   - Adverse environmental impact: prioritize actions with low environmental impact.
   - Environmental benefit: prioritize actions that provide an environmental benefit.
   - Timeline for completion: prioritize actions that are ongoing, or that can be completed in the short term.
   - Ongoing: fund and implement projects under existing programs.
   - Short-term: complete projects in one to five years.
   - Long-term: complete projects in more than five years.

5.2.1 High-Priority Development and Adaptation Strategies

During the ART Oakland/Alameda Resilience Study, the “Plan” and “Implement” steps of the ART process were completed for Bay Farm Island. These steps identified potential adaptation responses for critical assets that could be the basis for high-priority or “fast-track” adaptation strategies given the substantial work conducted to date. As part of the study, the ART Pilot Project Bay Farm Island Technical Memorandum (2014) included a detailed sea level rise exposure analysis and adaptation strategy for
specific locations on Bay Farm Island, including the Veteran’s Court Seawall, the tide gate structure, and low points on Doolittle Drive. The memo identified key vulnerability areas, including the sources, mechanisms, and timing of inland inundation and flooding, using a detailed process of ground-truthing elevation data with field surveys.

The City has also identified several high-priority areas as targets for accelerated implementation of adaptation actions, including the Eastshore community and Alameda Point. In 2014, the Alameda Point Master Infrastructure Plan was released, providing a framework for site development. The plan considers flooding impacts and sea level rise and lays out strategies for addressing these threats during site development. Any activities conducted on Alameda Point during development should be integrated into other citywide actions, especially coastal protection structures like levees.

Table 5-13 below summarizes highly vulnerable assets that have been the target of preliminary strategizing to brainstorm potential adaptation actions.

**Table 5-13. Highly Vulnerable Assets Already Identified and Summary of Progress**

<table>
<thead>
<tr>
<th>Asset and Location</th>
<th>Vulnerabilities</th>
<th>Progress Made</th>
</tr>
</thead>
<tbody>
<tr>
<td>Doolittle Drive (Bay Farm Island)</td>
<td>• Overtopped with water levels of MHHW+36”. • Critical transportation corridor onto Bay Farm Island.</td>
<td>• Culverts under Doolittle Drive identified as high risk. • Initial implementation pathway investigated (). • Initial conversations with relevant stakeholders (Port of Oakland, East Bay Regional Parks District, City of Alameda, Caltrans).</td>
</tr>
<tr>
<td>Harbor Bay Island Lagoon System (Bay Farm Island)</td>
<td>• Sea level rise is likely to cause overtopping and subsequent inundation. • Existing dike was not designed as an engineered flood control structure.</td>
<td>• Initial discussions with Harbor Bay Isle Homeowner’s Association.</td>
</tr>
<tr>
<td>East Shore Neighborhood (Alameda Island)</td>
<td>• Neighborhood experiences flooding at MHHW+36”. • Low points on existing seawall have potential for shoreline overtopping.</td>
<td>• Public Works has conducted a preliminary assessment to identify low points on the seawall. • Initial recommendations for coastal protection structures on City-owned property.</td>
</tr>
<tr>
<td>Alameda Point (Alameda Island)</td>
<td>• Very flat land built on infill. • Exposed to inundation at MHHW+36” and emergency access blocked at MHHW+66”.</td>
<td>• Alameda Point Master Infrastructure Plan (2014) outlines flood management strategies based on sea level rise inundation mapping.</td>
</tr>
</tbody>
</table>
Figure 5-6. Preliminary Planning for Doolittle Drive Adaptation. From Oakland/Alameda Resilience Study.
6.0 Status of GHG Emissions and Reductions: Synthesis

As shown in Table 2-1, the City has developed numerous plans with different GHG emissions and reduction components in the last 10 years. This chapter reviews the objectives, approaches, key results, and implementation status, as applicable, for each plan document. Next steps focus on how each study’s results inform the further GHG emissions and mitigation analysis that ERG will conduct for the CAP update and emphasize the importance of input from stakeholders and City community groups in this process.

6.1 2008 Climate Action Plan

The objective of the 2008 CAP was to acknowledge the importance and potential impact of global warming and build upon the City’s position as having the lowest per capita GHG emission rate in Alameda County. The 2008 CAP recommended a target of reducing the City’s GHG emissions to 25 percent below 2005 levels by 2020. The City Council and Mayor Beverly Johnson subsequently adopted this target (CoA, 2008a).

In July 2006, the City Council adopted a resolution to join the International Council for Local Environmental Initiatives’ (ICLEI’s) Alameda County Cities for Climate Protection Campaign in partnership with the Alameda County Waste Management Authority and Recycling Board and the Conference of Mayors. By participating in ICLEI’s Climate Protection Campaign, the City pledged to take a leadership role in promoting public awareness about climate change causes and impacts by accomplishing five milestones that will reduce GHG and air pollution emissions throughout the community:

1. Inventory emissions
2. Set target/goal
3. Establish local action plan
4. Implement local action plan
5. Monitor/evaluate progress

To oversee and help guide CAP development and meet milestones, the City Council appointed a Climate Protection Task Force consisting of one member each from the Planning Board, Economic Development Commission, Transportation Commission, and Public Utilities Board (PUB), as well as a representative from Alameda County Industries and four public members at large. As a result of the Task Force’s considerable work, the City made significant progress on the first three milestones, including CAP development, which completes milestone 3 (CoA, 2008a).

The 2008 CAP identified several initiatives to undertake and reduce GHG emissions in the major categories of transportation and land use, energy, and waste and recycling. These sectors correspond to the City’s GHG inventory as the primary contributors to Alameda’s GHG emissions. Additionally, the CAP included a community outreach and education category of initiatives. The Climate Protection Task Force identified five of these initiatives as “the most critical of those listed in the Plan, and of the most immediate priority”:

It is absolutely critical that the City Council, its staff, local businesses, industries, institutions and the citizens of Alameda actively dedicate themselves to participating in and supporting these endeavors.

Alameda Climate Protection Task Force, 2008 CAP
• Adopt “Zero Waste Strategy” programs and ordinances.
• Develop a multifaceted community outreach program to increase public awareness and participation in GHG reductions.
• Amend the Alameda Municipal Code to include sustainable design and green building standards for all new, substantially expanded, and remodeled buildings.
• Encourage the Alameda PUB to require that AMP (formerly Alameda Power & Telecom) maintain and expand its source mix to 100 percent carbon-free energy.
• Develop and fund alternative transportation strategies in the City’s budget.

