CITY OF
LONG BEACH

Development Services
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January 5, 2021

R-17

HONORABLE MAYOR AND CITY COUNCIL
City of Long Beach
California

RECOMMENDATION:

Receive a report and confirm the proposed Climate Action and Adaptation Plan, and direct staff to prepare the subsequent Environmental Impact Report. (Citywide)

DISCUSSION

Overview and Background

The Climate Action and Adaptation Plan (CAAP) is a mechanism for the City of Long Beach (City) to establish a set of iterative programs and policies for how the City will achieve two main objectives: (1) meet the statewide greenhouse gas (GHG) target of 40 percent below 1990 levels by 2030 and generally minimize its contribution to global GHG emissions (Action); and, (2) adapt to the impacts of climate change while maintaining quality of life, prosperity, and equity for all of its citizens (Adaptation). The City completed technical studies of climate stressors and communitywide vulnerabilities to inform development of the CAAP. The CAAP establishes a framework for creating or updating its policies, programs, practices, and incentives to reduce the City's GHG footprint while enhancing local economic, environmental, and social benefits. The proposed plan and all its technical appendices can be found in Attachments A and B.

The City has been a leader in sustainability through efforts that have included the adoption of the San Pedro Bay Ports Clean Air Action Plan (2006) and the Sustainable City Action Plan (2010) and incorporation of sustainable policies into the City Mobility Element Update (2013) and General Plan Land Use Element Update (2019). In 2015, Mayor Robert Garcia signed the Compact of Mayors (now the Global Covenant of Mayors) signaling the City's commitment to an array of efforts to reduce its carbon footprint and better prepare for the impacts of climate change. As part of that commitment, in December 2016, the City Council initiated development of the City's first CAAP to meet State GHG reduction targets and provide a roadmap for preparing for climate change impacts, including intensifying heat waves, flooding, worsening air quality, and sea level rise.

Table 1 demonstrates forecasted GHG emissions in 2030 and the amount of GHG reduction that will be required to meet the State's 2030 goal. Business-as-usual forecasts, which project emissions in the absence of specific local action as outlined in the CAAP, estimate 2,176,931 Metric Tons of Carbon Dioxide Equivalent (MT CO_2e) generated in Long Beach in 2030. To meet the statewide target, Long Beach will need to reduce emissions to 1,984,272 MT CO_2e by 2030, thus necessitating a 192,659 MT CO_2e reduction to meet the target goal. The CAAP provides a suite of actions to guide the City in reaching this GHG reduction target by 2030. Additionally, the City has set an aspirational goal of carbon neutrality by 2045 consistent with

State goals. The City would have to reduce its GHG emissions by more than 1.5 million MT CO2e by 2045 to meet this goal.

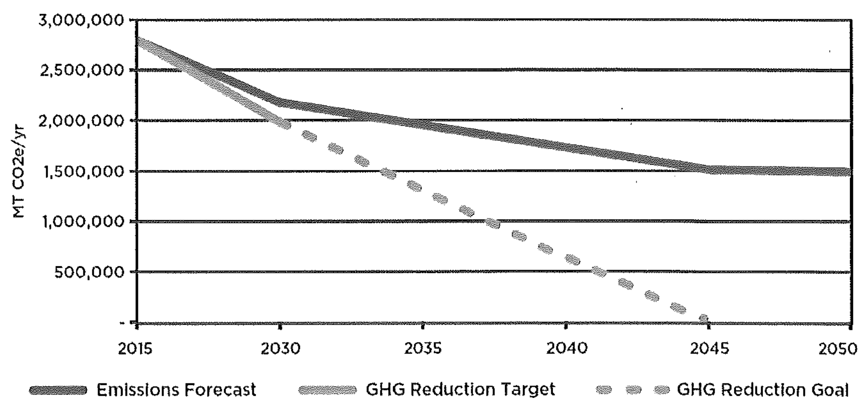
Table 1. GHG Reduction Targets

2030 GHG Target	MT CO_2e/Service Population
Business as Usual Forecast	2,176,931 MT CO_2e
Target Level	1,984,272 MT CO_2e
GHG Reductions Needed	**192,659 MT CO_2e**
2045 GHG Goal	**Net-carbon Neutrality**
Business as Usual Forecast	1,513,047 MT CO_2e
Target Level	0 MT CO_2e
GHG Reductions Needed	**1,513,047 MT CO_2e**

The Pathway to the GHG Reduction Target

Figure 1 illustrates the City's GHG emissions forecast (business-as-usual) compared to the reductions needed to achieve State targets. The forecasted business-as-usual decline in GHG emissions is largely a result of statewide actions influencing the City's electricity emissions and an estimated decrease in natural gas use in the energy sector. The difference between the emissions forecast and GHG reduction target in 2030 represents the 192,659 MT CO2e reduction needed from business-as-usual forecasts to meet the 2030 GHG target goal. The dashed line goes to zero in 2045 representing the carbon neutrality goal.

Figure 1. City GHG Emissions Targets vs. Forecasts 2015-2050



The CAAP is necessary to implement the vision and goals of the Mayor and City Council and enable the City to meet the above-stated targets. The CAAP is also a required mitigation measure of the General Plan Land Use Element (LUE) as detailed below.

Development Services, with the participation of many of the City's departments and bureaus, has conducted an extensive public engagement process and completed a Vulnerability Assessment and other technical studies to inform the CAAP, which resulted in the release of a draft CAAP in June 2019. The City Council heard updates on the CAAP from staff on March 19, 2019 and October 20, 2020. On March 19, 2019, the City Council further established a carbon neutrality goal by 2045. On October 20, 2020, the City Council directed staff to coordinate with City departments to finalize a preliminary list of GHG reduction measures that respective departments will commit to implementing as part of the CAAP, to ensure the City can meet its 2030 GHG reduction target, in compliance with State law, as well as other stated environmental goals.

The Proposed Plan

What is the CAAP?

The CAAP is a set of enforceable commitments for the City to reach State GHG emissions mandates by 2030 and adapt to the impacts of climate change, while improving quality of life and supporting economic vitality. The CAAP also establishes a framework for creating and/or updating policies, programs, practices, and incentives for Long Beach to reduce the City's GHG footprint, and will help ensure that Long Beach residents, businesses, and physical assets are better protected from the impacts of climate change. The plan includes a baseline communitywide GHG emissions inventory, forecasts of future GHG emissions, and reduction targets. The Plan's mitigation actions identify the steps that will be taken to meet State reduction mandates, while the adaptation actions identify the measures the City will take to adapt to climate change impacts: extreme heat, air pollution, drought, flooding, and sea level rise. Mitigation actions reduce GHG emissions and are comprised of measures that will be taken in the building, transportation, and waste sectors, which are the sources of GHG emissions in Long Beach. Of the range of mitigation actions identified in the plan, a subset of those actions is quantified toward the City's 2030 GHG reduction target. While 2030 is the focus of the CAAP, the plan also identifies longer term actions that will help the City reduce its GHG emissions and adapt to climate change beyond the 2030 plan horizon year. The CAAP was developed with an equity lens, seeking to address disproportionate environmental burden and helping to ensure benefit to communities most impacted by climate change. The City seeks to reduce GHG emissions while promoting a prosperous local economy for all and highlighting actions that promote education, job training, and workforce development in emerging green industries for people most impacted by climate change.

Why is a CAAP Needed?

In addition to addressing the effects of climate change, which are already impacting Long Beach, the CAAP will help the City comply with various local, regional, State, and federal regulations to reduce GHG emissions. As shown in Table 2, the City is obligated under AB 32 (The Global Warming Solutions Act of 2006), SB 375 (The Sustainable Communities and Climate Protection Act of 2008), and various California Executive Orders to do its part to reduce GHG emissions. Generally, statewide targets aim to reduce emissions to 1990 levels by 2020, 40 percent below 1990 levels by 2030, and 80 percent below 1990 levels by 2050. The CAAP is a plan for Long Beach to reach the statewide GHG target of 40 percent below 1990 levels by 2030.

Table 2. State GHG Legislation and City Status

Target Year	State Target	Corresponding Legislation	City Status
2020	1990 GHG levels by 2020	AB 32, Global Warming Solutions Act (2006)	California met this target statewide
2030	40% below 1990 levels by 2030	SB 32, Global Warming Solutions Act (2006)	The CAAP is a plan for Long Beach to meet this target by 2030
2045	Carbon neutrality by 2045	Executive Order B-55-18 of 2018	Aspirational for Long Beach
2050	80% below 1990 levels by 2050	Executive Order S-3-05 of 2005	CAAP's plan horizon is 2030

The CAAP is also a mitigation measure of the recently adopted General Plan Land Use Element (LUE) Environmental Impact Report (EIR), which commits the City to adopting a CAAP with specified GHG reduction targets. GHG emissions are associated with growth anticipated by the LUE from activities such as additional vehicle trips and electricity usage associated with future development. As a mitigation measure to address GHG emissions associated with the LUE, the City has committed to adoption of a CAAP within three years of LUE adoption, and subsequent monitoring of GHG emissions. Under the California Environmental Quality Act (CEQA), adoption of a "qualified" CAAP will also allow future development projects that comply with the LUE to streamline their GHG review for CEQA purposes. By allowing projects to take advantage of environmental streamlining, the City will also be facilitating housing production and economic development to address the City's housing shortage and homelessness crisis and lagging wages. For the CAAP to meet these obligations, it must detail a GHG reduction strategy that is reasonable, enforceable, and meets the State's numerical targets.

California has a history of demonstrated leadership in addressing climate change and is on track to meeting 2030 GHG reduction targets statewide. However, local climate action plans are needed to implement mitigation measures at the local level through local actions, help communities adapt to climate change, and advance equity. Examples of actions that occur at the local level are updating building and zoning codes and siting electric vehicle infrastructure. Local climate action plans help cities be more resilient against current and future climate threats and help ensure that efforts address environmental justice such as enhancing climate funding opportunities to communities most impacted by climate change.

Climate Change Impacts

The CAAP identifies five climate impacts anticipated to affect Long Beach: extreme heat, poor air quality, drought, flooding, and sea level rise, and the plan seeks to mitigate against those impacts and generally improve the resiliency of the City in the face of worsening impacts. A Climate Stressors Review and Climate Change Vulnerability Assessment were conducted as part of development of the CAAP, which go into detail about each of these climate impacts.

Following is a quick overview of each of the climate stressors and their anticipated impacts in the City:

- **Extreme Heat.** Extreme heat is the climate impact that is anticipated to affect the greatest number of people in Long Beach, with approximately 275,000 residents living within extreme heat vulnerability zones. Heat waves will occur more frequently, be more intense, and be longer lasting. Extreme heat is associated with increased risk of heat-, cardiovascular-, and respiratory-related mortality, increased hospital admission and emergency room visits. Vulnerable populations include children, the elderly, people with respiratory diseases, and those who spend a lot of time outdoors. A social vulnerability analysis was conducted as part of the Vulnerability Assessment, which considered factors including race, income, education, age, and asthma. The distribution of socially vulnerable populations correlates with areas impacted by extreme heat in Central, West, and North Long Beach.

- **Air Quality.** Higher temperatures are anticipated to increase the frequency, duration, and intensity of conditions conducive to air pollution formation. Specifically, studies have shown that ozone concentrations increase when maximum daytime temperatures increase. The Greater Los Angeles and Long Beach Area already have among the worst air quality in the country. There are several local sources that impact air quality in the City, including the 710 and 405 freeways, neighboring refineries, the Port of Long Beach, and major industrial sources.

- **Drought.** An overall drying trend in the region will affect the City, resulting in longer and more frequent droughts. There is anticipated reduced snowpack and increased intensity of runoff events in watersheds that supply water to Long Beach. Higher temperatures will lead to higher water demand.

- **Flooding: Riverine and Sea Level Rise**. There are three sources of flooding in Long Beach: riverine flooding, urban flooding, and sea level rise and associated coastal storms. With precipitation events projected to increase in intensity as a result of climate change, riverine and urban flooding, which occurs around the Los Angeles and San Gabriel rivers and other parts of the stormwater collection system, may increase. Low lying areas including Belmont Shore, Naples, and the Peninsula are also already experiencing coastal flooding. Sea level rise models developed as part of CAAP development anticipate 11 inches of sea level rise in 2030, 24 inches in 2050, and 37-66 inches in the mid-range and high-range scenarios in 2100. Sea level rise projections will be revised periodically based on available data; however, the projections based on information available at the time of the study help the City focus attention to where public infrastructure and other development may be affected. As sea levels rise, the City is expected to be more frequently impacted by higher storm tides, more extensive inland flooding, and increased coastal erosion. Flooding threatens safety, can have subsequent health impacts, and can result in damage to or loss of critical infrastructure.

Greenhouse Gas Emissions Inventory

Development Services staff prepared three types of GHG emissions inventories: production, consumption, and lifecycle oil and gas. The production-based inventory is the inventory that is used for the purposes of establishing a communitywide baseline of GHG emissions and is the inventory from which GHG reduction targets are established. The latter two inventories were prepared for informational purposes. Additional information about each of the inventories is detailed below.

The production-based inventory, which is the standard of the Global Protocol for Community Scale GHG Emissions Inventories, is used for the purposes of forecasting and determining the City's reduction strategy. A production inventory takes into account emissions occurring from local activities and is designed to focus on opportunities for local action that are within the City's control. The consumption inventory takes into account lifecycle emissions from consumption activities within the City. The consumption inventory was completed for informational purposes; however, there is a growing consensus about the importance of consumption inventories in helping communities more fully understand their contributions to global emissions through their consumption behaviors. The third type of inventory conducted was of the lifecycle emissions of oil and gas production and activities. Emissions associated with the lifecycle of oil and gas production occur both within and outside of the City and thus not all emissions associated with these activities are within the control of the City. This inventory was completed in response to public and City Council requests and provides a picture of emissions from oil and gas extraction activities both within and outside of Long Beach.

As shown in Table 3, the City's 2015 production GHG inventory estimated a total of 2.79 million MT CO2e of jurisdictional emissions. The City's 2015 consumption inventory estimated a total of 7.08 million MT CO2e and the City's 2015 oil and gas emissions inventory estimated a total of 8.30 MT CO2e. It should be noted that the consumption and oil and gas emissions inventories are both lifecycle inventories so are not directly comparable to the production inventory but provide insight into emissions-generating activities within Long Beach.

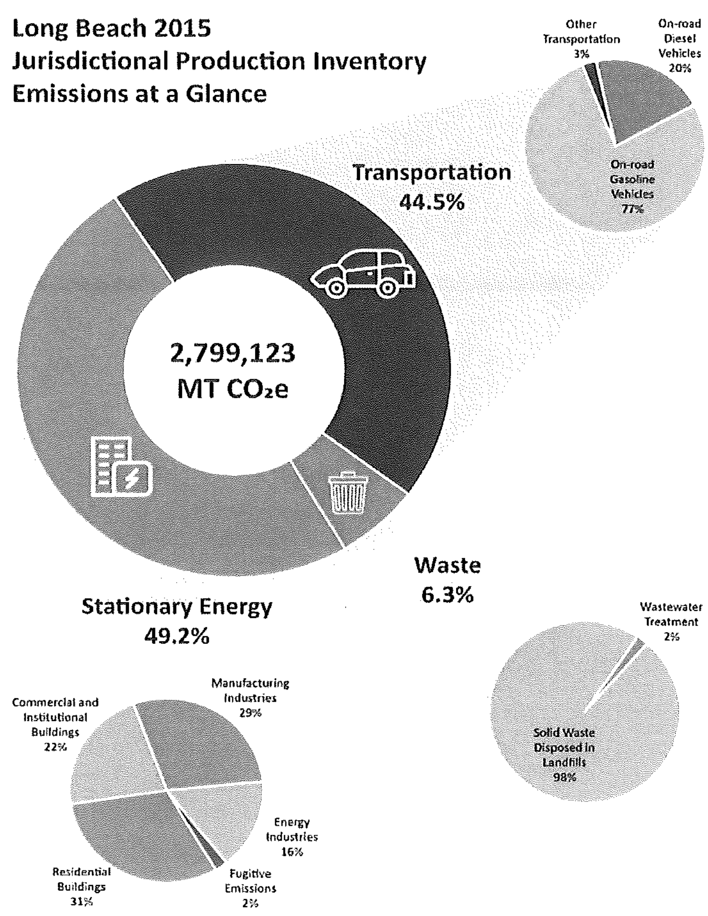
Table 3. Long Beach Inventories

Inventory Type	MT CO2e
Production Inventory	2,799,123
Consumption Inventory (Lifecycle)	7,077,346 (1)
Oil and Gas Emissions Inventory (Lifecycle)	8,300,000 (1)

(1) Shown for informational purposes only, the productional inventory will be used for regulatory and progress-tracking purposes.

As shown in Figure 2, in the production inventory, emissions come from three main sectors: stationary energy at 49 percent, transportation at 44 percent, and waste at 6 percent.

Figure 2. Long Beach 2015 Production Inventory



The three sectors that are the source of emissions in the City are described briefly below:

- **Stationary Energy.** Stationary energy is made up of emissions from building electricity and natural gas use in residential, commercial, institutional, and industrial buildings, as well as emissions from energy industries operating within Long Beach. Emissions from the buildings where people live and work, known as stationary energy or building emissions, accounts for 49 percent of Long Beach GHG emissions. Reductions in GHG emissions from the building sector can be made through three types of strategies: constructing new buildings to stricter standards, energy efficiency improvements in existing buildings, and switching to a cleaner source of energy. New buildings constructed today are built under strict standards for energy usage and could be held to even higher standards. However, most stationary energy use is due to the GHGs associated with the continued use of older buildings. These emissions can be reduced through a combination of energy efficiency improvements or by switching to cleaner sources of electricity. Since 72 percent of Long Beach's housing stock was built before the year 1970, and 98 percent was built before the year 2000, this is a major issue in Long Beach.

- **Transportation.** Transportation is made up of emissions associated with passenger vehicles, buses, trucks, rail transit, freight rail, off-road vehicles, and aviation operations within the city limits. Port waterborne activity have been quantified but have been excluded from the jurisdictional inventory because emissions occurring from vessel operations at the Port are in part regulated at the State level by the California Air Resources Board (CARB), and the City does not have direct authority to dictate emissions reduction policies for private shipping companies that operate from the Port. Even without maritime emissions, transportation still accounts for 45 percent of all GHG emissions in Long Beach. While transportation emissions are one of largest GHG contributors, they are also the area where the City has the least control due to pre-emption from State and Federal transportation and air quality regulations. Most emissions coming from the transportation sector are from gasoline vehicles.

- **Waste.** Waste is made up of emissions from waste disposal as well as emissions from wastewater treatment. Solid waste disposal creates emissions when organic waste such as food scraps, yard trimmings, and paper and wood products are buried in landfills and decomposition occurs that emits methane, which is responsible for approximately 6 percent of the City's GHG inventory. The City and its franchise waste haulers are responsible for collecting solid waste from homes and businesses in Long Beach. The portion of waste that the City collects is currently processed at the Southeast Resource Recovery Facility (SERRF), where it is sorted to remove recyclables and then incinerated to generate electricity. Through this process, SERRF provides energy recovery that can offset additional use of non-renewable energy sources for electricity generation.

GHG Reduction Target

Business-as-usual forecasts estimate 2,176,931 MT CO2e will be generated in the City in 2030 (Table 1). As seen in Table 1, to meet the statewide target, Long Beach will need to reduce emissions to 1,984,272 MT CO2e by 2030. Thus, a 192,659 MT CO2e reduction is needed to meet the 2030 target goal. This is estimated to be equivalent to emissions from 41,623 passenger vehicles for one year or electricity use in 32,618 homes for one year. As seen in Table 4, on a service population basis, which counts individuals who live or work in Long Beach, the 2030 GHG reduction target is from business-as-usual estimates of 3.34 MT CO2e to 3.04 MT CO2e. In other words, each person who lives or works in Long Beach would need to reduce their GHG emissions by about 9 percent in 2030 to reach target levels. In 2045, business-as-usual forecasts estimate 1.51 million MT CO2e. To reach the aspirational goal of net carbon neutrality, these GHG emissions will need to be reduced to zero.

Table 4. GHG Reduction Target by Service Population

2015 Emissions	4.5 MT CO_2e
2030 Business-as-Usual (BAU) Target	3.34 MT CO_2e
2030 Emissions Target Level	3.04 MT CO_2e
2030 Reductions Needed (BAU vs. Target)	**0.3 MT CO_2e**

The CAAP has many actions that reduce GHG emissions; however, only a subset of those actions are quantified toward reaching the State-mandated 2030 GHG target. Actions across building energy, transportation, waste, and other sectors are quantified toward the GHG reduction target, which are summarized below and detailed in Attachment C.

- **Building Energy Sector GHG Reductions.** Within the building energy sector, actions quantified toward the GHG reduction target include:
  - Greater use of renewable residential and commercial electricity achieved in part through Southern California Edison's commitment to an 80 percent carbon free energy supply by 2030 (which exceeds the State's Renewable Portfolio Standard (RPS) of 60 percent);
  - Developing an increased amount of citywide solar potential; and,
  - The City purchasing 100 percent carbon-free electricity for all municipal accounts.

- **Transportation Sector GHG Reductions.** Within the transportation sector, actions quantified toward the GHG reduction target include Port actions associated with its Clean Trucks Program and a 1 percent reduction in vehicle miles traveled (VMT) for passenger and light duty vehicles.

- **Waste Sector GHG Reductions.** Within the waste sector, actions quantified toward the GHG reduction target include increased commercial recycling and commercial organics diversion.

- **GHG Reductions from Oil Extraction.** Within the building energy sector, actions quantified toward the GHG reduction target include emissions reductions associated with a 20 percent reduction from 2018 oil production levels by 2030 due to depletion.

Adopting a set of actions that are estimated to provide reductions beyond the minimum of 192,659 MT CO2e will provide flexibility and help the City ensure successful compliance with reduction targets. See Attachment B (CAAP Appendix A) for the detailed pathway to achieving the GHG target.

CAAP Monitoring

The City will inventory its GHG emissions on a bi-annual basis, report those emissions to the public, and monitor its progress toward meeting the 2030 GHG reduction target. If in the future the City is not making sufficient progress to meet its reduction target, the City must continue to consider and adopt more aggressive GHG reduction actions to ensure compliance. Therefore, the process of monitoring GHG emissions in relation to reduction targets will be iterative even once the plan is adopted.

City Leadership

The City is committed to demonstrating leadership in CAAP implementation by integrating climate action throughout department operations. Several of the CAAP adaptation and mitigation actions include components defining City leadership roles. An example is the City's commitment to transition municipal buildings and facilities to 100 percent renewable electricity and reducing natural gas consumption by 5 percent by 2030. Another is the City's commitment to perform energy and water audits in existing facilities and complete subsequent efficiency upgrades and incorporating CAAP goals into its budgeting and capital improvement programming. City leadership will further include efforts such as transitioning the City vehicle fleet to low and zero emissions vehicles, integrating sea level rise considerations into plans and policies, pursuing funding for urban greening, and engaging and providing education to City employees and the general public on climate action. The City will seek opportunities to create jobs and train residents in emerging green technologies including partnerships with local workforce and economic development entities and educational institutions.

The Process

Interdepartmental Coordination

The development of the CAAP involved extensive interdepartmental coordination and participation. Development Services staff have hosted all-Department meetings to share information and receive input on the CAAP. In a CAAP survey of 17 departments, 100 percent reported that they experienced climate impact to infrastructure assets or core services, 88 percent reported that they are engaging in GHG emission-reducing actions, and 53 percent are engaging in adaptive capacity actions. Of the climate stressors the City is experiencing, the greatest number of departments reported being impacted by extreme heat followed by major storm events. Departments provided comments on the draft plan in 2019 and staff incorporated feedback as appropriate.

Development Services staff have also conducted interdepartmental coordination to identify GHG reduction measures to be implemented by respective departments. This process included discussions with the Port, Energy Resources, Airport, Public Works, and Environmental Services Bureau to identify CAAP mitigation actions to quantify toward the City's GHG reduction target. The results of these discussions have been incorporated into the CAAP GHG reduction pathway in CAAP Appendix A (Attachment B) or have otherwise been included qualitatively in the plan.

Inclusive Public Process

Staff have reached over 10,000 members of the public through over 60 outreach and engagement events in the process of developing the CAAP. Over the last three years, Development Services staff have convened scientific, business, and community working groups; partnered with institutions and schools; and, conducted extensive community outreach to receive input on CAAP development and to develop a plan of action. Through the CAAP public outreach process, staff sought to disseminate information and solicit feedback from the community at large, while also targeting outreach efforts on communities most impacted by climate change. Development Services staff hosted three open house events and attended numerous events occurring in communities throughout Long Beach to share information about the CAAP. Community events were held in each of the Council Districts. Select events were held in Spanish and Khmer. The plan calls for continued engagement with Long Beach population as well as specifically with communities most affected by climate change through CAAP implementation.

Governance

Development Services staff were tasked with leading the planning process for developing the CAAP since the plan is a mitigation measure of the General Plan LUE. However, effective implementation of the CAAP will require substantial cross-departmental collaboration to carry out the broad reach and scope of the plan including coordinating public infrastructure projects, aligning budgeting with CAAP goals, pursuing funding opportunities, developing new policies and programs, and conducting ongoing public education and engagement. CAAP implementation will be overseen by the City Manager's Office through a task force that will include climate designees from each department and coordinated by Development Services. Development Services will additionally take the lead on planning-related implementation actions such as Zoning Code updates and CAAP compliance for future development projects as well as overall CAAP monitoring and updates as necessary.

Public Notice and Environmental Compliance

Although a public notice for this item is not required, a public meeting notice was published in the Long Beach Press-Telegram on December 17, 2020, notice posting was provided at City Hall, and electronically distributed through the City's LinkLB e-mail blast system and to individual stakeholders who have requested notification on this item.

After City Council's confirmation of the proposed CAAP, staff will prepare the subsequent Environmental Impact Report (EIR) and bring the plan back to City Council for certification of the EIR and final CAAP adoption in Fall 2021.

This matter was reviewed by Assistant City Attorney Michael Mais on December 14, 2020 and by Budget Analysis Officer Julissa José-Murray on December 9, 2020.

TIMING CONSIDERATIONS

City Council action is requested on January 5, 2021. Timely action is required to meet the City's obligations under the General Plan Land Use Element Mitigation Monitoring and Reporting Program (LUE MMRP).

FISCAL IMPACT

This recommendation does not have a fiscal impact; however, implementation of its recommendations will have a fiscal impact in the future. The CAAP calls for City actions to focus on identifying opportunities to better align with the annual City budget, Capital Improvement Program, and other expenditures with CAAP actions. Funding for future resources related to the plan have not yet been identified and further detailed cost estimates will be determined as resources are identified. As these actions and objectives are pursued their financial implications will be disclosed and brought back to the City Council for approval. This recommendation has no staffing impact beyond the normal budgeted scope of duties and is consistent with existing City Council priorities. There is no local job impact associated with this recommendation. While the CAAP does seek to help improve the local economy, the exact fiscal impact of these actions is dependent on future macro-economic conditions that will occur over two decades, and therefore, cannot be estimated at this time.

SUGGESTED ACTION:

Approve recommendation.

Respectfully submitted,

OSCAR W. ORCI
DIRECTOR OF DEVELOPMENT SERVICES

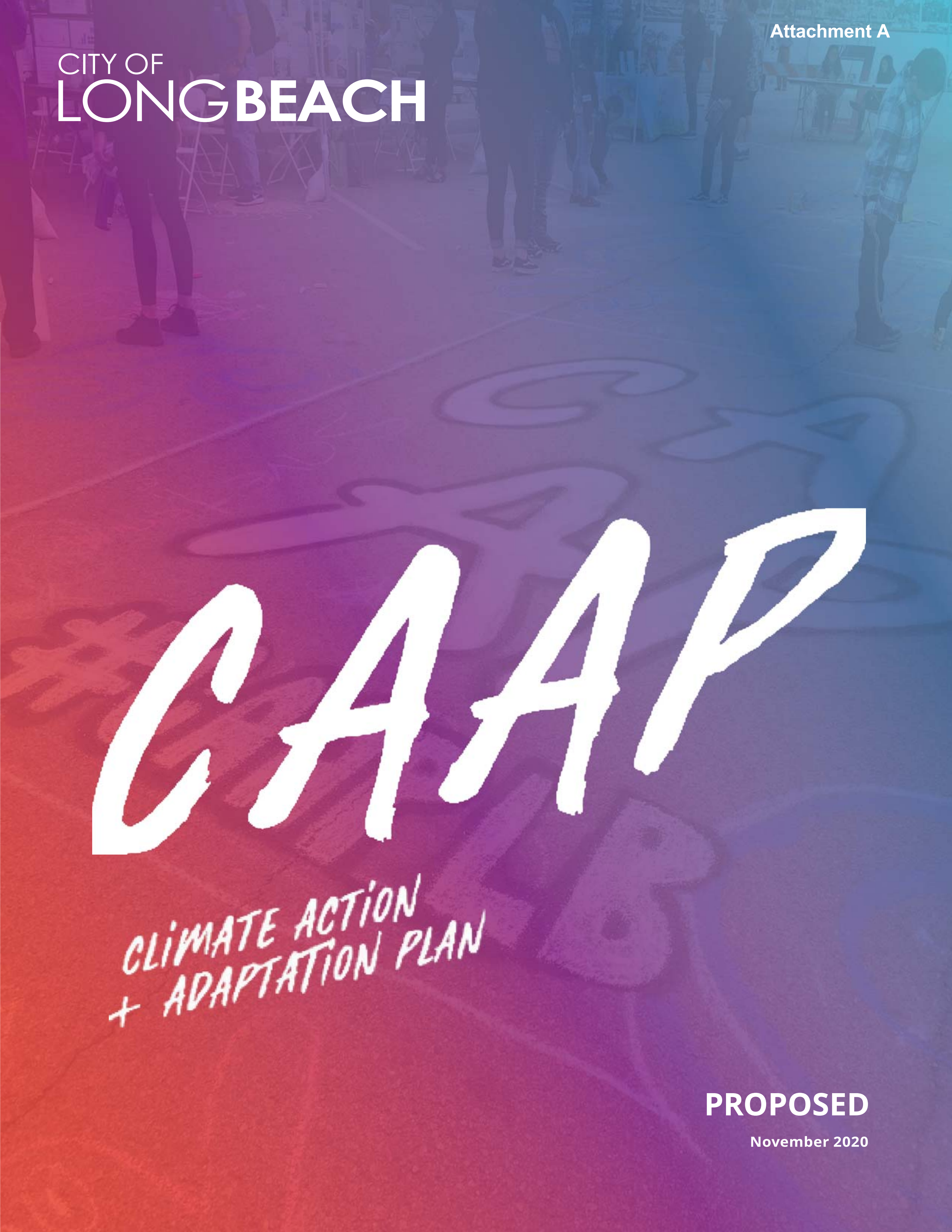
ATTACHMENTS: A – PROPOSED CAAP
B – PROPOSED CAAP PLAN APPENDICES
C – PROPOSED CAAP GREENHOUSE GAS REDUCTION PATHWAY (APPENDIX A, EXCERPTED)

APPROVED:

THOMAS B. MODICA
CITY MANAGER

Attachment A

CITY OF
LONG**BEACH**



CAAP

CLIMATE ACTION + ADAPTATION PLAN

PROPOSED

November 2020

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Executive Summary

CLIMATE ACTION AND ADAPTATION PLAN VISION

Preparing Long Beach for climate change presents both daunting challenges and extraordinary opportunities. It will require changes to many things we take for granted—how we power our homes, how we get around, how businesses and industry are run, how and where buildings get built, what we consume, and what we throw away. But rather than just an inconvenient necessity, adapting Long Beach to climate change and reducing our contribution to its causes also presents an unprecedented opportunity to improve quality of life for all Long Beach residents and remedy long-standing inequities.

Through implementing a coordinated response to climate change, we can address public health disparities, foster economic opportunities, and realize a vision of Long Beach where everyone can live in thriving communities built on sustainability and resilience. Here we summarize the vision and actions for the Climate Action and Adaptation Plan (CAAP) that the City of Long Beach has developed through extensive stakeholder and community input.

VISION

The vision of the Long Beach CAAP is to create a more sustainable, resilient and equitable city by addressing climate change in a way that remedies existing environmental health disparities while also improving health,quality of life, and enhancing economic vitality throughout Long Beach.

The implementation of the CAAP will help Long Beach realize:

1. **Low carbon, climate resilient buildings and neighborhoods**
2. **Safe and adaptable infrastructure**
3. **Protected and enhanced natural systems**
4. **A healthy, resilient and ready population**
5. **Residents and businesses with minimized carbon footprints**

The City, in conjunction with relevant partners, will implement a range of actions to reduce greenhouse gas (GHG) emissions and adapt to climate change impacts. The actions the City will take are organized overleaf by desired outcomes that represent the underlying values of the CAAP.

HOW LONG BEACH WILL ACHIEVE THE CAAP OUTCOMES

These themes are desired high level outcomes of the plan, and what will be done generally to achieve them. However, it is not an exhaustive list of all the actions, please see p20 through p23 for the full list.

THEME	SECTOR/ STRESSOR	ACTION	ACTION NUMBER
Low carbon, climate resilient buildings and neighborhoods	Building + Energy	Increase use of solar power including by promoting community solar and microgrids	BE-2 BE-3
	Building + Energy	Develop a residential and commercial energy assessment and benchmarking program and provide energy efficiency financing, rebates,and incentives for building owners	BE-4 BE-5
	Building + Energy	Perform municipal energy and water audits	BE-6
	Building + Energy	Update building codes to incentivize electric new residential and commercial buildings	BE-7
	Air Quality	Incentivize installation of photocatalytic tiles	AQ-1
	Drought	Continue development and implementation of water use efficiency programs and implement additional water conservation programs	DRT-1
	Extreme Heat	Increase presence of cool roofs and cool walls	EH-1
	Extreme Heat	Enhance and expand urban forest cover and vegetation	EH-3

THEME	SECTOR/ STRESSOR	ACTION	ACTION NUMBER
Safe and adaptable infrastructure	Extreme Heat	Increase presence of reflective streets, surfaces, shade canopies, and bus shelter amenities	EH-2 EH-7
	Drought	Expand usage of green infrastructure and green streets	DRT-3
	Sea Level Rise + Flooding	Address sea level rise in citywide plans, policies, and regulations and incorporate adaptation strategies into City lease negotiations	FLD-2 FLD-4
	Sea Level Rise + Flooding	Update the City's existing Stormwater Management Plan	FLD-5
	Sea Level Rise + Flooding	Relocate/elevate critical infrastructure, including elevating riverine levees and flood proofing vulnerable sewer pump stations	FLD-9 FLD-10 FLD-11
	Sea Level Rise + Flooding	Elevate streets/pathways and retreat/ realign beach parking lots	FLD-14 FLD-15 FLD-17
	Sea Level Rise + Flooding	Retrofit/extend sea walls and storm surge barriers as appropriate	FLD-16 FLD-18 FLD-20

THEME	SECTOR/ STRESSOR	ACTION	ACTION NUMBER
Protected and enhanced natural systems	Drought	Incorporate increased rainfall capture and other actions to maximize local water supplies and offset imported water	DRT-5
	Sea Level Rise + Flooding	Review and conduct studies on the effects of combined riverine/coastal flooding and increased severity of rainfall events on watershed flooding	FLD-7
	Sea Level Rise + Flooding	Conduct a citywide beach stabilization study, enhance dunes, expand beach nourishment based on study findings	FLD-6 FLD-8 FLD-12 FLD-13

THEME	SECTOR/ STRESSOR	ACTION	ACTION NUMBER
A healthy, resilient and ready population	Extreme Heat	Install additional water fountains and undertake other actions to increase public access to water	EH-4
	Extreme Heat	Identify future vulnerability potential for power outages related to extreme heat and develop plans to prevent outages	EH-5
	Extreme Heat	Enhance and expand accessibility to cooling centers	EH-6
	Extreme Heat	Improve beach and coastal transit access during extreme heat events	EH-6
	Air Quality	Encourage urban agriculture practices that reduce air quality pollution	AQ-2
	Air Quality	Increase monitoring and regulation of the oil extraction and refining process	AQ-7
	Drought	Enhance outreach and education related to water conservation	DRT-2
	Drought	Expand use of recycling water and grey water for non-potable use	DRT-4
	Sea Level Rise + Flooding	Update the floodplain ordinance	FLD-1
	Sea Level Rise + Flooding	Establish a flood impacts monitoring program	FLD-3
	Sea Level Rise + Flooding	Investigate feasibility of managed retreat in the longer term	FLD-19

THEME	SECTOR/ STRESSOR	ACTION	ACTION NUMBER
Residents and businesses with minimized carbon footprint	Transportation	Expand and improve pedestrian and bikeway infrastructure citywide	T-2 T-3
	Transportation	Implement the San Pedro Bay Ports Clean Trucks Program	T-4
	Transportation	Increase access to additional electric vehicle charging stations	T-5
	Transportation	Increase employment and residential development along primary transit corridors and increase frequency of public transit and access to multimodal transportation	T-1 T-6
	Transportation	Increase density and mixing of land uses and update the Transportation Demand Management Ordinance to require strategies that encourage multimodal transportation use	T-7 T-8 T-9
	Building + Energy	Provide access to renewably generated electricty	BE-1
	Building + Energy	Implement short-term measures to reduce emissions related to oil and gas extraction	BE-8
	Waste	Increase recycling in multifamily and commercial development, in compliance with state law	W-1
	Waste	Develop an organic waste collection program and identify organics processing options such as composting, mulching or anaerobic digestion	W-2 W-3 W-4
	Air Quality	Support sustainability planning efforts at the Long Beach Airport and San Pedro Bay Ports and support LBUSD school bus electrification	AQ-3 AQ-5 AQ-6
	Air Quality	Electrify local, small GHG emitters such as lawn and garden equipment, outdoor power equipment, and others	AQ-4

HOW WE DEVELOPED THE PLAN – LISTENING TO YOU

Stakeholder engagement was key to the process and had two main components – first, working with a series of stakeholder working groups, and second, extensive public outreach. The City is grateful to all those who provided input. Input from the scientific community input is reflected in the climate science, vulnerability assessment, and other technical appendices. Community input is reflected in the plan's vision and goals, the policies and strategies that have been included and prioritized, and the way in which various actions are anticipated to be implemented.

Early in the engagement process, staff set out to create an inclusive, community-centered planning process to broadly engage the Long Beach community, but with particular attention to those most affected by climate change. The community engagement strategy for the CAAP was based on an equity assessment conducted in partnership with other City departments, including Long Beach Parks, Recreation, and Marine, and the Health and Human Services Department.

10,260 TOTAL estimated participants

1,395 sign-ins

67 events

#1 OPEN HOUSE

200 ESTIMATED PARTICIPANTS
98 sign-ins

- Validate the project methodology;
- Provide feedback and input on local data;
- Review results and early actions.

#2 OPEN HOUSE

200 ESTIMATED PARTICIPANTS
97 sign-ins

- Provide input on climate-related; their concerns
- Review existing actions;
- Recommend future opportunities.

#3 OPEN HOUSE Long Beach ClimateFest

500 ESTIMATED PARTICIPANTS
107 sign-ins

- Input on the public engagement approach;
- Provide input on Climate-related concerns;
- Review proposed actions.

SCIENTIFIC WORKING GROUP

13 Independent Experts

3 meetings

California State University, Long Beach; Long Beach Community College; the University of California, Los Angeles; the Aquarium of the Pacific, the South Coast Air Quality Management District, and RAND Corporation.

BUSINESS WORKING GROUP

24 Businesses

2 meetings

Including architecture, engineering, utilities, sustainability consultants, business association leaders and the Chamber of Commerce.

COMMUNITY WORKING GROUP

20 Local Community Groups

2 meetings

Neighborhood associations, environmental justice organizations, church and religious organizations, clean energy advocates, community assets and open space organizations, and health and wellbeing organizations.

ENGAGED YOUTH LEADERS

13 Educational Institutes

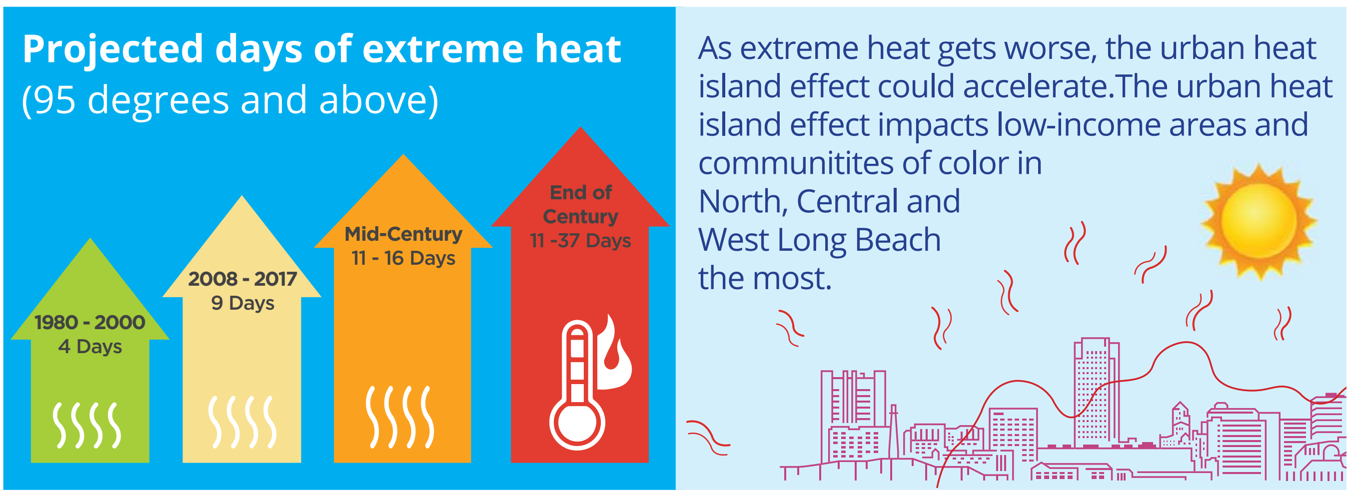
multiple meetings

California State University, Long Beach; Long Beach City College; Long Beach Unified School District; St. Anthony's High School; Youth Leadership Long Beach; and Aquarium of the Pacific youth volunteers

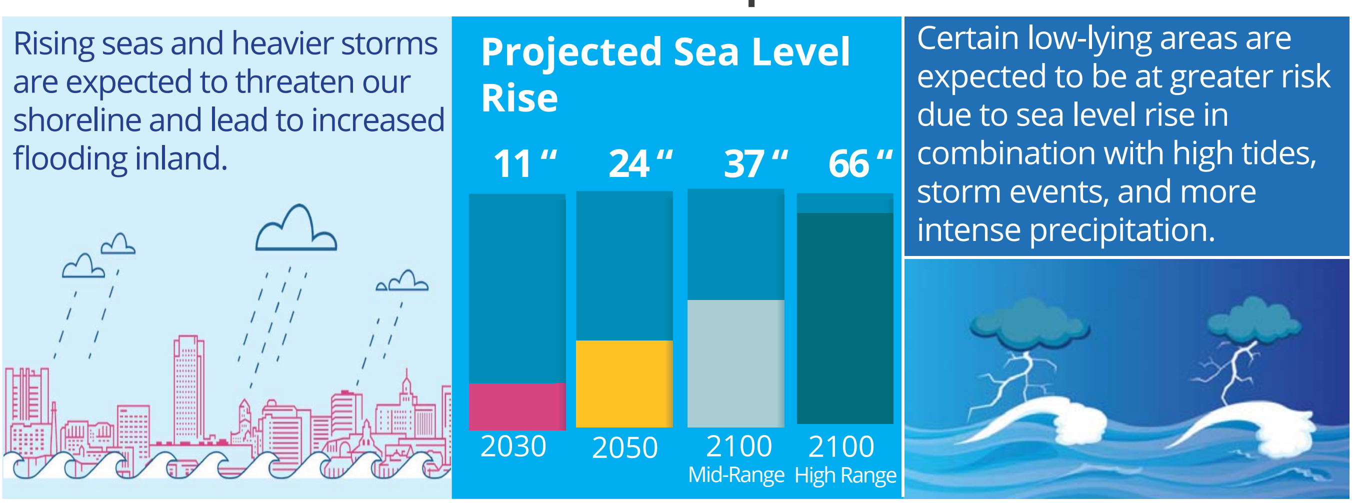
HOW CLIMATE CHANGE WILL IMPACT LONG BEACH

As part of the CAAP process, the most up-to-date science and local climate projections for the main climate change impacts—extreme heat, sea level rise, and precipitation—and two secondary impacts relating to air quality and drought were reviewed. The City used this information to carry out a Climate Vulnerability Assessment, which explored how these climate stressors will impact different types of city assets (see the graphic below). As climate models and projections are improved and updated with new data and observations, they will be used to inform future updates of the CAAP.

Extreme Heat



Sea Level Rise and Increased Precipitation

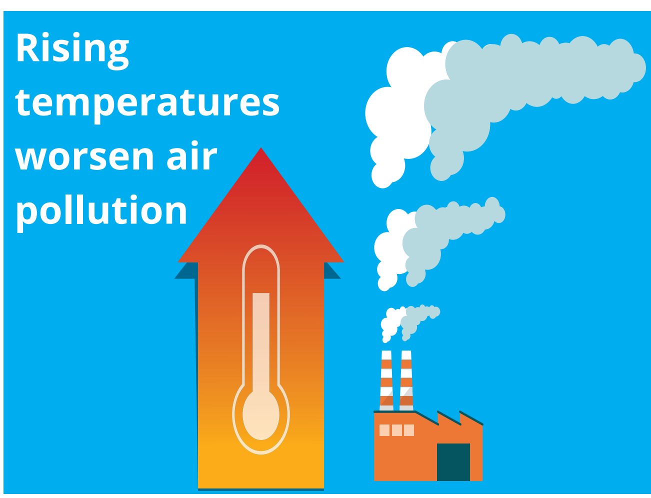


Although climate change is impacting the entire city, some communities within Long Beach already experience disproportionate environmental health burdens and have the highest social vulnerability to climate change. As Long Beach prepares for an uncertain climate future, the City will support these communities to make sure they can thrive.

Drought

Temperature and precipitation changes are expected to worsen droughts and reduce snowpack and access to imported water, all while increasing demand for water.

Air Quality



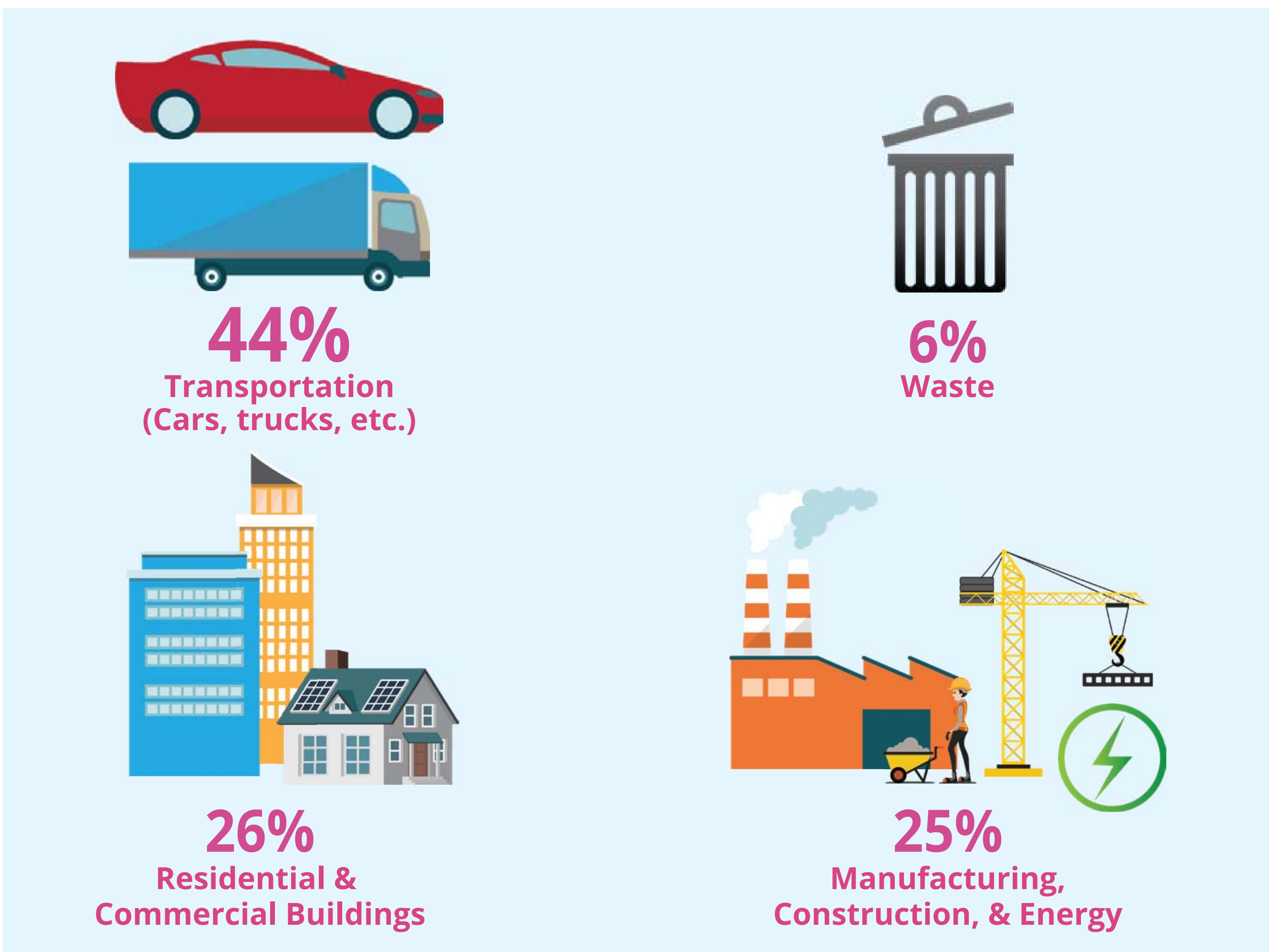
Air quality varies greatly in Long Beach. Impacts will be felt most by people sensitive to poor air quality and communities adjacent to emissions sources.

HOW LONG BEACH IMPACTS CLIMATE CHANGE

The reduction of GHG emissions is one of the primary objectives of the CAAP, and the goal is net zero emissions by 2045. An interim target for 2030 has been identified to help the City achieve this goal. Developing meaningful reduction strategies and evaluating their ability to meet a GHG target first requires an understanding of the community's baseline and projected future emissions levels.

The City developed a production inventory that analyzes emissions from local activities such as vehicle travel, building energy use, and waste disposal. Emissions occurring from vessel operations at the Port of Long Beach are, in part, regulated at the state level by the California Air Resources Board (CARB), and the City of Long Beach does not have the direct authority to dictate emissions reduction policies for private shipping companies that operate from the port. For this reason, port waterborne activity is not considered for GHG target-setting purposes.

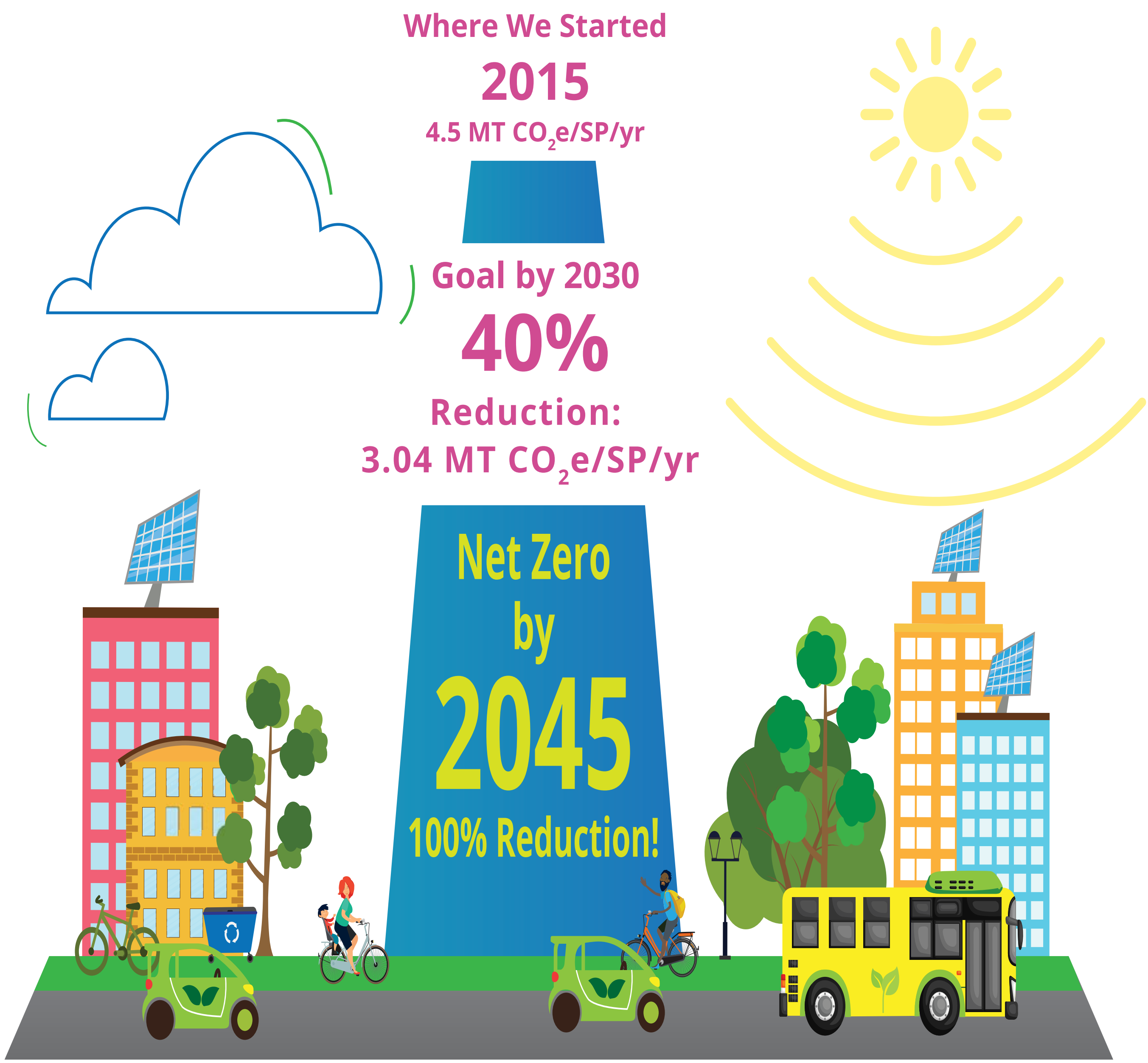
Where do Our Emissions Come From?



Notes: Residential & commercial buildings and manufacturing, construction and energy are consolidated as "stationary energy" in the Production Inventory. The Total Production Inventory also includes port waterborne activity emissions. (chapter 5)

The City developed a high-level consumption-based inventory to understand emissions resulting from the consumption of goods and services by city residents (for information purposes only). The City also analyzed the life cycle emissions associated with oil and gas extraction activities in Long Beach to present a holistic view of the City's total contribution to global emissions and to help identify possible reductions in the long term. The City can most directly influence emissions related to the production-based inventory, and CAAP actions will aim at reducing emissions from this inventory.

Our Carbon Challenge



MT CO_2e/SP/yr = Metric tons of carbon dioxide equivalent per service population (population + employment)

HOW WE ARE GOING TO REDUCE OUR VULNERABILITY TO CLIMATE IMPACTS

EH Extreme Heat

Goal: Long Beach buildings, neighborhoods, and infrastructure are climate resilient, reduce the urban heat island effect, and are set up to ensure and improve public health and safety in the face of extreme heat events

OBJECTIVES	NO.	ACTIONS
New and existing buildings, streets, and public spaces reduce extreme heat through incorporation of cool surfaces and green infrastructure	EH-1	Increase presence of cool roofs and cool walls
	EH-2	Increase the presence of reflective streets, cool surfaces, and shade canopies
	EH-3	Enhance and expand urban forest cover and vegetation
All residents have access to services and programs to withstand extreme heat events	EH-4	Install additional water fountains and other actions to increase public access to water
	EH-5	Identify future vulnerability potential for power outages related to extreme heat and develop plans to prevent such outages
	EH-6	Enhance and expand the accessibility of cooling centers
Public transit is a comfortable and viable mobility option during extreme heat events, especially for transit-dependent populations	EH-7	Provide bus shelter amenities
	EH-8	Improve beach and coastal transit access during extreme heat events

AQ Air Quality

Goal: All Long Beach communities have clean air and improved public health

OBJECTIVES	NO.	ACTIONS
Buildings and facilities actively reduce air pollution as a component of a broader energy reduction strategy.	AQ-1	Incentivize installation of photocatalytic tiles
	AQ-2	Encourage urban agriculture practices that reduce air quality pollution
Emissions are reduced by shifting to cleaner equipment and vehicles.	AQ-3	Support the development of the Long Beach Airport Sustainability Plan
	AQ-4	Electrify small local emitters, such as lawn and garden equipment, outdoor power equipment, and others
	AQ-5	Work with Long Beach Unified School District (LBUSD) to support school bus electrification
	AQ-6	Implement the Port of Long Beach Clean Air Action Plan
Air quality impacts from local oil and gas operations are minimized.	AQ-7	Increase monitoring and regulation of oil extraction and refining process

DRT Drought

Goal: Long Beach has a more sustainable and diverse water supply that reduces dependence on imported water and improves long-term water security

OBJECTIVES	NO.	ACTIONS
Maximize water efficiency and conservation.	DRT-1	Continue development and implementation of water use efficiency programs and implement additional water conservation programs
	DRT-2	Enhance outreach and education related to water conservation
Maximize water that is captured and reused locally.	DRT-3	Expand usage of green infrastructure and green streets
	DRT-4	Expand usage of recycled water and greywater for non-potable use
	DRT-5	Incorporate increased rainfall capture and other actions to maximize local water supplies and offset imported water

FLD Sea Level Rise + Flooding

Goal: Long Beach understands and is prepared for its future flood risk

OBJECTIVES	NO.	ACTIONS
Short-Term Actions (to 2030)		
City plans and policies are forward-looking and ensure projects and investments account for projected sea level and flooding impacts	FLD-1	Update and augment floodplain regulations as necessary
	FLD-2	Incorporate sea level rise language into citywide plans, policies, and regulations
	FLD-3	Establish a flood impacts monitoring program
	FLD-4	Incorporate adaptation into City lease negotiations
	FLD-5	Update the City's existing Stormwater Management Plan
Clear and sufficient information is on hand to identify and prioritize near-term adaptation needs and best practices	FLD-6	Conduct citywide beach stabilization study
	FLD-7	Review and conduct studies of combined riverine/coastal flooding and increased severity of rainfall events on watershed flooding
Adaptation strategies are implemented to protect vulnerable shoreline areas and wastewater infrastructure	FLD-8	Enhance dunes
	FLD-9	Inventory and flood-proof vulnerable sewer pump stations

For Medium and Long Term Actions - see main plan document.

HOW WE ARE GOING TO ACHIEVE OUR GREENHOUSE GAS REDUCTION TARGETS

BE Building + Energy

Goal: Long Beach buildings are energy-efficient and our communities run on affordable, renewable electricity

GHG Reductions 247,700 MT CO_2e

OBJECTIVES	NO.	ACTIONS
Transition to a carbon-free, more resilient electricity system	**BE-1**	Provide access to renewably generated electricity
	BE-2	Increase use of solar power
	BE-3	Promote community solar and microgrids
Increase the energy efficiencyof existing buildings/facilities	**BE-4**	Develop a residential and commercial energy assessment and benchmarking program
	BE-5	Provide access to energy efficiency financing, rebates, and incentives for building owners
	BE-6	Perform municipal energy and water audits
Ensure new buildings are low-carbon or carbon-neutral	**BE-7**	Update building codes to incentivize electric new residential and commercial buildings
Reduce emissions from local oil and gas extraction	**BE-8**	Implement short-term measures to reduce emissions related to oil and gas extraction

T Transportation

Goal: Affordable, safe, carbon-free transportation choices connect all Long Beach communities to opportunity, clean air, and improved health

GHG Reductions 30,480 MT CO_2e

OBJECTIVES	NO.	ACTIONS
Decrease reliance on personal motor vehicles and increase transit, biking, andwalking trips	**T-1**	Increase the frequency, speed, connectivity, and safety of transit options
	T-2	Expand and improve pedestrian infrastructure citywide
	T-3	Increase bikeway infrastructure citywide
Shift to low- and zero-emissions vehicles to move people and freight	**T-4**	Implement the Port of Long Beach Clean Trucks Program
	T-5	Develop an Electric Vehicle Infrastructure Master Plan
Prioritize the development of transit-oriented neighborhoodswith a mix of jobs, services, and housing	**T-6**	Increase employment and residential development along primary transit corridors
	T-7	Update the Transportation Demand Management Ordinance
	T-8	Increase the density and mixing of land uses
	T-9	Integrate SB 743 planning with the CAAP process

W

Waste

Goal: Long Beach is a zero-waste city

GHG Reductions 116,680 MT CO_2e

OBJECTIVES	NO.	ACTIONS
Materials that can be recycled are recycled	W-1	Ensure compliance with state law requirements for multifamily and commercial property recycling programs
	W-2	Develop an organic waste collection program for City-serviced accounts
Collect all organic waste for composting or clean energy generation	W-3	Partner with private waste haulers to expand organic waste collection community-wide
	W-4	Identify organic waste management options

WHAT CAN YOU DO?

- Upgrade to energy-efficient lighting and appliances and improve building insulation. Seek programs and rebates for conducting energy assessments, installing solar panels, etc.
- Take public transit, bicycle, and walk instead of driving when possible.
- Conserve water by installing water-saving fixtures and adopting behavioral changes, such as reducing shower length, reducing flush frequency, and reusing greywater (e.g., sink to garden).
- Reduce the use of single-use disposables and compost food scraps at home to reduce the waste sent to landfills.
- Replace lawns with native and drought-tolerant gardens and landscaping.
- Use blackout curtains to keep your home cool and be aware of local air-conditioned locations such as cooling centers.
- Prepare your home for flooding by storing sandbags and elevating equipment off the ground or floor. Sign up for Alert Long Beach for flood alert notifications.
- Shop locally at farmers markets, local businesses, and thrift stores to reduce transportation emissions and support the local economy.
- Learn a nutritious, plant-based recipe. Commit to more meatless meals to help reduce the contribution of meat and dairy production to climate change.
- Create an emergency plan with your household. Get to know your neighbors so that all can be better connected in case of an emergency.
- Keep a journal recording your observations of plants and animals near your home. Cultivate a practice of observing the effects of climate change impacts and witness how nature is responding.[1]
- Join an environmental organization that participates in advocacy, community service such as local tree plantings and cleanups, environmental education, and other activities.

[1]Hineline, Mark L. Ground Truth: A Guide to Tracking Climate Change at Home. University of Chicago Press, 2018.

CITY OF
LONG BEACH

1

What is the Climate Action and Adaptation Plan?


CITY OF LONGBEACH
CAAP
Climate Action & Adaptation Plan (CAAP)
SMALL CHANGE
BIG IMPACT
Share your ideas, and join the CAAP conversation on Facebook and Twitter using
#ClimateActionLB
For more information, visit:
www.lbds.info/climateactionlb

1

INTRODUCTION

The City of Long Beach's Climate Action and Adaptation Plan (CAAP) is a comprehensive planning document outlining the City's proposed approach both to address climate impacts on the city and to reduce the city's impact on the climate by reducing greenhouse gas (GHG) emissions. Climate change is already affecting Long Beach residents, businesses, and neighborhoods through extreme weather events like heat waves and flooding, and climate change impacts, such as poor air quality, are projected to worsen in the coming years. Adapting Long Beach to climate change and reducing the City's contribution to its causes are necessary. Planning for climate change is also an opportunity to address structural and systemic inequities that have led to disproportionate environmental burdens on low-income communities and communities of color in the city. Through a coordinated response to climate change that includes addressing public and environmental health disparities, investing in youth, and fostering jobs and economic opportunity, Long Beach can move to a more equitable, low-carbon, climate-resilient future where everyone can live in thriving communities that are built on sustainability and resilience.

This CAAP will guide the City in preparing for and protecting the city and its residents from future climate impacts. At the same time, the CAAP will ensure that the City, all its residents and businesses, and the greater Long Beach community contribute towards both the State of California's climate goals and global efforts to address the climate crisis that the world is facing. The role of cities has never been more important, as cities account for more than 70 percent of GHG emissions globally. The CAAP is an important next step in furthering the City's leadership in sustainability. Through this plan, the City is demonstrating its continued commitment to and leadership in climate action.

By addressing both mitigation and adaptation together, the City has been able to consider how actions can synergistically produce multiple co-benefits. For example, by addressing existing environmental health disparities, the City can improve the quality of life and health of all its residents. The CAAP includes the City's first community-wide GHG inventory and climate vulnerability assessment, which provided the fundamental local data and information from which the CAAP's actions were developed.

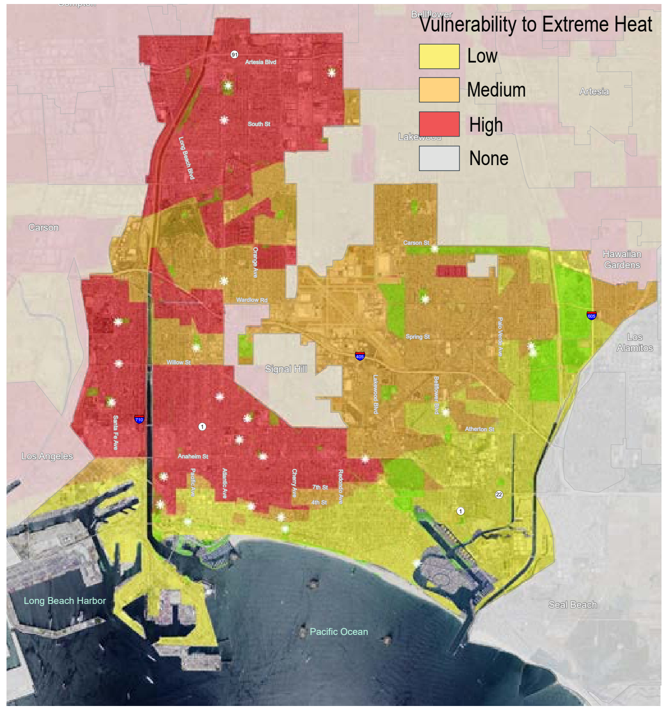
The CAAP includes a roadmap for implementing new polices, programs, incentives, requirements, projects, and initiatives in the immediate future, as well as longer-term actions that will need to be studied further while monitoring how the climate continues to change and evaluating the effectiveness of actions taken.

WHAT IS CLIMATE ACTION?
WHAT IS CLIMATE ADAPTATION?
WHAT IS SUSTAINABLE PLANNING?

Climate action (sometimes referred to as mitigation) refers to actions taken to address the causes of climate change and reduce the impacts we (people) have on the climate system by reducing our future GHG emissions. Climate change is already taking place, and climate adaptation refers to adjusting our behaviors, systems, and infrastructure to reduce the impact that the effects of climate change, such as heat waves, worsening air quality, and flooding, will have on infrastructure, services, and the well-being of the community. In addition to addressing these challenges, the CAAP will enable the City to continue to be at the forefront of sustainable planning. Sustainable planning is about meeting the needs of the present without compromising the future.

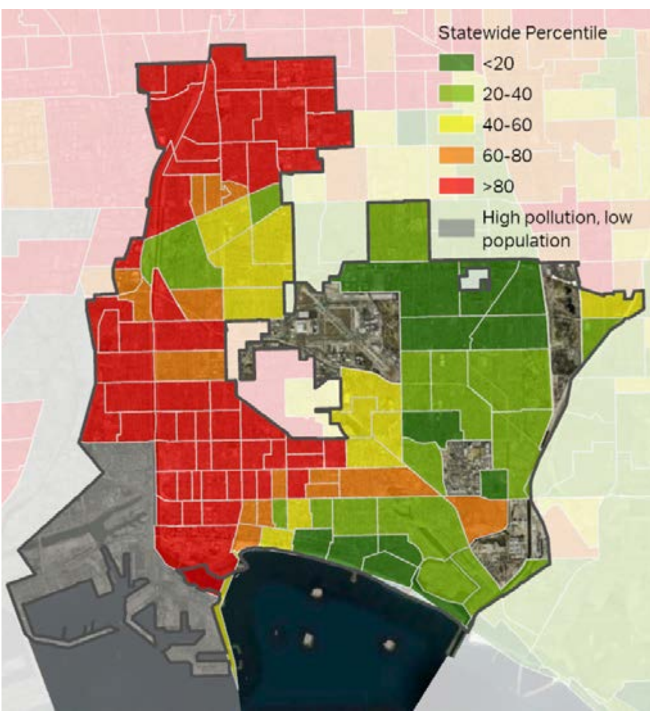
Sustainable Planning in an Environmental Justice Context:

Although climate change will impact all of Long Beach, some of the city's communities already experience disproportionate environmental health burdens today. Long Beach is very diverse, which can be a source of strength, vibrancy, and resilience. However, it also has racial and economic disparities that are manifested spatially across the city. Tools such as CalEnviroScreen help identify the California communities that are most affected by many sources of pollution and the areas where people are often especially vulnerable to pollution's effects. For Long Beach, CalEnviroScreen shows how Central, West and North Long Beach experience some of the highest pollution impacts in California. It reveals that many areas are worse off than 95 percent of the state. Only 2.2 miles away, communities in eastern Long Beach face a less cumulative burden than 85 percent to 90 percent of the state. Extreme heat stemming from climate change is expected to affect the greatest number of people in Long Beach, and its impacts are more concentrated in Central, West, and North Long Beach.

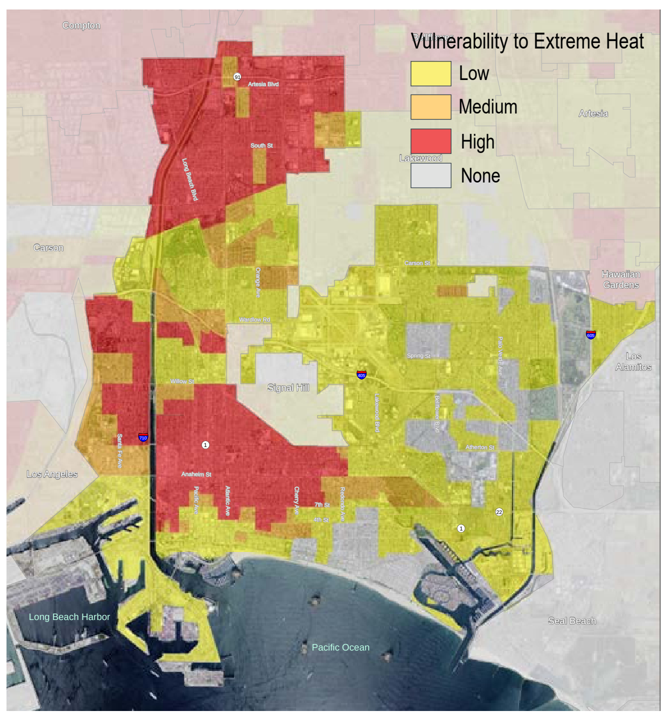


Sensitivity to extreme heat related to the Urban Heat Island Effect from Climate-Smart Cities Los Angeles Project

Figure 1: Maps showing social vulnerability



Output from CalEnviroScreen 3.0



Social Vulnerability from Climate-Smart Cities Los Angeles Project

It is no coincidence that the populations living in these areas tend to be low-income communities of color. Low-income communities and communities of color in Long Beach are more likely to live in areas with poor air quality, in regions with little green space, and along the Los Angeles River channel where the risk of urban flooding is expected to increase. These geographic patterns exist due to socioeconomic inequality caused by long-standing discriminatory practices in education, housing, employment, local political representation, and access to resources. Low-income communities of color were historically excluded from neighborhoods with less environmental pollution and greater public investment, and these practices partly explain why low-income communities of color today are still concentrated in the portions of the city with the poorest air quality and environmental health indicators. Looking further back, it is important to acknowledge that the land that became the city of Long Beach, like other cities throughout the region, state, and the country, was originally occupied by Indigenous Peoples, in particular, the Tongva/Gabrieleño and Acjachemen/Juaneño Nations. We should recognize them as the first stewards and traditional caretakers of this area we now call Long Beach.

Inclusive planning is based on meaningful community engagement and strategies to address social inequities. While the CAAP development process reached out to people throughout the city, it placed a significant focus on reaching those communities most impacted by climate change, including young people and communities of color. The CAAP's strategies for inclusive planning included:

- Partnering with youth groups, schools, and community-based organizations to engage and solicit input from the communities most impacted by climate change
- Providing healthy and sustainable food at events and giveaways that raise environmental awareness and promote sustainability, including the use of reusable straws and bags, air filters and emergency kits
- Providing health and dental screenings and access to the wide-ranging resources and services of government and educational institutions at CAAP events
- Acknowledging native lands at CAAP events
- Facilitating co-learning processes to identify issues, priorities, and solutions, such as best practices from people's lived experiences
- Conducting CAAP outreach in the places where people already gather, including health fairs and community and cultural events
- Drawing from and identifying culturally relevant examples of best practices locally and globally from Latin America and Asia
- Using iterative and two-way, culturally competent and multilingual engagement
- Using art and other creative strategies for engaging a broader audience for both in-person and online engagement opportunities

For more details, see the Community Engagement section of this chapter and the Community Engagement appendix.

This plan is based on the knowledge and insight gained from the community and these inclusive planning strategies, and every action in the CAAP includes an Equity Strategy or strategies for guiding equitable implementation of CAAP actions. To ensure successful implementation of the CAAP, continued engagement, co-learning, and assessment of equity strategies are ongoing objectives.

WHY DO WE NEED THE CAAP?

According to research compiled by the UCLA Fielding School of Public Health, climate change is not only already impacting our health in Los Angeles County, but will continue to impact our social, cultural, and natural resources as extreme climate events—heat waves, floods, storms, and droughts—become more frequent and powerful. That meta-analysis showed that 97 percent of climate experts agree that humans are causing climate change.i Therefore, the CAAP is needed to help prepare and protect Long Beach from climate change while reducing future GHG emissions.

The CAAP will also help the City comply with various local, regional, state, and federal regulations to significantly reduce emissions. The City is obligated under the California Environmental Quality Act, Assembly Bill 32 (The California Global Warming Solutions Act of 2006), Senate Bill (SB) 375 (The Sustainable Communities and Climate Protection Act of 2008), and various California Executive Orders to do its part to reduce GHG emissions. Generally, statewide targets aim to reduce emissions to 1990 levels by 2020, to 40 percent below 1990 levels by 2030, and to 80 percent below 1990 levels by 2050. California SB 379 requires cities and counties to include climate adaptation and resiliency strategies in their General Plans to ensure the safety and protection of their communities in the future.

Finally, the CAAP will help the City meet its various voluntary climate commitments. In November 2015, Long Beach Mayor Robert Garcia signed an official commitment to the Compact of Mayors (now called the Global Covenant of Mayors for Climate and Energy), a global coalition to collectively reduce GHG emissions and enhance resilience to climate change. In order to comply with the Global Covenant's requirements, the City of Long Beach must establish a plan for climate action and a plan for adaptation. In addition, in 2017 Mayor Garcia joined 406 mayors across the United States in pledging to continue the goals of the Paris Climate Agreement to make sustainable changes to limit global temperature rise to well below 2 degrees Celsius (2°C), and in 2019 Mayor Garcia encouraged the City to achieve a 2045 carbon neutrality goal.

The CAAP is an important next step in furthering the City's leadership in sustainability. Environmental sustainability entails understanding the limitations of our finite resources (e.g., water, fossil fuel, natural gas), and adopting practices that limit or eliminate waste and pollution. Long Beach has already adopted significant green and sustainable approaches to improve the health of residents, businesses, neighborhoods, and the natural environment.

The CAAP will provide a roadmap for Long Beach to continue towards its goal of a more environmentally healthy, economically prosperous, and equitable city. The plan will include a prioritized list of policy, infrastructure, and programmatic needs that will be pursued to reduce the city's carbon footprint and prepare for the impacts of climate change.

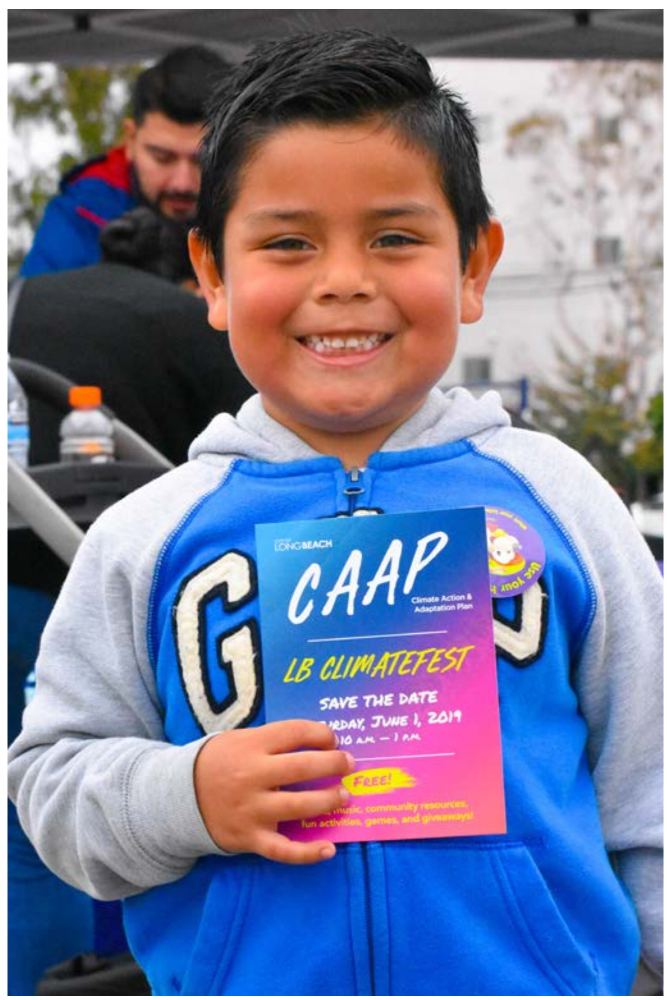
WHAT IS OUR COMMUNITY VISION AND MISSION FOR THE CAAP?

The vision of the Long Beach CAAP is to create a more sustainable, resilient, and equitable city by addressing climate change in a way that also addresses existing environmental health disparities while improving health and quality of life and enhancing economic vitality throughout Long Beach.

The CAAP process has been driven by a mission to:

- **Create** an inclusive, community-centered planning process to broadly engage the Long Beach community, paying particular attention to those most affected by climate change, including low-income communities and people of color, youth, and older adults.
- **Communicate** climate change impacts in Long Beach by meeting residents and community members where they already gather, such as community events, cultural festivals, senior centers, schools, and trusted community organizations.
- **Build capacity** to co-define solutions and priorities to inform the CAAP.
- **Collaborate** with internal (City departments) and external stakeholders (community members, business community, neighborhood associations, the scientific community).
- **Commit** to ensuring that the Long Beach community and its physical assets are better protected from the impacts of climate change.

Long Beach has already taken a significant green and sustainable approach to improving the health of residents, businesses, neighborhoods and the natural environment. For example, Long Beach was one of the first cities to create a Port Clean Air Action Plan (the 2006 San Pedro Bay Ports Clean Air Action Plan), a Sustainable City Commission (2007), an Office of Sustainability (2008), a Sustainable City Action Plan (2010), and a commitment to the Compact of Mayors (2015). As a result, the City has been in the process of incorporating sustainability in all major policies to build resilience and ensure Long Beach thrives for the next 100 years and beyond. The City has also focused on creating sustainable land use and transportation systems. The City's Mobility Element, adopted in 2013, focuses on providing active transportation options throughout Long Beach neighborhoods. The City has made significant investments in bicycle, pedestrian, and transit-supporting infrastructure in recent years. The City's General Plan Land Use Element update, adopted in 2019, supports this progress by promoting land use patterns that concentrate density around transit and promote active transportation through a mix of uses and careful urban design.

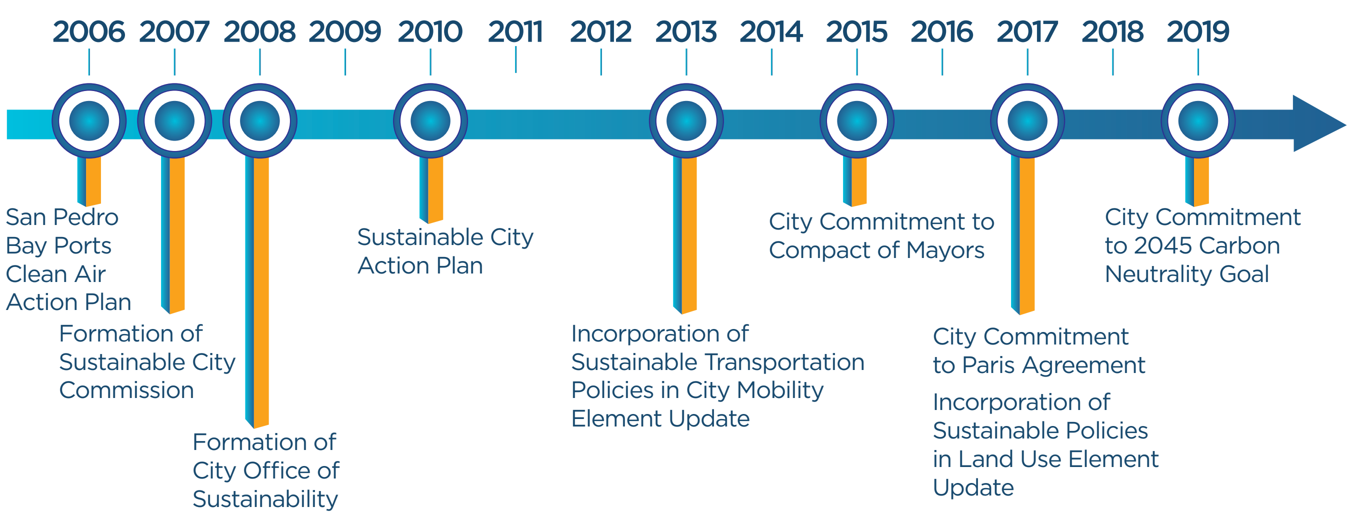


PLAN GOALS

Based on community input throughout the CAAP development process, the following goals were established:

- Be inclusive and incorporate the views of the entire community while prioritizing populations that are vulnerable to and disproportionately impacted by climate change.
- Create a healthier community by addressing climate change.
- Consider social, environmental, and economic co-benefits holistically.
- Empower young people to be leaders in creating a more sustainable community.
- Invoke a personal sense of responsibility in residents and businesses.
- Create an actionable plan (with the right balance between innovation and practicality).
- Distinguish Long Beach as a leader in climate mitigation and adaptation planning.