6.1.1 Transportation and Land Use Initiatives

According to the 2005 GHG inventory on which the 2008 CAP was based, transportation was (and continues to be) the greatest contributor to GHG emissions in Alameda. The CAP’s transportation and land use initiatives were designed to:

• Reduce the number of automobile trips by implementing initiatives that encourage Alameda residents, employees, and visitors to use alternative modes of transportation such as public transit, cycling, and walking.
• Promote land development that makes transit, bicycling, and walking more attractive alternatives.
• Encourage the use of cleaner-running vehicles and alternative fuel vehicles (CoA, 2008a).

The initiatives included in the CAP’s transportation and land use category are described below.

**Initiative 1**: Require that all new major developments’ short- and long-term transportation emission impacts are reduced by 10 percent. This initiative suggested the following types of measures:

• Alameda Point transit-oriented development.
• Transportation demand management.
• City of Alameda bike plan.
• Revised parking standards.
• Revised street design standards and re-engineering of existing streets to promote pedestrian and bicycle use, as well as alternative modes of transportation.

Based on certain assumptions outlined in Appendix C of the CAP, the estimated cumulative GHG reduction associated with this measure was 1,040 MTCO$_2$e.

**Initiative 2**: Provide transit and shuttles with signal priority lanes and queue jumpers to make transit a more attractive alternative to automobiles. The estimated GHG reduction from this initiative was 167 MTCO$_2$e.

**Initiative 3**: Develop and fund alternative transportation strategies in the City’s budget. This initiative suggested the following measures:

• Create an alternative transportation funding priority list for the City’s CIP, including project costs and funding.
• Implement a new transportation mitigation fee to fund alternative transportation priorities.
- Charge staff to engage actively with federal, state, and regional organizations to secure capital and operational funding for sustainable transportation.

The GHG reduction potential of this initiative was estimated to be negligible.

**Initiative 4**: Continue to convert the City’s fleet to alternative fuel vehicles, such as biodiesel, electric, and other alternative fuels. The GHG reduction potential of this initiative was estimated to be 5,654 MTCO$_2$e.

**Initiative 5**: Encourage Alameda employers to provide opportunities for “flex hours” (compressed workweek and telecommuting schedules to reduce VMT) and reintroduce transportation reduction programs. The GHG reduction potential of this initiative was estimated to be 966 MTCO$_2$e.

**Initiative 6**: Expand the geographic area of the work/live ordinance to provide greater opportunities for reduced work-related commutes. The GHG reduction potential of this initiative was estimated to be negligible.

**Initiative 7**: Encourage alternative fuel “car share” programs. The GHG reduction potential of this initiative was estimated to be 29 MTCO$_2$e.

**Initiative 8**: Develop park-and-ride lots and expand ridesharing opportunities in large-scale developments at major transportation access nodes. The GHG reduction potential of this initiative was estimated to be 281 MTCO$_2$e.

### 6.1.2 Energy Initiatives

Energy was the second largest contributor to Alameda’s GHG emissions inventory in 2005, accounting for 47 percent of emissions. Natural gas usage comprised 74 percent of that amount, and electricity comprised 26 percent. The CAP addressed these emission sources based on three major objectives:

1. Encourage the increased use of renewable energy resources.
2. Reduce energy consumption from existing residential commercial, industrial, and institutional buildings and uses.
3. Ensure that all new residential, commercial, industrial, and institutional buildings are designed and constructed to minimize energy consumption and GHG emissions (CoA, 2008a).

The CAP recommended six energy-related initiatives to meet these objectives, which are described below.

**Initiative 1**: Encourage the Alameda PUB to require that AMP (formerly Alameda Power & Telecom) maintain and expand its source mix to 100 percent carbon-free energy. The GHG reduction potential of this initiative was estimated to be 14,559 MTCO$_2$e.

**Initiative 2**: Require that all recommended City Council actions analyze or evaluate whether the action supports or is consistent with Alameda’s local action plan initiatives and furthers progress toward the GHG reduction target. The GHG reduction potential of this initiative was estimated to be negligible.

**Initiative 3**: Provide technical assistance for energy efficiency and track progress through recognition programs. If feasible, develop financial incentives to educate and encourage Alameda residents and businesses to be energy-efficient. The GHG reduction potential of this initiative was estimated to be 4,739 MTCO$_2$e.
Initiative 4: Amend the Alameda Municipal Code to include sustainable design and green building standards for all new, substantially expanded, and remodeled buildings. The GHG reduction potential of this initiative was deemed “not quantifiable.”

Initiative 5: Develop a program to reduce the use of two-cycle combustion engines, including the enforcement of existing ordinances. Encourage the establishment of trade-in programs. The GHG reduction potential of this initiative was estimated to be negligible.

Initiative 6: Develop a wood-burning prohibition ordinance to reduce air pollution for new residential construction. The GHG reduction potential of this initiative was estimated to be negligible.

6.1.3 Waste and Recycling Initiatives

While waste comprised a smaller source of GHG emissions than transportation and energy, the 2008 CAP estimated that every person in Alameda generated over 1,600 pounds of waste in 2005. As it decomposes in landfills, this waste generates methane, a potent GHG. The CAP established two major initiatives to reduce waste-related GHG emissions by maximizing recycling, reuse, and composting. They are described below.

Initiative 1: Adopt “Zero Waste Strategy” programs and ordinances. Subsequent to the 2008 CAP, this initiative developed into Alameda’s Zero Waste Implementation Plan in 2010 (discussed further below). The 2008 CAP suggested the following programs and requirements as part of this initiative:

- Ban polystyrene foam (i.e., Styrofoam) to-go containers, enacted in January 2008.
- Develop a stronger environmental purchasing policy.
- Develop a stronger construction and demolition ordinance.
- Work with the Alameda Unified School District (AUSD) to fully implement recycling, reuse, and composting at schools. AUSD implemented these practices in 2009.
- Work with the State Department of Conservation to develop more centrally located California Redemption Value recycling drop-off areas for bottles and glass. A new center opened in February 2008.

The GHG reduction potential of this initiative was estimated to be 44,114 MTCO$_2$e from a 30 percent reduction in waste sent to landfills, or 73,526 MTCO$_2$e from a 50 percent reduction in waste sent to landfills.

Initiative 2: Encourage the development of the biodiesel industry in Alameda, including local collection of used animal fats and vegetable oils for rendering into biodiesel. In addition, the City should develop policies that encourage the creation of biodiesel and compressed natural gas facilities in Alameda by revising the municipal code. The GHG reduction potential of this initiative was estimated to be 69 MTCO$_2$e.