Figure 2 The CAAP builds upon a history of local sustainability accomplishments



* The San Pedro Bay Ports Clean Air Action Plan was subsequently updated in 2010 and 2017.

HOW DOES THE CAAP ALIGN WITH STATE POLICIES?

One of the drivers behind the Plan is to align with the various existing State policies guiding cities on how they can contribute to the overall State goals around climate change. The key policies are highlighted below.

RENEWABLE ENERGY

Senate Bill 1078 - California Renewables Portfolio Standard Program (2002)

Established the California Renewables Portfolio Stndard Program, which required electric utilities to meet 20 percent of their renewable power by December 31, 2017.

Senate Bill 350 - Clean Energy and Pollution ReductionAct (2015)

The latest in a series of updates to California's Renewables Portfolio standard Program, which requires retail sellers and publicly owned energy utilities to procure 50 percent of their electricity-from eligible renewable energy resources by 2030

CLIMATE CHANGE ADAPTATION

Assembly Bill 691 - State lands: granted trust lands: sea level rise (2013)

Requires local holders of public trust lands, including all coastal areas and tidelands, to assess the impacts of sealevel rise and describe how the local trustee intends to protect those lands in a report to the Califronia State Lands Commission.

Senate Bill 379 - Land Use: General Plan: Safety Element (2013)

Requires local governments to include climate adaptation and resiliency strategies, including a vulnerability assessment and implementation measures, in the Safety Element of their General Plans.

CLIMATE ADAPTATION ACTION PLAN

EMISSIONS REDUCTION TARGETS

Senate Bill 32 - California Global Warming Solutions Act (2016)

Updates AB 32, requiring California to reduce greenhouse gas emissions to 40 percent below 1990 levels by 2030.

Executive Order-B-30-15 (2015)

Updated existing statewide green house gas emissions reduction goals to 40 percent below 1990 levels by 2040, and 80 percent below 1990 levels by 2050.

Assembly Bill 32 - California Global Warming Solutions Act (2006)

California's landmark climate change mitigation legislation set initial statewide greenhouse gas emissions targets and directs the California Air Resources Board to periodically update a Scoping Plan to outline the State's plan for achieving emissions reductions. The 2017 Scoping Plan Update recomments local government goals of 6 metric tons $C0_2e$ per capita by 2030 and 2 metric tons CO_2e per capita by 2050.

TRANSPORTATION & LAND USE

Senate Bill 743 - California Environmental Quality Act (CEQA) Transportation Impacts (2013)

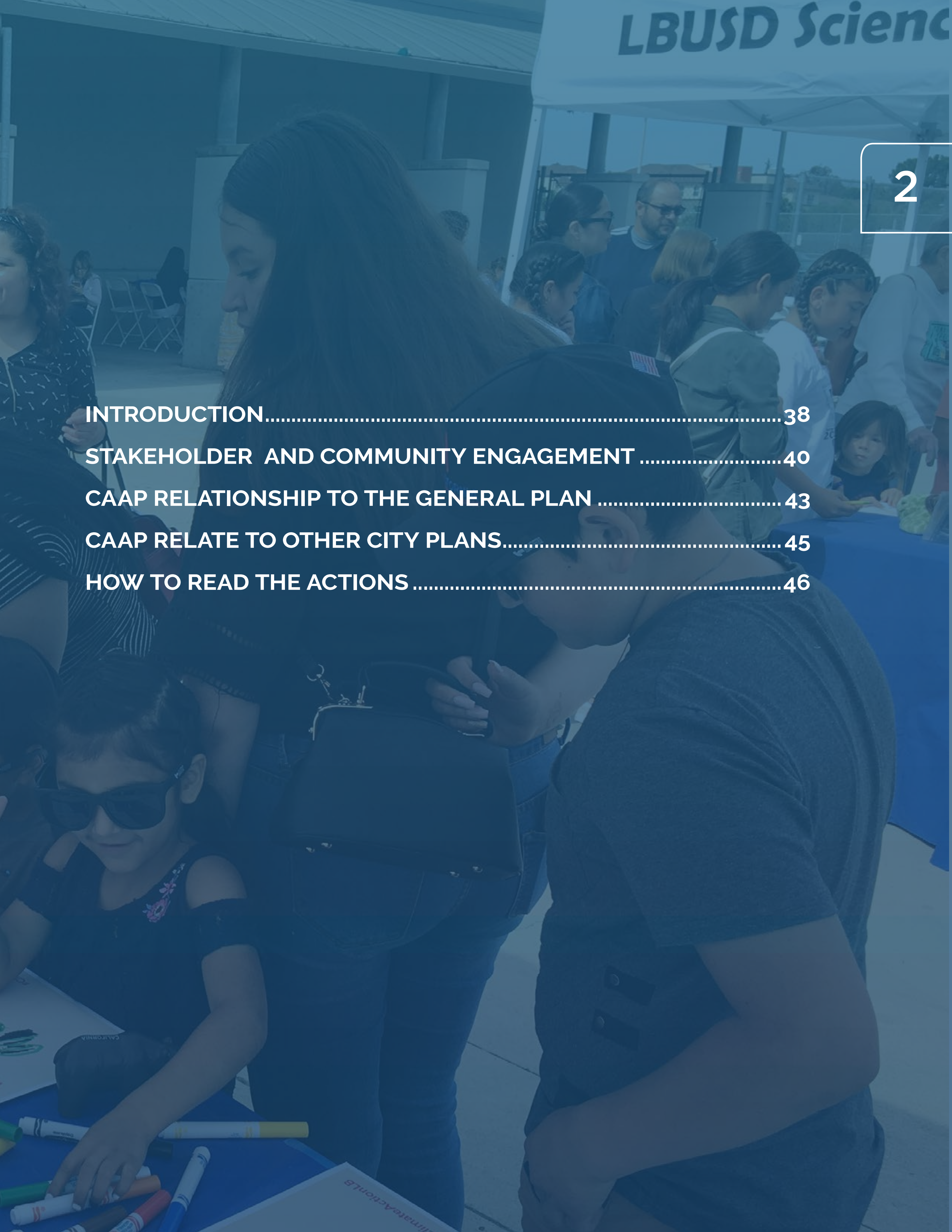
This legislation mandated a change (implemented in 2019) in the focus of tranportation impact analysisin CEQA from measuring impacts to drivers to measuringthe impact of driving, in order to promote the reductionof greenhouse gas emissions and the development of multimodal transportation networks.

Senate Bill 375 - Sustainable Communities and Climate Protection Act (2008)

Directs the California Air Resources Board to set regional targets for the reduction of greenhouse gas emissions anddirects each metropolitan planning organization in the state to develop an integrated land use and transportationstrategy with the goal of reducing greenhousegas emissions.

CITY OF
LONG BEACH

2 How was the CAAP Developed?



2

INTRODUCTION

The CAAP was developed by the City in partnership with the community over more than 3 years, following the steps shown in the illustrations below for the climate adaptation planning and climate mitigation planning processes. Community and stakeholder engagement, which was an integral part of the CAAP development process, is also described in this chapter.

Climate Adaptation Process

1+2+3 Review Science, Inventory Assets and Operations, and Assess Vulnerability: Critical city assets were assessed for vulnerability to sea level rise (SLR), precipitation, wildfire, and extreme heat. See Chapter 3 for further details.

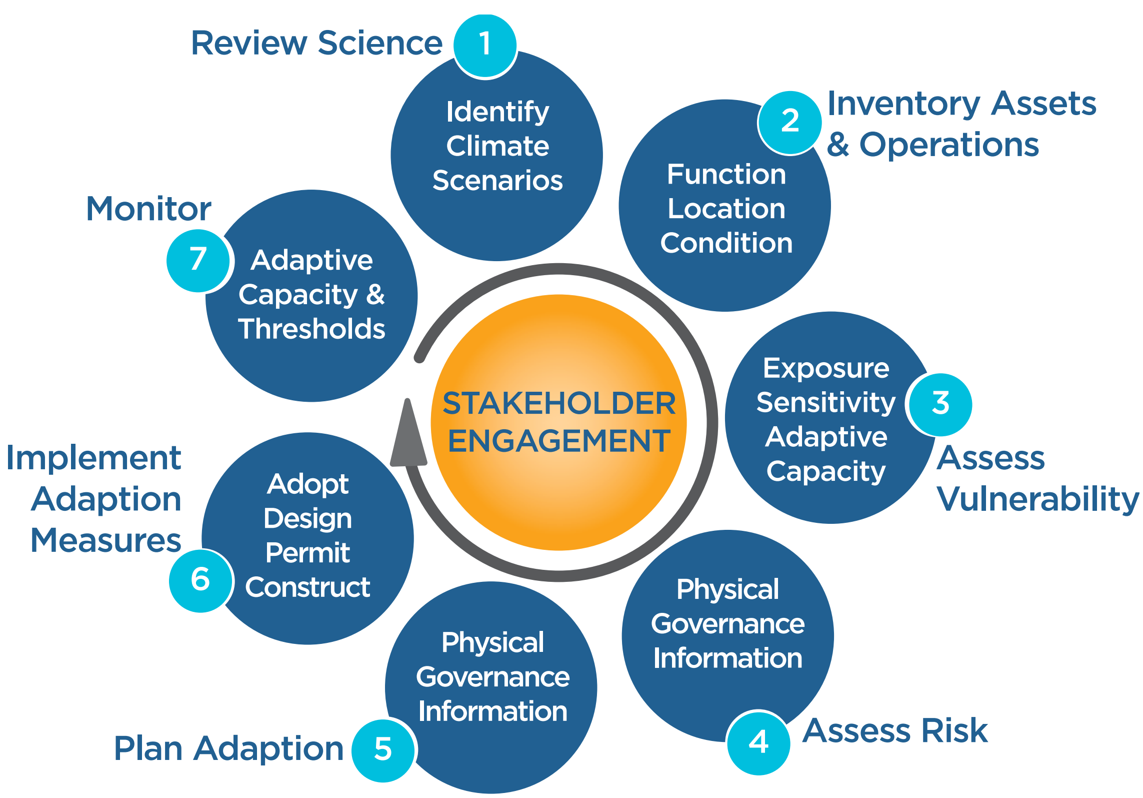
4. Assess Risk: Once vulnerabilities had been identified, their health, safety, and economic consequences were assessed in line with State requirements. See Chapter 3 for further details.

5. Plan Adaptation: With input from stakeholders, the community, and City departments, a long list of actions was developed to adapt critical assets and neighborhoods to climate impacts. These were then prioritized using community and City input, in line with a set of performance criteria/guiding principles developed for the actions. See Chapter 4 for the full set of adaptation actions selected for the CAAP.

6. Implementation: For short-term actions, initial implementation steps have been identified. These actions are part of each action write-up in Chapter 4.

7. Monitor: Given the evolving nature of climate science and observed climate changes, the City will monitor updates on a regular basis as well as the performance of early implementation measures. See Chapter 8 for more details.

Figure 3: The Climate Adaptation Process



Climate Mitigation Process

1+2+3 Greenhouse Gas Inventory, Forecast of Projected Emissions, and Reduction Target: The City carried out its first GHG inventory for this Plan to understand which sectors will need to be focused on. See Chapter 5 for further details.

4. Analysis of Existing Actions: The City reviewed all current existing actions and initiatives that are contributing to mitigation and adaptation to understand the baseline to build from.

5. Action Development: With input from stakeholders, the community, and City departments, a long list of actions was developed that could provide GHG reductions. These were then prioritized using community and City input, in line with a set of performance criteria/guiding principles developed for the actions. See Chapter 6 for the full set of mitigation actions selected for the plan, and Chapter 7 for City leadership and financing strategies.

6. Strategy Implementation: For short term actions, initial implementation steps have been identified. These can be found as part of each action write up in Chapter 6.

7. Monitoring and Measuring: Performance towards the City's GHG reduction target will be monitored in part by regular GHG inventories. See Chapter 8 for further details.

Figure 4: The Climate Mitigation Process

GHG = Greenhouse Gas

STAKEHOLDER AND COMMUNITY ENGAGEMENT

Stakeholder engagement was key to the process and had two main components – first, working with a series of stakeholder working groups, and second, extensive public outreach. The City is grateful to all those who provided input. Input from the scientific community input is reflected in the climate science, vulnerability assessment, and other technical appendices. Community input is reflected in the plan's vision and goals, the policies and strategies that have been included and prioritized, and the way in which various actions are anticipated to be implemented.

Stakeholder Working Groups – Incorporating Local Expertise

Three stakeholder working groups were convened throughout the process:

- **A Scientific Working Group** was convened three times to validate the project methodology, to provide feedback and input on local data, and to review results and early actions. The Scientific Working Group included 13 independent experts from California State University, Long Beach; Long Beach Community College; the University of California, Los Angeles; the Aquarium of the Pacific, the South Coast Air Quality Management District, and RAND Corporation.
- **A Business Working Group** was convened twice to provide input on their climate-related concerns, existing actions, and future opportunities. The group included approximately 30 attendees from 24 businesses, including architecture, engineering, utilities, sustainability consultants, and various other local businesses. Among the firms represented were firms large and small, global and local. The group also consulted with business association leaders and the Chamber of Commerce.
- **A Community Working Group** was convened twice to provide input on the public engagement approach, climate-related concerns, and actions. The group included about 20 representatives from local community groups.

Public Outreach – Listening to You

In addition to the stakeholder working groups, the proposed CAAP has also been informed by an extensive public engagement process, which reached out to almost 10,000 residents at more than 60 events, including community meetings, open houses, resource fairs, and expert panel discussions hosted throughout the city.

Early in the engagement process, staff set out to create an inclusive, community-centered planning process to broadly engage the Long Beach community, but with particular attention to those most affected by climate change. The community engagement strategy for the CAAP was based on an equity assessment conducted in partnership with other City departments, including Long Beach Parks, Recreation, and Marine, and the Health and Human Services Department.

Throughout the outreach process, staff has held various CAAP presentations and activities in collaboration with the City Council offices and other community partners. By "meeting people where they are," (e.g., at community events, cultural festivals, neighborhood association meetings, faith-based organizations) the City made a concerted effort to engage Long Beach residents and community members and to solicit their input on the CAAP while sharing data and information about local climate science projections and climate change vulnerabilities in Long Beach. Through partnerships with community-based organizations, environmental groups, and educational institutions, the City has been able to reach out to youth, multilingual communities, and older adults. Here are a few highlights:

Open House Events

The City hosted three open house events at key points in the engagement process to share information being developed for the CAAP (e.g., the greenhouse gas (GHG) emissions inventory, the vulnerability assessment, and mitigation and adaptation actions) and to engage the public on the topic of climate change in Long Beach. Each open house was held in a different geographical area of the city. Each included a sustainability resource fair, with information and resources from various City departments and public agencies, and distributed free food and environmental giveaways such as tote bags and reusable straws. LB ClimateFest (Open House #3), held at Marine Stadium, included distribution of the draft plan, a showcase of environmental projects from local students and emerging leaders, and chalk art of a sea level rise scenario drawn on the ground to engage attendees on the impacts of SLR in Long Beach.

Figure 5: Summary of Community and Stakeholder Engagement

10,260 TOTAL estimated participants

1,395 sign-ins

67 events

#1 OPEN HOUSE

200 ESTIMATED PARTICIPANTS

98 sign-ins

- Validate the project methodology;
- Provide feedback and input on local data;
- Review results and early actions.

#2 OPEN HOUSE

200 ESTIMATED PARTICIPANTS

97 sign-ins

- Provide input on climate-related; their concerns
- Review existing actions;
- Recommend future opportunities.

#3 OPEN HOUSE Long Beach ClimateFest

500 ESTIMATED PARTICIPANTS

107 sign-ins

- Input on the public engagement approach;
- Provide input on Climate-related concerns;
- Review proposed actions.

Panel Discussions

In partnership with local organizations, the City hosted panel discussions on extreme heat and SLR. Both events covered an overview of the CAAP, specific climate hazards and their impacts in Long Beach, and strategies for keeping residents safe and healthy during extreme weather events.

Multilingual Outreach

Through partnerships and early conversations with community-based organizations and local leaders, staff co-created culturally appropriate activities and ideas for collaboration to implement at community resource fairs and other community events. Through the outreach process, staff continued to evaluate engagement approaches to make them more linguistically and culturally appropriate and to further strengthen relationships between the City and local communities. Interpretation services were available at all CAAP public workshops and events.

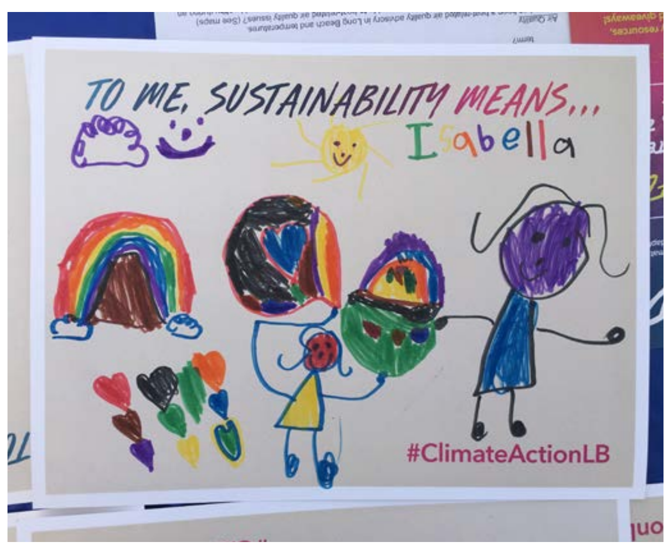
Engaging Youth Leaders

Recognizing that young people will be those most impacted by climate change in the long term, the City partnered with youth leadership programs and local schools across Long Beach to engage youth and emerging leaders in developing the CAAP. As part of this effort, the City partnered with California State University, Long Beach; Long Beach City College; Long Beach Unified School District; St. Anthony's High School; Youth Leadership Long Beach; and Aquarium of the Pacific youth volunteers.

Art, Creativity, and Online Engagement

Art and creativity were central to engaging children and their families. For example, at community resource fair events, staff used drawing prompts like "To me sustainability means..." to encourage children and their families to draw ways that climate change is affecting them at home or to share strategies they have implemented at home or at school to reduce their carbon footprint. In addition, to supplement in-person outreach, staff connected with residents and community members digitally through periodic e-newsletters and on social media using hashtags such as #CAAPLB and #ClimateActionLB. Easy to understand, animated videos and infographics were created to further explain what the CAAP is and why the City is developing it.

The Community Engagement Appendix provides more details on the outreach process.



CAAP RELATIONSHIP TO THE GENERAL PLAN

The CAAP is being incorporated into the Long Beach General Plan as a mitigation measure of the Land Use Element. Recognizing that the State of California obligates the City to create opportunities for increased housing and jobs to meet the needs of a growing population, the CAAP outlines requirements, incentives, and potential policies to ensure more sustainable development.

In order to meet their obligations under state law, local governments may prepare a Plan for Reduction of Greenhouse Gases that is consistent with Assembly Bill 32 and Senate Bill (SB) 32 goals. The development of such a plan can be used to streamline the GHG analysis for future plans and projects undergoing review pursuant to Section 15183.5 of the California Environmental Quality Act (CEQA). CEQA review of subsequent plans and projects that are consistent with the GHG reduction strategies and targets in the CAAP may take advantage of CEQA streamlining. This approach allows jurisdictions to address GHG emissions at a community-wide level to determine the most effective and efficient methods to reduce them, to identify the reduction measures that would promote the goals of the General Plan, and to employ the reduction measures that have the most co-benefits (for improving mobility and access, increasing local economic development, reducing household and business utility and transportation costs, improving public health).

Therefore, the CAAP has been included as a mitigation measure in the General Plan Land Use Element update, and the CAAP will be used as the basis for future assessments of consistency with this plan in lieu of a project-specific GHG CEQA analysis for future projects. A project-specific environmental document that relies on this plan for its cumulative impacts analysis would identify specific reduction measures applicable to the project that are consistent with the CAAP; it would also describe how the project incorporates those measures. If the measures are not otherwise binding and enforceable, they must be incorporated as mitigation measures or project conditions of approval, or as some other mechanism to ensure implementation. Each of the actions described in the CAAP provides details on implementing the GHG reduction strategies, including the party or parties responsible for implementation. The actions in the CAAP include the GHG reduction strategies that apply to the City itself. For each action that is related to development projects, the City will determine whether: (a) the project is consistent; (b) the project with conditions would be consistent; (c) the strategy is relevant for new development, but not the subject project; or (d) the project includes one or more replacement strategies that would be equally or more effective in reducing GHG emissions, and such replacement strategy or strategies are not included in the CAAP or required by any other regulation, standard, design criteria, or other existing requirement.[ii] See Chapter 8 for a more detailed explanation of action implementation and monitoring to ensure the City achieves its adopted GHG target.

To meet the standards of a qualified GHG reduction plan, Long Beach's CAAP must achieve the following criteria (which elaborate upon criteria established in State CEQA Guidelines Section climate mitigation 15183.5[b][1]):

- Complete a baseline emissions inventory and project future emissions.
- Identify a community-wide reduction target.
- Prepare a CAP to identify strategies and measures to meet the reduction target.
- Monitor the effectiveness of reduction measures and adapt the plan to changing conditions.
- Adopt the CAP in a public process following environmental review.

The CAAP addresses each of these recommended plan elements, as summarized below.

Chapter 5 includes the GHG inventory and presents the 2015 base year emissions inventory and forecasts, the City's 2030 emissions target, and the 2045 aspirational goal to achieve net carbon neutrality. Chapter 6 contains three subsections, one for each CAAP emissions sector area, that describe the reduction actions that will be implemented to achieve the GHG targets. Chapter 7 includes City leadership, funding, and financing strategies, and Chapter 8 describes the City's process for monitoring, evaluating, and revising the CAAP to ensure that the estimated strategy reductions do occur so that the targets are achieved. As part of its CAAP, the City has included an adaptation plan that identifies strategies the City will pursue to adapt to and protect against major anticipated climate change impacts — extreme heat, worsening air quality, drought, and SLR and flooding. See Chapter 4 for the mitigation and adaptation strategies.

In addition to CEQA streamlining, the CAAP is included as part of the General Plan in order to meet the requirements of SB 379, which states that cities and counties must include climate adaptation and resiliency strategies in their General Plans to ensure the safety and protection of their communities. In addition, through the CAAP process, information was gathered to develop a report to comply with SB 691, which requires local planning to address SLR in the Tidelands area, and to comply with SB 1000, which requires local governments to identify disadvantaged communities and address environmental justice in their General Plans.

Incorporating the CAAP into the General Plan is important because the City Council and Planning Commission use the goals and policies of the General Plan as the basis for making decisions, determining long-term objectives, generating and evaluating budgets, planning capital improvements, and prioritizing tasks.

HOW DOES THE CAAP RELATE TO OTHER CITY PLANS?

Many City plans touch on issues that are covered in this CAAP, and all City departments worked closely with the City's Planning Bureau to ensure alignment as part of the CAAP development process. The table below identifies these City relationships and the synergies among the various City plans.

Table 1: How the CAAP relates to other city plans

Organization	Plan	Date	Summary/Connection
Relevant City of Long Beach Plans			
City of Long Beach	General Plan – Land Use Element	2019	Addressing and adapting to climate change is one of the stated goals of the Land Use Element, which will directly and indirectly reduce GHG emissions though transit-oriented development and mixed-use development, increased active transportation, promotion of green technology, and establishment of sustainable development goals and policies.
City of Long Beach	Hazard Mitigation Plan	2017	Details the City's vulnerability to earthquakes, floods, windstorms, tsunamis, public health crises, technological disasters, and drought, along with strategies to mitigate disasters before they strike.
City of Long Beach	General Plan – Mobility Element	2013	Includes complete streets and multimodal transportation policies that have the potential to reduce GHG emissions from private vehicles.
City of Long Beach	Sustainable City Action Plan	2010	Targets reductions and implementation steps for municipal and private buildings, municipal vehicles, solid waste, and water use.
City of Long Beach	Local Coastal Program*	1980	Contains ground rules for development and protection of coastal resources in the Long Beach coastal zone.
Relevant Port of Long Beach Plans			
Port of Long Beach	Master Plan Update	In Progress	Outlines strategic goals, operational initiatives and environmental policies, and evaluates the consistency of future developments and land uses with those goals, initiatives, and policies.
Port of Long Beach and Port of Los Angeles	San Pedro Bay Ports Clean Air Action Plan**	2017 Update	Sets port-related GHG reduction targets for 2030 and 2050. Strategies proposed include establishing incentive programs for efficient ships, installing shore power infrastructure, revamping the Clean Trucks Program, and encouraging cleaner and more efficient locomotives and harbor craft.
Port of Long Beach	Climate Adaptation and Coastal Resiliency Plan	2016	Sets forth vulnerability assessment and adaptation strategies to protect Port assets from future climate stressors, including extreme heat, storm surge, and sea level rise.

* The Local Coastal Program will be updated to reflect the Land Use Element and the CAAP.

** The initial San Pedro Bay Ports Clean Air Action Plan was adopted in 2006 and updated in 2010; the current iteration followed in 2017.

HOW TO READ THE ACTIONS

The following graphic outlines the content of each action in Chapter 4: Adaptation Actions and Chapter 6: Mitigation Actions. The actions described will be implemented across time frames and with a range of partners. The actions will reduce GHG emissions and climate vulnerability and provide many co-benefits for Long Beach.

EH-1 Increase presence of cool roofs and cool walls

Increase the installation of cool roofs and cool walls to keep buildings and neighborhoods cooler.

Implementation Lead: Development Services
Partners: Long Beach Department of Health and Human Services; City of Long Beach Office of Sustainability; SCE; Long Beach Parks, Recreation, and Marine
Timeline: Short, Medium, and Long
Potential Cost Level: Low

Description

The City will consider instituting a requirement that cool roofs be used on new and replaced commercial and residential roofs. The City will also develop a process for assessing the feasibility of cool and green roofs on future development projects and existing candidate buildings, focusing on neighborhoods that would benefit most from reduced temperatures and additional green space. While this action provides broader public health and quality of life benefits, populations most impacted by climate change, especially the sick, the young, and the elderly and low-income communities stand to benefit the most.

Cool roofs and walls are made of materials that help reflect the sun's energy, such as light-colored paints, roof tiles, coatings and shingles. Such materials effectively reduce the amount of the sun's energy that enters a building. This keeps homes and businesses cooler, and reduces the amount of additional cooling that may be needed to keep internal air temperatures at a healthy level (particularly during heat waves). Reflective surfaces also lower temperatures in the surrounding neighborhood. Green roofs are covered partially or completely with living plants. Their benefits include cooler buildings, reduced GHG emissions, and reduced stormwater runoff.

Co-benefits:

- ✓ Improved air quality
- ✓ Increased thermal comfort
- ✓ Reduced energy use and increased cost savings
- ✓ Reduced GHG emissions

Implementing Actions

EH-1.1: Update the building code to mandate the installation of cool roofs on all new and retrofitted roofs.

EH-1.2: Explore opportunities to incentivize the establishment of cool roofs on existing roofs. Explore the feasibility of incentivizing the use of green roofs on new and existing roofs, focusing on areas with a high urban heat island effect and taking CalEnviroScreen and other relevant factors into consideration.

EH-1.3: Conduct education and outreach about cool roofs and the associated resources and incentives for commercial businesses, residents, and roofing companies that operate within the city.

Equity Strategy

Prioritize neighborhoods that are most impacted by extreme heat, focusing on communities burdened with the poorest air quality.

PARTNERS
The City departments and other organizations that will support the implementation of the action.

TIME LINE
Short (0-2 years)
Medium (2-5 years)
Long (5+ years)

COST
Rough order of magnitude costs;
Low ($0-$150k)
Medium ($150k-$1M)
High ($1M+)

DESCRIPTION
Brief description of the action. Further details may be found in Appendix B.

CO-BENEFITS
The additional benefits the action may provide in addition to GHG emission reductions or reduction in climate vulnerability.

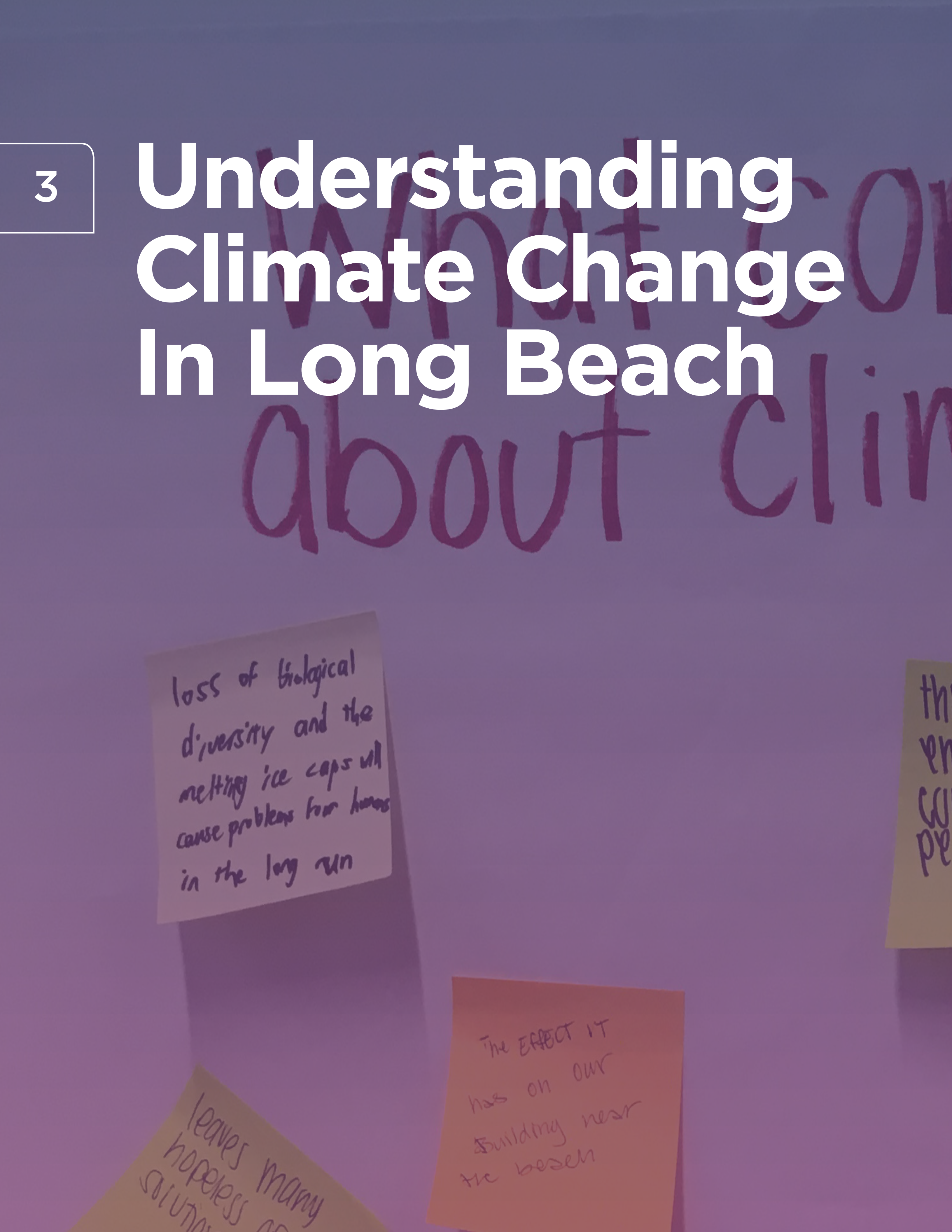
ACTIONS
The specific steps needed for the action to be implemented.

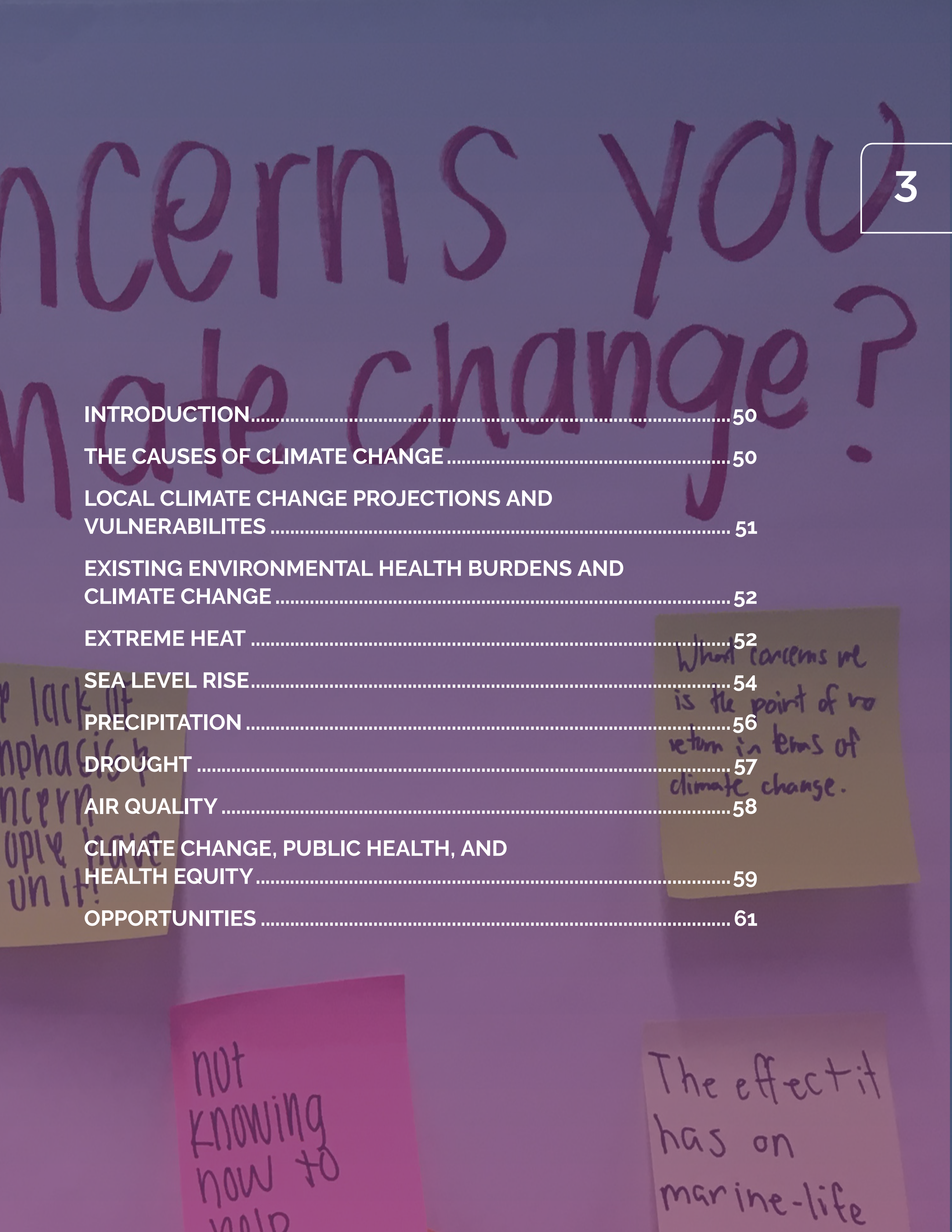
EQUITY STRATEGY
Summary of how the action will attempt to address inequities in Long Beach.

CITY OF
LONG BEACH

3

Understanding Climate Change In Long Beach

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nate change?
What concerns me is the point of no return in terms of climate change.
not knowing how to
The effect it has on marine-life

INTRODUCTION

Preparing Long Beach for climate change presents both daunting challenges and significant opportunities. It will require changes to many things we take for granted—how we power our homes, how we get around, how businesses and industry are run, how and where buildings get built, what we consume, and what we throw away.

But rather than an inconvenient necessity, reducing our contribution and adapting the city to climate change calls for addressing the structural and systemic inequities in our community in order to realize a vision of Long Beach where everyone has the opportunity to live in thriving communities built on sustainability and resilience. Through implementing a coordinated response to climate change, we can help move Long Beach towards a more equitable, low-carbon, climate-resilient future.

This chapter begins with a brief explanation of the science behind climate change and summarizes the local impacts that are expected in Long Beach. It highlights the City's primary vulnerabilities and the communities that are particularly vulnerable due to socioeconomic, racial, and environmental health disparities. Finally, it concludes with a discussion of the economic, social, and environmental co-benefits associated with climate change adaptation and mitigation.

THE CAUSES OF CLIMATE CHANGE

The earth's habitable climate is maintained by the Greenhouse Effect – a blanket of gases that trap heat in the atmosphere and keep surface temperatures relatively stable. Greenhouse gases (GHGs) trap warmth generated from solar radiation, much as a car or a greenhouse heats up in the sun.

If it were not for these gases, the earth's surface would be frigid and we would have no air to breathe. However, since the Industrial Revolution in the mid-1800s, human activities, such as the burning of fossil fuels and the conversion of natural lands into agriculture and settlements, have resulted in the release of additional GHGs into the atmosphere at an unprecedented rate.

Major GHGs include:

- **Carbon Dioxide (CO_2) –** generated from the burning of fossil fuels or organic matter
- **Nitrous Oxide (N_2O) –** a byproduct of the burning of fossil fuels and the fertilization of crops
- **Methane (CH_4) –** created from the decomposition of waste and off-gassing from livestock
- **Chlorofluorocarbons (CFCs) –** originally released into the atmosphere as refrigerants, propellants, and cleaning solvents, but now illegal under international law due to their impact on the ozone layer; past emissions remain in the atmosphere for several years to more than a thousand years, depending on the CFC
- **Hydrofluorocarbons (HFCs) –** now used as a substitute for CFCs because they do not contribute to ozone depletion, but do contribute to global warming
- **Perfluorocarbons (PFCs) and Sulfur hexafluoride (SF6) –** byproducts of industrial processes, including aluminum production

LOCAL CLIMATE CHANGE PROJECTIONS AND VULNERABILITIES

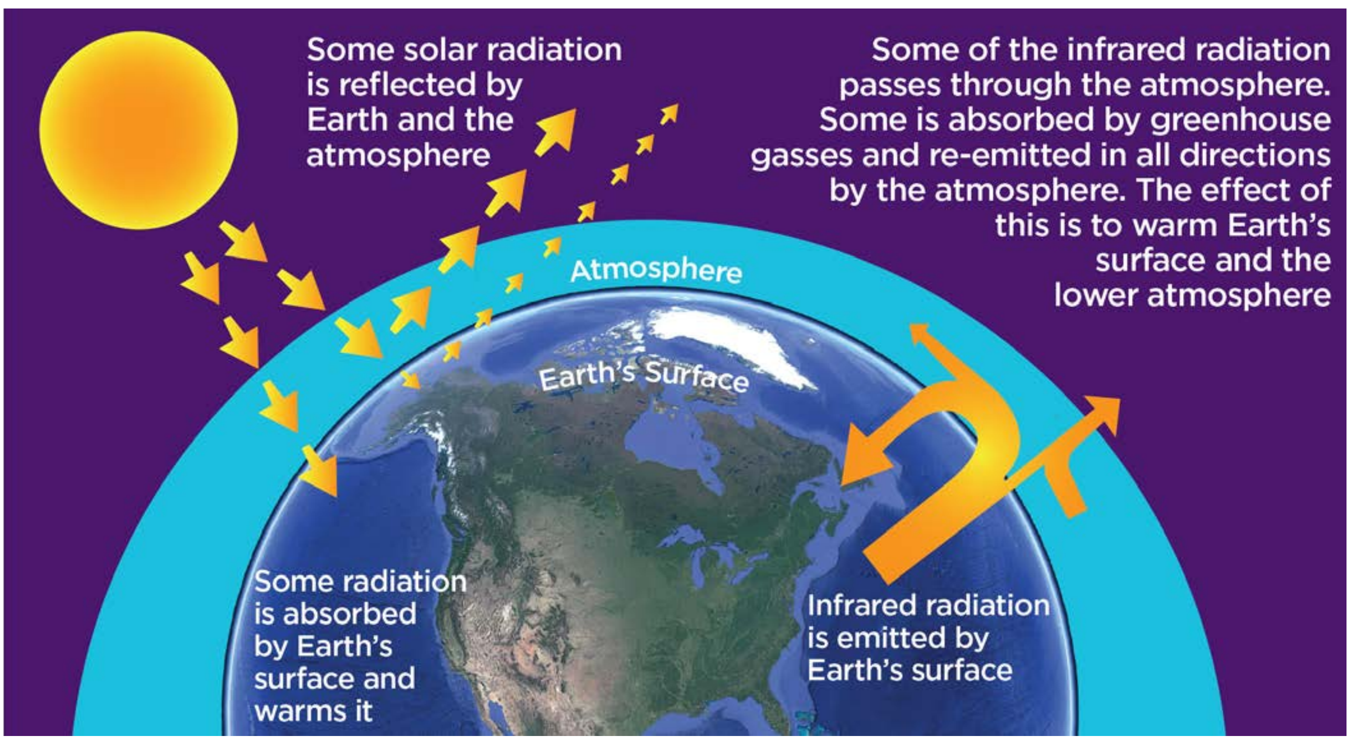
As part of the CAAP process, the most up-to-date science and local climate projections for three primary climate change stressors (extreme heat, sea level rise (SLR), and precipitation) and two secondary stressors (air quality and drought) were reviewed (see the 2018 Long Beach Climate Stressors Review, Appendix D). Primary climate change stressors are first-order local conditions that are directly affected by changes in global atmospheric and oceanic temperatures. Secondary climate stressors are conditions affected by complex interactions between primary variables and other factors.