6.1.4 Outreach and Education Initiatives

Although not directly related to GHG emissions, the 2008 CAP acknowledged that achieving the planned GHG reduction targets would require active cooperation from all Alameda residents and businesses. To that end, the CAP included the initiative described below to increase awareness and participation in the plan’s other initiatives.
**Initiative 1:** Develop a multifaceted community outreach program to increase public awareness and participation in GHG reductions. Such a program could include:

- A citywide education forum
- Public information
- A brochure or press kit
- A review of all environmental programs and materials
- An “adopt a tree” program
- City energy and recycling audit advertisements
- An emission offset program and junk mail reduction partnership

The GHG reduction potential of this initiative was estimated to be negligible.

### 6.2 2015 GHG Emissions Inventory

Based on the 2008 CAP, the Alameda City Council adopted a resolution to set the citywide GHG reduction target at 25 percent below the 2005 level by 2020. Alameda’s 2015 GHG emissions inventory updated the City’s earlier 2010 GHG emissions inventory (CoA, 2013). The inventory used ICLEI’s *U.S. Community Protocol for Accounting and Reporting of GHG Emissions* to estimate emissions, including “downstream” or “post-consumer” emissions from direct activities located within city limits. The inventory did not calculate or estimate upstream emissions but noted that the City may consider including upstream emissions in future inventory updates as methodologies and data improve (CoA, 2017a).

**Figure 6-1. 2015 GHG Emissions by Sector (CoA, 2017a)**

Overall, the City’s GHG emissions increased from 359,776 MTCO₂e in 2010 to 409,039 MTCO₂e in 2015 (an 11 percent increase from the 2005 baseline inventory). Figure 6-1 and Figure 6-2 show the breakdown of GHG emissions by sector.
The 2015 GHG emissions inventory also projected emissions in 2020 and 2030 under a “business as usual” (BAU) scenario (assumes no new City actions) and estimated GHG emission reductions of five planned City actions. Table 6-1 describes those actions and their estimated emissions reduction.

Table 6-1. Planned City GHG Reduction Actions and Estimated GHG Emissions Reduction (CoA, 2017a)

<table>
<thead>
<tr>
<th>City GHG Reduction Action</th>
<th>Estimated GHG Emissions Reduction (MTCO₂e)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2020</td>
</tr>
<tr>
<td>Provide carbon-neutral electricity to all residential and commercial end-users in Alameda.</td>
<td>116,075</td>
</tr>
<tr>
<td>Achieve 90% electrification of commercial building stock and 50% electrification of residential building stock by 2030.</td>
<td>-</td>
</tr>
<tr>
<td>Achieve 14% increase in non-drive-alone trips by 2030 through the success of the TCP (assume even ramp-up of programs through 2030).</td>
<td>3,500</td>
</tr>
<tr>
<td>Achieve 95% diversion of all divertible waste materials by 2030 (assume linear success rate until 2030).</td>
<td>154</td>
</tr>
<tr>
<td>Plant 2,000 trees by 2030.</td>
<td>-</td>
</tr>
<tr>
<td><strong>Total emissions reduction from City actions</strong></td>
<td><strong>119,729</strong></td>
</tr>
</tbody>
</table>
Despite these significant emissions reduction estimates, the 2015 GHG inventory predicted the City would miss its 2020 GHG emissions reduction target by 31,300 MTCO₂e based on the BAU scenario of GHG emissions in 2020 (see Figure 4-1) (CoA, 2017a). It is notable, however, that on a per capita basis, the City has a lower GHG emission rate (3.82 MTCO₂e predicted for 2020) compared to the state target (6.0 MTCO₂e by 2030).

6.3 Transportation-Related Plans

For the transportation sector, the City has developed three main plans that address GHG emission reductions in some way, including (in chronological order):

- *City of Alameda Pedestrian Plan (component of the City’s Transportation Master Plan)* (CoA, 2009a)
- *City of Alameda 1990 Bicycle Master Plan* (updated November 2010) (CoA, 2010a)
- City of Alameda TCP (CoA, 2018a)

6.3.1 Pedestrian Plan

The 2009 Pedestrian Plan provides guidance to City staff, residents, developers, and decision-makers on how to improve pedestrian access in the City. The plan’s vision is to plan, construct, and adequately maintain a functional, comfortable, and convenient pedestrian network throughout Alameda that addresses pedestrians’ mobility needs while enhancing community identity and livability (CoA, 2009a). By enabling more safe pedestrian travel, the plan indirectly promotes less automobile traffic, lower VMT, and lower GHG emissions from the cars that are displaced by foot travel. The Pedestrian Plan is divided into three priority levels for extensive public outreach efforts and group projects:

- High-priority projects that are expected to receive funding in three to five years and total roughly $5.2 million. High-priority projects include eight education programs (e.g., education/enforcement), island access (estuary crossing), formation of pedestrian districts, 25 public walkways, Safe Routes to Schools, sidewalk installation and maintenance, street crossings (three main projects), and building trails.
- Medium-priority projects that are expected to be funded in as early as five years through nontraditional funding sources and total roughly $75.1 million. Medium-priority projects include island access (estuary crossing), Miller-Sweeney Bridge improvements, formation of pedestrian districts, sidewalk installations/maintenance, street crossings, and trails.
- Low-priority projects that are considered to be beyond the scope of the plan and lack sufficient funds for implementation during the plan’s horizon (10 years).

6.3.2 Bicycle Master Plan

The 2010 update to the Bicycle Master Plan was developed to provide opportunities for a comfortable experience to a broad cross-section of Alameda residents, employees, and visitors. The updated plan accounted for recent changes in the City, built upon work accomplished over the past 11 years, supported City-adopted policies related to transportation and climate planning, and recommended projects that could be achieved within the next 10 years via funding from a variety of sources (CoA, 2010a).
The Bicycle Master Plan also groups projects into three priority levels based on the following criteria: 1) potential to increase circulation, 2) contribution to livability (e.g., creating a livable human and natural environment), 3) contribution to encouraging transportation modes other than single-occupant automobiles, and 4) facilitating implementation of a planned transportation system in a coordinated and cost-effective manner. The plan assigned points to each potential project based on these criteria and determined their ability to be financed within given timeframes. The bicycle plan projects are as follows:

- **High-priority projects:**
  - 17 studies and capital projects that can be funded and initiated within 10 years (e.g., West End estuary crossing study, Encinal Avenue bike lane).
  - Three maintenance and minor capital projects (e.g., trail maintenance, bicycle parking enhancement).
  - Seven programs (e.g., promotion of bicycling-related events and services, Safe Routes to Schools mapping).

- **Medium-priority projects** (to be pursued within 10 years if funding is available): eight projects (e.g., Neptune Park bike path, Mecartney Road bike lane).

The plan also identified 9 projects not under City jurisdiction and 14 projects for potential development or redevelopment (e.g., Shoreline Drive bike path enhancements, Cross Alameda Trail/Bay Trail).

### 6.3.3 The Transportation Choices Plan

The 2018 TCP was developed to guide future transportation decisions in the City and provide a framework for implementing future transit and travel demand projects and programs with these goals:

- Provide effective travel choices and reduce single-occupant vehicle trips.
- Quantify existing and future expected travel characteristics of cross-estuary trips and trips within Alameda.
- Identify projects and programs to move the City toward achieving its transportation goals.

Some of the secondary effects of TCP project/program implementation include:

- Increase the number of people who bicycle, walk, carpool, and take the bus or ferry.
- Reduce the total number of vehicles on the roadways.
- Reduce parking demand.
- Improve safety and accessibility.
- Reduce environmental impacts from transportation.

These goals and effects include reduced GHG emissions, which is the most significant anticipated outcome of TCP project and program implementation as related to the CAP update.

The specific projects identified by the plan are listed in
Table 6-2. The high-priority projects from the pedestrian and bicycle plans described above are included within the high-priority projects and programs in the TCP.
Table 6-2 also provides the status of each project based on the latest quarterly status report from City of Alameda Public Works Department (ATC, 2018) and conversations with Public Works staff (CoA, 2018c).
## Table 6.2. Summary of Projects Identified in the 2018 Transportation Choices Plan

<table>
<thead>
<tr>
<th>Project No.: Title</th>
<th>Status</th>
<th>GHG Reduction Potential (MT=MTCO\textsubscript{2}e)</th>
<th>Estimated Cost</th>
<th>Co-Benefits and Implementation Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>HIGH-PRIORITY PROJECTS AND PROGRAMS (Completion Estimated 1–3 Years)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1: Alameda Shuttle Expansion</td>
<td>Consultant hired; meeting in summer 2018 to refine priorities, concepts, routes, and implementation.</td>
<td>Not identified</td>
<td>$10K for consultant plus full construction/implementation cost TBD.</td>
<td>Safety improvement; good community support.</td>
</tr>
<tr>
<td>3: Bus Stop Improvements</td>
<td>10 benches purchased; City staff to meet with AC Transit and others for approvals, then install.</td>
<td>Up to 44 MT/yr</td>
<td>$300K–$1M capital, depending on extent of improvements.</td>
<td>Safety improvement; some drive-alone trip reduction.</td>
</tr>
<tr>
<td>4: EasyPass Expansion</td>
<td>Paid for by Measure B/BB; City staff working with AC Transit, schools, and Alameda Housing Authority to expand program.</td>
<td>&gt; 88 MT/yr</td>
<td>$70/annually per rider (5,000 served) = $350K plus $25K in program administration during life of program.</td>
<td>Safety improvement; good community support; significant drive-alone trip reductions.</td>
</tr>
<tr>
<td>5: Harbor Bay Ferry Terminal Access and Parking Management Improvements</td>
<td>Implementation began August 2017; City, HOAs, and WETA monitoring parking changes and reliability of AC Transit Line 21.</td>
<td>Up to 44 MT/yr</td>
<td>Cost of short-term bus improvements in TCP project 24; other costs TBD.</td>
<td>Community support; some drive-alone trip reductions.</td>
</tr>
<tr>
<td>6: Main Street Ferry Terminal Access and Parking Management Improvements</td>
<td>Ongoing; City, WETA, and AC Transit working on short- and long-term solutions for ferry access to the web end; Seaplane Lagoon ferry terminal service still planned to begin early 2020.</td>
<td>Up to 44 MT/yr</td>
<td>Costs for accessing the Main St. ferry terminal are included in TCP projects 22, 28, 30; parking management improvement costs TBD.</td>
<td>Community support; some drive-alone trip reductions; equity improvement.</td>
</tr>
<tr>
<td>7: Parking Management</td>
<td>Council approved 85% occupancy goal; City implementing signage to better guide on-street parkers; evaluating progress and executing improvements under FY17–19 capital budget.</td>
<td>44–88 MT/yr</td>
<td>TBD</td>
<td>Moderate drive-alone trip reductions.</td>
</tr>
<tr>
<td>Project No.: Title</td>
<td>Status</td>
<td>GHG Reduction Potential (MT=MTCO$_2$e)</td>
<td>Estimated Cost</td>
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<td><strong>HIGH-PRIORITY PROJECTS AND PROGRAMS (Completion Estimated 1–3 Years)</strong></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10: Transit Signal Priority</td>
<td>Construction began mid-2018.</td>
<td>&gt; 88 MT/yr</td>
<td>$500K capital costs.</td>
<td>Significant drive-alone trip reduction; equity improvement; community support.</td>
</tr>
<tr>
<td>11: Transportation Awareness Campaign</td>
<td>Consultant to be selected late-2018; staff to receive training fall-2018; bicycle safety events to start in August 2018.</td>
<td>Up to 44 MT/yr</td>
<td>$50K–$100K annually for campaigns.</td>
<td>Community support; some drive-alone trip reductions; safety improvement.</td>
</tr>
<tr>
<td>12: Transportation Partnerships and Existing Businesses and Residences</td>
<td>Launched Alameda TMA; sponsored free bus passes to employees; working on other shared initiatives.</td>
<td>&gt; 88 MT/yr</td>
<td>Up to $400K for project administration and planning (combined with TCP project 29).</td>
<td>Significant drive-alone trip reduction; community support.</td>
</tr>
<tr>
<td><strong>HIGH-PRIORITY PROJECTS AND PROGRAMS (Completion Estimated 3–8 Years)</strong></td>
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<td></td>
<td></td>
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</tr>
<tr>
<td>19: Alameda Point Bus Rapid Transit Service</td>
<td>Bus lane funded in Alameda’s CTC 2018 CIP; next steps are to hire consultant for planning, outreach, environmental review, permits, and design.</td>
<td>&gt; 88 MT/yr</td>
<td>$9M capital plus $2.1M annual O&amp;M.</td>
<td>Significant drive-alone trip reduction; community support; equity improvement.</td>
</tr>
<tr>
<td>20: Bicycle and Pedestrian Corridor Improvements</td>
<td>Many projects in other plans; Miller-Sweeney Bridge Replacement; City/County meeting to understand how to proceed with funding opportunities.</td>
<td>44–88 MT/yr</td>
<td>Individual project costs ranging from $1M to $20M each; see TCP pg. 89 for full list.</td>
<td>Moderate drive-alone reduction; community support; equity and safety improvement.</td>
</tr>
<tr>
<td>21: Citywide Safe Routes to School audits and Improvements</td>
<td>Expansion of program (four schools already audited).</td>
<td>44–88 MT/yr</td>
<td>$500K–$1M for program expansion and school audits; capital improvements TBD.</td>
<td>Moderate drive-alone reduction; community support; safety improvement; equity improvement depending on location of project.</td>
</tr>
</tbody>
</table>
## HIGH-PRIORITY PROJECTS AND PROGRAMS (Completion Estimated 3–8 Years)