The City also carried out a Climate Vulnerability Assessment, which explored how the climate stressors predicted for Long Beach will impact different types of city assets. The study assessed vulnerability (see the 2018 Climate Vulnerability Assessment, Appendix C) based on the following categories:

- Public Health
- Housing and Neighborhoods
- Buildings and Facilities
- Parks and Open Space
- Transportation Assets
- Energy Assets
- Stormwater Assets
- Wastewater Assets
- Portable Water Assets

Key information from both the Climate Science Memo and Climate Vulnerability Assessment is summarized below, organized by climate stressor. It is important to note that the science of understanding climate change is being regularly revised, as climate models and projections are improved and updated with new data and observations. The outputs from these climate models will inform future updates of this CAAP. These revisions improve our understanding of the impacts we can expect in the future. However, this does not mean that there is uncertainty around whether there will be impacts or whether human activity is a major contributing factor, but rather uncertainty about the timing and extent of impacts.

Figure 6: The Greenhouse Effect



EXISTING ENVIRONMENTAL HEALTH BURDENS AND CLIMATE CHANGE

Though climate change will impact the entire city environs, some communities within Long Beach already experience disproportionate environmental health burdens today. Long Beach is very diverse, which can be a source of strength, vibrancy, and resilience. However, it also has racial and economic disparities that are manifested spatially across the city. Tools such as CalEnviroScreen help identify the California communities that are most affected by many sources of pollution and the areas where people are often especially vulnerable to pollution's effects. For Long Beach, CalEnviroScreen shows how Central, West and North Long Beach have some of the highest pollution impacts in California, and how many areas are worse off than 95 percent of the state. It is not a coincidence that the communities that live in these areas tend to be low-income communities of color.

Low-income people and communities of color in Long Beach are more likely to live in areas with poor air quality, in regions with little green space, and in areas along the Los Angeles River channel where urban flood risk may increase. The geography of differentiated risk is due to socioeconomic inequality caused by historic racial and economic injustices (discussed in the section on Climate Change, Public Health, and Health Equity). When reviewing the summary of how future climate change is projected to impact Long Beach, existing environmental health burdens and social vulnerabilities to climate change should be considered. In addition to the need to prioritize communities with existing environmental health burdens as well as communities that are most vulnerable to the impacts of climate change, lessons in resiliency need to be shared, including how disproportionately impacted communities have withstood the combined effects of segregation and pollution to adapt and prepare for changing conditions. As Long Beach prepares for an uncertain climate future, the City must lift up and learn from these communities to make sure they can thrive.

Extreme Heat

Trends and Projections

Long Beach's pleasant Mediterranean climate is expected to warm considerably in the coming decades, and the region will experience a greater number of extreme heat days (>95 degrees Fahrenheit [°F]). Cal-Adapt predicts that average annual temperatures in the Los Angeles region will increase 3-4°F by midcentury and 3-8°F by the end of the century.[iii] The average number of extreme heat days each year has already increased from the baseline average of 4 extreme heat days per year in the period from 1980 to 2000,[iii] to the average 9.2 extreme heat days per year recorded between 2008 and 2017.[iv] Extreme heat days are projected to increase even more by mid-century, to 11 to 16 days per year by midcentury, and 11 to 37 extreme heat days per year by the end of the century.[iii] Heat waves will occur more frequently and be longer lasting,[v] and more humidity will mean less cooling at night.[vi] These changes will have wide impacts on Long Beach's environment, infrastructure, and residents. Extreme heat will also disproportionately affect already vulnerable populations, including the elderly and infants who are more susceptible to the health impacts of extreme heat. It will also disproportionally affect low-income households or households where English is the second language, which are less likely to have access to resources to cope with extreme heat.

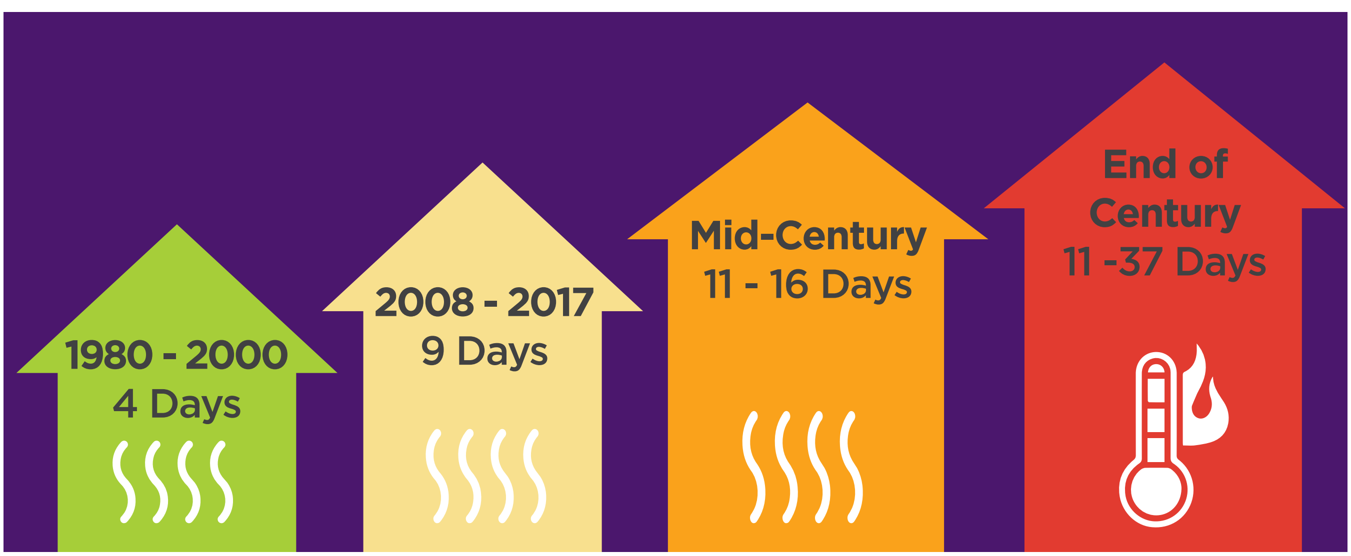
Key Vulnerabilities

Of all the climate stressors Long Beach will face, extreme heat is expected to be the greatest health threat to the largest number of residents. Analysis of census population data (from 2010) and data from the Climate-Smart Cities Los Angeles heat vulnerability zone indicates that approximately 275,000 residents of Long Beach live in the high-vulnerability areas. Extreme heat events can increase heat-related, cardiovascular-related, and respiratory-related mortality, and they can increase hospital admission and emergency department visits. Particularly vulnerable populations include children, the elderly, people with respiratory diseases, people with physical disabilities, a nd those who work outdoors.[viii] (See the section on Climate Change, Public Health, and Health Equity in this plan for details on geographic vulnerabilities to extreme heat in Long Beach.)

Increased electricity demand for air conditioning during heat waves can cause power outages, which can put vulnerable populations at even higher risk. Traffic disruptions from a loss of power to traffic lights can also result from the increased demand. Heat-related power outages are already common in Southern California. In the summer of 2015, Long Beach residents experienced four separate power outages. In July 2015, high temperatures may have been a factor in equipment failures that caused two powers outages in downtown Long Beach that left thousands of residents and businesses without power for days. The power outage stranded people without medical devices, refrigeration, air conditioning or elevator service during a period of high temperatures. This was particularly challenging for seniors living in high-rise apartments.[viii]

Low-income residents, who already spend a higher proportion of their income on utilities, will be hit hardest by increased power bills. They are also more likely to live in substandard housing with inefficient insulation or without any air conditioning at all. Roads can be damaged by asphalt, softening when temperatures remain above 100°F with no cooling at night, particularly in areas with high truck traffic.[ix]

Figure 7: Projected Days of Extreme Heat (95 degrees and above)



Sea Level Rise

Trends and Projections

Sea level rise is already occurring off of Long Beach and is projected to accelerate over the coming decades. Analysis of historical sea levels at the nearest National Oceanic and Atmospheric Administration tide gauge in Los Angeles indicates a long-term trend of sea levels rising at approximately 0.96 millimeter per year from 1923 to 2016.

The projections for future SLR considered in this CAAP are from the National Research Council's (NRC's) Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present, and Future,[x] which represented a synthesis of the best available SLR science when the CAAP planning process began in 2017.

Note that the Ocean Protection Council's (OPC's) new SLR guidance document was adopted in March 2018. Not only were the OPC[xi] SLR projections not yet available at the time of the vulnerability assessment, but the SLR projections from NRC[x] show higher potential SLR for near-term planning horizons (2030 and 2050). Given the differences in projections, it was determined that a conservative approach would be adopted in developing a plan to preserve life and property and that the more aggressive forecast should be used. To understand the implications of a worst-case scenario and to include a factor of safety, particularly for critical assets, the high end of the NRC[x] SLR range was selected for each planning time frame.

Examples of King Tides in Long Beach

Marine Stadium | Naples Island | Alamitos Bay | Peninsula

This rationale aligns with the State Guidance from the OPC (2011) and the California Coastal Commission (2015). Because there is increased uncertainty (wider ranges of SLR) after 2050 both the projection (mid-range) and high-range magnitudes were selected to guide planning for 2100. In addition, including the mid-range magnitudes for 2100 allows for a range of SLR scenarios to better understand thresholds for exposure of city assets or subareas of the city. The City also recognizes the OPC[xi] H++ scenario, which estimates a potential for 10 feet of SLR by 2100. Although the likelihood of this scenario is unknown, it is important to consider, particularly for high-stakes, long-term decisions, given that the probabilistic projections listed above may underestimate the likelihood of extreme SLR resulting from loss of the West Antarctic ice sheet, especially under high emissions scenarios. This potential scenario suggests that the 66-inch SLR projection could happen sooner than 2100.

Best practices in climate change adaptation planning, as recommended by the State of California Sea Level Rise Guidance,[xi] are to use worst-case projections for midcentury and to use both middle-range to worst-case projections for the end of-century analysis, because uncertainty increases into the future.

The National Research Council (2012) indicates that sea levels in Southern California are expected to rise between 5.0 inches and 23.9 inches by midcentury (2050) and between 17.4 inches and 65.6 inches by the end of the century (2100).[x] The CAAP's SLR vulnerability assessment matched these ranges to available SLR inundation model data from the U.S. Geological Survey's Coastal Storm Modeling System to understand what portions of the City are expected to be at risk, and when they will be at risk. The City used inundation scenarios of 11-inch SLR for 2030, 24-inch SLR for midcentury, and both 37- and 66-inch SLR for the end of the century.

The projected increases in mean sea level will also result in secondary impacts – higher storm tides, more extensive inland flooding, increased coastal erosion during storm events, and increased frequency of these events. Evidence of these impacts is already being felt in Long Beach.

Key Vulnerabilities

For the low-lying coastal communities of Long Beach, permanent inundation from SLR as well as increased frequency and intensity of temporary flooding from king tides and storm surges will become a very real threat in the near future. Approximately 1.3 million square feet of buildings in Long Beach could be exposed to annual king tides by 2030. Approximately half of these buildings are residential (624,100 square feet) and half are commercial (689,600 square feet). These buildings are primarily located in Marina Pacifica and along Shoreline Drive south of Ocean Boulevard. An additional 9.5 million square feet of buildings, primarily residential, are exposed to flooding from a 100-year storm surge by 2030. These buildings are primarily located in Naples Island, Belmont Shore, and the Peninsula. By 2050, up to 8.4 million square feet of buildings could be exposed to annual king tide flooding.

City infrastructure exposed to flooding from king tides by 2030 includes a solid waste facility; 17 city parks; 4 miles of roads that provide access to Port of Long Beach facilities, the NRG power station, and other industrial operations; a natural gas power generation station; and 18 storm drain outfalls, which could cause inland urban flooding if they are inundated during a rainstorm. Sea level rise will also cause increased erosion to, and possibly the loss of, the city's beaches and coastal access points, which are central to the lifestyle, culture, and economy of the Long Beach community. Projections anticipate widespread daily high tide flooding impacts by 2100 under the no action scenario.

Precipitation

Trends and Projections

Climate change will also have a substantial impact on local precipitation patterns. Cal-Adapt, the State of California's official synthesis of the latest climate models, predicts a 6 percent to 11 percent increase in average annual precipitation in Long Beach by midcentury and a 1 percent to 25 percent increase by the end of the century.[xii] There is a wide range in the projections because local climate is influenced by a wide variety of factors and because there is uncertainty in the model projections of future precipitation changes.

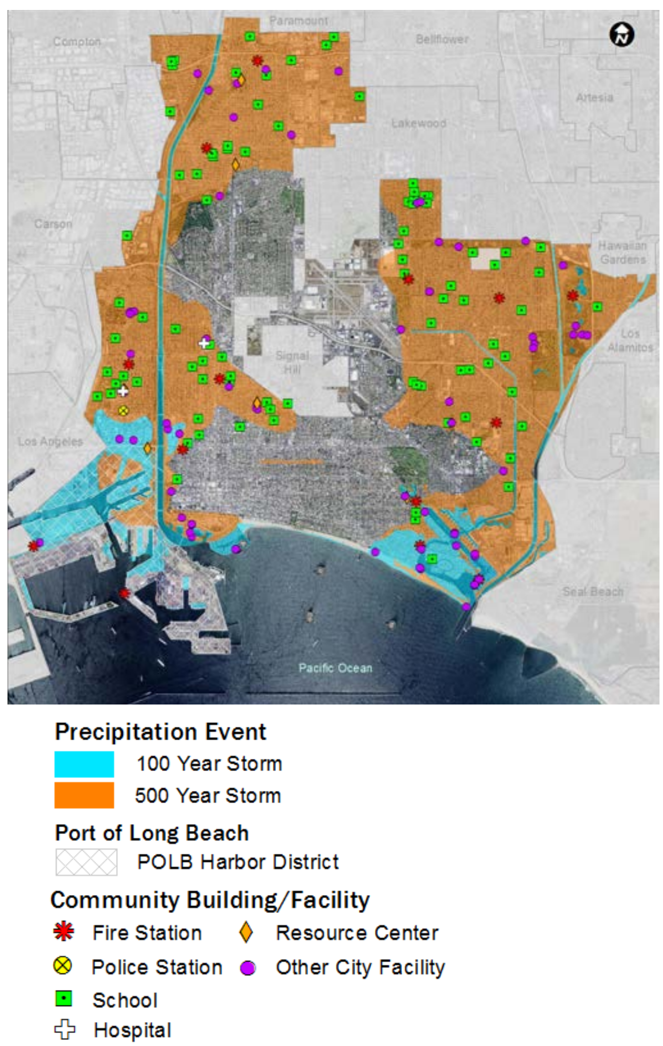
Changes in average annual precipitation are only half the story. The impacts that will have the most consequences for day-to-day life in Long Beach will be increased intensity of rain events leading to greater flood risk,[xiiixiv] and high year-to-year variability, which will affect the availability of fresh water.[xvxvi]

Key Vulnerabilities

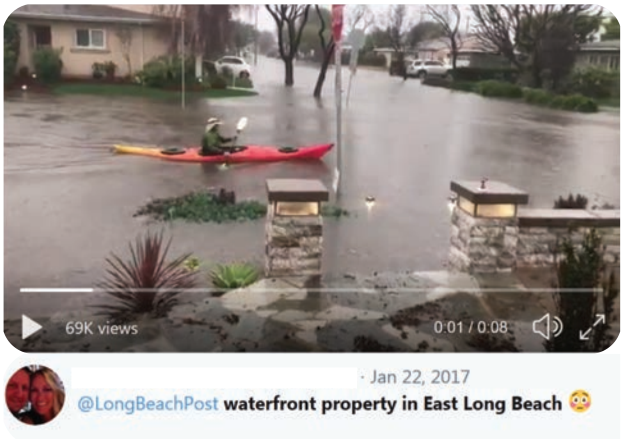
For this CAAP, exposure to riverine flooding was assessed based on the Federal Emergency Management Agency's (FEMA's) 100- and 500-year riverine floodplains. These FEMA floodplains serve as proxies for areas that may be at risk to increased exposure to riverine flooding in the future. In general, 100-year floodwaters flow along the primary riverine waterways and are contained within their channels by existing levees. However, the 500-year floodplain, which represents a scenario that will become more likely in the future due to the increased intensity of precipitation events, covers a much larger area, which includes certain disadvantaged populations along the Los Angeles River. Within the 500-year floodplain are two hospitals, 11 fire stations, one police station, 96 schools, 600 miles of roads, 26 power substations, more than 20 wastewater pump stations, and 20 potable water facilities.

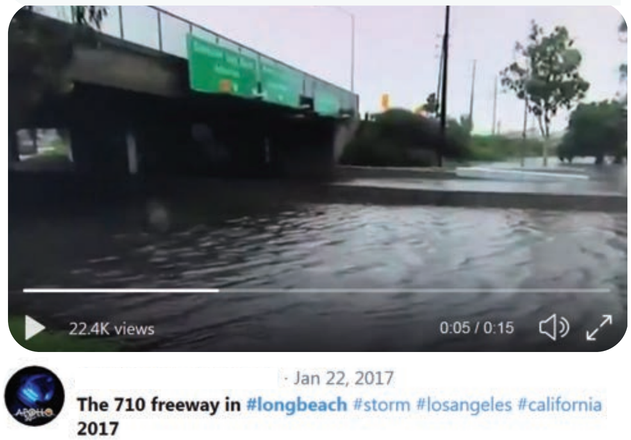
Urban flooding during precipitation events is already a problem in Long Beach, and extreme events today provide an example of what may become more common in the future, when more intense precipitation events are projected. In January 2017, severe rainstorms overwhelmed storm drains and resulted in widespread flooding of streets and homes. More intense precipitation events, coupled with higher tides due to SLR, will worsen urban flooding in developed areas if no action is taken to increase stormwater system capacity so that discharge runoff can be collected during combined flooding events.

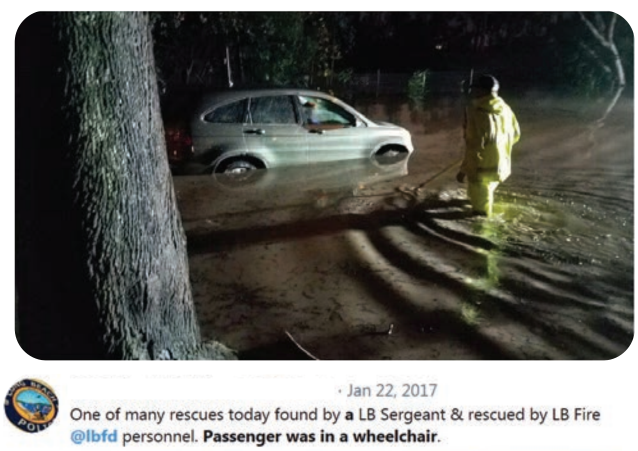
Figure 8: Map showing 100-year and 500-year flood plain and community assets



Images of flooding during January 2017 extreme precipitation events







(source: twitter.com)

Drought

Trends and Projections

Changes in drought patterns are a secondary climate stressor that will be influenced by changes in temperature and precipitation. Changes in temperature and precipitation are predicted to produce longer and more frequent droughts that will have an impact on Long Beach's water supply. According to Long Beach Water, approximately 25 percent of the City's water supply is from the Colorado River and 15 percent is from the Northern California Bay-Delta. Future drought patterns are expected to result in regional drying, continued reduction of the Sierra Nevada snowpack, and snowmelt runoff earlier in the season that will stress supplies from the Northern California Bay-Delta. The Colorado River will also face similar dynamics. Local water demand is also expected to increase without a shift to drought-tolerant plant species. The Los Angeles region is expected to experience an overall drying trend with longer and more frequent droughts.[xiiixvi] To respond to this challenging dynamic, Long Beach will need to build on its successful efforts to use existing water resources more efficiently and to diversify its water supply.

Key Vulnerabilities

Higher temperatures will lead to drier soils and drier vegetation in natural areas,[xiv] which will increase local wildfire risk. Additional examples include increased water demand for irrigating planted areas unless there is a major shift towards planting drought-tolerant species. In addition to regional drying, reduced snowpack in the Sierra Nevada and snowmelt runoff earlier in the season will threaten Long Beach's water supply.[xiiixiv]

Air Quality

Trends and Projections

Air quality is another secondary climate stressor that will be influenced by changes in weather and other factors. Despite air quality improvements in the past three decades, which resulted from concerted efforts and increased regulation, higher temperatures will increase the formation of air pollution. Absent further air pollution[xvii] reduction efforts, by the end of the century, the number of days when air quality standards in the Los Angeles region are violated could increase by 25 percent to 80 percent due to warming.[xviii] Higher temperatures, precipitation change, and increasing CO_2 concentrations are also expected to increase pollen and some airborne allergens. An increase in wildfires, even far from Long Beach, could worsen air quality, as evidenced by the dangerous air quality levels in Long Beach during the wildfires in Southern California during the fall of 2019. Increased energy consumption in the region due to greater demand for air conditioning could also negatively impact air quality.[xviii]

Key Vulnerabilities

Air quality is especially relevant as a secondary climate stressor in Long Beach, as there are several sources that impact local air quality and thousands of people. These sources include the 710 and 405 freeways, refineries, the Port of Long Beach, and major industrial sites.[xix] People who are especially sensitive to poor air quality include the young, the elderly, those who have existing respiratory conditions, and those who work outside. Air quality in Long Beach is considerably worse near the Port and major freeways, and near concentrations of low-income residents and communities of color due to historic patterns of marginalization and disinvestment. An in-depth discussion of inequities in exposure to the hazards induced by climate change is presented in the following section.

CLIMATE CHANGE, PUBLIC HEALTH, AND HEALTH EQUITY

Increased extreme heat events, flooding, and worsened air quality may negatively affect human health. While all people are vulnerable to the impacts of climate change, the degree of vulnerability is a function of place-based conditions and demographic and socioeconomic factors that influence an individual or community's sensitivity to environmental change. As described above, communities in Central, West and North Long Beach face a disproportionately high exposure to many sources of pollution and are more vulnerable to pollution's effects.

This geography of differentiated risk is due to the socioeconomic inequality caused by historic racial and economic injustices, such as discrimination in education, housing, employment, education, local political representation, and access to resources. Low-income communities of color were historically excluded from Long Beach neighborhoods with less environmental pollution and greater public investment, and still today are concentrated in the portions of the city with the worst air quality and environmental health metrics. These same communities not only bear the highest environmental health burdens, but they also have the highest social vulnerability to climate change due to factors such as age, race, and income. The existing health conditions in low-income neighborhoods affect the ability of individuals and low-income communities of color to prepare for, respond to, and recover from an extreme weather event or climate stressor.

Low-income individuals and communities of color in Long Beach are not only more likely to live in areas with poor air quality, but are also more likely to live in areas with little green space and along the Los Angeles River channel, where urban flood risk may increase. People experiencing homelessness are also likely to face additional exposure to extreme heat, lack of access to water, and even vector-borne diseases (e.g., mosquito-borne diseases). In addition, by the end of the century, the Long Beach Multi-Service Center, which serves individuals experiencing homelessness, is projected to be exposed to king tides.

These structural inequalities both increase the risk that people will suffer climate-related impacts and reduce their ability to cope with and respond to climate stressors. Low-income residents are also more likely to live in housing with substandard insulation, inefficient air conditioning, or no air conditioning at all, and are more likely to be cost-burdened renters with no other housing options. As temperatures increase, they will need to spend more of their limited income on utility bills. Low-income seniors and children with limited mobility are particularly at risk during heat waves. Flooding is more disruptive for low-income residents, who are less likely to have low-deductible insurance or emergency savings to cover the cost of repairs.

Low-income residents and communities of color are more likely to live in areas of the city with little green space. Data from the Climate Smart Cities Los Angeles tool on modeling of the urban heat island effect indicates that North and West Long Beach are more susceptible to high surface temperatures and air pollution. The amount of green space varies considerably across Long Beach, and Central, West, and North Long Beach have the lowest amount[xx].

The following are some of the key considerations regarding vulnerable populations in Long Beach.

Communities of Color

A majority of Long Beach residents are people of color. As of the 2010 census, the population is 41 percent Hispanic/Latino, 13 percent Black or African American, 13 percent Asian, and 1 percent Native Hawaiian or Pacific Islander.[xx] Communities of color in Long Beach already experience health disadvantages. For example, the Black or African American community in Long Beach has the highest rates of hospitalization for heart disease, diabetes, and asthma compared to other races and ethnicities. The asthma hospitalization rate for Black or African American residents, which is directly impacted by poor air quality, is nearly three to four times that of the other races and ethnicities.[xx] In Long Beach, lack of access to health insurance is highest among those identifying themselves as Hispanic or Latino (31.8 percent), followed by those identifying as Black or African American (19.8 percent), Asian (19.2 percent), and White (11.0 percent).[xx]

Age

Elderly populations can be more vulnerable to extreme weather and climate stressors. They may be less able to evacuate, as a higher proportion do not drive, often live alone, and may rely on public transportation. They may also have pre-existing health conditions that can be exacerbated by climate stressors. In Long Beach, almost 40 percent of people over the age of 65 report a disability, compared to 10 percent of the overall Long Beach population. Children are also disproportionately impacted by certain climate change effects, including extreme heat and air pollution. Central, West and North Long Beach have disproportionately younger populations, as the largest and highest percentages of children live there compared to other parts of the city.

Language

Non-English speakers may struggle to communicate with service providers and experience difficulties making use of preparedness, response, and recovery resources. In Long Beach, 34 percent of households speak Spanish at home and 10 percent speak Asian or Pacific Islander Languages at home. English proficiency in the city varies by age. People over the age of 65 are most likely to report speaking English “not well” or “not at all” (38 percent).[xx]

Income

Low-income communities face disproportionately higher rates of poor health outcomes and greater obstacles to achieving good health, and they are more likely to live in neighborhoods with higher environmental health burdens.[xxi] Income varies across race and ethnic groups, and people of color have lower incomes and wealth than White communities. Black or African American and Hispanic or Latino households had the lowest median incomes—about $10,000 less than the overall median income in Long Beach.[xx] Median income also varies by neighborhood, with higher incomes in East and Southeast Long Beach and lower incomes in North, West Central, and Southwest Long Beach. In addition, approximately 15.3 percent of all residents in Long Beach live below the poverty line, which is 2 percent higher than the statewide poverty rate of 12.8 percent.[xxii]

Geography of Combined Social Vulnerability

The Climate-Smart Cities Los Angeles Project and its Technical Advisory Team, which included public health experts, local academic and research institutions, and community leaders, developed a geographic information system decision support tool that includes a social vulnerability index consisting of 10 indicators. This index is based primarily on the U.S. Environmental Protection Agency's EJSCREEN definition of demographic factors that indicate a community's potential susceptibility to environmental stressors. These factors include people of color, low income, educational attainment less than a high school degree, linguistic isolation, population under the age of 5, and population over the age of 64. The index includes three additional characteristics—unemployment, asthma, and low birth weight—which were added based on recommendations from the Technical Advisory Team.

The neighborhoods of Southeastern Long Beach, which are most susceptible to SLR and flooding, exhibit many demographic factors that make them less at risk to the health impacts of climate change (higher income, lower rates of respiratory disease, higher share of residents that identify as white), but also have a higher share of elderly residents, who can be more vulnerable during flood events due to limited mobility.

North, Central, and West Long Beach neighborhoods have the lowest amounts of green space and experience a high urban heat island effect, which can further stress existing health conditions during extreme heat events. West and North Long Beach have poor air quality and high levels of hospitalizations for asthma.

OPPORTUNITIES

While responding to climate change presents the City with urgent challenges, addressing the city's vulnerabilities is an opportunity to tackle issues and systemic inequities that residents face today. Climate adaptation and mitigation actions will have a wide range of co-benefits, including improved air quality, improved access to green space, and the potential for sustainable economic growth and job opportunities for all income and education levels. Policies that seek to improve environmental justice outcomes for Long Beach's most vulnerable residents will also lead to better outcomes for all.

Public Health Co-Benefits

As described in the previous section, differences in health outcomes between residents are often a result of socioeconomic and racial inequities. Addressing these issues now will increase our community's resilience in the future, and vice versa; actions taken to reduce our contribution to climate change will also address public health problems now.

Urban greening, which will reduce the impact of future extreme heat events on residents in areas that are currently threatened by the urban heat island effect, offers a myriad of benefits for current residents. Proximity to green space improves mental health by reducing stress and anxiety, improves physical health by providing recreation space, and increases community cohesion by creating pleasant public spaces for social interaction and gatherings. Increasing the urban tree canopy also helps address local air pollution, as trees absorb particulate matter from the air and, by shading sidewalks, encourage walking and biking.

Policies that seek to reduce carbon emissions in the transportation sector can also positively address health in a variety of ways. Investments in public transit and walkable, bikeable neighborhoods increase mobility and accessibility, lead to more active and healthy communities, reduce vehicle miles traveled, and improve air quality. Similarly, expanding electric vehicle infrastructure also leads to a reduction in transportation emissions and improved air quality as more electric vehicles take to our roads.

Building efficiency, building decarbonization, and increasing electricity generation from renewable sources will also improve local air quality.

In addition to directly addressing public health disparities, climate adaptation and mitigation actions have the potential to spur economic development, create jobs, expand access to economic opportunity, and mitigate income inequality, thereby directly addressing one of the underlying causes of public health disparities. A discussion of the economic benefits of climate change adaptation and mitigation is included in the next section.

Economic Opportunities

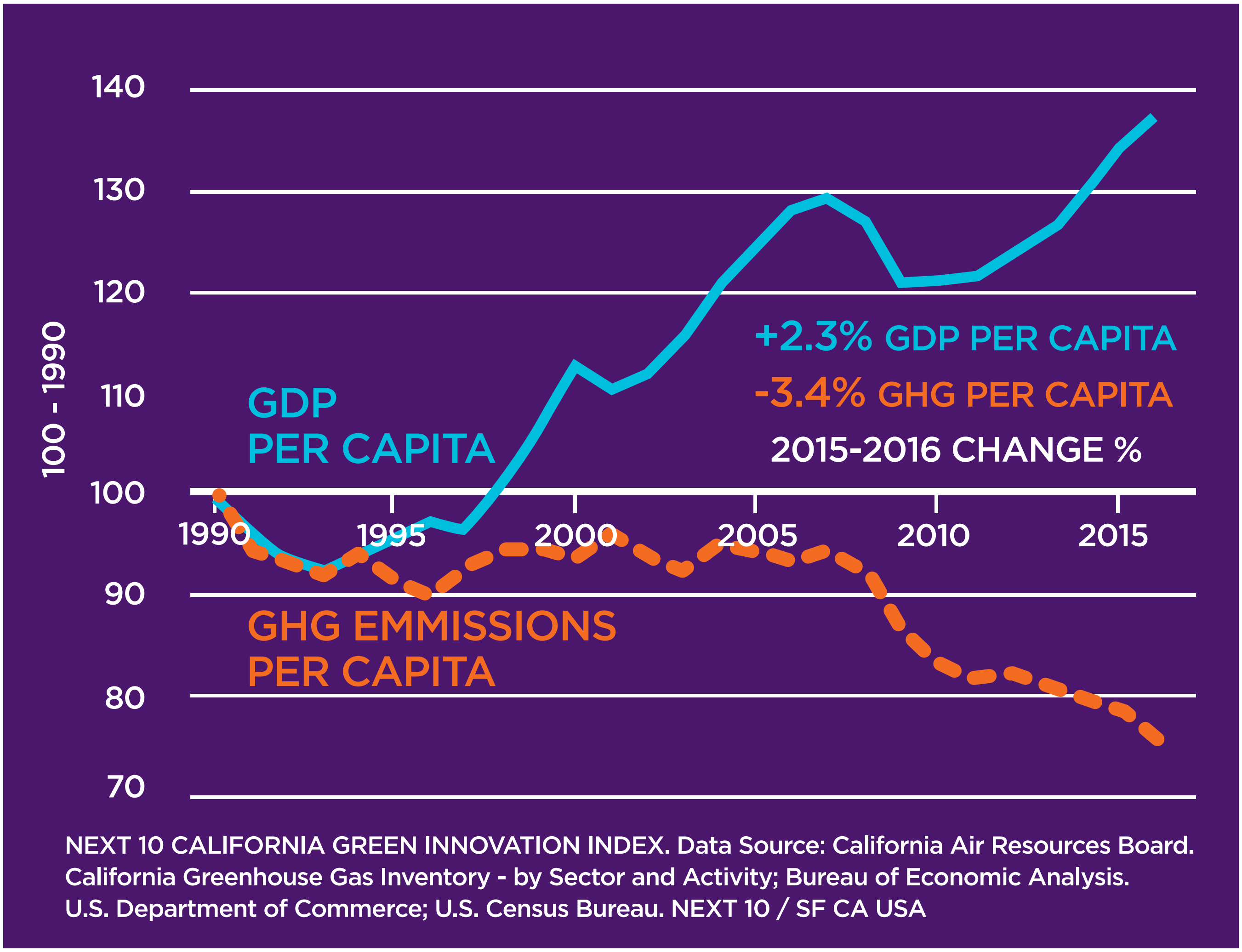
A common misconception is that addressing climate change and reducing GHG emissions will harm economic growth. Evidence in California contradicts this perception. When the State of California passed Assembly Bill 32 in 2006, many were skeptical that the State could reach its ambitious climate goals without sacrificing economic growth. Ten years later, California not only reached its goal of reducing emissions to 1990 levels by 2020, which was four years earlier than planned, but did so while achieving one of the largest economic expansions in state history.[xxiii] Studies conducted by the California Air Resources Board show that economic growth need not be compromised to achieve the State's goal of an 80 percent reduction in GHG emissions below 1990 levels by 2050.[xxiv]

The State of California is making considerable investments to drive technological innovation and the decarbonization of the economy. The State's policies, along with the local actions recommended in subsequent chapters in this plan, present an enormous opportunity for Long Beach to promote sustainable economic development through infrastructure projects, innovation and deployment of new technologies, and the creation of green jobs for various backgrounds and education levels.

Increased economic opportunities are already emerging as investments are directed towards meeting the State's goals. Building efficiency retrofits, decarbonization of energy generation, construction of high-performance buildings, rooftop and community solar deployment, and transit infrastructure are all examples of market responses to climate change that are taking advantage of current technologies to create jobs today.

Addressing climate change not only creates job opportunities, it helps residents and businesses save money on utilities and transportation—savings that can be redirected to other areas of the economy. More fuel-efficient vehicles and public transportation will also help Long Beach residents reduce their transportation costs.

Figure 9: GDP and Emissions. California, in 2016 $



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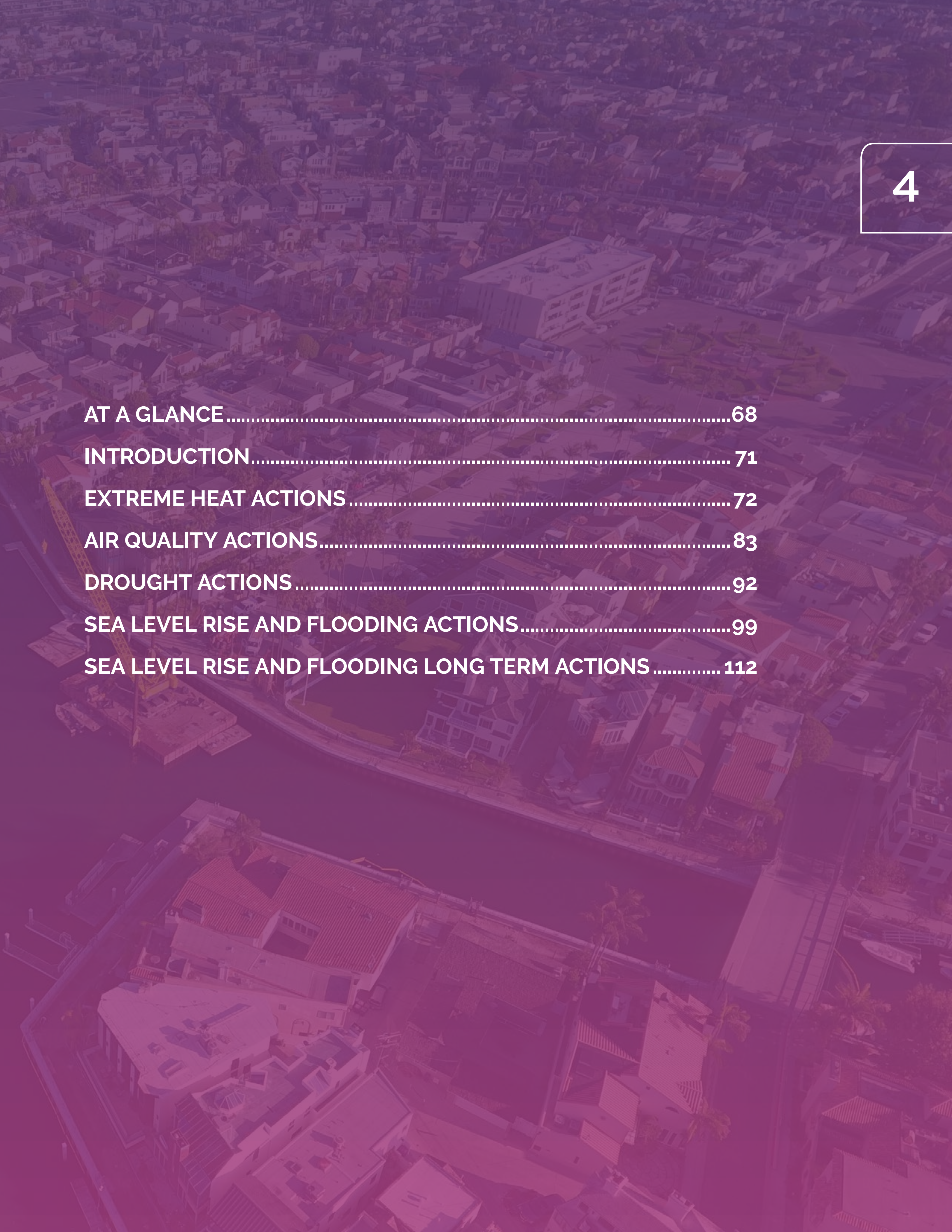
CITY OF
LONG BEACH

4

Adaptation Actions

Image: Tetra Tech, Inc.