<table>
<thead>
<tr>
<th>Project No.: Title</th>
<th>Status</th>
<th>GHG Reduction Potential (MT=MTCO2e)</th>
<th>Estimated Cost</th>
<th>Co-Benefits and Implementation Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>22: Crosstown Express Bus Service</td>
<td>New</td>
<td>44–88 MT/yr</td>
<td>$3M capital plus $4.2M annual operating costs.</td>
<td>Moderate drive-alone reduction; community support; safety improvement.</td>
</tr>
<tr>
<td>23: Increase Frequency and Span of Service for Ferry Service</td>
<td>Possible bolster with passage of Measure 3, although appeal underway.</td>
<td>44–88 MT/yr</td>
<td>$3M annual O&amp;M; $34M vessel procurement; $18M Main St. terminal operations.</td>
<td>Moderate drive-alone reduction; community support; equity improvement.</td>
</tr>
<tr>
<td>24: Increase Frequency and Span of Service for Local Bus Routes</td>
<td>New</td>
<td>&gt; 88 MT/yr</td>
<td>$9M capital plus $3.5M O&amp;M for five lines.</td>
<td>Significant drive-alone trip reduction; community support; equity improvement.</td>
</tr>
<tr>
<td>25: Increase Frequency and Span of Service for Transbay Bus Service</td>
<td>New</td>
<td>44–88 MT/yr</td>
<td>$260K/yr for addition Line OX span plus $2M/year for Line W.</td>
<td>Moderate drive-alone reduction; community support; equity improvement.</td>
</tr>
<tr>
<td>26: Miller-Sweeney Multimodal Lifeline Bridge</td>
<td>City and County staff meeting to better understand how to proceed with potential funding opportunities.</td>
<td>&gt; 88 MT/yr</td>
<td>$3M study report plus $90M bridge construction.</td>
<td>Significant drive-alone trip reduction; community support; safety improvement.</td>
</tr>
<tr>
<td>27: New Seaplane Lagoon Ferry Terminal &amp; Service</td>
<td>Part of other plans; funding identified; permit request to BCDC made; updating ferry terminal plan; additional funding from WETA requested; completion planned first quarter of 2020.</td>
<td>&gt; 88 MT/yr</td>
<td>$4M operating plus $18.2M capital.</td>
<td>Significant drive-alone trip reduction; community support; equity improvement.</td>
</tr>
<tr>
<td>28: Regional Transit Hub Connector Bus Service</td>
<td>New</td>
<td>44–88 MT/yr</td>
<td>$3.7M operating plus $3M capital (four buses).</td>
<td>Moderate drive-alone reduction; community support; equity improvement.</td>
</tr>
<tr>
<td>Project No.: Title</td>
<td>Status</td>
<td>GHG Reduction Potential (MT=MTCO(_2)e)</td>
<td>Estimated Cost</td>
<td>Co-Benefits and Implementation Factors</td>
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<tr>
<td>HIGH-PRIORITY PROJECTS AND PROGRAMS (Completion Estimated 3–8 Years)</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>29: TDM Ordinance Update</td>
<td>New</td>
<td>&gt; 88 MT/yr</td>
<td>Up to $400K for project administration and planning (combined with TCP project 12).</td>
<td>Significant drive-alone trip reduction.</td>
</tr>
<tr>
<td>30: Vision Zero Safety Improvements and Traffic Calming</td>
<td>Part of other plans: Central Ave. (workshopping potential alternatives); Clement Ave. (Caltrans to field review; City hiring consultant for outreach, environmental review, design); Otis Dr. (City hiring consultant for design, outreach; completion Fall 2019).</td>
<td>Up to 44 MT/yr</td>
<td>Grants and government matching are funding projects.</td>
<td>Some drive-alone trip reduction; equity improvement; safety improvement; community support.</td>
</tr>
<tr>
<td>MEDIUM-PRIORITY PROJECTS AND PROGRAMS (Completion Estimated 1–3 Years)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13: Bike Share</td>
<td>Selecting new 2-year provider; City will monitor.</td>
<td>Up to 44 MT/yr</td>
<td>$460K–$720K initial capital cost for 120 bikes; $225K–$350K for annual operating costs.</td>
<td>Some drive-alone trip reduction; equity improvement.</td>
</tr>
<tr>
<td>14: Casual Carpool Additional Pickup Locations</td>
<td>New</td>
<td>Up to 44 MT/yr</td>
<td>$50K for planning and signage.</td>
<td>Some drive-alone trip reduction; community support.</td>
</tr>
<tr>
<td>15: Constitution Way Carpool Lane</td>
<td>New</td>
<td>Up to 44 MT/yr</td>
<td>$570K for signal improvements, plus periodic enforcement by Alameda Police Department.</td>
<td>Some drive-alone trip reduction; community support.</td>
</tr>
<tr>
<td>16: Estuary Water Shuttle Crossing and WETA Ferries to Oakland</td>
<td>Staff working with WETA to develop the water shuttle landing locations, operator options, and funding.</td>
<td>Up to 44 MT/yr</td>
<td>$200K for feasibility study plus up to $2M annually (TBD).</td>
<td>Some drive-alone trip reduction; community support; safety improvement.</td>
</tr>
<tr>
<td>17: Westline Drive Bus Lane</td>
<td>New</td>
<td>Up to 44 MT/yr</td>
<td>$340K for design, engineering, and construction.</td>
<td>Some drive-alone trip reduction; community support.</td>
</tr>
<tr>
<td>18: Shared Ride Service for Seniors and People with Disabilities</td>
<td>New</td>
<td>Up to 44 MT/yr</td>
<td>Minimal planning costs plus $50K–$150K per year for taxi subsidies.</td>
<td>Some drive-alone trip reduction; community support; safety improvement.</td>
</tr>
</tbody>
</table>
### MEDIUM-PRIORITY PROJECTS AND PROGRAMS (Completion Estimated 3–8 Years)