4

ADAPTATION OBJECTIVES AND ACTIONS AT A GLANCE

EH Extreme Heat

Goal: Long Beach buildings, neighborhoods, and infrastructure are climate resilient, reduce the urban heat island effect, and are set up to ensure and improve public health and safety in the face of extreme heat events

OBJECTIVES	NO.	ACTIONS
New and existing buildings, streets, and public spaces reduce extreme heat through incorporation of cool surfaces and green infrastructure	**EH-1**	Increase presence of cool roofs and cool walls
	EH-2	Increase the presence of reflective streets, cool surfaces, and shade canopies
	EH-3	Enhance and expand urban forest cover and vegetation
All residents have access to services and programs to withstand extreme heat events	**EH-4**	Install additional water fountains and other actions to increase public access to water
	EH-5	Identify future vulnerability potential for power outages related to extreme heat and develop plans to prevent such outages
	EH-6	Enhance and expand the accessibility of cooling centers
Public transit is a comfortable and viable mobility option during extreme heat events, especially for transit-dependent populations	**EH-7**	Provide bus shelter amenities
	EH-8	Improve beach and coastal transit access during extreme heat events

AQ Air Quality

Goal: All Long Beach communities have clean air and improved public health

OBJECTIVES		ACTIONS
Buildings and facilities actively reduce air pollution as a component of a broader energy reduction strategy.	**AQ-1**	Incentivize installation of photocatalytic tiles
	AQ-2	Encourage urban agriculture practices that reduce air quality pollution
Emissions are reduced by shifting to cleaner equipment and vehicles.	**AQ-3**	Support the development of the Long Beach Airport Sustainability Plan
	AQ-4	Electrify small local emitters, such as lawn and garden equipment, outdoor power equipment, and others
	AQ-5	Work with Long Beach Unified School District (LBUSD) to support school bus electrification
	AQ-6	Implement the Port of Long Beach Clean Air Action Plan
Air quality impacts from local oil and gas operations are minimized.	**AQ-7**	Increase monitoring and regulation of oil extraction and refining process

DRT Drought

Goal: Long Beach has a more sustainable and diverse water supply that reduces dependence on imported water and improves long-term water security

OBJECTIVES	NO.	ACTIONS
Maximize water efficiency and conservation.	**DRT-1**	Continue development and implementation of water use efficiency programs and implement additional water conservation programs
	DRT-2	Enhance outreach and education related to water conservation
Maximize water that is captured and reused locally.	**DRT-3**	Expand usage of green infrastructure and green streets
	DRT-4	Expand usage of recycled water and greywater for non-potable use
	DRT-5	Incorporate increased rainfall capture and other actions to maximize local water supplies and offset imported water

FLD Sea Level Rise + Flooding

Goal: Long Beach understands and is prepared for its future flood risk

OBJECTIVES	NO.	ACTIONS
Short-Term Actions (to 2030)		
City plans and policies are forward-looking and ensure projects and investments account for projected sea level and flooding impacts	**FLD-1**	Update and augment floodplain regulations as necessary
	FLD-2	Incorporate sea level rise language into citywide plans, policies, and regulations
	FLD-3	Establish a flood impacts monitoring program
	FLD-4	Incorporate adaptation into City lease negotiations
	FLD-5	Update the City's existing Stormwater Management Plan
Clear and sufficient information is on hand to identify and prioritize near-term adaptation needs and best practices	**FLD-6**	Conduct citywide beach stabilization study
	FLD-7	Review and conduct studies of combined riverine/coastal flooding and increased severity of rainfall events on watershed flooding
Adaptation strategies are implemented to protect vulnerable shoreline areas and wastewater infrastructure	**FLD-8**	Enhance dunes
	FLD-9	Inventory and flood-proof vulnerable sewer pump stations
Medium-Term Actions (2030-2050)		
Vulnerable infrastructure is elevated or relocated	**FLD-10**	Relocate/elevate critical infrastructure
	FLD-11	Elevate riverine levees
Long-Term Actions (2050-2100)		
Long-term physical adaptation strategies are selected and implemented based on additional research and community adaptation priorities, and prioritize natural solutions whenever possible.	**FLD-12**	Expand beach nourishment
	FLD-13	Construct living shoreline/berm
	FLD-14	Elevate street hardscapes
	FLD-15	Elevate streets/pathways
	FLD-16	Retrofit/extend sea wall
	FLD-17	Retreat/realign parking lots
	FLD-18	Extend/upgrade existing seawalls
Additional long-term adaptation options are evaluated using the best available science.	**FLD-19**	Investigate feasibility of managed retreat
	FLD-20	Evaluate feasibility of storm surge barrier at Alamitos Bay

INTRODUCTION

This chapter includes adaptation actions identified to improve the ability of Long Beach and its residents and businesses to adapt to climate change, and related impacts now and in the future. Actions are organized into four climate impacts:

- Extreme Heat
- Air Quality
- Drought
- Sea level rise and flooding

These adaptation actions were developed based on the 2018 Long Beach Climate Stressors Review (Appendix D) and the Long Beach Climate Change Vulnerability Assessment Results (Appendix C).

A range of factors were considered in the design and selection of the various actions, including:

- The projected timeframe and estimated likelihood of the vulnerability
- The importance and effectiveness of each action in increasing resilience
- Technical feasibility and City implementation capacity
- Public and stakeholder feedback throughout the CAAP development process

The City has placed a high priority on public engagement and input to identify and select actions. Major points of public emphasis included selecting actions that have the potential for strong, positive, and inclusive impacts on low-income communities most impacted by climate change. As a result, a majority of the actions include implementation steps that will require the City to prioritize these actions in areas of highest need. Each action consists of an implementation lead and partners, general timeline (short, medium, long) and City costs (low, medium, high), co-benefits, implementing sub-actions, and an equity strategy. The City has included a preliminary set of potential performance metrics associated with each action in Appendix F.

These actions establish an initial roadmap to withstand rising temperatures, flooding associated with sea level rise and intense storm events, and drought among others. Over time as understanding of climate change science evolves and local impacts are observed, the City will evaluate the need for adjustment of existing actions and the need for new ones. This process will take place through regular CAAP monitoring and reporting and future CAAP updates.

While Long Beach is already experiencing the effects of climate change, adaptation to SLR and its related impacts will require the City to incorporate a long-term adaptive management approach to its planning and investment decision making processes. This will be particularly important due to the long lifespan of infrastructure and land uses that will need to be resilient in the face of future SLR and related impacts that are not immediate or near-term.

EXTREME HEAT ACTIONS

In the coming decades extreme heat is expected to be the greatest climate-related health threat to Long Beach residents, causing an increase in heat-related mortality, cardiovascular, and respiratory related mortality, and an increase in hospital admissions and emergency department visits. Extreme heat events disproportionately impact vulnerable populations such as young children, the elderly, people with respiratory diseases, people with physical disabilities, and those that work outdoors. Low-income households that already spend a higher proportion of their income on utilities and may live in energy inefficient, substandard housing also are more at risk.

According to an analysis of 2010 U.S. Census and Climate Smart Cities Los Angeles data, at least 275,000 Long Beach residents live within areas that are highly vulnerable to extreme heat. As temperatures and the number of extreme heat days (>95°F) increase there is strong potential for this number to increase. The number of extreme heat days has increased from an average of 4 days per year in 1980-2000 to 9 days per year from 2008-2017. Cal-Adapt predicts that average annual temperatures in the Los Angeles region will increase 3-4°F by mid-century and 3-8°F by end-of-century and extreme heat days to 11-16 per year by mid-century, and 11-37 per year by end-of-century.

The adaptation actions in this section establish a roadmap for the City to implement new and improved existing programs to address extreme heat now and in the future. Prioritizing tree planting in communities that are most vulnerable to higher temperatures is an example of an improvement that will be made to an existing program. An example of a new effort includes requirements for cool roofs and reflective surfaces to reduce temperatures and save energy. As it implements each action, the City will prioritize specific populations and communities that are most vulnerable to extreme heat.

EH Extreme Heat

Goal: Long Beach buildings, neighborhoods, and infrastructure are climate resilient, reduce the urban heat island effect, and are set up to ensure and improve public health and safety in the face of extreme heat events

OBJECTIVES	NO.	ACTIONS
New and existing buildings, streets, and public spaces reduce extreme heat through incorporation of cool surfaces and green infrastructure	EH-1	Increase presence of cool roofs and cool walls
	EH-2	Increase the presence of reflective streets, cool surfaces, and shade canopies
	EH-3	Enhance and expand urban forest cover and vegetation
All residents have access to services and programs to withstand extreme heat events	EH-4	Install additional water fountains and other actions to increase public access to water
	EH-5	Identify future vulnerability potential for power outages related to extreme heat and develop plans to prevent such outages
	EH-6	Enhance and expand the accessibility of cooling centers
Public transit is a comfortable and viable mobility option during extreme heat events, especially for transit-dependent populations	EH-7	Provide bus shelter amenities
	EH-8	Improve beach and coastal transit access during extreme heat events

EH-1 Increase Presence of Cool Roofs and Cool Walls

Increase the installation of cool roofs and cool walls to keep buildings and neighborhoods cooler.

Implementation Lead: Development Services
Partners: Long Beach Department of Health and Human Services; City of Long Beach Office of Sustainability; SCE; Long Beach Parks, Recreation, and Marine
Timeline: Short and Medium
Potential Cost Level: Low

Description

The City will consider instituting a requirement that cool roofs be used on new and replaced commercial and residential roofs. The City will also develop a process for assessing the feasibility of cool and green roofs on future development projects and existing candidate buildings, focusing on neighborhoods that would benefit most from reduced temperatures and additional green space. While this action provides broader public health and quality of life benefits, populations most impacted by climate change, especially the sick, the young, and the elderly and low-income communities stand to benefit the most.

Cool roofs and walls are made of materials that help reflect the sun's energy, such as light-colored paints, roof tiles, coatings and shingles. Such materials effectively reduce the amount of the sun's energy that enters a building. This keeps homes and businesses cooler, and reduces the amount of additional cooling that may be needed to keep internal air temperatures at a healthy level (particularly during heat waves). Reflective surfaces also lower temperatures in the surrounding neighborhood. Green roofs are covered partially or completely with living plants. Their benefits include cooler buildings, reduced GHG emissions, and reduced stormwater runoff.

Co-benefits:

- ✓ Improved air quality
- ✓ Increased thermal comfort
- ✓ Reduced energy use and increased cost savings
- ✓ Reduced GHG emissions

Implementing Actions

EH-1.1: Update the building code to mandate the installation of cool roofs on all new and retrofitted roofs.

EH-1.2: Explore opportunities to incentivize the establishment of cool roofs on existing roofs. Explore the feasibility of incentivizing the use of green roofs on new and existing roofs, focusing on areas with a high urban heat island effect and taking CalEnviroScreen and other relevant factors into consideration.

EH-1.3: Conduct education and outreach about cool roofs and the associated resources and incentives for commercial businesses, residents, and roofing companies that operate within the city.

Equity Strategy

Prioritize neighborhoods that are most impacted by extreme heat, focusing on communities burdened with the poorest air quality.

EH-2 Increase the Presence of Reflective Streets, Cool Surfaces, and Shade Canopies

Treat paved surfaces such as streets, parking lots, and playgrounds with reflective surfaces and install shade canopies to reduce urban heat.

Implementation Lead: Public Works Department
Partners: Long Beach City College; Cal State Long Beach; parking lot owners; Long Beach Parks, Recreation, and Marine; LBUSD
Timeline: Short
Potential Cost Level: Low to Medium

Description

The City will identify priority areas for shade structures, cool pavement, and other reflective surfaces focusing on areas with high exposure to sunlight, heavy foot traffic, and populations vulnerable to heat. These areas may include playgrounds in addition to streets and parking lots. The City will consider disadvantaged communities (using CalEnviroScreen) as candidate sites for shade structures, cool pavement, and other reflective surfaces and include community engagement to inform cool street planning where applicable.

Roads that have been treated with a grey-colored, water-based asphalt emulsion that reflects the sun's rays instead of absorbing them, have shown to be an average of 10 to 15 degrees cooler than roads with traditional, untreated blacktop. Whereas traditional asphalt reflects around 10 percent of solar radiation and absorbs and radiates the remaining 90 percent as heat, cool pavement reflects 35 to 50 percent of the sun's rays. Shade is also a highly effective way of reducing temperatures and improving thermal comfort.

Co-benefits:

- ✓ Increased life span for asphalt surfaces
- ✓ Improved air quality
- ✓ Reduced energy use and increased cost savings
- ✓ Reduced GHG emissions

Implementing Actions

EH-2.1: Identify and establish priority corridors to focus effective pavement application where heat impacts are most severe.

EH-2.2: Conduct community engagement to identify playgrounds and parking lots that would benefit from cool pavement and shade installations.

EH-2.3: Identify necessary changes and amend the City's Municipal Code as appropriate to incentivize or require the use of cool pavement on projects.

EH-2.4: Identify and secure funds for capital improvements to increase the presence of reflective streets, surfaces, and shade canopies.

Equity Strategy

Identify corridors in the areas most impacted by extreme heat and/or poor air quality to prioritize them for shade, cool pavement, and other reflective surfaces.

EH-3 Enhance and Expand Urban Forest Cover and Vegetation

Expand and enhance urban forest cover and vegetation to mitigate urban heat island conditions.

Implementation Lead: Neighborhood Services Bureau; Public Works Department; City of Long Beach Office of Sustainability

Partners: Long Beach Parks, Recreation, and Marine; Conservation Corps of Long Beach; local community/neighborhood groups and stakeholders

Timeline: Short

Potential Cost Level: Low to Medium

Description

The City will increase the urban forest and expand and enhance vegetation citywide to reduce the urban heat island effect. The City will build upon the Urban Forest Management Plan, with attention to reducing urban heat island conditions. The City will prioritize neighborhoods that are most impacted by extreme heat and poor air quality and that have higher vulnerability because they lack a sufficient amount of urban forest and green space or have fewer resources to limit exposure to heat (e.g., shelter, air conditioning). Emphasis is placed on selecting drought-tolerant plants or California natives, which require less water and offer multiple benefits.

Urban forest cover and vegetation can serve an important role in climate change adaptation by lowering temperatures and providing shade and evaporative cooling. This is important because extreme heat is projected to increase in Long Beach, leading to intensification of the urban heat island effect, which could exacerbate heat-related illnesses and infrastructure deterioration.

Implementing Actions

EH-3.1: Update the Urban Forest Management Plan with a focus on prioritizing reduction of urban heat island conditions through both increased urban forest and enhanced vegetation.

EH-3.2: Identify tree planting opportunities in subwatershed areas with the lowest urban forest cover to minimize stormwater runoff and help protect the area from flooding during intense storm events.

EH-3.3: Identify and prioritize the planting of drought-tolerant or California native trees to enhance and expand urban forest cover and vegetation.

EH-3.4: Identify and involve community stakeholders in the planning process to inform urban forest cover needs and priorities.

EH-3.5: Evaluate the cost of water and other infrastructure to provide ongoing maintenance for trees, and seek ways to meet those costs through the City's budget process, Capital Improvement Program, grants and other funding or financing opportunities.

EH-3.6: Incorporate tree planting into partnerships with different groups, such as students involved in group courses to design neighborhood adaptation approaches to extreme heat.

Co-benefits:

- ✓ Increased carbon sequestration
- ✓ Improved energy conservation
- ✓ Enhanced wildlife habitat
- ✓ Improved air quality
- ✓ Increased natural stormwater management
- ✓ Increased access to green spaces
- ✓ Enhanced aesthetic and property values
- ✓ Increased creation of green jobs

Equity Strategy

Prioritize the enhancement and expansion of urban forest cover in neighborhoods that are the most impacted by extreme heat and poor air quality and that lack urban forest coverage and green space.

Existing Program: Tree Planting to Enhance the Urban Forest Cover

The "I Dig Long Beach - 10,000 trees by 2022 Initiative," which hosts neighborhood tree planting events and engages residents in planting, watering, and caring for new trees, has planted 5,000 trees in the city to date. This program is part of the City's efforts to expand the urban forest and increase the canopy cover.

Existing Program: Equity Toolkit

The Long Beach Equity Toolkit is a framework for equity offering specific strategies that can be applied to make positive changes through the City's policies, programs, and services. Acknowledging that a history of unfair laws and practices in Long Beach and the United States created many of the racial and social inequities that persist today, the toolkit supports the City in evaluating burdens, benefits, and outcomes for historically underserved or underrepresented communities while improving conditions for all citywide.

EH-4 Install Additional Water Fountains and Take Other Actions to Increase Public Access to Water

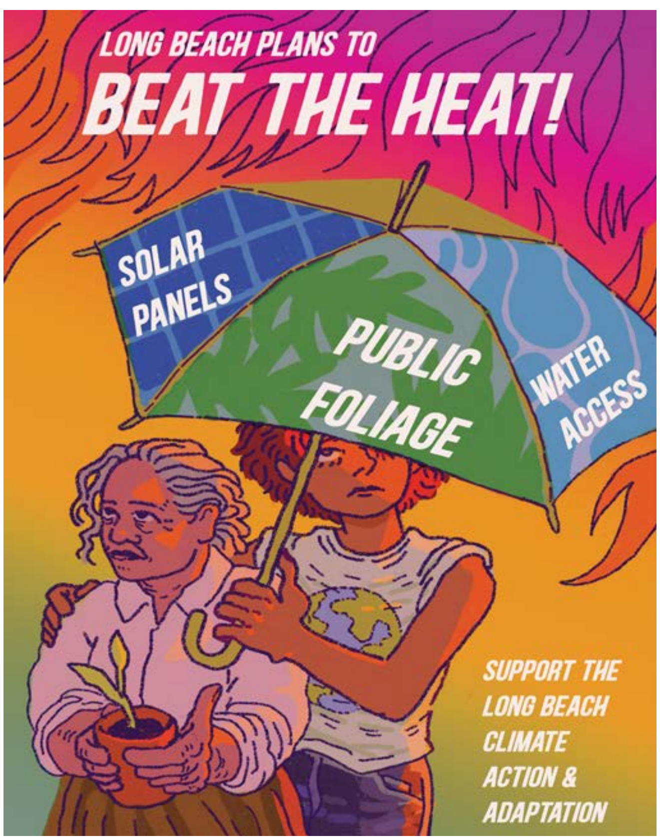
Ensure that water fountains are available in all public facilities, parks, and beaches, and where feasible at other public amenities.

Implementation Lead: Public Works Department
Partners: Long Beach Water Department; Long Beach Parks, Recreation, and Marine; LBUSD
Timeline: Medium
Potential Cost Level: Low

Description

The City will identify locations and complete installations of water fountains at City facilities, partnering with other agencies such as LBUSD as appropriate. The City will also conduct outreach and promote awareness on the benefits of reusable water bottles in reducing plastic pollution, especially as it relates to the ocean and wetlands.

Climate change will bring more days of extreme heat, which can lead to dehydration, heat-related illness, injury, or death. Drinking fluids is crucial to staying healthy. Public water fountains offer access to free water and reduce waste. Outdoor workers, the homeless, and older adults often do not get enough fluids and risk becoming dehydrated and sick, especially during the summer.



Co-benefits:

- ✓ Reduced dependence on single-use plastic water bottles
- ✓ Reduced plastic trash
- ✓ Reduced GHG emissions from single-use plastic production

Implementing Actions

EH-4.1: Survey the location of public drinking fountains in the city to determine where water drinking fountains and water stations are needed or in need of repair or replacement.

EH-4.2: Work with LBUSD to ensure that school fountains are in a state of good repair.

EH-4.3: Work with WeTap to ensure that the smart phone app provides the coordinates of public water fountains.

EH-4.4: Support the Long Beach Water Department's efforts to spread awareness of its various services and outreach and engagement programs.

EH-4.5: Develop an education and awareness campaign at beaches and through schools to encourage people to carry refillable bottles. Explore additional opportunities with other organizations, such as the Long Beach Aquarium, to demonstrate plastic pollution impacts.

Equity Strategy

Prioritize public water access in areas most impacted by extreme heat, with a focus on opportunities to serve children, seniors, core transit riders, and low-income communities.

Image: ArtCenter College of Design, Designmatters. Image + Idea Course, spring 2020

EH-5 Identify Future Vulnerability Potential for Power Outages Related to Extreme Heat and Develop Plans to Prevent Such Outages

Continue to partner with Southern California Edison to assess current grid vulnerabilities related to extreme heat to prevent future potential power outages due to worsening heat waves because of climate change.

Implementation Lead: Disaster Preparedness and Emergency Communications; Public Works
Partners: City of Long Beach Office of Sustainability; SCE
Timeline: Short
Potential Cost Level: Medium

Description

The City will continue to work with SCE to assess potential grid vulnerabilities due to worsening extreme heat and to develop and refine strategies and actions to prevent future power outages related to extreme heat. Depending on the results of the assessment, actions will be identified and prioritized to reduce pressure on the grid as well as to build Long Beach's resilience to these power outages, such as by establishing microgrids. This will also include using the recently developed guidelines produced by SCE for conducting maintenance outages in relation to extreme heat events.

Extreme heat events result in increased use of air conditioning, which causes strain on the transmission lines and the electrical grid. Sagging of power lines in high heat events can cause safety and/or outage issues. This means heat waves can cause power outages that could be inconvenient and even life threatening for vulnerable residents of Long Beach.

Co-benefits:

- ✓ Expansion of renewable energy capacity
- ✓ Enhanced grid stability

Implementing Actions

EH-5.1: Collaborate with SCE to determine how Long Beach can contribute to their existing efforts to prevent and prepare for power outages related to extreme heat.

EH-5.2: Develop a mitigation plan to prevent and be prepared for future power outages related to extreme heat.

EH-5.3: Identify and prioritize actions to build resiliency into the local electrical infrastructure through new actions or by partnering and expanding upon existing SCE actions.

Equity Strategy

Develop a power outage plan that prioritizes emergency response and resiliency of the elderly, young, and low-income communities.

EH-6 Enhance and Expand Accessibility of Cooling Centers

Evaluate the existing cooling center network, facilitate the usage of cooling centers citywide and identify areas of expansion, prioritizing the communities most vulnerable to extreme heat.

Implementation Lead: Disaster Preparedness and Emergency Communications; Long Beach Department of Health and Human Services; Long Beach Parks, Recreation, and Marine; Library Services Department

Partners: LBUSD; faith- and community-based organizations

Timeline: Short

Potential Cost Level: Low to Medium

Description

The City will evaluate the existing cooling center network to better understand the utilization characteristics of community centers and libraries. Factors to be evaluated include the hours of operation, capacity, characteristics such as presence of functioning HVAC systems, access in neighborhoods most vulnerable to extreme heat, community awareness of the centers, staff preparedness, transit accessibility, digital inclusion, and other variables. The City will develop a set of strategies to increase the usage and effectiveness of the network and individual centers. Improvements will be prioritized in low-income communities most vulnerable to extreme heat. The City will also work with faith- and community-based organizations to strengthen the public use of churches, temples, mosques, and other buildings as cooling centers.

As climate change increases the likelihood of frequent and extreme heat events, indoor facilities (e.g., cooling centers) can provide relief for those who are impacted by heat illnesses, such as heat cramps, heat exhaustion, and heat strokes.

Co-benefits:

- ✓ Enhanced use of public buildings

Equity Strategy

Prioritize increasing access to cooling centers for those most at-risk of heat-related injury, illness and death, such as people experiencing homelessness, seniors, young children and infants, pregnant women, people with chronic illnesses, transit riders, and outdoor workers.

Implementing Actions

EH-6.1: Evaluate the existing cooling center network and identify various means to expand access, prioritizing neighborhoods and households most vulnerable to extreme heat.

EH-6.2: Partner with the school district and faith- and community-based organizations to identify and provide resources to existing and new cooling centers.

Image: ArtCenter College of Design, Designmatters. Image + Idea Course, spring 2020

EH-7

Provide Bus Shelter Amenities

Provide more bus shelter amenities to help prevent health effects from long sun exposure and to incentivize usage of public transportation.

Implementation Lead: Public Works Department; Long Beach Transit
Partners: Outdoor advertising companies
Timeline: Short
Potential Cost Level: Low to Medium

Description

The City will work with Long Beach Transit to complete a full assessment of bus stops to identify potential improvements. This will include focusing on such right-of-way improvements as sidewalk width, bulb-outs, and Americans with Disabilities Act accessibility, which are often prerequisites for bus stop improvements. In addition, the City will ensure that the permitting and installation process is carried out through completion.

High-quality bus stops that include a combination of amenities, such as shade, seating, and hydration stations, can provide transit riders a refuge from high temperatures. This is especially critical for transit-dependent residents who rely on transit as their primary or only means of accessing key destinations and services. Transit-dependent youth and the elderly, sick, and disabled are particularly vulnerable to extreme heat. Shaded, high-quality bus stops also play an important role in attracting new transit riders and retaining existing ones, and increased transit ridership has strong air

Co-benefits:

- ✓ Increased transit ridership
- ✓ Reduced GHG emissions

Implementing Actions

EH-7.1: Work with Long Beach Transit to identify and prioritize bus stops without shade structures on highly utilized routes that are in areas with high heat vulnerability.

EH-7.2: Partner with Long Beach Transit to engage with transit riders and other stakeholders in identifying priority locations and desired bus stop features.

EH-7.3: Pursue public and private funding opportunities for bus shelter amenities, such as the Low Carbon Transit Operations Program, and through advertising companies.

EH-7.4: Facilitate the permitting and installation of new bus stop amenities.

Equity Strategy

Prioritize bus stop amenities and improvements in neighborhoods with the largest populations of core transit riders and those that are most affected by extreme heat and many sources of pollution, as identified by CalEnviroScreen.

EH-8 Improve Beach and Coastal Transit Access During Extreme Heat Events

Identify options to improve beach and coastal transit access during extreme heat events, with priority given to communities and populations that are most affected by extreme heat.

Implementation Lead: Long Beach Transit
Partners: California Coastal Commission; community organizations
Timeline: Short
Potential Cost Level: Low

Description

The City will support Long Beach Transit in evaluating a range of options to improve beach access during extreme heat events, with priority given to highly vulnerable populations such as children, the elderly, people with disabilities, and communities and neighborhoods that are most susceptible to extreme heat. These options could include improvements to existing fixed transit routes, new fixed transit routes, shuttles or flexible transit service, and reduced or free transit rides.

During extreme heat events, coastal temperatures are often significantly lower than those farther inland. For those residents who do not have access to a car or are unable to drive, public transit that accesses the coast and beach offers a reprieve from high temperatures and provides additional recreational opportunities.

Co-benefits:

- ✓ Increased transit ridership
- ✓ Reduced GHG emissions

Implementing Actions

EH-8.1: Evaluate the beach and coastal transit access of communities and neighborhoods that are most vulnerable to extreme heat events.

EH-8.2: Identify options to improve the beach and coastal transit access of communities and neighborhoods that are vulnerable to extreme heat events.

EH-8.3: Partner with Long Beach Transit to identify strategies and funding mechanisms to expand or increase the frequency of transit services in order to improve beach access for communities that are the most vulnerable to extreme heat.

Equity Strategy

Improve beach and coastal transit access for the populations most vulnerable to extreme heat, such as youth, the elderly, and people with disabilities, and for the geographic areas of the city most impacted by extreme heat conditions.

AIR QUALITY ACTIONS

Air pollution is a major threat to public health and carries increased risk for vulnerable populations. In a 2006 assessment, the Long Beach Health Department found that 14 percent of residents suffer from asthma which is 2.5 percent higher than Los Angeles and 6 percent higher than the entire U.S. The report found that people of color and low-income communities were disproportionately impacted. All air quality actions taken by the City will prioritize vulnerable communities.[i]

Regional air quality has improved substantially over the past three decades, but it is still a major health issue in Long Beach, in particular for communities near freeways, industry, and the Port of Long Beach. Climate change has the potential to make air quality worse, negating some improvements in air quality that have been achieved and reducing the effectiveness of future efforts. Warming could increase the number of days violating air quality standards in the region by as much as 25-80 percent by end-of-century. Additionally, an increase in wildfires in the broader region could also lead to dangerous air quality levels. The combination of higher temperatures, precipitation change, and increasing CO_2 concentrations is expected to increase pollen and some airborne allergens.

The City of Long Beach has made improved air quality a core priority through existing efforts such as the San Pedro Bay Ports Clean Air Action Plan, efforts to improve transit service, and efforts to spur the development of walkable, transit-oriented communities. The CAAP both continues and builds upon these and other efforts. The air quality adaptation actions target air pollution reductions from a variety of sources such as buses, landscaping equipment, the Long Beach Airport, and food transportation. Combined with the air pollution reduction co-benefits that are expected to result from the mitigation actions, the CAAP has the potential to lead to substantial improvements in air quality and public health.

[i] http://www.calhealthreport.org/2016/03/07/breathing-air-into-asthma-prevention-in-long-beach/

AQ Air Quality

Goal: All Long Beach communities have clean air and improved public health

OBJECTIVES		ACTIONS
Buildings and facilities actively reduce air pollution as a component of a broader energy reduction strategy.	**AQ-1**	Incentivize installation of photocatalytic tiles
	AQ-2	Encourage urban agriculture practices that reduce air quality pollution
Emissions are reduced by shifting to cleaner equipment and vehicles.	**AQ-3**	Support the development of the Long Beach Airport Sustainability Plan
	AQ-4	Electrify small local emitters, such as lawn and garden equipment, outdoor power equipment, and others
	AQ-5	Work with Long Beach Unified School District (LBUSD) to support school bus electrification
	AQ-6	Implement the Port of Long Beach Clean Air Action Plan
Air quality impacts from local oil and gas operations are minimized.	**AQ-7**	Increase monitoring and regulation of oil extraction and refining process

AQ-1 Incentivize Installation of Photocatalytic Tiles

Support the installation of photocatalytic tiles to improve air quality.

Implementation Lead: Development Services
Partners: Long Beach Department of Health and Human Services; Harbor Department; South Coast Air Quality Management District (SCAQMD)
Timeline: Medium
Potential Cost Level: Low

Description

To improve air quality, the City will support the installation of photocatalytic tiles by actively pursuing grant funding options to incentivize the installation of photocatalytic tile products. Typically embedded into cool roofing products, these tiles are covered with titanium-dioxide-coated granules that act as a catalyst for sunlight-activated chemical reactions that convert smog (nitrogen oxide [NOx]) into other substances, such as calcium nitrate and water. This action will include collaborating with SCAQMD, community partners, developers, and other stakeholders to identify projects that could incorporate photocatalytic tiles as part of a more holistic emissions reduction strategy that prioritizes the neighborhoods and communities near the Port and the Interstate 710 (I-710) corridor, which are heavily impacted by air pollution.

Co-benefits:

- ✓ Reduced air pollution through use of smog-reducing granules, when combined with reflective material, as well as lower both indoor and outdoor temperature
- ✓ Reduced greenhouse gas (GHG) emissions

Implementing Actions

AQ-1.1: Work with SCAQMD, community groups, and stakeholders to identify projects that could incorporate photocatalytic tiles as part of a more holistic emissions reduction strategy.

AQ-1.2: Pursue funding to retrofit existing buildings, new developments, and/or redevelopments that could incorporate photocatalytic tiles as part of a more holistic emissions reduction strategy.

AQ-1.3: Partner with SCAQMD to monitor air pollutant reductions resulting from the installation of photocatalytic tiles.

AQ-1.4: Contingent on initial success, explore code changes to require or incentivize photocatalytic tiles in communities with poor air quality.

Equity Strategy

Evaluate the air quality benefits of installing photocatalytic tiles in neighborhoods with high pollution levels and prioritize projects that will provide the greatest benefits in Long Beach communities with the poorest air quality.

AQ-2 Encourage Urban Agriculture Practices that Reduce Air Quality Pollution

Continue to incentivize urban agriculture practices and projects in community and home gardens that increase local food production and reduce air quality impacts from food transportation.

Implementation Lead: City of Long Beach Office of Sustainability; Long Beach Water Department
Partners: Library Services Department
Timeline: Short
Potential Cost Level: Low

Description

The City will provide new incentives that encourage the overall expansion of urban agriculture in home and community gardens. Local urban agriculture has the potential to improve air quality and access to healthy food for Long Beach residents. Food imported from outside the region is generally transported long distances by trucks and ships that produce substantial quantities of air pollution. In addition, urban agriculture can incorporate drought-tolerant practices that further increase the water and emissions efficiency of local food production.

The Long Beach Water Department has a robust Lawn-to-Garden (L2G) program that provides rebates for replacing grass with drought-tolerant gardens. Expanding the L2G program to include urban agricultural components may include identifying incentives for drought-tolerant seeds and plants, rain capture and drip irrigation systems, and other water conservation equipment.

Co-benefits:

- ✓ Increased local food security and strengthened local food system
- ✓ Increased public health benefits resulting from healthy food access
- ✓ Decreased urban heat island effect

Implementing Actions

AQ-2.1: Develop new incentives that encourage the expansion of urban agriculture in home and community gardens.

AQ-2.2: Explore ways to incorporate urban agriculture components in the L2G program, including incentives.

AQ-2.3: Evaluate ways to reduce barriers to urban agriculture in home and community gardens, including amending the zoning code, waiving and reducing fees, and providing guidance on City processes.

AQ-2.4: Develop educational and training opportunities for drought-tolerant urban agriculture.

Equity Strategy

Support urban agriculture as a means of enhancing local food access and decreasing neighborhood food insecurity, and prioritize options for renters.

AQ-3 Support the Development of the Long Beach Airport Sustainability Plan

Work with Long Beach Airport to support the development of the Long Beach Airport Sustainability Plan, with a focus on reducing emissions from vehicles and equipment at the airport.

Implementation Lead: Long Beach Airport
Partners: City of Long Beach Office of Sustainability; airlines; aviation industry companies
Timeline: Long
Potential Cost Level: Low to Medium

Description

The City will support the development and implementation of the Long Beach Airport Sustainability Plan to ensure the success of the airport's efforts to reduce emissions from ground vehicles and equipment, including expanding zero emission vehicle fleets, increasing electric-charging infrastructure, and pursuing Airport Carbon Accreditation. Over the long term, the City will also support efforts to explore the feasibility of longer-term technologies for the integration of electric airplanes into the airport's fleet.

Overall, the aviation industry accounts for 11 percent of all transportation-related GHG emissions in the United States, which are a result of burning jet fuel and releasing NOx and carbon dioxide (CO_2). By transforming Long Beach Airport into a center of GHG reduction innovation, the City will both improve local air quality and become a national leader in climate mitigation.

Equity Strategy

Implement actions that improve air quality for impacted communities around Long Beach Airport.

Co-benefits:

- ✓ Reduced GHG emissions
- ✓ Increased potential for energy savings
- ✓ Increased energy efficiency
- ✓ Reduced waste

Implementing Actions

AQ-3.1: Work with Long Beach Airport to support the development and implementation of the Long Beach Airport Sustainability Plan, which includes reducing fuel use, reducing facility waste output, and replacing on- and off-road vehicles and equipment with zero- or low-carbon alternatives at the Long Beach Airport.

AQ-3.2: Encourage airlines to help customers in buying carbon offsets through their ticket purchase process.

AQ-3.3: Support the long-term integration of sustainable fuels and electric-powered airplanes operating out of Long Beach Airport.

Existing Program: Sustainability at Long Beach Airport

In August 2018, the Long Beach City Council directed Long Beach Airport to work with its airlines and other partners to become an incubator of clean technology in aviation, with the goal of becoming a carbon-neutral facility. The City, which is the airport's owner and operator, has begun to develop a Long Beach Airport Sustainability Plan to reduce the airport's carbon footprint through actions that address air emissions, energy, water conservation, water quality, and solid waste and recycling. The Airport Modernization Program includes sustainability improvements ranging from facility upgrades to energy efficiency enhancements.

AQ-4 Electrify Small Local Emitters, Such as Lawn and Garden Equipment, Outdoor Power Equipment, and Others

Support the replacement of small, fossil-fuel-powered engine equipment with electric-powered equipment.

Implementation Lead: Public Works Department; Long Beach Parks, Recreation, and Marine
Partners: SCAQMD; California Air Resources Board (CARB)
Timeline: Short and Medium
Potential Cost Level: Low to Medium

Description

City staff will support the replacement of small fossil-fuel-powered engine equipment with electric-powered equipment. These small off-road engines, which are primarily used for lawn, garden, commercial utility, and other outdoor power equipment (e.g., generators, utility carts), contribute greatly to local air pollution. At least 50 cities across the state already have some sort of regulation on lawn and garden equipment.

As of 2017, the population of small engines in California (16.7 million) is estimated to be greater than that of light-duty passenger cars (13.7 million). This engine population consists of 77 percent residential lawn and garden equipment, 9 percent commercial lawn and garden equipment, 11 percent federally regulated construction/farming equipment, and 3 percent other equipment types (e.g., generators, utility carts). In Long Beach, the amount of fossil-fuel-powered small engines operated by the City, by commercial landscapers, and by residential owners is unknown. As an initial step, the City will immediately implement the recommendation of the Board of Health and Human Services that City-owned fossil-fuel-powered leaf blowers be model years 2007 or newer and be 65 decibels (sound level) or less. This will be followed by a process to identify options to require all-electric equipment to be used in the future in City operations and City-owned equipment as well as privately owned equipment.

Co-benefits:

- ✓ Reduced noise from leaf blowers, lawn mowers, and other landscaping equipment
- ✓ Reduced GHG emissions

Implementing Actions

AQ-4.1: Conduct outreach and education efforts to inform the general public of the emissions impacts of this equipment and work with SCAQMD to publicize its Electric Lawn and Garden Equipment Incentive and Exchange Program and Residential Lawn Mower Rebate Program.

AQ-4.2: . Collaborate with SCAQMD and CARB to advance regulations restricting the use of small fossil-fuel-powered emitters.

AQ-4.3: Phase out City-owned fossil-fuel-powered lawn and garden equipment, and establish requirements for vendors contracted by the City to do the same.

Equity Strategy

Work with the regulatory agencies to provide assistance and incentives for private phase out to reduce financial barriers for commercial landscapers and residents as needed.

AQ-5 Work With LBUSD to Support School Bus Electrification

Explore opportunities to support the LBUSD in transitioning the district's school bus fleet from diesel-powered to electric vehicles.

Implementation Lead: LBUSD
Partners: CARB; California Energy Commission; SCAQMD; Southern California Edison (SCE); Long Beach Transit
Timeline: Short
Potential Cost Level: Low to Medium

Description

LBUSD discontinued daily school bus transportation in 2013. However, school buses are still used for transporting students to field trips and athletic events. School buses are also regularly used by students enrolled in the district's Special Education Program. LBUSD is working on programs to transition to electric buses, including working with vendors that already have renewable natural gas electric buses. In partnership with LBUSD and others, the City will explore opportunities to support the transition of the school bus fleet from diesel-powered to electric vehicles. Moving forward, the City will identify ways to support LBUSD in exploring opportunities to transition its current diesel-powered fleet, , including applying for incentives for buses and supportive infrastructure such as charging stations.

The negative impacts of using diesel-powered school buses are well documented and are known to affect lung development and have respiratory health effects over time. Transitioning diesel-powered buses to electric power will have positive, long-term public health impacts on children and neighborhoods along bus routes.

Equity Strategy

Target efforts to phase out diesel-powered buses for electric buses in school and bus route service areas with the poorest air quality.

Co-benefits:

- ✓ Reduced GHG emissions

Implementing Actions

AQ-5.1: Identify ways to support LBUSD and other partners in applying for funding from state and local sources to transition from diesel-powered to electric buses.

AQ-5.2: Evaluate air quality impacts on specific school and bus route service areas to prioritize planning efforts.

AQ-6 Implement the San Pedro Bay Ports Clean Air Action Plan

Continue to implement the San Pedro Bay Ports Clean Air Action Plan and align with the City's overall GHG emissions reduction targets.

Implementation Lead: Harbor Department
Partners: Drayage truck owners; terminal operator; intermodal rail yards
Timeline: Ongoing
Potential Cost Level: Low to High

Description

The Port will continue to implement the San Pedro Bay Ports Clean Air Action Plan, which contains a comprehensive set of strategies focused on improving air quality. This includes achieving up to 100 percent compliance with state requirements for ships to use shore power or alternative capture technologies while docked. It also includes continuing implementation of the Clean Trucks Program and adoption of a suite of additional actions. The Port will continue to work in partnership with its tenants; regional, state, and federal agencies; and other stakeholders to implement the plan, invest in developing and deploying clean technologies, and advocate for needed policies and funding. The Port has engaged with environmental groups and local communities to encourage input and provides regular public updates on plan implementation.

The San Pedro Bay Ports Clean Air Action Plan provides a suite of strategies organized into the categories of clean vehicles and equipment technology and fuels, freight infrastructure planning and investments, freight efficiency, and energy resource planning. Actions include plugging ships into shore power while docked; reducing ship speeds; increasing the percentage of clean and alternative-fuel trucks accessing the Port; increasing the use of more efficient locomotives, hybrid and electric cargo equipment, and harbor craft; increasing energy efficiency and renewable power generation; investing in infrastructure to increase the efficient movement of cargo; and continuing the implementation of a Clean Trucks Program.

Co-benefits:

- ✓ Reduced GHG emissions
- ✓ Improved public health

Implementing Actions

AQ-6.1: Collaborate with the Port to implement Clean Air Action Plan strategies, maximizing air quality improvements and GHG emissions reductions.

AQ-6.2: Support the Port in implementing and expanding the Green Ports Collaborative.

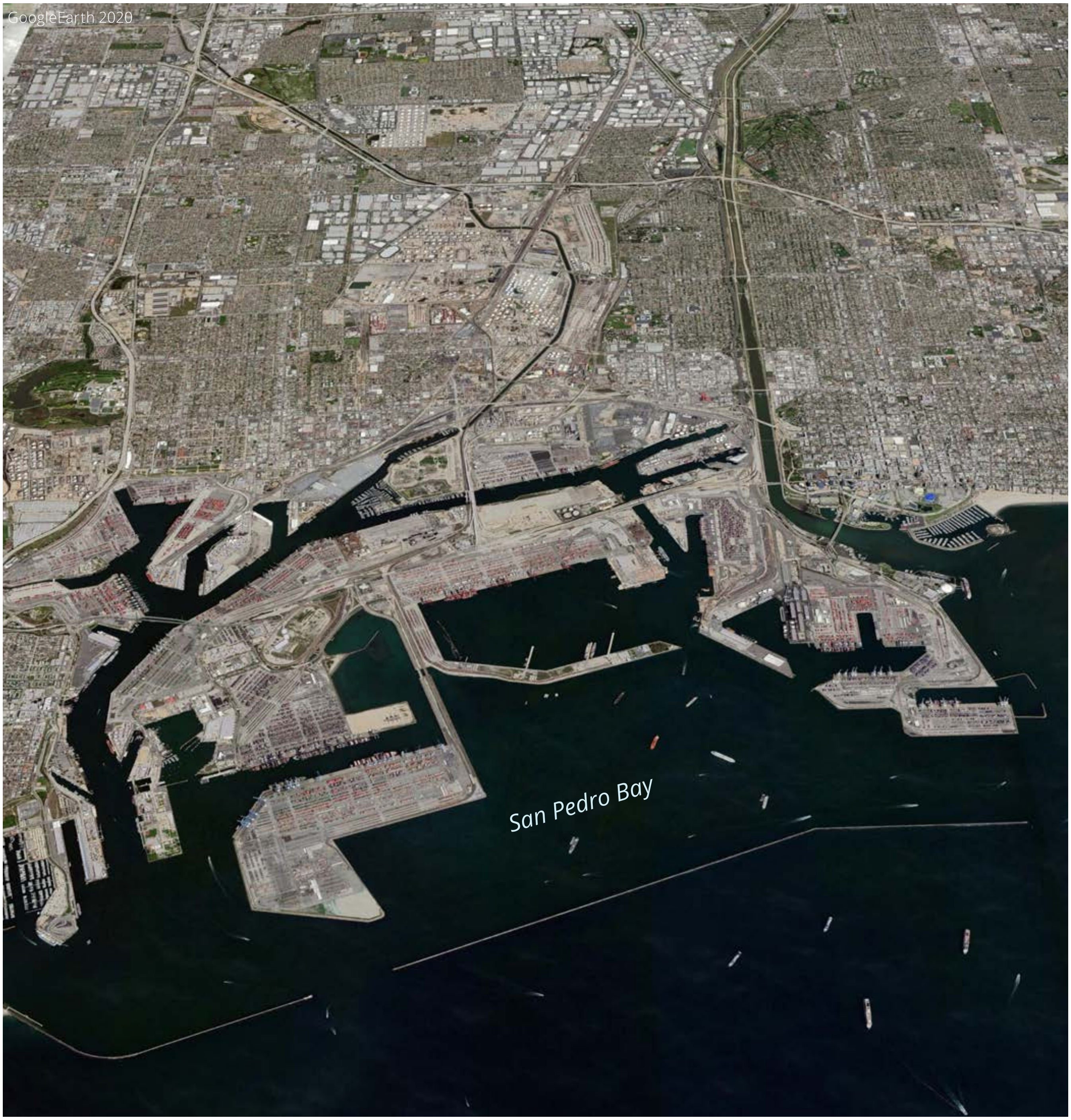
AQ-6.3: Support the Port's investments in the Technology Advancement Program to encourage green technology development and piloting.

AQ-6.4: Continue to provide quarterly and annual progress reports that are available to the public.

AQ-6.5: Collaborate with the Port to further reduce shipping-related emissions through use of 100% emissions-free cargo handling equipment by 2030 and implementation of state's shore power regulation for at-berth vessels.

Equity Strategy

Prioritize actions that improve air quality for impacted communities surrounding the Port and along industrial corridors, and meaningfully include those communities in decisions about how actions should be implemented.



Existing Program: San Pedro Bay Ports Clean Air Action Plan

The San Pedro Bay Ports Clean Air Action Plan accelerates the Port's progress toward a zero-emissions future. Since 2005, port-related air pollution emissions in San Pedro Bay have dropped 87 percent for diesel particulate matter, 56 percent for nitrogen oxides, and 97 percent for sulfur oxides. In 2017, the Mayors of the City of Los Angeles and City of Long Beach announced a joint declaration for creating a zero-emissions goods movement future, with goals of zero emissions for cargo-handling equipment by 2030 and zero emissions for on-road drayage trucks serving the ports by 2035.

AQ-7 Increase Monitoring and Regulation of Oil Extraction and Refining Process

Establish air monitors outside of active wells that are within the Long Beach city limits. Conduct an audit survey of all methane emissions to check possible emissions coming from either active or abandoned oil wells.

Implementation Lead: Energy Resources Department; Long Beach Department of Health and Human Services

Partners: City of Long Beach Office of Sustainability; CARB; California Air Pollution Control Officers Association (CAPCOA)

Timeline: Medium

Potential Cost Level: Low

Description

The State of California has some of the strictest air emission policies in the United States. In 2013, the Interagency Refinery Task Force was formed, and CARB and the California Air Pollution Control Officers Association (CAPCOA) were tasked with monitoring refineries across the entire state. Their March 2019 Report stated the need to increase air monitoring systems to gather relevant, reliable air quality data in real time to help make informed safety decisions. This is a priority for the State and impacts Long Beach and its residents. The City will increase its participation in this process and help grow this air monitoring network. The City will also audit all methane emissions from active or abandoned oil wells to check for possible noncompliance and make this data available to the public.

Existing Program: West Long Beach Air Quality Monitoring

The Wilmington/Carson/West Long Beach community was designated by the California Air Resources Board for year one Assembly Bill (AB) 617 implementation. AB 617 is a law that focuses on reducing air pollution in California's environmental justice communities. As part of this effort, stakeholders in West Long Beach contributed to the development of a Community Air Monitoring Plan that will inform actions to reduce local exposure to harmful air pollutants.

Co-benefits:

- ✓ Availability of data to inform both state and regional regulators and others looking to protect their health
- ✓ If leaks identified through the monitoring, could lead to a reduction in fugitive methane emissions, a gas with a potent global warming potential

Implementing Actions

AQ-7.1: Work with CARB and CAPCOA while developing the air monitoring program for oil wells.

AQ-7.2: Establish air monitors outside of active wells and create a schedule to regularly check their methane emissions. Conduct audits at wells to monitor compliance.

AQ-7.3: Regularly send air monitoring reports to regulators and CARB for review.

AQ-7.4: Make air monitoring data available to the public.

Equity Strategy

Using CalEnviroScreen and other appropriate data tools, identify locations for air monitors in neighborhoods that are the most impacted by poor air quality.

DROUGHT ACTIONS

Changes in temperature and precipitation are predicted to produce longer and more frequent droughts that will have an impact on Long Beach's water supply. According to Long Beach Water, approximately 60 percent of the City's water supply is from local ground water, 25 percent is from the Colorado River, and 15 percent is from the Northern California Bay-Delta. Future drought patterns are expected to result in regional drying. This is expected to include continued reduction of the Sierra Nevada snowpack and snowmelt runoff earlier in the season that will stress supplies in the Northern California Bay-Delta. The Colorado River will also face similar dynamics. Local water demand is also expected to increase absent a shift to drought tolerant plant species. To respond to this challenging dynamic Long Beach will need to build on its successful efforts to use existing water resources more efficiently and diversify its water supply. The City has made significant strides through the initiation of a number of programs to respond to drought and meet and exceed state water use efficiency targets. This includes successful public outreach, education, and incentives to residents and businesses to conserve water. The City's Water Reclamation Plant recycles up to 25 million gallons of wastewater per day for reuse. The water is used at over 60 sites and for uses such as irrigation, both replenishment of groundwater supply and protection from saltwater intrusion, and re-pressurization of oil-bearing strata off the coast. What is not used is discharged to Coyote Creek.

To establish a more diverse and sustainable water supply the City will identify ways to increase the supply and use of recycled water, expand green infrastructure and streets, and increase the capture and storage of rainfall. These actions have numerous potential co-benefits such as water and energy savings, expansion of green space, and reduced urban heat island effects. The City will prioritize programs and infrastructure that benefit communities most impacted by climate change.

DRT Drought

Goal: Long Beach has a more sustainable and diverse water supply that reduces dependence on imported water and improves long-term water security

OBJECTIVES	NO.	ACTIONS
Maximize water efficiency and conservation.	DRT-1	Continue development and implementation of water use efficiency programs and implement additional water conservation programs
	DRT-2	Enhance outreach and education related to water conservation
Maximize water that is captured and reused locally.	DRT-3	Expand usage of green infrastructure and green streets
	DRT-4	Expand usage of recycled water and greywater for non-potable use
	DRT-5	Incorporate increased rainfall capture and other actions to maximize local water supplies and offset imported water

DRT-1 Continue Development And Implementation Of Water Use Efficiency Programs And Implement Additional Water Conservation Programs

Continue development and implementation of additional water use efficiency and conservation programs to help reduce water use.

Implementation Lead: Long Beach Water Department
Partners: City of Long Beach Office of Sustainability; Metropolitan Water District of Southern California (MWD)
Timeline: Short
Potential Cost Level: Low to Medium

Description

Building upon Long Beach's Water Resources Plan and Urban Water Management Plan, the City will identify and move forward with further water conservation programming and efficiency measures to help reduce overall usage. Water use efficiency programs provide cost savings to customers through water utilities and through electricity and gas utilities, due to the reduced need for these resources to transport and heat water. Mitigating utility cost burdens will play a role in controlling costs for residents and businesses.

Long Beach's Water Resources Plan and Urban Water Management Plan are intended to ensure that Long Beach will achieve the water use reduction and efficiency targets set by the State of California. Identifying additional strategies will help reduce reliance on imported water and reduce GHG emissions, since importing water to Southern California accounts for 20 percent of the state's electricity.1

Equity Strategy

Conduct targeted water efficiency program outreach to ensure that low-income communities benefit from cost savings.

Existing Program: Certified Blue Restaurant Program

The Certified Blue Restaurant program supports and recognizes Long Beach restaurants for achieved water efficiency. Restaurants can receive a no-cost, on-site efficiency survey, free water-efficient devices, and an assessment for other possible rebates.

Co-benefits:

- ✓ Reduced GHG emissions through conservation of gas and electricity needed to distribute and heat water
- ✓ Increased protection of upstream rivers and wildlife habitat
- ✓ Reduced urban runoff and thus reduced pollution of coastal waters (based on reduced landscape irrigation)

Implementing Actions

DRT-1.1: Monitor Assembly Bill 1668 and Senate Bill 606 on water restriction and conservation.

DRT-1.2: Identify partners and participants for water use efficiency outreach and education. Conduct outreach to residents to ensure they understand the programs that are available and the eligibility requirements.

DRT-1.3: Establish water use efficiency programs tailored to commercial, industrial, and institutional water users.

DRT-1.4: Identify potential incentives and requirements that can be included in City contracts to reduce the use of potable water and spur access to and use of recycled/reclaimed water for uses such as sidewalk pressure washing and landscape irrigation.

DRT-1.5: Establish programs to invest in City infrastructure that can create water efficiency, such as irrigation systems and water-reuse systems in parks.

DRT-1.6: Conduct an analysis of program and rebate participation by census tracts to spur greater participation in new and existing programs within the low-income communities most impacted by climate change.

[1] http://www.lbwater.org/Residential%20

DRT-2 Enhance Outreach and Education Related to Water Conservation

Enhance public outreach campaigns to promote water conservation and efficient water use.

Implementation Lead: Long Beach Water Department
Partners: City of Long Beach Office of Sustainability; Library Services Department
Timeline: Short
Potential Cost Level: Low

Description

The City will build upon its existing water conservation educational programs and consider launching an ad campaign focusing on water conservation at home, the importance of water to the region, and how water conservation translates to cost savings for Long Beach residents. The City will seek opportunities to enhance its water conservation trainings and workshops. Outreach and education will consider targeting high water usage behaviors to reduce consumption and low-income communities to share the resources and cost savings associated with water conservation. Water conservation should complement efforts to maximize local water supplies and improve water efficiency. Water conservation efforts can aim to share various water conservation practices and resources with residents and businesses.

Co-benefits:

- ✓ Increased conservation of gas and electricity needed to distribute and heat water, resulting in reduced GHG emissions
- ✓ Reduced water, electricity, and gas utility costs to residents
- ✓ Increased opportunities to coordinate community engagement with other Climate Action and Adaptation Plan (CAAP) initiatives

Implementing Actions

DRT-2.1: Identify partners and participants for water conservation outreach and education.

DRT-2.2: Continue to develop outreach and educational programming.

DRT-2.3: Continue the existing educational campaign to achieve citywide goals for residential water use reductions.

Equity Strategy

Ensure that low-income and drought-vulnerable communities receive information about the cost savings and other benefits from water conservation. Identify and implement ways to maximize costs savings and other benefits for those communities.

DRT-3 Expand Usage Of Green Infrastructure And Green Streets

Incorporate green infrastructure and green streets to diversify water supply, increase natural and stormwater capture, prevent urban runoff, reduce the demand on existing infrastructure, reduce the heat island effect, and increase sustainability and resiliency.

Implementation Lead: Public Works Department; Long Beach Parks, Recreation, and Marine
Partners: City of Long Beach Office of Sustainability; Harbor Department
Timeline: Medium
Potential Cost Level: Medium to High

Description

Green infrastructure – such as permeable pavement, bioretention areas, bioswales, or vegetated strips – can often be easily retrofitted into existing infrastructure, as evidenced by the Long Beach Water Department's Lawn-to-Garden program. The City will identify and implement strategies to diversify the water supply, reduce demand on existing infrastructure, and increase resiliency during droughts as well as heavy rainstorms. Examples of green infrastructure and green streets include approaches such as permeable pavement, bioretention areas, bioswales, and vegetated strips.

To start, the City will study and identify locations that are best suited for green infrastructure (i.e., areas that are prone to frequent flooding during rainfall events) and alleys or streets that are best suited for grey to green conversion. In addition, the City will start to identify potential incentives and requirements that can be included in City contracts and on new developments.

Equity Strategy

Prioritize investments in communities with the least green space and the greatest climate risks, and that are located in the most vulnerable subwatershed areas.

Co-benefits:

- ✓ Increased green space
- ✓ Reduced urban heat island effect
- ✓ Improved water quality
- ✓ Improved walkability

Implementing Actions

DRT-3.1: Study and identify locations that are best suited for green infrastructure, such as areas that are prone to frequent flooding during heavy rainfall events.

DRT-3.2: Study and identify alleys or streets that are best suited for grey to green conversion for inclusion in the City's Capital Improvement Program and other investment prioritization. Conduct outreach to residents to discover any existing concerns with the alley or street, such as frequent flooding, low lighting, or pedestrian and bicycle safety, and to understand how the space could best be used by the community.

DRT-3.3: Identify potential incentives and requirements that can be included in City contracts and in new developments to increase the amount of stormwater capture and reduce the amount of impervious areas in projects.

DRT-3.4: Develop a green infrastructure design or technologies guide to facilitate and encourage the use of green infrastructure in new developments.

DRT-4 Expand Usage of Recycled Water and Greywater for Non-Potable Use

Increase and incentivize recycled water and greywater use to establish a more diverse water supply portfolio.

Implementation Lead: Public Works Department; Long Beach Parks, Recreation, and Marine
Partners: City of Long Beach Office of Sustainability; MWD; Water Replenishment District of Southern California; Long Beach Water Department
Timeline: Medium
Potential Cost Level: Medium to High

Description

Currently 6 million of the 25 million gallons of water treated per day at the Long Beach Water Reclamation Plant is reused at more than 60 reuse sites, which include schools and parks, and there is public support for continuing and expanding this use. The City will identify and implement strategies to expand the usage of recycled water and greywater for non-potable use, such as landscape irrigation. This would establish a more diverse water supply portfolio, which would increase resiliency to drought and reduce reliance on imported water. Initial strategies will include identifying partners and participants for recycled water and greywater outreach and education to ensure residents understand the available programs and eligibility. In addition, the City will also explore potential incentives and requirements that can be included in City contracts to reduce the use of potable water.

Co-benefits:

- ✓ Reduced GHG emissions from importing water
- ✓ Increased water and energy savings
- ✓ Expanded green space
- ✓ Reduced urban heat island effects

Implementing Actions

DRT-4.1: Identify partners and participants for recycled water and greywater outreach and education. Conduct outreach to residents to ensure they understand the programs and the eligibility requirements.

DRT-4.2: Identify potential incentives and requirements that can be included in City contracts to reduce the use of potable water and spur access to and use of recycled or greywater for uses such as irrigation.

DRT-4.3: Conduct analysis of program and rebate participation to spur greater participation in new and existing programs and expand the greywater infrastructure system.

DRT-4.4: Identify options to incentivize or require greywater use for irrigation and incorporate greywater into new building standards.

Equity Strategy

Prioritize investments in low-income communities and the most vulnerable subwatershed areas.

Existing Program: LB-MUST

In April 2016, the City Council approved a $28 million Cooperative Implementation Agreement with the California Department of Transportation (Caltrans) for the design and construction of an innovative stormwater treatment plant. The Long Beach Municipal Urban Stormwater Treatment Recycle Facility, or LB-MUST, will be built along the east bank of the Los Angeles River in the area between 4th and 7th Streets and will capture polluted urban runoff before it enters the river. This will stop pollution from entering the river and beaches, provide a source of water for use in create recreational space along the river.

Existing Program: Long Beach Water Department

The Long Beach Water Department installs, operates, and maintains the city's water distribution and sanitary sewer systems. Groundwater is pumped using groundwater wells located throughout the city and is enough to fulfill around 60 percent of Long Beach's water needs. The rest of the water supply in Long Beach, about 40 percent, comes from imported sources. The two main imported water sources are the Colorado River watershed and the Sacramento-San Joaquin Bay Delta. That water is imported into the region by the MWD. In addition, the Long Beach Water Department operates and maintains more than 700 miles of sanitary sewer lines that collect and deliver over 40 million gallons of wastewater per day for treatment.

DRT-5 Incorporate Increased Rainfall Capture and Other Actions to Maximize Local Water Supplies and Offset Imported Water

Increase and incentivize rainfall capture and other actions to establish a more diverse water supply portfolio and maximize local water supplies from stormwater capture, recycled water, and groundwater.

Implementation Lead: Public Works Department; Long Beach Parks, Recreation, and Marine
Partners: City of Long Beach Office of Sustainability; MWD; Water Replenishment District of Southern California; Long Beach Water Department
Timeline: Medium
Potential Cost Level: Low to Medium

Description

Long Beach receives its potable water supply from two main sources – groundwater and imported water. Roughly 60 percent of the Long Beach water supply is local groundwater. The rest of the City's drinking water comes from two imported water sources: the Colorado River and Northern California's Sacramento-San Joaquin Bay Delta region.

The City will pursue strategies that include identifying incentives and exploring regulatory options to encourage rainfall capture, and other actions that maximize local water supplies that can be incorporated in new developments when possible. The City will capture rainwater for use on-site when possible. The City will consider expanding community outreach and participation in rainwater collection and reuse, and will prioritize rainfall capture programs that benefit disadvantaged communities (as identified by CalEnviroScreen).

Equity Strategy

Ensure that low-income and drought-vulnerable communities can benefit from cost savings and augmenting household water supply through rainfall capture.

Co-benefits:

- ✓ Reduced GHG emissions from importing water
- ✓ Increased conservation of gas and electricity needed to distribute and heat water
- ✓ Reduced stormwater runoff and demand on existing infrastructure
- ✓ Increased benefits to parks and recreational opportunities through irrigation with harvested rainwater

Implementing Actions

DRT-5.1: Identify potential incentives and requirements for water reuse strategies, such as rainfall capture and harvesting in private developments.

DRT-5.2: Explore opportunities to integrate rainfall capture and harvesting in City facilities or by entities with whom the City has contracts.

DRT-5.3: Identify partners and participants for rainfall capture outreach and education. Conduct outreach to residents about available programs and eligibility, and target qualifying low-income renters and homeowners.

DRT-5.4: Apply for funding to supplement the existing MWD rebate for rain barrels and cisterns.

DRT-5.5: Conduct an analysis of existing program and rebate participation to inform efforts toward greater participation in new and existing programs to increase rainfall capture and harvesting.

SEA LEVEL RISE AND FLOODING ACTIONS

Mean sea levels off the coast of Long Beach rose by approximately one millimeter per year from 1923 to 2016 according to tide gauge data, for a total of around 3.7 inches. This is expected to accelerate in the coming decades. Relative to the year 2000, Long Beach could experience approximately 11-inch of sea level rise (SLR) by 2030, 24-inch by 2050, and 66-inch by 2100. Low-lying areas, such as Belmont Shore, Naples, and the Peninsula are already experiencing coastal flooding, particularly during combined high tide and rain events. As sea levels continue to rise, these areas of the City are expected to be more frequently impacted by higher storm tides, more extensive inland flooding and increased coastal erosion during storm events.

Homes, businesses, and City infrastructure, including roads, parks, buildings, the stormwater system, and utilities will increasingly be vulnerable to flood exposure. By 11-inch of SLR, critical assets at risk include, three fire stations in the Harbor District and along the Alamitos Bay Marina, marine safety facilities in the Harbor District, and a solid waste facility. Four miles of roads within the Harbor District would also be exposed under 11-inch of SLR from king tide flooding alone and an additional 45 miles from storm surge resulting from a 100-year storm. Although all beaches will likely experience erosion effects due to rising seas, by 11-inch of SLR, Alamitos Bay Beach, Mother's Beach, Belmont Shore Beach, and Peninsula Beach are largely exposed during king tide events. Without adaptation, exposure is expected to increase. By 2100 (66-inch of SLR), the number of critical facilities at risk increases to seven fire stations, three police facilities, and eight marine safety facilities. During king tide events, 89 miles of roadway would be exposed to king tide flooding with an additional 27 miles exposed due to storm surge flooding. Beaches likely to experience major erosion expand to include Alamitos Beach, Junipero Beach, Rosie's Dog Beach, and Long Beach City Beach. The City will employ an adaptive management approach to address existing and future impacts from sea level rise.

The foundation of this approach includes monitoring, keeping track of the latest projections, and updating plans for the near, medium, and long-term on a regular basis. The suite of adaptation actions includes establishing the monitoring program, integrating consideration of SLR and related impacts into City policies, plans, and programs, investing in resilient infrastructure and buildings, and striving to preserve coastal access and recreation among others. It will also require increased collaboration with regional, state, and federal partners to identify and fund adaptation strategies.

FLD Sea Level Rise + Flooding

Goal: Long Beach understands and is prepared for its future flood risk

OBJECTIVES	NO.	ACTIONS
Short-Term Actions (to 2030) City plans and policies are forward-looking and ensure projects and investments account for projected sea level and flooding impacts	FLD-1	Update and augment floodplain regulations as necessary
	FLD-2	Incorporate sea level rise language into citywide plans, policies, and regulations
	FLD-3	Establish a flood impacts monitoring program
	FLD-4	Incorporate adaptation into City lease negotiations
	FLD-5	Update the City's existing Stormwater Management Plan
Clear and sufficient information is on hand to identify and prioritize near-term adaptation needs and best practices	FLD-6	Conduct citywide beach stabilization study
	FLD-7	Review and conduct studies of combined riverine/coastal flooding and increased severity of rainfall events on watershed flooding
Adaptation strategies are implemented to protect vulnerable shoreline areas and wastewater infrastructure	FLD-8	Enhance dunes
	FLD-9	Inventory and flood-proof vulnerable sewer pump stations
Medium-Term Actions (2030-2050) Vulnerable infrastructure is elevated or relocated	FLD-10	Relocate/elevate critical infrastructure
	FLD-11	Elevate riverine levees
Long-Term Actions (2050-2100) Long-term physical adaptation strategies are selected and implemented based on additional research and community adaptation priorities, and prioritize natural solutions whenever possible.	FLD-12	Expand beach nourishment
	FLD-13	Construct living shoreline/berm
	FLD-14	Elevate street hardscapes
	FLD-15	Elevate streets/pathways
	FLD-16	Retrofit/extend sea wall
	FLD-17	Retreat/realign parking lots
	FLD-18	Extend/upgrade existing seawalls
Additional long-term adaptation options are evaluated using the best available science.	FLD-19	Investigate feasibility of managed retreat
	FLD-20	Evaluate feasibility of storm surge barrier at Alamitos Bay

FLD-1 Update and Augment Floodplain Regulations as Necessary

Update and augment floodplain regulations as necessary to limit, elevate, or provide floodproofing standards for development in areas designated as vulnerable to flooding in order to minimize physical damage to development.

Implementation Lead: Planning and Building
Partners: Federal Emergency Management Agency (FEMA); California Coastal Commission
Timeline: Short
Potential Cost Level: Low

Description

The City will update and augment, as necessary, floodplain regulations that address the fact that sea level rise will increase the height of floodwaters and the inland extent of floodplains in Long Beach. Regulations will include new base flood elevation requirements informed by current science. Future updates to the ordinance will be informed by the latest projections and local impact monitoring. Longer-term updates may consider managed retreat if projections and observed local impacts warrant it. Regulations will include incentives for building owners to invest in resiliency improvements by either meeting or exceeding flood-resistant construction standards, even when they are not required by FEMA or a City building code.

Floodplain regulations will encourage building owners living and/or working in the floodplain to design or retrofit buildings to reduce damage from existing and future floods and potentially reduce long-term flood insurance costs. Overall, implementation of the action would improve the ability of the city's flood-prone neighborhoods to withstand and recover quickly from coastal flooding.

The Local Coastal Program will also be amended as needed.

Equity Strategy

Evaluate risk and design assistance programs for building or retrofitting to a higher flood protection standard, with an emphasis on areas with social vulnerability to climate change, as defined by the Long Beach Vulnerability Assessment and other relevant information.

Co-benefits:

- ✓ Coordinated regulations with energy building retrofit improvements
- ✓ Reduced flood insurance rates, potentially, of 5 to 45 percent

Implementing Actions

FLD-1.1: Update Chapter 18.40 (Building Code) of the Long Beach Municipal Code and/or create new regulations, if necessary, to respond to future sea level rise conditions, referencing (FEMA) standards and other relevant guidelines as appropriate.

FLD-1.2: Develop minimum design standards to be considered for long-term flood protection, based on CAAP flooding maps and the most up-to-date projections as they become available.

FLD-1.3: Ensure other building code regulations (e.g., setbacks, building heights) are consistent with the updated standards developed for the Floodplain Ordinance.

FLD-1.4: Pursue FEMA grant program opportunities for adapting public facilities to flood impacts and other resilience investments.

FLD-1.5: Educate the public about resources available to individual property owners seeking to elevate and flood-proof their properties, including FEMA grant programs and potential insurance premium benefits.

FLD-1.6: Design flood protection assistance programs for low-income communities affected by flooding impacts, as feasible.

FLD-2 Incorporate Sea Level Rise Language into Citywide Plans, Policies, and Regulations

Incorporate sea level rise adaptation into relevant plans, policies, and regulations (e.g., the General Plan, neighborhood plans, Local Coastal Program, design standards for capital projects).

Implementation Lead: Planning and Building; Public Works Department
Partners: Varies based on planning document
Timeline: Short
Potential Cost Level: Low

Description

The City will incorporate consideration of sea level rise impacts and adaptation strategies into relevant plans, policies, and regulations in order to integrate sea level rise into a citywide planning framework. Consideration of sea level rise in various contexts by all city departments for various types of planning purposes (e.g., infrastructure planning, transportation planning, land use planning) is important. This effort will require coordination with and possible training for staff from the various departments responsible for relevant plans, policies, and regulations. Incorporating language related to sea level rise in City policies, plans, and guidelines can ensure that future investments by the City consider potential flood impacts and incorporate adaptation strategies, as appropriate.

SB 379 requires cities and counties to include climate adaptation and resiliency strategies in the Safety Elements of the General Plan. The Local Coastal Program will also be amended as needed.

Co-benefits:

- ✓ Increased longevity of the project from consideration of sea level rise
- ✓ Increased assistance with future applications to FEMA
- ✓ Compliance with SB 379

Implementing Actions

FLD-2.1: Identify and update as appropriate relevant city plans, policies, and regulations that should be prioritized due to sea level rise conditions, such as the Local Coastal Plan. Otherwise, incorporate sea level rise language in plans as they are updated.

FLD-2.2: Coordinate with and train staff from the various departments responsible for relevant plans, policies, and regulations.

FLD-2.3: Use CAAP sea level rise inundation maps and the most up-to-date projections, as they become available, to inform plan updates currently being prepared by the City.

Equity Strategy

Plan for flooding impacts, with an emphasis on areas with social vulnerability to climate change as defined by the Long Beach Vulnerability Assessment and other relevant information.

Image: ArtCenter College of Design, Designmatters. Image + Idea Course, spring 2020

FLD-3

Establish a Flood Impacts Monitoring Program

Establish a flood impacts monitoring program to monitor flood damage and inform the selection and deployment of adaptation and resilience strategies.

Implementation Lead: Disaster Preparedness and Emergency Communications; Public Works Department; Technology and Innovation Department; City of Long Beach Office of Sustainability; Tidelands Capital Improvement Division; Long Beach Parks, Recreation & Marine

Partners: Local schools; neighborhood associations; community organizations; local businesses; residents

Timeline: Short

Potential Cost Level: Low to Medium

Description

The City will establish a program in which it will monitor flood impacts with support from the public. City efforts will include identifying existing and potential data sources to track sea level rise trends and flooding impacts in different areas of Long Beach. The program will monitor changes in sea level, storm event data, and the impacts of specific flooding events. In addition to direct impacts on property and infrastructure, the City will establish a framework to track City resources used in responding to flooding events, such as resources for repair, maintenance, and cleanup, and to track the effectiveness of existing adaptation strategies. The program will also include a complementary measure — a citizen monitoring component designed to harness the potential of citizen reporting through crowdsourcing platforms such as smartphone photos, webcams, and social media posts. The City will perform annual data reporting that includes data from both the City and the citizen monitoring, and will use the data to inform the selection of adaptation trigger points and appropriate adaptation strategies.

Equity Strategy

Ensure low-income communities are well represented in the data collected through the flood impacts monitoring program in order to inform and prioritize improvements that enhance their resiliency.

Co-benefits:

- ✓ Increased engagement of the public in flood response from including them in efforts to ground truth the accuracy of flood projections
- ✓ Improved City flood response based on site- or neighborhood-specific data

Implementing Actions

FLD-3.1: Identify and use data sources such as tide gauges to track sea level rise and flooding impacts and trends.

FLD-3.2: Evaluate opportunities to install flood-monitoring technology to increase understanding of local impacts.

FLD-3.3: Develop and implement a public crowdsource flood impact monitoring platform and develop a process for evaluating submissions for incorporation in infrastructure improvements. Target outreach to low-income communities impacted by flooding to ensure an equitable geographic distribution of collected data.

FLD-3.4: Continue conversations with the Technology and Innovation Department about creating a public crowdsource flood impact monitoring program for the Go Long Beach app.

FLD-3.5: Complete annual or biannual evaluation and data reporting.

FLD-4 Incorporate Adaptation into City Lease Negotiations

Include requirements and incentives for implementing adaptation strategies into new and renewed leases on City-owned land.

Implementation Lead: Economic Development Department; Harbor Department; Long Beach Airport

Partners: Public Works Department; Tidelands; Long Beach Parks, Recreation, and Marine; Coastal Commission; City lease holders

Timeline: Short

Potential Cost Level: Low

Description

The City will develop and include an adaptation section in City lease applications and lease renewal negotiations. The new section will include a simplified map of flood vulnerability, extreme heat, and air quality zones or proximity to major emissions sources. For flood vulnerability, questions regarding the proposed location, cost, maximum life span of the infrastructure, and potential consequences of climate impacts, will guide tenants to the appropriate adaptation measures. The City will establish incentives and/or requirements to address extreme heat, air quality, drought, and reduce GHG emissions, which will be based on the exposure to climate change impacts and the potential benefits of adaptation strategies.

Dr. Jerry Schubel, President & CEO of the Aquarium of the Pacific discusses sea level rise.

Co-benefits:

- ✓ Reduced service interruptions for tenants located in flood zones
- ✓ Increased awareness of flood risks for potential tenants
- ✓ Reduced GHG emissions from opportunity to incorporate other GHG mitigation and adaptation strategies

Implementing Actions

FLD-4.1: Identify and develop mapping and GIS resources to best communicate the anticipated impacts of sea level rise, flooding, extreme heat, and air quality on City-owned property.

FLD-4.2: Establish leasing guidelines that include incentives, requirements, or a combination thereof, to incorporate adaptation components (and mitigation co-benefits) into new and renewed leases.

FLD-4.3: Develop sea level rise and flood provisions for tenant lease agreements.

FLD-4.4: Develop internal guidance and train City staff on how to perform evaluations effectively and provide information to applicants.

Equity Strategy

Assess City-owned property based on social vulnerability to climate change, as defined by the Long Beach Vulnerability Assessment and other relevant information, to inform adaptation measures and priorities.

FLD-5 Update the City's Existing Stormwater Management Plan

Update the City's existing Stormwater Management Plan to account for flood risks associated with climate change and develop a funding/implementation plan for fully fund storm drain and pump station improvements.

Implementation Lead: Public Works Department
Partners: Los Angeles County; Long Beach Parks, Recreation, and Marine
Timeline: Short
Potential Cost Level: Low to Medium

Description

The City will update its Stormwater Management Plan to account for and adapt to additional flood risks associated with climate change, including sea level rise and more frequent and intense rain events. In addition to protecting water quality, the City will work with Los Angeles County to update the Stormwater Master Plan to prioritize efficient conveyance of excess stormwater to prevent inland flooding. Based on the findings of the evaluation, capital improvement projects to increase drainage efficiency and protect new and existing electrical and mechanical equipment (e.g., pump stations) from potential flood damage will be identified.

Co-benefits:

- ✓ Increased longevity of projects from consideration of sea level rise and riverine flooding
- ✓ Increased assistance with future FEMA applications
- ✓ Compliance with SB 379

Implementing Actions

FLD-5.1: Review and identify sections of the Stormwater Management Plan that could be updated with sea level rise language.

FLD-5.2: Review and incorporate data collected from the flood impacts monitoring program.

FLD-5.3: Assess, prioritize, and seek funding for stormwater management projects in low-income communities impacted by flooding. Identify co-benefit strategies for such projects, including urban greening.

FLD-5.4: Explore opportunities for tree planting in sub-watershed areas with the lowest urban forest cover to minimize stormwater runoff and help protect the area from flooding during intense storm events.

Equity Strategy

Assess the Stormwater Management Plan from perspective of social vulnerability to climate change, as defined by the Long Beach Vulnerability Assessment and other relevant information to prioritize projects and solutions in areas of greatest need.

FLD-6 Conduct Citywide Beach Stabilization Study

Conduct a citywide study to assess the feasibility of a combined nourishment and sand retention program. The study will estimate the sand volumes required to keep pace with sea level rise, costs, and potential sources of sand.

Implementation Lead: Long Beach Parks, Recreation, and Marine; Public Works Department
Partners: U.S. Army Corps of Engineers (USACE); California Coastal Commission, U.S. Geological Service; local universities
Timeline: Short
Potential Cost Level: Low

Description

The City will perform a citywide beach stabilization study of how beaches may respond to sea level changes. The study will inform sound engineering and a cost-effective approach to planning for a future nourishment schedule. Beach nourishment refers to the introduction of sediment onto a beach and is primarily used to offset eroding conditions. Several scenarios will be considered in the modeling, including volumes of sand, material placement, sand composition, and the addition of hard engineering structures (e.g., groins and breakwaters) to promote the accumulation and longevity of placed sand.

Beach nourishment has been an ongoing component of the City's efforts to manage beaches. To maintain property protection and the recreational benefits of the City's beaches in the face of rising sea levels, engineering intervention will be necessary.

Co-benefits:

- ✓ Increased recreational opportunities for residents and tourists

Implementing Actions

FLD-6.1: Establish partnerships to cooperatively complete a stabilization study for regional beaches.

FLD-6.2: Conduct a citywide beach stabilization study and identify priority areas and strategies for beach nourishment and/or sand retention to inform future projects.

Equity Strategy

Seek to increase beach stability with attention to public access to facilitate recreational opportunities and relief for all people during extreme heat days.

FLD-7 Review and Conduct Studies of Combined Riverine/Coastal Flooding and Increased Severity of Rainfall Events on Watershed Flooding

Review and conduct studies to understand the potential influence of sea level rise and increased precipitation on flood risk at the riverine/coastal interface and along river channels.

Implementation Lead: Public Works Department; USACE; Los Angeles County

Partners: Other municipalities within the Los Angeles River Watershed and San Gabriel River Watershed

Timeline: Short

Potential Cost Level: Low to Medium

Description

The City will carry out or partner on new studies and/or review existing studies of combined riverine/coastal flooding. The studies should provide both hydrologic and hydraulic analyses of watersheds and drainages that flow through Long Beach, and account for future projected changes in precipitation and sea level rise. The analyses will provide a more detailed understanding of future riverine flooding vulnerabilities. Urban flooding variables, such as the condition of stormwater infrastructure and the extent to which its characteristics exacerbate or mitigate flooding, will be factored in as well.

These analyses will help the City assess the potential impacts that flooding at the riverine/coastal interface will have on the surrounding neighborhoods and infrastructure. Similarly, a study of the impacts of changes in precipitation on watershed flooding will be used to understand how future flood conditions could increase flooding along river channels and in urban neighborhoods and to develop prioritized locations and timelines for elevating levees.

Equity Strategy

Evaluate flooding in the neighborhoods along the three major river channels; these neighborhoods have high social vulnerability to climate change, based on the Long Beach Vulnerability Assessment.

Co-benefits:

- ✓ Redeveloped channels that could provide recreation, open space, and/or habitat, and benefit disadvantaged communities in West and North Long Beach

Implementing Actions

FLD-7.1: Identify and review existing studies of combined riverine/coastal flooding.

FLD-7.2: Conduct a study of combined riverine/coastal flooding to understand how flooding at the riverine and coastal interface will impact surrounding neighborhoods and infrastructure. Integrate consideration of urban flooding variables into the study to understand combined impacts.

FLD-7.3: Conduct a study of the impacts of increased precipitation on watershed flooding to understand how future flood conditions could increase flooding along river channels.

FLD-7.4: Based on studies of combined riverine/coastal flooding and increased precipitation impacts on watershed flooding, work with partners such as Los Angeles County to prioritize the locations and timelines for elevating levees and to prioritize other adaptive strategies, such as watershed restoration or green infrastructure, to reduce flood impacts.

FLD-8 Enhance Dunes

Convert seasonal storm berms to year-round dunes through active dune restoration as part of an adaptive management strategy. Discontinue beach grooming and plant native dune species to allow natural vegetation to stabilize dunes and hold sand.

Implementation Lead: Long Beach Parks, Recreation, and Marine
Partners: Public Works Department; California Coastal Commission
Timeline: Short
Potential Cost Level: Medium to High

Description

The City will convert seasonal storm berms to year-round dunes through active dune restoration as part of an adaptive management strategy. Dune restoration activities will include planting native beach vegetation, installing sand fencing to capture additional sand, and discontinuing beach grooming along the landside portion of each beach. Because residents of Long Beach have come to expect the beaches to be devoid of vegetation, educational signage will be necessary to communicate the purposes and advantages of dune restoration.

The communities of Belmont Shore and Alamitos Peninsula are vulnerable to flooding from a 100-year storm surge after 11 inches of sea level rise, and to flooding from a king tide after 24 inches of sea level rise. Both areas are fronted by coastal beaches, which could provide improved protection from storm surges if strategies are implemented to support the growth of sand dunes as a buffer.

Co-benefits:

- ✓ Enhanced dunes may provide habitat benefits
- ✓ Decreased disruption to beach habitat and species, as beach grooming will be discontinued
- ✓ Reduced City expenditure over time on annual sand berm engineering

Implementing Actions

FLD-8.1: Implement active dune enhancement strategies, including the planting of native beach vegetation and building of wooden fences to help retain sand.

FLD-8.2: Discontinue beach grooming to allow dunes and dune vegetation to form.

FLD-8.3: Protect dune restoration areas by using fences and build dune crossovers for beach access.

FLD-8.4: Develop multilingual public messaging materials and signage to communicate the purpose of dune enhancement.

FLD-8.5: Consider combinations of options to provide flood/erosion protection in Belmont Shore and the southeast tip of Alamitos Peninsula.

Equity Strategy

Increase beach stability with attention to public access to facilitate recreational opportunities and relief during extreme heat days for all people.

FLD-9 Inventory and Flood-Proof Vulnerable Sewer Pump Stations

Assess potential for flood damage at all sewer pump stations, and for pump stations identified as vulnerable to flooding, apply floodproofing techniques and add emergency generators.