<table>
<thead>
<tr>
<th>Project No.: Title</th>
<th>Status</th>
<th>GHG Reduction Potential (MT=MTCO$_{2e}$)</th>
<th>Estimated Cost</th>
<th>Co-Benefits and Implementation Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>31: Bikes and Buses through Webster/Posey Tubes</td>
<td>New</td>
<td>Up to 44 MT/yr</td>
<td>Up to $100K for coordination and bus retrofit.</td>
<td>Some drive-alone trip reduction; community support; equity and safety improvement.</td>
</tr>
<tr>
<td>32: Citywide Transportation Management Association</td>
<td>Ongoing</td>
<td>Included in TDM projects</td>
<td>$150K administration costs for startup.</td>
<td>Unknown</td>
</tr>
<tr>
<td>33: Faster Line 51A Bus Service</td>
<td>New</td>
<td>Up to 44 MT/yr</td>
<td>Up to $650K annual O&amp;M.</td>
<td>Some drive-alone trip reduction; community support; equity improvement.</td>
</tr>
<tr>
<td>34: New Technologies and Innovations</td>
<td>Launching  car share pilot with Gig Car Share; monitoring progress.</td>
<td>Unknown</td>
<td>TBD</td>
<td>Unknown</td>
</tr>
</tbody>
</table>

### LONG-TERM PROJECTS AND PROGRAMS (Completion Estimated 8+ Years)

<table>
<thead>
<tr>
<th>Project No.: Title</th>
<th>Status</th>
<th>Co-Benefits and Implementation Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>35: BART to Alameda</td>
<td>No activity.</td>
<td>Not determined.</td>
</tr>
<tr>
<td>36: Comprehensive Congestion Management</td>
<td>No activity.</td>
<td></td>
</tr>
<tr>
<td>37: New Transit/Bike/Pedestrian Lifeline Tube</td>
<td>Staff meeting with possible funders; developing milestone schedule for funding and implementation.</td>
<td></td>
</tr>
<tr>
<td>38: Webster/Posey Multimodal Lifeline Tubes</td>
<td>No activity.</td>
<td></td>
</tr>
</tbody>
</table>

**Long-term Projects and Programs (Completion Estimated 8+ Years)**

<table>
<thead>
<tr>
<th>Project No.: Title</th>
<th>Status</th>
<th>Co-Benefits and Implementation Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>39: West End Bicycle/Pedestrian Crossing</td>
<td>Staff meeting with possible funders; developing milestone schedule for funding and implementation.</td>
<td>Not determined.</td>
</tr>
</tbody>
</table>

BART = Bay Area Rapid Transit; CTC = Alameda County Transportation Commission; HOAs = Home Owners Associations; O&M = operations and maintenance; TBD = to be determined; TDM = transportation demand management; TMA = Transportation Management Association; WETA = Water Emergency Transportation Authority
6.4 Alameda Municipal Power Energy Efficiency Efforts

California Assembly Bill 2021 (AB 2021) requires all publicly owned utilities in California to develop 10-year estimates of energy efficiency savings, including annual targets for all potentially achievable cost-effective energy efficiency savings. These targets must be updated every four years. AMP most recently completed these estimates in 2017 with projections for 2018–2027 (AMP, 2017).

Senate Bill 1037 (SB 1037) requires yearly reporting of all energy efficiency activity and compares actual data with the target developed under the AB 2021 process. AMP’s energy efficiency program goals are to:

1. Meet board-approved annual energy efficiency targets, as approved on March 20, 2017, and comply with AB 2021.
2. Acquire all available energy efficiency and demand-reduction resources that are cost effective, reliable, and feasible.
3. Enhance customer satisfaction.
4. Comply with all state policies.
5. Provide equal opportunity for all customers to participate (AMP, 2018).

According to AMP’s FY 2017 report, customers had various opportunities to participate in energy efficiency programs. These energy efficiency programs are listed below, along with their estimated energy savings and cost:

- **Energy Plus Program**: A non-residential direct-install lighting, refrigeration, heating, ventilation, and air conditioning program that will remain open until December 2019.
  - Estimated energy savings: 1,383,182 kilowatt-hours (kWh)
  - Estimated cost: $745,660
- **My Energy**: Provided residential customers with regular mail and email distributions of energy efficiency tips and behavior changes. Concluded in December 2016.
  - Estimated energy savings: 676,666 kWh
  - Estimated cost: $116,164
- **Non-Residential Lighting (Custom) Program**: Similar to the Energy Plus program, offers non-residential customers rebates for lighting upgrades.
  - Estimated energy savings: 156,777 kWh
  - Estimated cost: $43,069
- **Residential Online Rebates**: Rebates available for light-emitting diode (LED) bulbs, LED fixtures, LED decorative string lights, electric clothes dryers, washing machines, heat pump water heaters, refrigerators, freezers, and refrigerator/freezer recycling. This program will remain open in FY 2018.
  - Estimated energy savings: 72,626 kWh
  - Estimated cost: $189,351
- **Instant Rebate Program (Upstream Lighting)**: Provided residents the opportunity to purchase pre-rebated LEDs from select Alameda retailers.
  - Estimated energy savings: 4,072 kWh
  - Estimated cost: $9,863
- **LED streetlight retrofit**
  - Estimated energy savings: 1,431 kWh
  - Estimated cost: $179
These energy efficiency programs cost $1,104,284 in FY 2017. AMP reports it saved 2,295 megawatt-hours (MWh) in FY 2017—4 percent above its target of 2,207 MWh. These energy savings represented 0.7 percent of FY 2017 energy sales and equated to a GHG reduction of 753 MTCO₂e in FY 2017. The total estimated GHG reduction from AMP’s energy efficiency programs since 2013 (give years) is 4,349 MTCO₂e (AMP, 2018).

6.5 Zero Waste Implementation Plan

In response to the recommendations and initiatives put forth in the 2008 CAP, the City began efforts to identify the policies, programs, and facilities needed to achieve zero waste. In September 2010, Alameda published the Zero Waste Implementation Plan as the beginning of a long-term systematic effort to:

- Reduce the overall solid waste generated within the City.
- Reduce the quantity of solid waste generated per person within the City.
- Increase the quantity of recyclable and compostable materials diverted from landfills.
- Support state and federal efforts to build the environmental and social costs into the price of products and packaging and require manufacturers to take back products at the end of their useful life (CoA, 2010b).