Implementation Lead: Public Works Department

Partners: Long Beach Water Department; Long Beach Parks, Recreation, and Marine; Department of Disaster Preparedness and Emergency Communications

Timeline: Short

Potential Cost Level: Low to High

Description

Given the increased likelihood of future flooding due to sea level rise, the City will perform a detailed inventory of all sewer pump stations to assess the potential for flood damage at these stations. Pump stations rely on an uninterrupted power supply to maintain operations. A power failure due to flooding may cause sewage overflows, and backups may result. Many of the City's pump stations are located in or near areas at risk of flooding and power outages, such as Belmont Shore, Naples, and the area in downtown around the Shoreline Marina. For pump stations identified as vulnerable to flooding, the City will implement protective measures through capital projects to reduce flood damage to pump stations identified as vulnerable to future flood conditions. Such measures include incorporating floodproofing techniques (such as elevating pump housing entryways, sealing buildings and entryways to projected flood depth, elevating electrical equipment) and adding emergency generators to ensure an uninterrupted supply of power. If floodproofing techniques are not possible due to the configuration or location of components, the entire pump station may need to be relocated.

Co-benefits:

- ✓ Protection of water quality by preventing the failure of sewer pump stations, which could have serious environmental and public health consequences

Implementing Actions

FLD-9.1: Assess potential for flood damage and timing of vulnerability for each sewer pump station.

FLD-9.2: For pump stations identified as vulnerable, apply floodproofing techniques, elevate, or relocate as necessary.

FLD-9.3: Equip all vulnerable pump stations with a flood-proof backup generator to ensure continued operation during power outages.

Equity Strategy

Prioritize floodproofing of pumps in the low-income communities most vulnerable to flooding.

FLD-10 Relocate/Elevate Critical Infrastructure

Carry out more detailed studies to assess the need to raise or relocate critical infrastructure outside of the sea level rise vulnerability zone.

Implementation Lead: Public Works Department; Financial Management; Tidelands; Long Beach Parks, Recreation, and Marine

Partners: Long Beach Fire Department; Long Beach Police Department; LBUSD; Long Beach Department of Health and Human Services; local hospitals

Timeline: Medium

Potential Cost Level: High

Description

To maintain essential assets and services for the economy, society, and health of the public, the City will identify critical assets that are vulnerable to sea level rise and either relocate them or incorporate protective adaptation measures to ensure the assets continue to maintain their functionality. Critical assets include buildings, such as fire stations, hospitals, schools, police stations, and key government facilities, as well as critical components of transportation, wastewater, potable water, and energy distribution systems.

Many of these critical facilities have limited adaptive capacity and long-life spans that require an adaptive management approach that is informed by the potential impacts of extreme sea level rise scenarios. For assets identified as vulnerable to potential flood exposure, the City will perform a more in-depth study of the critical infrastructure to evaluate the elevations of components sensitive to flood exposure, potential flood entry points (e.g., doors, vents), and the cost of asset replacement. The study will help inform decisions regarding applicable approaches to adaptation.

Whenever possible, the City will prioritize relocation of critical infrastructure and services to a less vulnerable area. As an alternative, the City may retrofit existing infrastructure facilities to reduce the risk of flood impacts. Examples of retrofitting include: elevation and protection of electrical control systems, elevation of access routes, installation of a flood-proofed power generator, interventions to protect underground utilities and telecommunications from water damage, backflow prevention for buildings, and floodproofing of building entries that could become a flood pathway.

Co-benefits:

- ✓ Uninterrupted critical services during storm events

Implementing Actions

FLD-10.1: For critical facilities identified as vulnerable to inundation from sea level rise and/or coastal storm flooding, evaluate whether implementation of a shoreline protection strategy (e.g., raising shoreline elevations, restoring dunes, etc.) would provide long-term protection for the site.

FLD-10.2: If shoreline protection strategies were not identified for the asset, perform an asset-level study for each critical facility identified as vulnerable to sea level rise flooding to evaluate potential site-specific strategies to increase flood resilience.

FLD-10.3: For facilities identified as vulnerable, recommend floodproofing techniques or the raising or relocating of the facility as necessary.

FLD-10.4: Prioritize implementation of upgrades based on expected timing of the inundation.

Equity Strategy

Protect access to public services and facilities, focusing on neighborhoods with high social vulnerability based on the Long Beach Vulnerability Assessment.

FLD-11 Elevate Riverine Levees

Based on results of a riverine flood study (FLD-7), work with partner agencies to elevate channel banks and levees to provide enhanced flood protection.

Implementation Lead: Public Works Department; USACE
Partners: Los Angeles County Harbor Department; Port of Los Angeles; Los Angeles County Flood Control District; Long Beach County Flood Control District; California Coastal Commission; California State Lands Commission; U.S. Fish and Wildlife Service
Timeline: Medium
Potential Cost Level: Medium to High

Description

Based on the results of FLD-7 (study increased watershed flooding due to climate change), portions of existing levees adjacent to the City's channels and rivers (Los Angeles River, Los Cerritos Channel, and San Gabriel River) may need to be elevated or modified to provide enhanced flood protection. As flood protection structures along the major river channels are owned and managed by an array of public entities, including USACE, Los Angeles County, and others, modification projects will require a high degree of interagency and regulatory coordination. Therefore, design and permitting should begin well before overtopping is expected to occur. The City will work with these agencies and other relevant partners to prioritize channel modification projects based on an assessment of the consequences and likely timing of flooding at each portion that is at risk.

As part of this process there may be design opportunities for multipurpose uses such as open space integrated with commercial and residential development.

Equity Strategy

Evaluate flooding in neighborhoods along the three major river channels that have high social vulnerability to climate change, based on the Long Beach Vulnerability Assessment. Prioritize projects in socially vulnerable communities and maximize the inclusion of co-benefits such as urban greening.

Co-benefits:

- ✓ Protection of water quality by preventing the failure of sewer pump stations, which could have serious environmental and public health consequences

Implementing Actions

FLD-11.1: Work with partner agencies to identify portions of major river channels at risk of overtopping based on riverine flooding studies performed in action FLD-7.

FLD-11.2: Work with partners to prioritize at-risk portions of channel levees based on timing of potential flooding.

FLD-11.3: Work with partners to ensure the design process is informed by input from stakeholders on design alternatives.

FLD-11.4: Work with partners to implement channel modification projects with owners of flood control structures and project leads.

FLD-11.5: Seek creative funding options to prioritize investments that bring co-benefits, such as green space, and opportunities for active and passive recreation to communities with limited access.

SEA LEVEL RISE AND FLOODING LONG TERM ACTIONS

Long-term adaptation actions for sea level rise and riverine flooding are anticipated to occur from 2050 to 2100. The table below briefly summarizes information about the actions, which will be selected and implemented based on

Action No.	Action Title	Action Description	Specific Location (where applicable)	Potential Co-Benefits	Equity Impacts and Other Considerations
		Structural/Physical (See Maps Overleaf)			
FLD-12	Expand beach nourishment	Based on findings from the beach stabilization study, beaches identified as suitable could be elevated and preserved through beach nourishment actions designed to meet regulatory and permitting requirements of relevant state and federal agencies.	Bay View Beach and Peninsula Beach	Increased tourism	Beaches offer recreational opportunities for inland residents and low-income communities impacted by extreme heat, particularly on hot days. If climate change exacerbates heat in Long Beach, beaches will become an even more valuable resource for inland residents.
FLD-13	Construct a living shore-line/berm	The shoreline could be elevated to tie in with the landscape and park facilities to prevent flooding of inland areas while continuing to provide beach access.	Mothers Beach	Mothers Beach is used heavily on the weekdays and weekends by city residents and visitors for swimming, dragon boat racing, picnicking, and other forms of recreation. Protecting this park and beach would protect other areas in Naples from flooding and also preserve the park.	Mothers Beach provides residents with park and beach access, particu-larly on hot days, and could become an even more important resource as climate change exacerbates heat in Long Beach.
FLD-14	Elevate street hardscapes	Street hardscapes such as curbs could be elevated and extended to eliminate gaps that could become flood pathways.	Bay Shore Drive in Alamitos Bay	Long-term preservation of access to restaurants, shops, and the library on 2nd Street. Elevating the curb may also provide flood protection for additional inland assets.	The businesses along 2nd Street serve many residents and visitors.

additional research and community adaptation priorities that are yet to be determined. Each of the actions will be evaluated from an equity lens to ensure that climate change impacts and adaptation benefits to low-income communities are considered.

Action No.	Action Title	Action Description	Specific Location (where applicable)	Potential Co-Benefits	Equity Impacts and Other Considerations
FLD-15	Elevate streets/path-ways	Waterfront streets and paths may need to be elevated to protect transportation routes and provide flood protection for infrastructure behind the road/path.	2 Areas: - Communi-ties adjacent to Alamitos Bay, including Belmont Shore, Naples, and Marina Pacifica - Long Beach Shoreline Marina	This action could also be combined with drainage improvements to reduce flooding associated with heavy rainfall. This action would provide enhanced shel-tering from wave overtopping that could occur during coastal storm events.	This action would protect schools and the fire department, which provide critical services for community members in need throughout the region.
FLD-16	Retrofit/ extend walls	The existing wall may currently provide some flood protection, but it is segmented and was not designed for flood protection. It could be retrofitted or rebuilt to provide adequate protection against sea level rise (SLR).	E. Paoli Way near the Marine Stadium	The Marine Stadium and E. Paoli Way are a pathway for flooding and inundation under future SLR. Upgrading the wall here would protect Appian Way (a major connecting road) and several inland neighborhoods.	Residents, visitors, and the general public use Appian Way to access beach areas and visit the Belmont Shore neighbor-hood. Protecting these areas will preserve access.
FLD-17	Retreat/ realign parking lots	Relocate, reduce size of, or realign parking lots as beach narrows.	Beachfront parking lots	Action would protect parking lots from erosion and reduce the habitat impacts of beach narrowing.	Preservation of parking lots retains access for those who do not live within walking distance of the beach.
FLD-18	Extend/ upgrade existing seawalls	Sheet pile seawalls could be expanded to other areas of the Naples shoreline that are not being addressed by the current upgrade.	Treasure Island, areas to the east near the Yacht Club, and areas to the north (which could also be protected by a berm if space allows)	Would result in long-term preservation of access to local public beaches and businesses.	Consider options that balance infrastructure improvements with natural adaptation solutions, as appropriate.

Action No.	Action Title	Action Description	Specific Location (where applicable)	Potential Co-Benefits	Equity Impacts and Other Considerations
Informational					
FLD-19	Investigate the feasibility of managed retreat	Explore managed retreat options for vulnerable shoreline infrastructure through land acquisition and relocation programs.	Communities adjacent to Alamitos Bay, including Belmont Shore, Naples, and Marina Pacifica	Managed retreat may create more space for flood events and alleviate flood conditions on adjacent properties.	
FLD-20	Evaluate the feasibility of a storm surge barrier at Alamitos Bay	Conduct a feasibility study to evaluate construction of a storm surge / tide gate barrier at the entrance to Alamitos Bay.	Alamitos Bay		Action would protect all inland areas along the Alamitos Bay shoreline from storm surge flooding.

Figure 10: Locations of potential long-term flood protection actions

Figure 11: Locations of potential long-term flood protection actions in Alamitos Bay area

4

Adaptation Actions

5 GHG Inventory, Forecasts and Targets

5

INTRODUCTION

The reduction of greenhouse gas (GHG) emissions is one of the primary objectives of the Long Beach CAAP. Developing meaningful reduction strategies and evaluating their ability to meet a GHG target first requires an understanding of the community's baseline year and projected future emissions levels. This chapter describes the sources and scale of emissions generated by activities in Long Beach, using a baseline year of 2015 to reflect current conditions, and how emissions are estimated to grow through 2050. It also describes the City's emissions reduction target for 2030 and its aspirational GHG goal for 2045 to demonstrate the reductions needed in each target year from implementation of local actions. This is the first time that the City has calculated a community-wide inventory or set a GHG reduction target.

To provide a robust understanding of its GHG profile, the City analyzed emissions through three different lenses. The primary emissions analysis was through development of a production-based inventory that represents emissions occurring from local activities, such as vehicle travel, home energy use, and waste disposal. The production-based inventory is the foundation for the City's emissions forecasts and target setting, and it is the inventory against which CAAP implementation will be measured, as is typical for a CAAP. The City also developed a high-level, consumption-based inventory to better understand the upstream emissions that occur as a result of residents' travel and consumption of energy, water, goods, and services. This analysis primarily focuses on households and takes into account the emissions embedded in the food residents eat, the products they purchase, and the fuels they use. It also accounts for some City operations. Finally, the City analyzed the life cycle emissions associated with oil and gas extraction activities in Long Beach. This analysis estimates the total emissions that occur as a result of local fossil fuel production. Each inventory analyzes the community's emissions in a different way, and so the results of the three inventories cannot be summed into one comprehensive emissions total. Although the production-based inventory is used for the CAAP, as it is the Global Covenant of Mayors' protocol as well as standard practice, the results of each inventory informed the CAAP and were used to define the CAAP's specific actions.

The emissions results presented in this chapter are expressed as metric tons of carbon dioxide equivalent per year (MT CO_2e/yr) to provide a standard measurement that incorporates the varying global warming potential (GWP) values of different GHGs. The GWP describes how much heat a GHG can trap in the atmosphere relative to carbon dioxide, which has a GWP of 1. For example, methane has a GWP of 28, which means that 1 metric ton of methane will trap 28 times more heat than 1 metric ton of carbon dioxide, which makes it a more potent GHG.

EMISSIONS INVENTORY DIFFERENCES

Several City departments have prepared their own department or facility-specific GHG emissions inventories that follow methodological guidance designed for those specific facilities. This CAAP, however, represents a community-wide GHG inventory that follows the Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GPC) to support consistency in community-wide inventory preparation and comparison. The result of this use of differing methodologies is that the City's various GHG inventories are not directly comparable to each other. For example, the port waterborne activity emissions reported in the total production inventory differ from the total emissions reported in the Port of Long Beach GHG inventories because each inventory differs as to the scope of emissions to be analyzed and, in some cases, uses different quantification methods. Readers should note that each of the City's inventories has been prepared to serve a specific purpose, and while the CAAP overlaps topically with some of these other sources, the community-wide GHG inventory does not replace those other facility-specific analyses or plans.

2015 PRODUCTION INVENTORY

Long Beach's community emissions inventory follows the guidance provided in the GPC, which is the globally accepted framework for calculating and reporting community GHG emissions. It is also the standard used by the Global Covenant of Mayors, the world's largest cooperative effort among mayors and city officials to reduce global GHG emissions, track progress, and prepare for the impacts of climate change. The City of Long Beach joined the Global Covenant of Mayors in 2015. Therefore, this inventory is used as the basis for the Long Beach CAAP.

The GPC requires cities to report their emissions by GHG, sector and subsector, and scope. The scopes framework helps to differentiate emissions occurring physically within the city (Scope 1) from those occurring outside the city (Scope 3), and from the use of energy supplied by grids (e.g., electricity) that may cross city boundaries (Scope 2).

The GPC also provides two levels of reporting, referred to as BASIC and BASIC+, for the sources of the emissions analyzed. Table 2 presents the three emissions scopes analyzed in the GPC framework, along with the BASIC inventory reporting requirements. Long Beach developed a total production inventory that achieves the BASIC reporting requirements and allows a comparison of the city's emissions with those of other cities that follow the GPC methodology.

BASIC+ reporting requires more comprehensive coverage of emissions sources, including some sources over which a city has limited control to reduce emissions. During preparation of the Long Beach BASIC inventory, data were collected for several of these additional BASIC+ emissions sources and analyzed separately from the City's BASIC level inventory to provide an additional emissions perspective. One example would be emissions from airplanes landing at Long Beach Airport, which are federally regulated and over which the City has limited control. In the BASIC inventory, those airplane emissions are not included, but emissions associated with airport operations that are in the City's control, such as ground transport, are included.

Table 2: GPC Protocol Scope Definitions for City Inventories

Scope	Definition	BASIC Requirement
Scope 1	GHG emissions from sources located within the city boundary	Fuel use in buildings, transport, and industry Waste generated within the city's boundary
Scope 2	GHG emissions occurring as a consequence of the use of grid-supplied electricity, heat,steam, and/or cooling within the city boundary	Use of grid-supplied energy
Scope 3	All other GHG emissions that occur outside the city boundary as a result of activities taking place within the city boundary	Waste (including wastewater) generated within the city's boundary

Source:Global Protocol for Community-Scale Greenhouse Gas Emission Inventories

Emission Sectors

The community production inventories are organized into three emissions categories, or sectors, based on their sources:

- **Stationary Energy:** Emissions from building electricity and natural gas use in residential, commercial, institutional, and industrial buildings, as well as emissions from energy industries operating within the city limits
- **Transportation:** Emissions associated with passenger vehicles, buses, trucks, rail transit, freight rail, off-road vehicles, port waterborne activity (omitted from the jurisdictional inventory), and aviation operations within the city limits
- **Waste:** Emissions from waste disposed in landfills or incinerated, and emissions from wastewater treatment

Jurisdictional Emissions Sources

One of the primary purposes of a community emissions inventory is to inform city climate policy development, and the CAAP was designed to focus on opportunities for local action that are within the City's and the community's control. Therefore, for target setting and monitoring purposes this CAAP focuses on "jurisdictional emissions" – those emissions sources over which the City and community have some amount of influence. These jurisdictional emissions sources are primarily aligned with the BASIC inventory described above, except for the removal of port-based waterborne activities like cargo shipping. Emissions occurring from vessel operations at the Port of Long Beach are, in part, regulated at the state level by the California Air Resources Board (CARB), and the City of Long Beach does not have the direct authority to dictate emissions reduction policies for private shipping companies that operate from the port. For this reason, the City has removed port waterborne activity from the emissions inventory analyzed in this CAAP.

Emissions associated with energy use in port facilities and with on-road trucking activities associated with the port are still included in the CAAP inventory and analyzed for GHG target-setting purposes. The Port of Long Beach not only develops its own annual emissions inventories, but also developed a Clean Air Action Plan that is designed to improve air quality and reduce GHG emissions associated with port activities.

Production Inventory Results

To provide a complete emissions analysis, the City evaluated its total production inventory (including the port waterborne activity) according to the BASIC and BASIC+ reporting frameworks. As shown in Table 3, the city's BASIC emissions totaled 3,100,468 MT CO_2e/yr in 2015, which equates to 6.6 MT CO_2e per Long Beach resident in 2015 (MT CO_2e/capita) and 5.0 MT CO_2e per service population (SP) (i.e., residents plus employees). The BASIC+ emissions sources analyzed for 2015 totaled 3,366,173 MT CO_2e/yr (or 7.2 MT CO_2e/capita and 5.4 MT CO_2e/SP), and reflect the BASIC inventory emissions with the addition of transboundary aviation and transboundary port waterborne activity emissions.

Table 3: Total Production Emissions Inventory by Subsector

Sector/Subsector	2015 Emissions – BASIC		2015 Emissions – BASIC+[1]	
	MT CO_2e	% of BASIC Total	MT CO_2e	% of BASIC+ Total
Stationary Energy	**1,377,291**	**44.4%**	**1,377,291**	**40.9%**
Residential Energy	428,245	13.8%	428,245	12.8%
Natural Gas	241,176	7.8%	241,176	7.2%
Electricity	187,070	6.0%	187,070	5.6%
Commercial and Institutional Buildings Energy	300,818	9.7%	300,818	9.0%
Natural Gas	109,593	3.5%	109,593	3.3%
Electricity	191,225	6.2%	191,225	5.7%
Manufacturing Industries and Construction Energy	399,089	12.9%	399,089	11.8%
Natural Gas	74,853	2.4%	74,853	2.2%
Electricity	324,235	10.5%	324,235	9.6%
Energy Industries	219,899	7.1%	219,899	6.5%
Fugitive Emissions from Natural Gas	29,240	0.9%	29,240	0.9%
Transportation	**1,546,326**	**49.9%**	**1,812,031**	**53.8%**
On-Road Transportation	1,213,601	39.1%	1,213,601	36.1%
Gasoline Vehicles	960,661	31.0%	960,661	28.5%
Diesel Vehicles	252,940	8.2%	252,940	7.5%
Railways	11,883	0.4%	11,883	0.4%
Aviation	4,550	0.1%	186,738	5.5%
Port Waterborne Activity	301,345	9.7%	384,862	11.4%
Off-Road Equipment	14,947	0.5%	14,947	0.4%
Waste	**176,850**	**5.7%**	**176,850**	**5.3%**
Solid Waste Methane Commitment	173,164	5.6%	173,164	5.1%
Solid Waste Incineration	95	0.0%	95	0.0%
Wastewater Treatment and Discharge	3,592	0.1%	3,592	0.1%
TOTAL	**3,100,468**	**100%**	**3,366,173**	**100%**
Per Capita	6.6	-	7.2	-
Per Service Population (residents + employees)	5.0	-	5.4	-

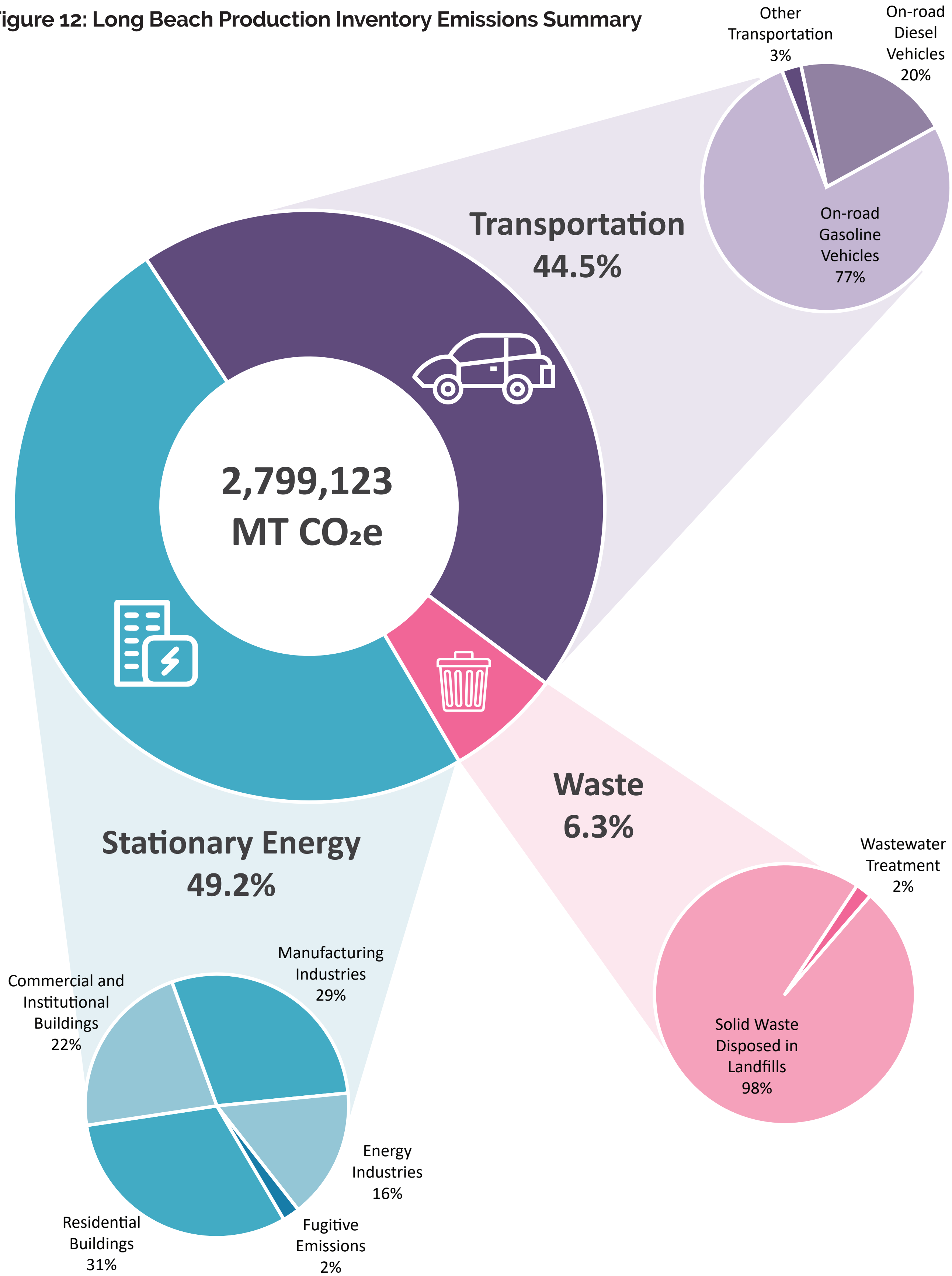
[1] Per the Global Protocol for Community-Scale Greenhouse Gas Emission Inventories, a complete BASIC+ inventory includes calculation of several additional emissions sources beyond those in the BASIC inventory. Long Beach has also calculated the BASIC+ emissions from transboundary journeys in the aviation and waterborne navigation subsectors because the supporting data were collected with data for the BASIC calculations. This column does not reflect a complete BASIC+ inventory, but does provide emissions information beyond the scope of the BASIC inventory.

Table 4 presents the jurisdictional inventory on which the CAAP target setting and analysis are based, and which excludes the port waterborne activity. The jurisdictional inventory totals 2,799,123 MT CO_2e in 2015. This equates to 6.0 MT CO_2e/capita and 4.5 MT CO_2e/SP in 2015. Stationary energy was the largest emissions source in the inventory (49 percent), with transportation contributing most of the remainder (44 percent). Energy and transportation emissions account for nearly 95 percent of the inventory, which indicates that local reduction efforts should

Table 4: Jurisdictional Production Emissions Inventory by Subsector

Sector/Subsector	2015 Jurisdictional Production Emissions *(inventory used in CAAP analysis)*	
	MT CO_2e	% of Total
Stationary Energy	**1,377,291**	**49.20%**
Residential Energy	428,245	15.30%
Natural Gas	241,176	8.62%
Electricity	187,070	6.68%
Commercial and Institutional Buildings Energy	300,818	10.75%
Natural Gas	109,593	3.92%
Electricity	191,225	6.83%
Manufacturing Industries and Construction Energy	399,089	14.26%
Natural Gas	74,853	2.67%
Electricity	324,235	11.58%
Energy Industries	219,899	7.86%
Fugitive Emissions from Natural Gas	29,240	1.04%
Transportation	**1,244,981**	**44.48%**
On-Road Transportation	1,213,601	43.36%
Gasoline Vehicles	960,661	34.32%
Diesel Vehicles	252,940	9.04%
Railways	11,883	0.42%
Aviation	4,550	0.16%
Off-Road Equipment	14,947	0.53%
Waste	**176,850**	**6.32%**
Solid Waste Methane Commitment	173,164	6.19%
Solid Waste Incineration	95	0.00%
Wastewater Treatment and Discharge	3,592	0.13%
TOTAL	**2,799,123**	**100.00%**
Per Capita	6.0	-
Per Service Population (residents + employees)	4.5	-

Figure 12: Long Beach Production Inventory Emissions Summary



focus on these areas to maximize progress toward the City's GHG reduction targets. Waste sector emissions make up the remainder and are important to consider in the context of the City's long-term carbon neutrality goal. In the rest of this chapter, all references to production inventory refer to the jurisdictional production inventory shown in Table 4. Figure 12 illustrates the City's 2015 production inventory results by sector and subsector.

2015 CONSUMPTION INVENTORY

A consumption-based inventory attempts to account for emissions inside and outside a community that occur from consumptive activities in the community. The City's consumption inventory was prepared based on guidance in the ICLEI U.S. Community Protocol for Accounting and Reporting of Greenhouse Gas Emissions (Community Protocol) and input from City staff. The Community Protocol describes a consumption inventory methodology that is applied at the household level to estimate a household carbon footprint. In other words, how much carbon is generated in the production and use of goods and services by households in Long Beach? The inventory analysis represents a high-level estimate based on the average household emissions factors for the City of Long Beach provided in CARB's Cool California household carbon calculator. Based on this methodology, the inventory primarily represents emissions from the sum of all household consumption in the city, with local government emissions also included where data were available from the City's 2015 Local Government Operations inventory.

Local businesses and industries are not directly included in the consumption inventory because emissions from the goods and services they produce are represented as household emissions from the consumption of goods and services.

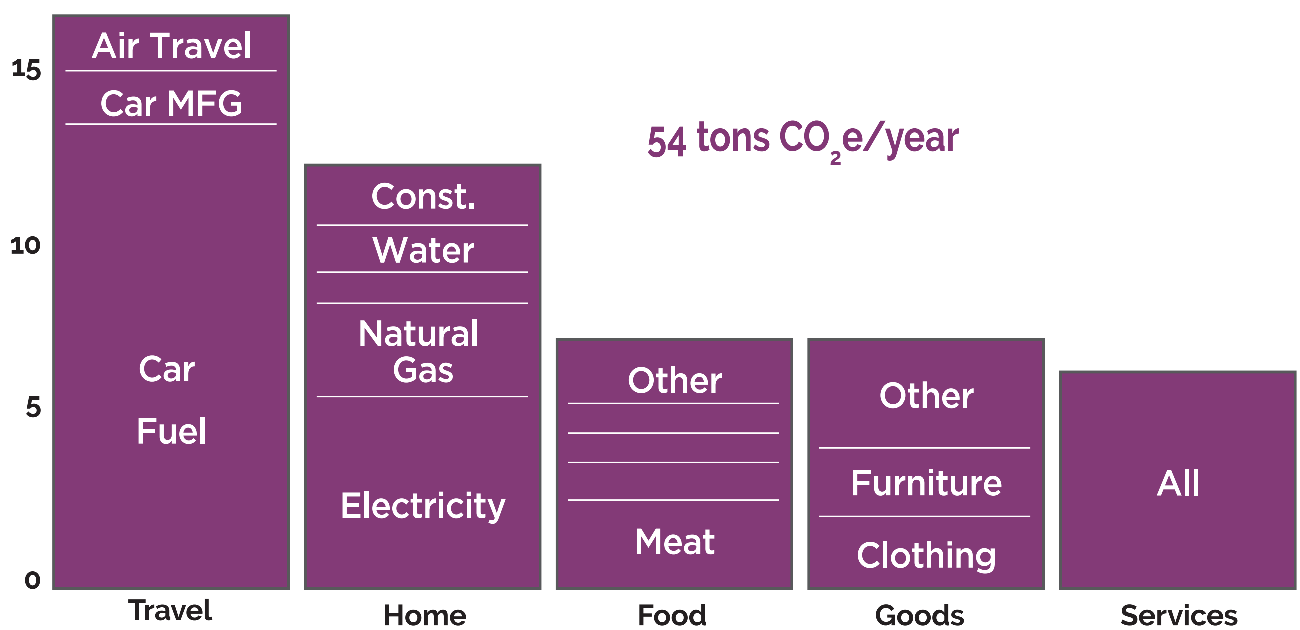
As with the production inventory, the consumption inventory is organized into categories of emissions sources. Cool California organizes emissions into travel, home, food, goods, and services. For purposes of comparison against the City's production inventory, the consumption inventory results are reported here as:

- **Energy:** Emissions associated with household and government operations energy use, including the production and distribution of energy sources to buildings and as energy used to provide water and to construct buildings
- **Transportation:** Emissions associated with fuel use in household vehicles and the City's vehicle fleet, public transit, and air travel; the production and distribution of vehicle fuels; and the manufacture of cars
- **Goods and Services:** Emissions associated with all household goods and services consumption, including emissions from the production and distribution of food and the extraction of raw materials for the production of goods (e.g., clothing, furniture) and emissions associated with businesses providing services to residents of Long Beach

Figure 13 is an example of the average household emissions outputs provided by Cool California. In addition to the subsector labels shown, the travel sector includes emissions from public transit; the home sector includes an "other" emissions category; and the food sector includes emissions from dairy, fruits and vegetables, and cereals.

In developing the consumption inventory, city-specific data were used where possible to further contextualize the analysis to Long Beach. For example, community vehicle travel data collected for the production inventory were used instead of the default car fuel assumptions that are built into Cool California calculations. Similar changes were made for the electricity, natural gas, and waste subsectors.

Figure 13: Long Beach Average Household Carbon Footprint



Source: CoolCalifornia.org, 2019

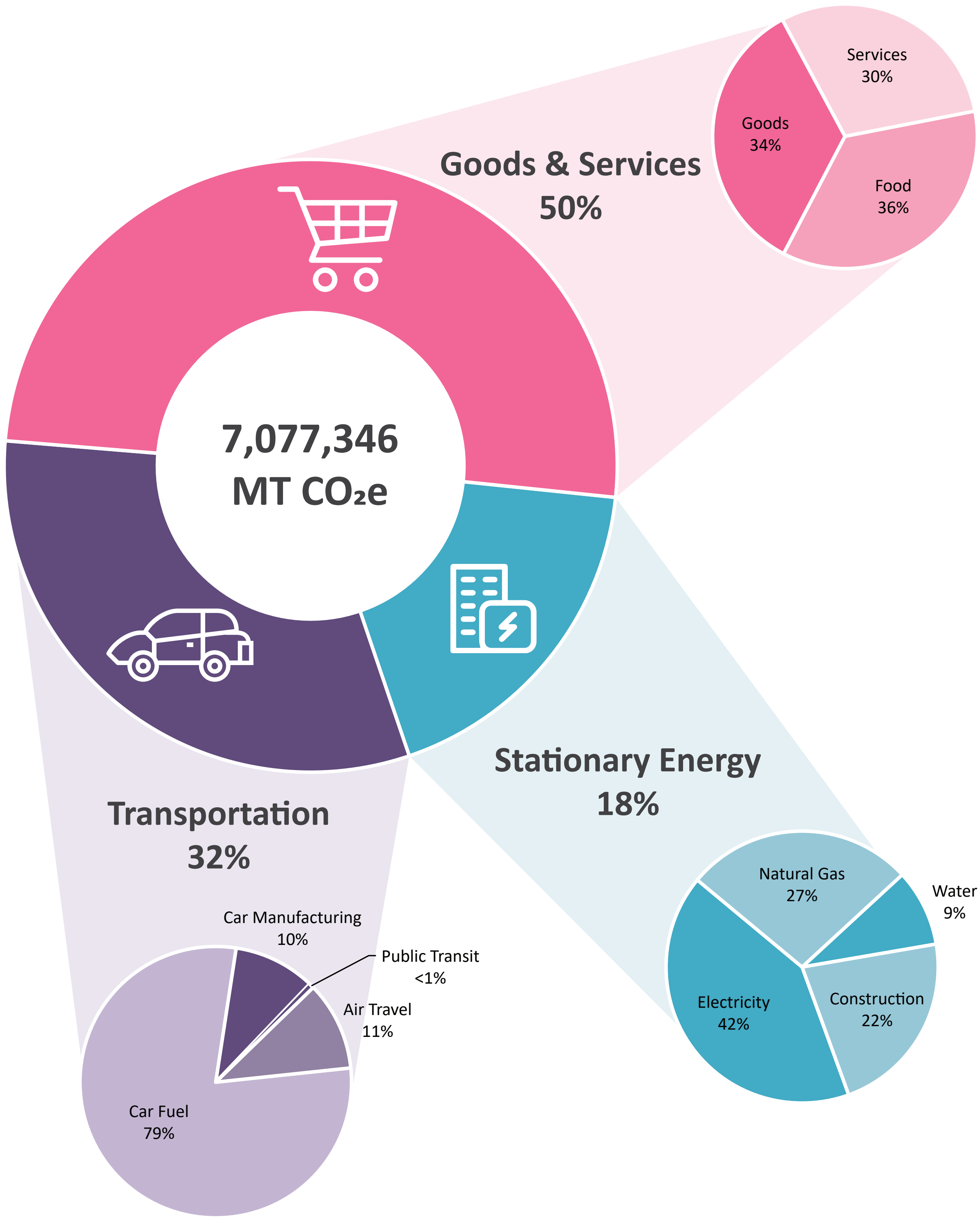
Consumption Inventory Results

The city's consumption emissions inventory totaled 7,077,346 MT CO_2e/yr in 2015, which is more than double the production inventory. As shown in Table 5, goods and services are the largest contributor of emissions in the community, followed by transportation and then energy. Note that emissions associated with the transportation of goods are included in the goods and services category rather than in the transportation category. Consumption emissions total 15.1 MT CO_2e/capita. Figure 14 illustrates the emissions by sector and subsector.

Table 5: Consumption Emissions Inventory by Subsector

Sector	2015 Emissions	
	MT CO_2e	% of Total
Energy	**1,284,173**	**18%**
Electricity	534,063	8%
Natural Gas	348,138	5%
Water	117,371	2%
Construction	284,600	4%
Transportation	**2,230,704**	**32%**
Vehicle Fuel	1,764,092	25%
Car Manufacturing	216,760	3%
Public Transit	13,237	<1%
Air Travel	236,615	3%
Goods and Services	**3,562,469**	**50%**
Food	1,272,429	18%
Goods	1,229,408	17%
Services	1,060,633	15%
TOTAL	**7,077,346**	**100%**
Per Capita	15.1	-

Figure 14: Long Beach Consumption Inventory Emissions Summary



COMPARISON OF PRODUCTION AND CONSUMPTION INVENTORIES

The community to which emissions from the consumption of goods is attributed highlights the primary difference between a production and consumption inventory. In a production-based inventory, a city with a large manufacturing industry producing goods would account for the energy used during production, even if the goods are exported for use elsewhere. In a consumption-based inventory, the city in which the consumers of goods live would account for those emissions, even if the goods consumed in the community were imported from elsewhere. The current industry standard in climate action planning is to evaluate a community's production-based inventory because they reflect emissions over which local governments have more direct control and because the supporting quantification methodologies and reporting frameworks are more fully developed at this time. However, there is a growing consensus about the importance of consumption inventory analysis to complement production inventories in helping communities more fully understand their contributions to global emissions.

Table 6 shows the results of the City's 2015 production and consumption inventories. The inventories are organized into three sectors for comparative purposes, although these sectors do not support a direct apples-to-apples comparison. As shown, the consumption inventory is more than 2.5 times larger than the production inventory. The primary difference in the two is in the waste/goods and services sector. Waste emissions in the production inventory represent end-of-use emissions when goods are disposed in a landfill or incinerator. Goods and services emissions in the consumption inventory reflect the complete life cycle of goods, including emissions from upstream production (e.g., raw material extraction, manufacturing, shipping) as well as downstream disposal.

Based on the results of this emissions comparison, the greatest opportunities to reduce consumption emissions are to pursue low-emissions diets (e.g., reduced meat and dairy consumption, which contribute 39 percent and 15 percent of food emissions, respectively), minimize purchases of goods and services, and increase the use of pre-owned goods or the purchase of products that minimize packaging and are produced locally. Figures 15 and 16 on the following page illustrate the production and consumption inventory results.

Table 6: Production versus Consumption Inventory Emissions by Sector

Sector	2015 Emissions			
	Production MT CO_2e	Production (%)	Consumption MT CO_2e	Consumption (%)
Stationary Energy [1]	1, 377,291	49 %	1,284,173	18%
Transportation	1,244,981	44%	2,230,704	32%
Waste / Goods and Services [2]	176,850	6%	3,562,469	50%
TOTAL	**2,799,123**	**100%**	**7,077,346**	**100%**
Per Capita	6.0	-	15.1	-

[1] Energy emissions in the production inventory include energy use from residential, commercial & local government, and industrial subsectors. The consumption inventory only includes household and local government energy use, which results in lower total energy emissions.

[2] These sectors from the production and consumption inventories are not directly compatible but are closely related as they represent emissions associated with the consumption and disposal of goods.
Values may not sum to 100 percent due to rounding.