6.5.1 Policies and Programs Options

As part of developing the plan, the City conducted a series of workshops in spring 2009 to present current policies, programs, and facilities and to gather stakeholder input and recommendations. The plan describes both the recommended policies and programs that could be implemented and the facility and technology options to achieve the City’s goal of zero waste, with an initial goal of 75 percent diversion (the City had already achieved 67 percent diversion as of 2008) (CoA, 2010b). These recommendations include the following:

- Add materials to the blue and green carts.
- Undertake a social media marketing campaign.
- Advocate for produce responsibility at the state level and work with local retailers to increase take-back programs.
- Increase commercial technical assistance.
- Increase construction and demolition (C&D) debris ordinance requirements to increase C&D technical assistance.
- Support product bans.
- Support disposal bans.
- Consider mandatory source-separation requirements.
- Process residual waste at material recovery facilities.

Additionally, the City formed a Green Team consisting of staff from Public Works, Community Development, and AMP to provide input to the zero waste planning and implementation process. Based on the Green Team’s recommendations and with Public Works sponsorship, the City Employee Recycling Program began in July 2008. Public Works staff provide food scrap recycling kits and technical assistance to all City departments to implement recycling and organics programs. As of 2010, the City government was achieving 40 percent diversion across all facilities (CoA, 2010b). Additional opportunities for increasing diversion include:
• Increasing recycling and organics participation and optimizing collecting services at all City facilities.
• Providing recycling and organics containers at key locations throughout City buildings.
• Increasing recycling participation and implementing organics collection at recreation centers and parks.
• Adding a roll-off box for scrap metal and other recyclable bulky items at the Alameda Maintenance Service Center.

As identified in the 2008 CAP, AUSD implemented an organics diversion program through Waste Management, Inc., to match the recycling and organics program that children have at their homes. “By recycling and composting at school, Alameda students learn the importance of reduction and conservation and bring the message back home to their families.” AUSD achieved an average of 41 percent diversion across all schools in 2008 (CoA, 2010b).

In early 2009, AUSD began the Alameda Green Schools Challenge to increase sustainable practices at school sites. In June 2009, AUSD received a three-year, $142,000 grant from the Altamont Education Advisory Board for equipment and outreach materials to implement new recycling and composting programs at all schools and district facilities. As part of the challenge, AUSD implemented an organics diversion pilot at five schools in fall 2009. The overall diversion rate at these schools increased from 30 to 64 percent as a result of the program (CoA, 2010b).

6.5.2 Facility and Technology Options
During the engagement process, stakeholders identified the need for more conveniently located facilities to handle materials that are difficult to recycle through curbside collection. At the time, all the regional solid waste and recycling facilities used by Alameda were located outside of the City limits in Oakland and San Leandro. The plan states that while Alameda will not likely develop large-scale industrial facilities within the City, it can support development of regional-scale facilities in nearby areas through new programs (e.g., recycling, composting) and diversion of new materials (e.g., C&D) (CoA, 2010b).

6.5.3 GHG Reduction Potential and Cost
Stakeholders supported a phased approach to the program, policy, and facility options, in which the City provided increased outreach and technical assistance before implementing mandatory requirements. Table 6-3 shows the plan’s estimates of the potential GHG reduction and cost associated with each phase of this approach.

<table>
<thead>
<tr>
<th>Implementation Phase</th>
<th>Total GHG Reduction Potential (MTCO₂e)</th>
<th>Estimated Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increase voluntary programs</td>
<td>24,120</td>
<td>$255,000</td>
</tr>
<tr>
<td>Implement mandatory requirements</td>
<td>38,374</td>
<td>$0</td>
</tr>
<tr>
<td>Add residual waste processing</td>
<td>44,424</td>
<td>$1,000,000</td>
</tr>
</tbody>
</table>

The plan presents a 10-year implementation timeframe to achieve these reductions, resulting in an overall diversion rate of 89 percent (CoA, 2010b).
6.6 Recommended Next Steps

Using the contents of the documents described in this chapter and related conversations with City staff and stakeholders, ERG will investigate and possibly update the 2030 and 2050 projections of the City’s GHG reduction impacts. In addition, ERG will conduct a gap analysis to determine the potential shortfall in GHG reductions as compared to the preliminary GHG reduction targets for 2030. ERG will also collect input from City staff and stakeholders on additional GHG reduction measures that may be considered for addition to the CAP update. For example, Figure 6-3 shows all the potential GHG reduction measures identified today (i.e., taken from the ERG contract’s scope of work, discussions with City staff, and meetings with the Task Force and other stakeholders).

ERG will vet this list with the City and stakeholders, then propose a list of the highest-priority measures for their consideration. Priority will be based on criteria such as GHG emissions reduction potential, estimated range of potential implementation costs, and other factors to be determined. Upon receiving additional City and stakeholder input, ERG will analyze in detail the selected mitigation measures, potential costs, and GHG emissions reduction impact of implementing them as part of the CAP update.
<table>
<thead>
<tr>
<th>Transportation</th>
<th>ENERGY</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Transportation</strong></td>
<td><strong>Electricity</strong></td>
</tr>
<tr>
<td>Track progress using Task 1 performance metrics for implementation of the TCP and associated plans, and 2008 CAP related to transportation</td>
<td>Track progress using Task 1 performance metrics for implementation of 2008 CAP related to renewable energy</td>
</tr>
<tr>
<td>Promote low-and zero-emission vehicles including EVs; standardize EV charging stations in new developments</td>
<td>Maintain compliance with state renewable power requirements</td>
</tr>
<tr>
<td>Relationship between large support of free/low-cost parking, VMT, and GHG emissions</td>
<td>Encourage PUB to continue promoting and providing innovative energy efficiency opportunities and incentives to residential and non-residential customers</td>
</tr>
<tr>
<td>Longer-term, vision, transportation projects such as congestion pricing (IMPT), new/replacement multi-modal crossing, citywide EasyPass program</td>
<td>Encourage PUB to explore opportunities for promoting and incentivizing electrification and fuel switching</td>
</tr>
<tr>
<td>Complete electrification of City's vehicle fleet</td>
<td>Encourage PUB to develop interconnection policies for battery storage systems</td>
</tr>
<tr>
<td>Plan for renewable, geothermal electricity powered hydrogen fuel station in Alameda</td>
<td>Electrification of buildings for new development</td>
</tr>
<tr>
<td>Reducing VMT through land use decisions: parking meter pricing, new development parking requirements, maximum parking requirements for residential and retail, no parking requirements for retail on Park, Webster, and stations</td>
<td>Land Use</td>
</tr>
<tr>
<td>Healthy Natural Environments</td>
<td>Track progress using the Task 1 metrics for implementation of strategies regarding land use in the 2008 CAP</td>
</tr>
<tr>
<td>Consider restrictions on woodsmoke</td>
<td>Evaluate impact of citywide 21 unit/acre residential density limit on City's ability to reduce GHG emissions</td>
</tr>
<tr>
<td>Increase tree cover to 1 tree per resident</td>
<td>Identify and evaluate land use policies and biological resource management policies that could contribute to GHG reduction or carbon sequestration, resilience and economic development (e.g., biodiesel and use of goat grazers)</td>
</tr>
<tr>
<td>Ban gas powered leaf blowers, lawn mowers and other 2-stroke engine lawn equipment (e.g., Berkeley)</td>
<td></td>
</tr>
</tbody>
</table>

**Figure 6-3. Summary of Potential GHG Reduction Measures**
7.0 GHG Reduction and Adaptation Overlap and Opportunities for Co-Benefits

In California and elsewhere in the country, municipalities are struggling to design and implement adaptation strategies that address uncertain future risks by reducing the severity of their potential impacts. Considering actions to reduce GHG emissions that prevent further climate change impacts together with actions that increase resilience to long-term climate change hazards enables the City of Alameda to identify synergies between these related aspects of climate change planning. This chapter provides the rationale for this holistic planning effort and describes some co-benefits that can result from co-implementation of GHG reduction and adaptation strategies.

7.1 Minimizing the Risk: Defining the Terms of This Two-Pronged Approach

GHG Reduction: Reduces the number and severity of potential future climate impacts compared to a future of un-checked GHG emissions. Decreases the probability of reaching the high end of projections for changes in temperature, precipitation, sea level, and other climate threats (Jones et al., 2007).

Adaptation: Increases resilience to current climate change impacts by reducing the sensitivity of the system, assets, residents, and community. Adaptations can also reduce the exposure of a city and its assets and residents to climate change impacts.

7.2 GHG Emissions and Sea Level Rise

California’s OPC published a report in April 2017 highlighting the process by which GHG emissions result in glacial melting and sea level rise (Griggs et al., 2017). This glacial melting elevates global sea level, putting coastal communities at risk of severe flooding and, ultimately, irreversible damage if the trajectory continues. OPC concluded that aggressive GHG reductions should dramatically reduce the risks associated with sea level rise. However, GHG reductions alone do not eliminate the risk, making it necessary to consider ways to adapt to sea level rise and other associated impacts.

7.3 Combining GHG Emissions Reduction and Adaptation

GHG emissions reduction and climate change adaptation are related measures that address climate change on different temporal scales (Lera St. Clair, n.d.). Reducing GHG emissions can reduce the severity of climate change’s future effects, while adaptation measures are designed based on uncertain projections, which can fluctuate based on GHG emission changes. The City can take a leadership role to proactively combine GHG emissions reduction strategies and climate change adaptation measures into a single, actionable plan by emphasizing the synergies between these actions and identifying complementary implementation pathways and funding opportunities.

7.4 Consistency with State Policy

California is a global leader in establishing policies to reduce GHG emissions and lessen the effects of climate change. In 2015, Governor Brown issued Executive Order B-30-15 requiring the state to achieve 40 percent GHG emissions reduction by 2030 (below 1990 levels), and 80% reduction by 2050. EO B-30-15 also directs state planning and investment to prioritize both GHG reduction and climate change adaptation measures.
levels]. EO B-30-15 acknowledges the importance of GHG reduction while simultaneously shining a light on the critical and necessary role of climate change adaptation. The EO notes that while California intends to do its part to reduce global GHG emissions, climate change has already started to impact the state. EO B-30-15 states, “projections of climate change show that, even under the best-case scenario for global emission reductions, additional climate change impacts are inevitable, and these impacts pose tremendous risks to the state’s people, agriculture, economy, infrastructure, and environment.” It also mandates that, “state agencies’ planning and investment shall be guided by the following principles:

- Priority should be given to actions that both build climate preparedness and reduce greenhouse gas emissions;
- Where possible, flexible and adaptive approaches should be taken to prepare for uncertain climate impacts;
- Actions should protect the state’s most vulnerable populations; and
- Natural infrastructure solutions should be prioritized” (Office of the Governor, 2015).

A joint GHG emissions reduction and adaptation plan will position the City of Alameda as a state leader, aligning its goals with EO B-30-15 to reduce GHG emissions and prepare for and protect against the projected effects of climate change on its citizens.

### 7.5 Intersection Between GHG Reduction and Adaptation Goals and Strategies

Figure 7-1 shows examples of adaptation and GHG reduction strategies and actions that can accomplish goals in both areas. Identifying these co-benefits is critical to maximizing implementation efficiency and reducing overall costs.

![Figure 7-1. GHG Reduction and Adaptation Overlap](image)

In addition, it is important for the City to consider both GHG reduction and adaptation strategies in the same planning effort to avoid identifying counterproductive strategies and actions. Figure 7-2—adapted from ICLEI (2012)—presents a matrix of situations that highlight the synergies and potential conflicts between GHG reduction and adaptation actions. Separating these components into individual plans
increases the risk of introducing conflict between identified strategies or failing to acknowledge a conflict where it is inevitable. A combined plan provides opportunities to maximize synergies and set Alameda on an optimal path toward implementation.

### 7.5.1 Examples of Co-Benefits Between Adaptation and GHG Reduction Strategies

GHG reduction strategies and climate change adaptation measures can result in “co-benefits,” such as the following:

- Green infrastructure, green roofs, and tree plantings reduce GHG emissions (via carbon sequestration), mitigate flooding and heat impacts, and improve water quality.
- Reducing reliance on single-occupancy vehicle trips by promoting other forms of transportation (e.g., bicycles, ferries) reduces GHG emissions and reliance on flood-prone transportation routes (e.g., Webster and Posey Tubes).
- Land use planning that encourages development near transit hubs reduces GHG emissions (via fewer VMT) and could also locate new development away from areas at high risk of sea level rise.
- Nature-based shoreline stabilization methods, such as living shorelines, can reduce coastal flooding impacts while increasing biodiversity, improving water quality, sequestering carbon, and reducing GHG emissions.
8.0 References


Association of Bay Area Governments (ABAG), 2015. Stronger Housing, Safer Communities: Strategies for Seismic & Flood Risks. ABAG Publication #P15002EQK.


California Environmental Protection Agency (CAEPA), 2018. Indicators of Climate Change in California. Prepared by Office of Environmental Health Hazard Assessment.


CoA, 2009a. City of Alameda Pedestrian Plan (component of the City’s Transportation Master Plan). Prepared by the City of Alameda Public Works Department with funding from Alameda County Transportation Improvement Authority (ACTIA). January.


and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. IPCC, Geneva, Switzerland.


Kitahara, M., 2018. Information provided in an email from Miya Kitahara (StopWaste.org) to Patrick Pelegri-O’day (City of Alameda). July 12.