Figure 15: Production versus Consumption Inventory – Total Emissions

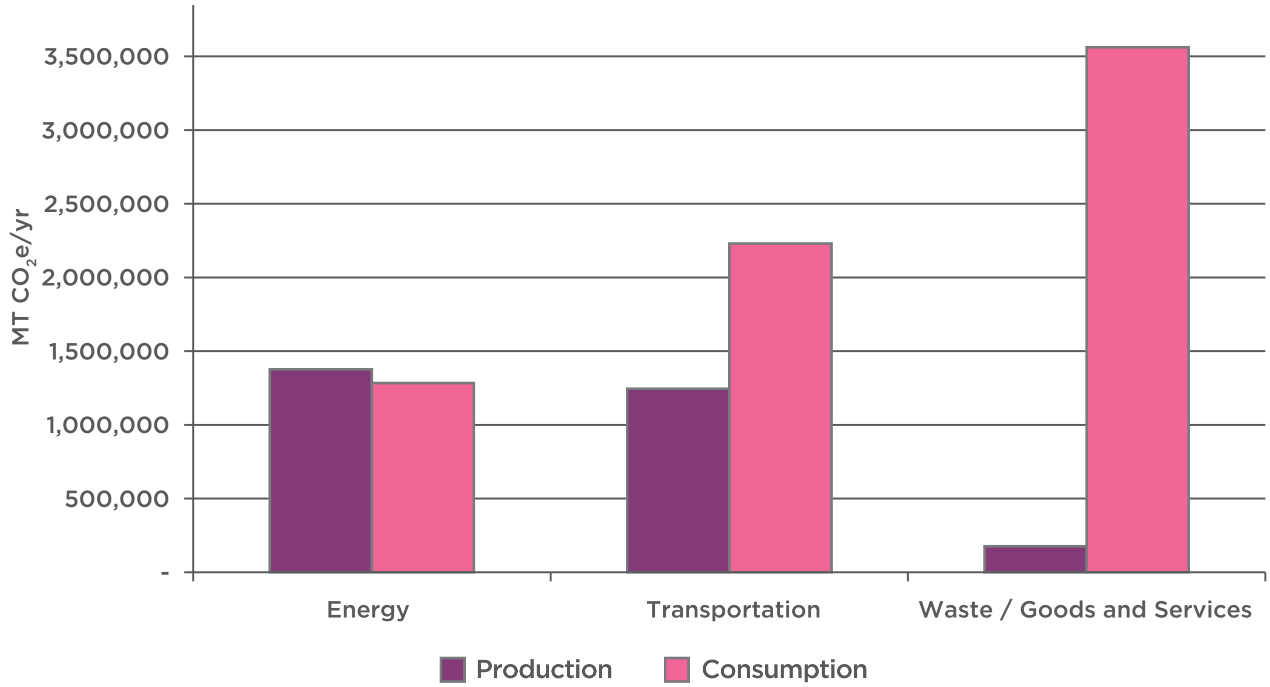
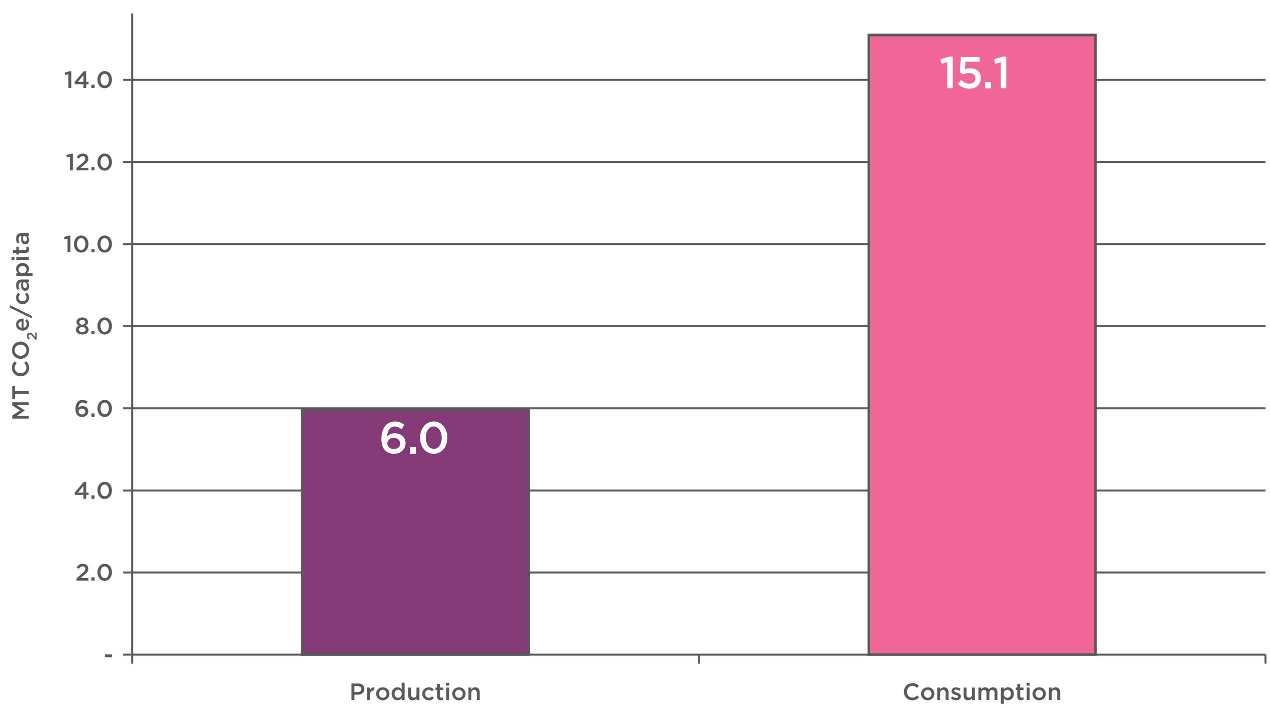


Figure 16: Production versus Consumption Inventory – Per Capita Emissions



OIL AND GAS LIFE CYCLE EMISSIONS ANALYSIS RESULT

As its third type of emissions analysis, the City analyzed the life cycle emissions associated with oil and gas extraction operations occurring within the city boundary. This analysis supports a more holistic view of the City's total contribution to global emissions and complements the production and consumption inventories. The analysis is summarized below. The City of Long Beach Oil and Gas Memo provides additional information, including data sources, methods, and detailed analysis.

In 2015, oil fields in the city produced more than 13 million barrels of crude oil and 5 billion cubic feet of natural gas. The resulting life cycle emissions total 8.3 million MT CO_2e, which is almost 3 times greater than the city's production inventory emissions. The life cycle emissions represent different phases of the oil supply chain, including upstream extraction activities at the city's oil fields, midstream refining activity occurring outside of the city, and downstream end use of the fuels produced, such as vehicle gasoline and diesel, which can be consumed inside and outside of the city. The life cycle emissions were estimated using a CARB-developed upstream emissions factor specific to the Long Beach oil fields and midstream and downstream emissions factors for the nearby Wilmington oil field, which were collected from the Oil-Climate Index.

Approximately 96 percent of the city's oil and gas life cycle emissions are attributed to crude oil, and the remaining 4 percent result from natural gas. The analysis estimated that all the natural gas extracted in Long Beach is consumed in the community and that all of the oil extracted in Long Beach is consumed within California. Of the total life cycle emissions, 76 percent occur downstream (i.e., transport to consumers and the end use of the fuel), 14 percent occur midstream (i.e., oil refining), and 5 percent occur upstream (i.e., extraction); the remaining 4 percent are life cycle natural gas emissions.

Understanding the life cycle emissions sources helps to identify the City's opportunities for intervention. Upstream emissions occur at the oil fields within the city boundary, where the City has issued well permits for petroleum operations. The City has made a number of investments to reduce GHG and air pollutant emissions and mitigate the environmental impacts of extraction activities. Further opportunities to reduce these emissions could include energy efficiency improvements in the extraction process or increased leak monitoring and detection. Oil extracted in Long Beach is refined into various end products, which are consumed inside and outside the city. Through this CAAP, the City is pursuing actions that would reduce local consumption of fossil fuels from building energy efficiency improvements, reduced vehicular travel, and expansion of electric vehicle technology. However, the City's ability to influence the use of Long Beach oil products outside of the city is limited. Similarly, the oil-refining process occurs outside the City's jurisdiction, and thus the City's ability to influence these midstream emissions is also limited.

The City's long-term strategy to address oil and gas life cycle emissions will need to be multi-pronged and collaborative. The strategy will need to include local action to replace fossil fuel consumption in Long Beach with clean electricity and other renewable energy sources; supporting efforts that minimize global demand for the types of oil and gas resources extracted in the city, which would lead to a reduction in local oil and gas extraction; and investments in future carbon capture technology. In the long term, to maximize carbon emission reductions, the City must explore ways to decrease and eventually phase out local oil and gas extraction.

PRODUCTION EMISSION FORECASTS

The production inventory was used to develop community-wide emissions forecasts for the 2030, 2040, and 2050 planning time frames. These "business-as-usual" forecasts estimate how emissions could change in the future if no local action is taken, such as through CAAP implementation. Emissions forecasts can provide useful insights about the scale of reductions necessary to achieve the City's emissions targets and represent a best estimate of the future for the purposes of CAAP development.

Emissions were forecast using a variety of factors that represent the drivers of emissions growth in the community, such as local population growth, employment, and travel demand modeling. The forecasts also take into account the implementation of several important components of the State's GHG reduction strategy, including the Renewables Portfolio Standard Program, a state law that requires increasing amounts of renewable electricity in California and various vehicle efficiency standards that will reduce emissions from on-road transportation to help achieve California's 2030 GHG targets.

For forecasting in the electricity sector, the City assumed a 60 percent Renewable Portfolio Standard (RPS) by 2030 as mandated statewide by Senate Bill (SB) 100. Since the City prepared the GHG inventory and forecasts, Southern California Edison (SCE) set a goal of an 80 percent carbon free energy supply by 2030. SCE's emissions factors, which are consistent with a greater carbon-free component of the energy supply and other measures to meet and exceed state GHG goals, were included in evaluating the GHG reduction potential of action BE-1 and will be monitored as the City conducts future inventories and forecasts. Other available local data on energy, transportation, and waste will also be considered, as appropriate, in inventory and plan updates and in the evaluation of GHG reductions and other benefits of CAAP actions.

Figure 17 illustrates the City's emissions forecasts by sector through 2050 and shows that emissions are estimated to decrease through 2050. The forecasted decline is largely a result of statewide actions influencing the City's electricity emissions and an estimated decrease in natural gas use in the energy sector. A higher local carbon-free component than the State RPS of 60 percent by 2030 would result in some additional GHG reductions within the energy sector in the 2030 and 2040 business-as-usual scenarios beyond what is shown in Figure 17. By 2045, the business-as-usual emissions forecast accounts for SB 100's requirement that California's electricity be derived from carbon-free sources. Vehicle efficiency improvements that reduce on-road transportation emissions serve to partially offset emissions growth in other transportation subsectors. All other emissions sources are forecast to experience growth from 2015 to 2050.

Table 7 on the following page shows the emissions forecasts by sector and subsector in 2015, 2030, 2040, and 2050. Per capita emissions are estimated to decrease through 2050 from 6.0 MT CO_2e/capita in 2015 to 3.1 MT CO_2e/capita in 2050, while per SP emissions are estimated to decrease from 4.5 MT CO_2e/service population to 2.2 MT CO_2e/SP in the same period.

Figure 17: Business-as-Usual Emissions Forecasts 2015 – 2050

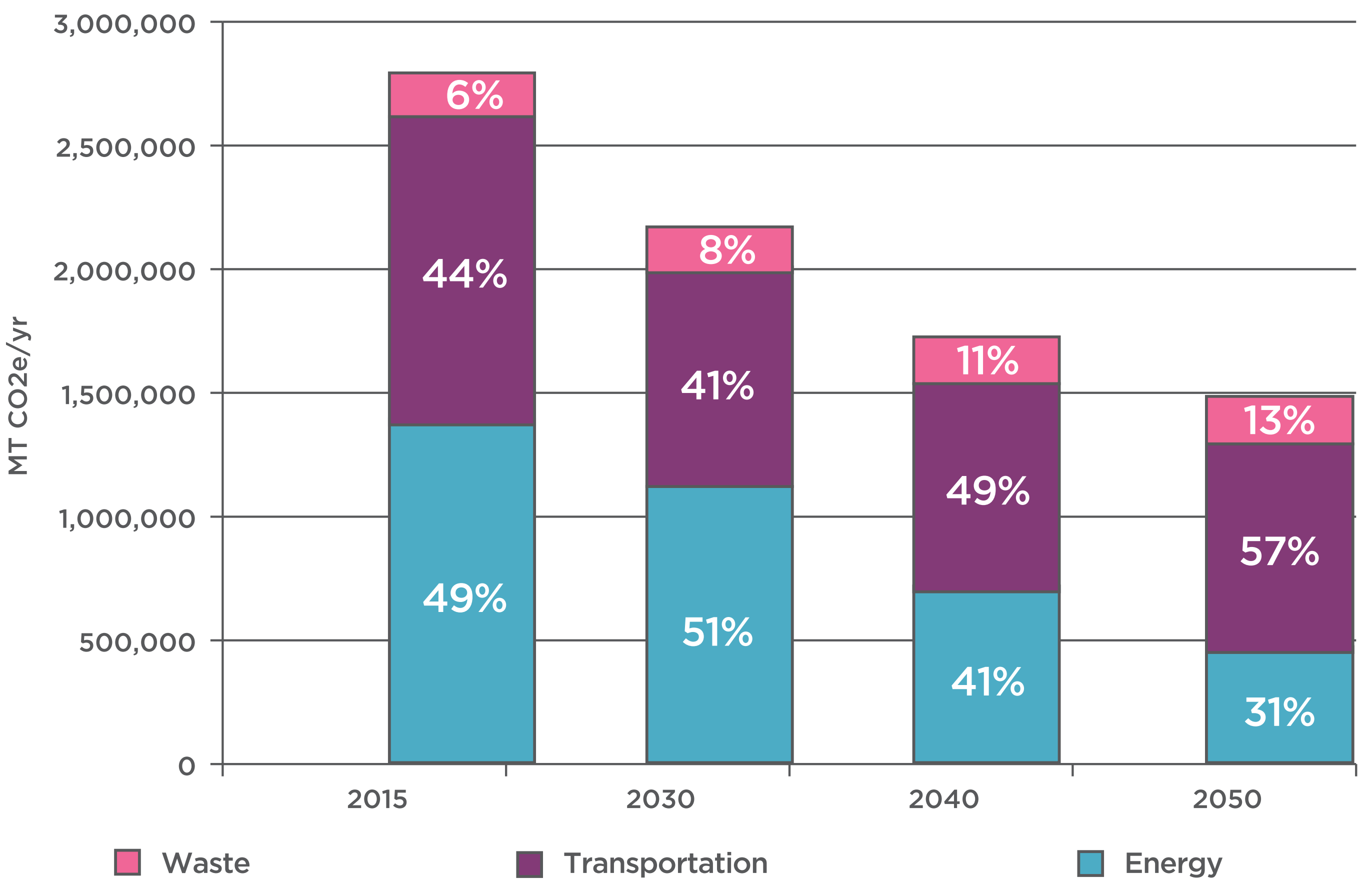


Table 7: Business as Usual Community Greenhouse Gas Emissions Forecasts 2015 - 2050

Sector	Emissions MT CO_2e			
	2015	2030	2040	2050
Stationary Energy	**1,377,291**	**1,104,313**	**702,391**	**456,608**
Stationary Energy % of Total	**49%**	**51%**	**41%**	**31%**
Residential Building Energy	428,245	327,162	213,538	136,957
Natural Gas	241,176	184,498	165,594	136,957
Electricity	187,070	142,664	47,945	-
Commercial and Institutional Building Energy	300,818	238,760	129,472	61,312
Natural Gas	109,593	81,780	74,452	61,312
Electricity	191,225	156,981	55,019	-
Manufacturing Industries and Construction Energy	399,089	329,692	150,682	49,640
Natural Gas	74,853	62,109	56,662	49,640
Electricity	324,235	267,583	94,020	-
Energy Industries	219,899	184,205	184,205	184,205
Fugitive Emissions from Natural Gas	29,240	24,494	24,494	24,494
Transportation	**1,244,981**	**887,732**	**840,924**	**843,529**
Transportation % of Total	**44%**	**41%**	**49%**	**57%**
On-Road Transportation	1,213,601	851,784	803,878	804,735
Railways	11,883	13,211	13,988	15,472
Aviation	4,550	7,110	7,110	7,110
Off-Road Equipment	14,947	15,627	15,948	16,212
Waste	**176,850**	**184,887**	**188,715**	**191,768**
Waste % of Total	**6%**	**8%**	**11%**	**13%**
Solid Waste Methane Commitment	173,164	181,043	184,768	187,820
Solid Waste Incineration	95	99	101	103
Wastewater Treatment and Discharge	3,592	3,744	3,845	3,845
TOTAL	**2,799,123**	**2,176,931**	**1,732,030**	**1,491,905**
Per Capita	6.0	4.5	3.6	3.1
Per Service Population (residents + employees)	4.5	3.3	2.6	2.2

GREENHOUSE GAS REDUCTION TARGET SETTING

Greenhouse gas reduction targets help focus local actions and serve as aspirational metrics for this CAAP. Establishing clear and attainable targets can also motivate community members and City staff, help guide long-term strategies, and increase transparency and accountability regarding the CAAP's goals. Establishing local GHG targets in Long Beach can also help to achieve the following objectives:

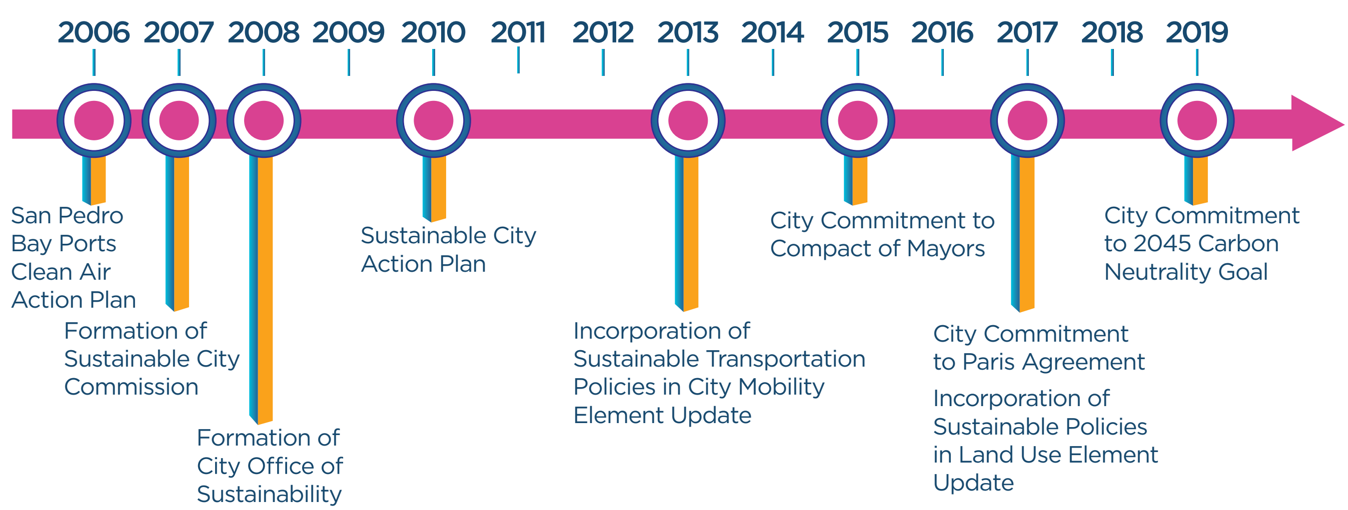
- Provide a goal post against which the cumulative progress of the City's GHG reduction actions over time can be evaluated.
- Comply with requirements of the Global Covenant of Mayors, to which the City of Long of Beach has been a signatory since 2015.
- Demonstrate the City's commitment to global efforts to address climate change.
- llustrate the relationship between the City's reduction target and the State's own reduction goals for compliance with State mandates for cities related to GHG reduction
- Demonstrate a level of GHG emissions below which Long Beach would have less than cumulatively considerable GHG impacts for future environmental review projects.

The City is already a leader in environmental sustainability and climate initiatives. Figure 18 illustrates a timeline with several examples of the City's sustainability-related activities, which include the following actions related to GHG commitments:

- In 2015, Mayor Robert Garcia signed the Compact of Mayors (now the Global Covenant of Mayors) to join the world's largest coalition of city governments to address climate change.
- In 2017, Mayor Garcia joined 406 mayors across the United States in pledging to continue the goals of the Paris Climate Agreement to make sustainable changes to limit global temperature rise to well below 2 degrees Celsius.
- In 2019, Mayor Garcia encouraged the city to achieve a carbon neutrality goal by 2045, consistent with California Executive Order B-55-18.

The CAAP charts a pathway to help the City fulfill these commitments. To that end, the City evaluated a series of GHG target options during the development of the CAAP. Several reduction target options were considered and were vetted by the CAAP Scientific Working Group—a body of 13 independent experts from California State University, Long Beach; Long Beach Community

Figure 18: Timeline of Long Beach Sustainability Activities



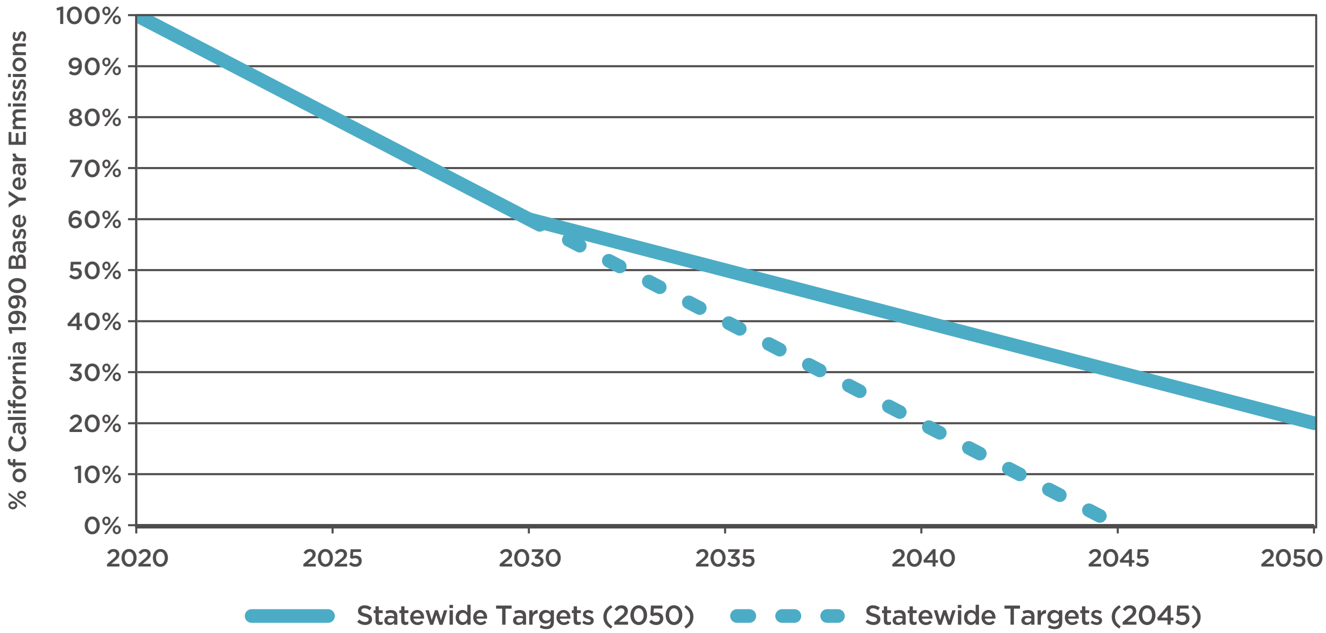
College; the University of California, Los Angeles; the Aquarium of the Pacific, and the South Coast Air Quality Management District. The targets selected represent the City's commitment to doing its fair share and meeting its requirements to help California achieve its ambitious statewide GHG targets. Table 8 outlines the State's GHG reduction commitments. Near-term targets for 2020 and 2030 have been formally adopted by the California State Legislature. Executive orders signed by previous Governors outline the state's potential long-term targets for 2045 and 2050 but do not represent official state policy at present.

Figure 19 illustrates the trajectory of California's GHG target-setting framework. The solid line shows an emissions trajectory for the 2050 executive order of 2005, and the dashed line shows a trajectory for the 2045 executive order of 2018.

Table 8: State of California Greenhouse Gas Targets

Target Year	Target	Corresponding Legislation
2020	Return to 1990 GHG levels by 2020	Assembly Bill 32, the California Global Warming Solutions Act of 2006
2030	40% below 1990 levels by 2030	Senate Bill 32, the Global Warming Solutions Act of 2006
2040	Carbon neutrality by 2045	Executive Order B-55-18 of 2018
2050	80% below 1990 levels by 2050	Executive Order S-3-05 of 2005

Figure 19: Statewide Emissions Target Trajectory



GHG REDUCTION TARGETS

2030

The City's near-term 2030 target was selected based on guidance provided in CARB's 2017 California Climate Change Scoping Plan and was developed to demonstrate consistency with the statewide 2030 target shown in Figure 8. The City's 2030 target is established on a per SP basis and aims to achieve emissions rates of 3.04 MT CO_2e/SP. This compares to the City's 2030 business-as-usual forecast of 3.34 MT CO_2e/SP. Based on the City's SP growth estimates, the 2030 target emissions level is 1,984,272 MT CO_2e/yr. GHG reductions of approximately 192,659 MT CO_2e will be required to achieve this target, or a reduction of approximately 0.3 MT CO_2e/SP.

2045

The City also used the CAAP to begin initial evaluation of a long-term aspirational GHG reduction goal and has begun considering the strategies that will be required to achieve it. The City has set an aspirational goal to achieve net carbon neutrality citywide by 2045, which is consistent with California Executive Order B-55-18, which calls for statewide net carbon neutrality in the same year. With no CAAP, under the business-as-usual emissions forecast scenario, the City's 2045 emissions are estimated to be approximately 1.5 million MT CO_2e. Achieving a net carbon neutrality target would require eliminating nearly all these emissions and purchasing carbon offsets for the remainder that cannot be reduced with future technologies. Table 9 summarizes the City's 2030 GHG target and its 2045 aspirational goal. Figure 20 illustrates the City's emissions forecasts and reduction targets. The gap between the emissions forecast (purple line) and the target (blue line) shows the amount of reductions needed in each year. The actions described in this CAAP will help the City achieve its near-term 2030 target and begin moving forward on its path toward the 2045 goal.

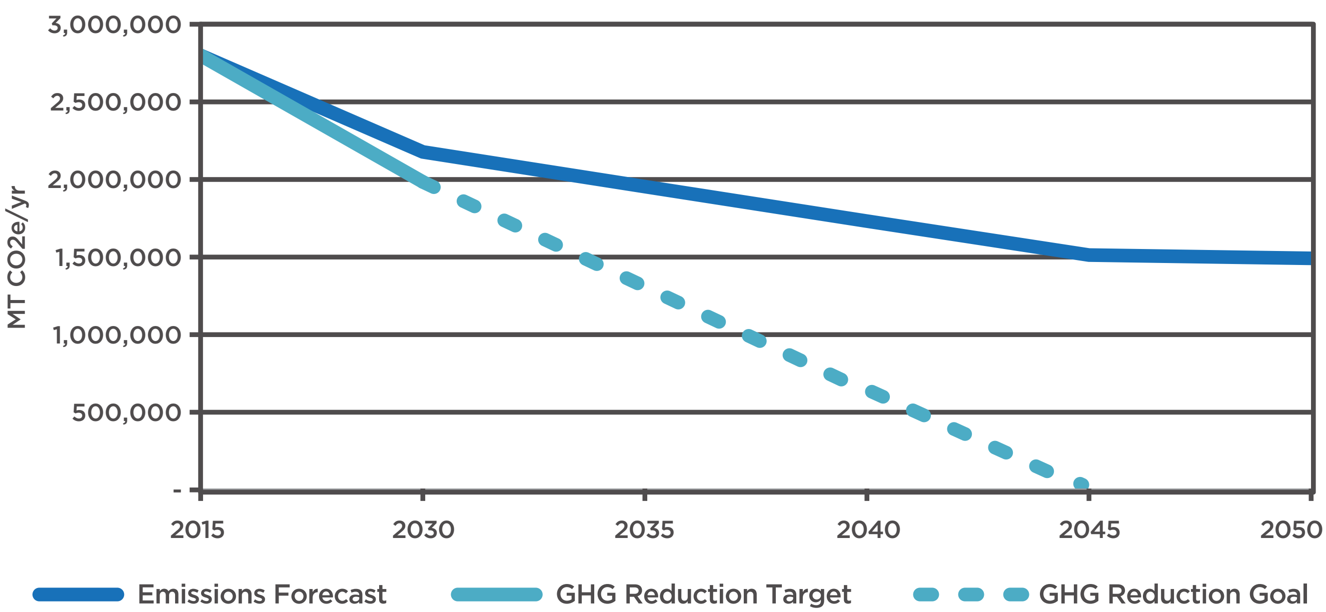
Chapter 6 identifies the actions the City will prioritize for implementation to achieve the 2030 emissions reduction target. It also contains a set of additional actions that the City could decide to implement to achieve greater reductions prior to 2030 and further support progress toward the 2045 net carbon neutrality goal. Chapter 7 includes actions the City will undertake to demonstrate climate action leadership in both reducing emissions and increasing resiliency. It also outlines the steps the City will take to establish a funding and financing strategy to secure the resources that will be necessary to implement the CAAP.

Chapter 8 outlines how the City will monitor and report on CAAP progress as well as the process that will be used to determine the regularity of inventory updates and changes and adjustments to the CAAP.

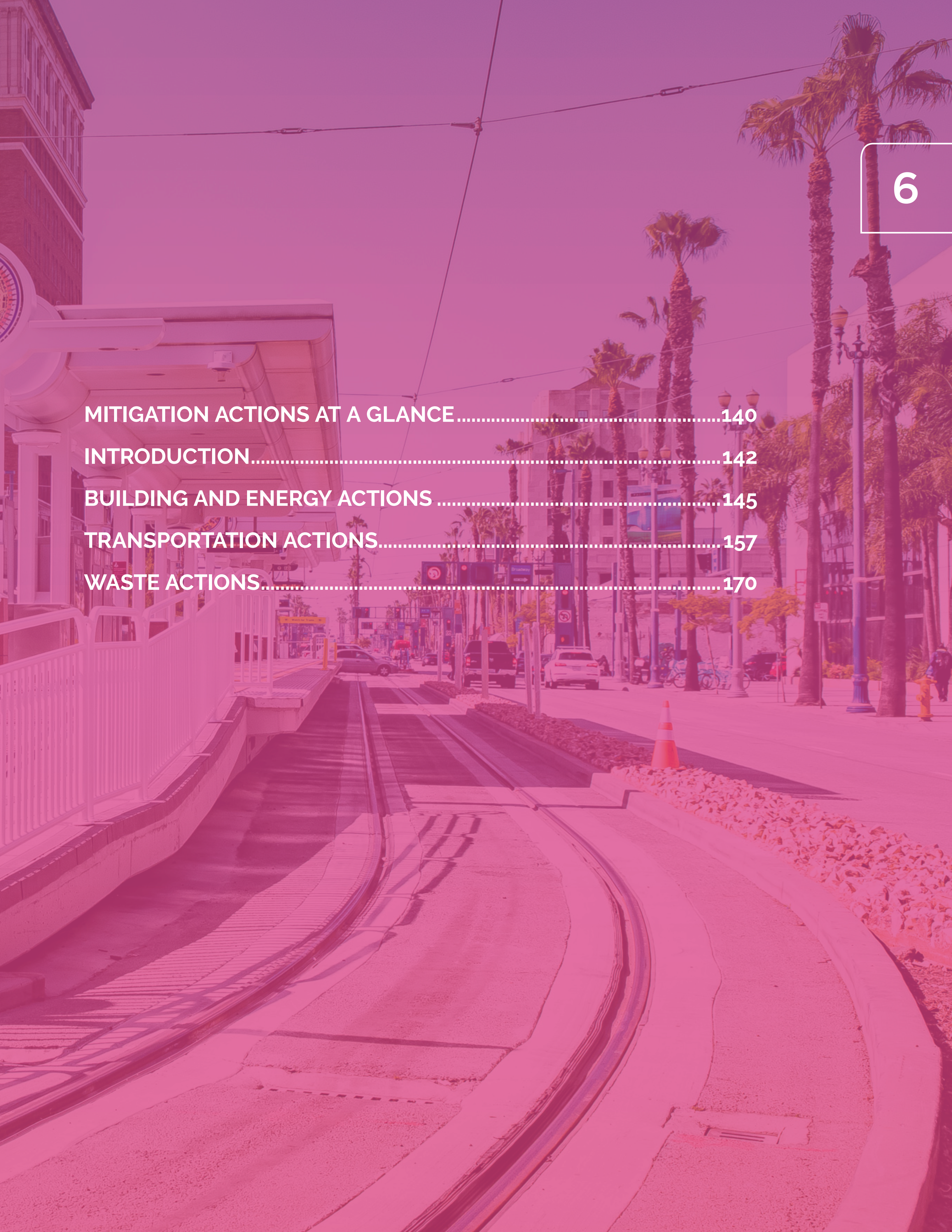
Table 9: City of Long Beach GHG Reduction Targets

2030 GHG Target	**3.04 MT CO_2e/Service Population**
Emissions Business as Usual Forecast	2,176,931 MT CO_2e/SP
Emissions Target Level	1,984,272 MT CO2e/SP
GHG Reductions Needed	**192,659 MT CO_2e/SP**
2045 GHG Aspirational Goal	**Net-Carbon Neutrality**
Emissions Business as Usual Forecast	1,513,047 MT CO_2e/SP
Emissions Target Level	0 MT CO_2e/SP
GHG Reductions Needed	**1,513,047 MT CO_2e/SP**

Figure 20: Emissions Targets versus Business-as-Usual Forecasts 2015-2050



6 Mitigation Actions



6

MITIGATION OBJECTIVES AND ACTIONS AT A GLANCE

BE Building + Energy

Goal: Long Beach buildings are energy-efficient and our communities run on affordable, renewable electricity

GHG Reductions 247,700 MT CO_2e

OBJECTIVES	NO.	ACTIONS
Transition to a carbon-free, more resilient electricity system	BE-1	Provide access to renewably generated electricity
	BE-2	Increase use of solar power
	BE-3	Promote community solar and microgrids
Increase the energy efficiencyof existing buildings/facilities	BE-4	Develop a residential and commercial energy assessment and benchmarking program
	BE-5	Provide access to energy efficiency financing, rebates, and incentives for building owners
	BE-6	Perform municipal energy and water audits
Ensure new buildings are low-carbon or carbon-neutral	BE-7	Update building codes to incentivize electric new residential and commercial buildings
Reduce emissions from local oil and gas extraction	BE-8	Implement short-term measures to reduce emissions related to oil and gas extraction

T Transportation

Goal: Affordable, safe, carbon-free transportation choices connect all Long Beach communities to opportunity, clean air, and improved health

GHG Reductions 30,480 MT CO_2e

OBJECTIVES	NO.	ACTIONS
Decrease reliance on personal motor vehicles and increase transit, biking, andwalking trips	T-1	Increase the frequency, speed, connectivity, and safety of transit options
	T-2	Expand and improve pedestrian infrastructure citywide
	T-3	Increase bikeway infrastructure citywide
Shift to low- and zero-emissions vehicles to move people and freight	T-4	Implement the Port of Long Beach Clean Trucks Program
	T-5	Develop an Electric Vehicle Infrastructure Master Plan
Prioritize the development of transit-oriented neighborhoodswith a mix of jobs, services, and housing	T-6	Increase employment and residential development along primary transit corridors
	T-7	Update the Transportation Demand Management Ordinance
	T-8	Increase the density and mixing of land uses
	T-9	Integrate SB 743 planning with the CAAP process

W Waste

Goal: Long Beach is a zero-waste city

GHG Reductions 116,680 MT CO_2e

OBJECTIVES	NO.	ACTIONS
Materials that can be recycled are recycled	W-1	Ensure compliance with state law requirements for multifamily and commercial property recycling programs
	W-2	Develop an organic waste collection program for City-serviced accounts
Collect all organic waste for composting or clean energy generation	W-3	Partner with private waste haulers to expand organic waste collection community-wide
	W-4	Identify organic waste management options

INTRODUCTION

This chapter presents the City of Long Beach greenhouse gas (GHG) emission reduction actions identified through extensive engagement with City staff, subject matter experts, local stakeholders, and Long Beach residents and businesses. As detailed in the GHG Inventory Chapter, the City has established a target to reduce per-service population (i.e., residents plus employees) emissions from a baseline of approximately 4.48 MT CO_2e per service population in 2015 to 3.04 MT CO_2e per service population (2.0 million MT CO_2e) in 2030, and by 2045 the City has established a goal of achieving net carbon neutrality.

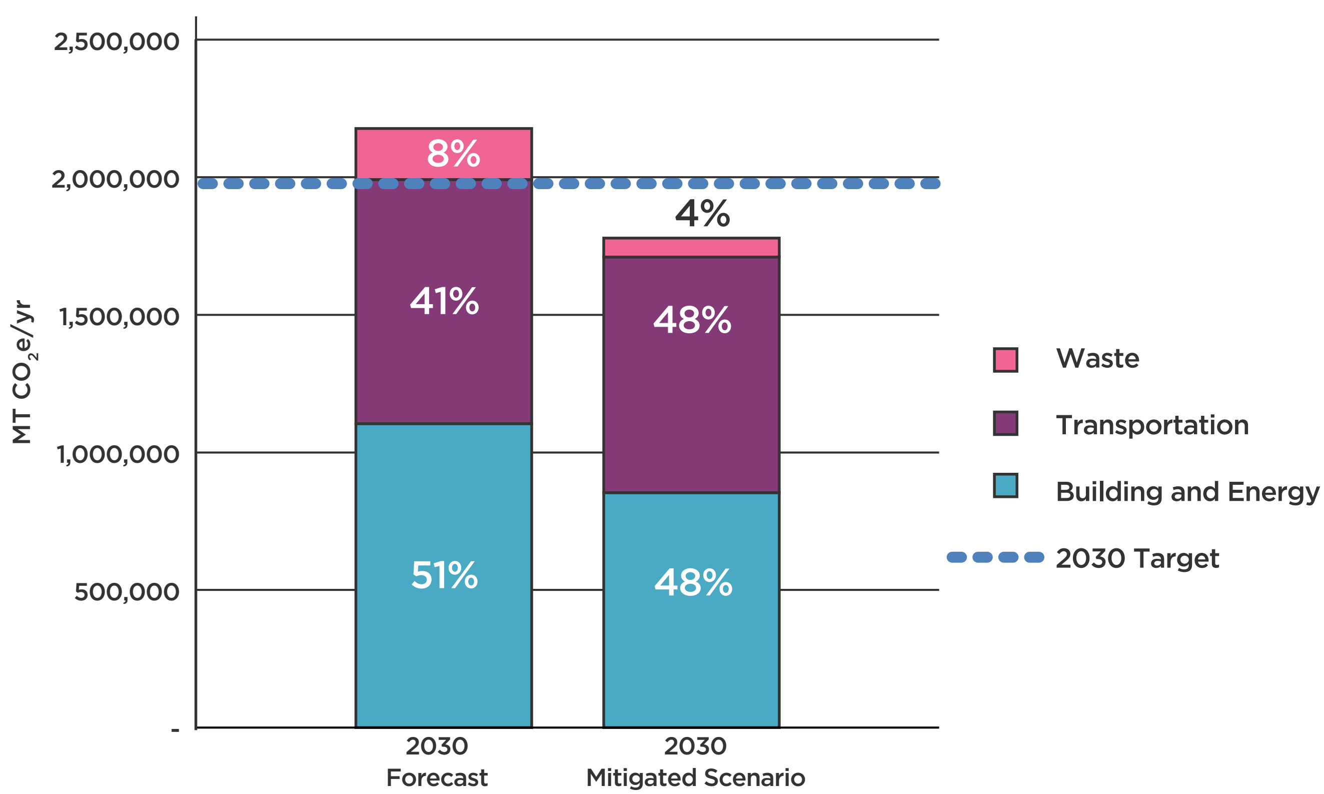
Meeting And Exceeding Our 2030 Emissions Reduction Target

21 priority actions have been identified in the following sectors:

- Building and Energy
- Transportation
- Waste

These priority actions, combined with reductions from state and federal initiatives, are estimated to result in the City meeting and slightly exceeding the 2030 target. Actions from the Building and Energy, Transportation, and Waste sectors are cumulatively estimated to achieve reductions totaling approximately 394,860 MT CO_2e, which represents emissions levels of 2.73 MT CO_2e per service population in 2030, compared to the target of 3.04 MT CO_2e per service population. Figure 21 shows the distribution of emissions by sector in the 2030 forecasts and the 2030 mitigated scenario, which reflects implementation of the priority actions.

Figure 21: 2030 Reduction Target



Approximately 63 percent of the reductions come from Building and Energy actions, 8 percent from Transportation actions, and 30 percent from Waste actions. This distribution of reductions by sector reflects the fact that significant GHG reductions are already included in the GHG forecasts which are attributed to the state's renewable electricity requirements and vehicle fuel efficiency requirements, as well as the expected vehicle use reductions from implementation of the City's General Plan 2040.

As newer and more local data becomes available in the future, these emission reduction estimates will be further refined. Data revisions will include aspects such as changes to the percentage of carbon-free energy sources included in SCE's energy portfolio. For example, SCE has committed to providing 80 percent carbon free energy by 2030 and this commitment is considered in the CAAP's GHG reductions estimates for the 2030 target. The City's monitoring activities and future inventories will incorporate the most up-to-date information available, along with other data updates related to the energy, transportation, and waste sectors to track GHG target progress and identify further opportunities for local climate action.

Moving Beyond 2030 to Carbon Neutrality in 2045

Full implementation of all 21 priority actions will not be enough to achieve carbon neutrality in 2045. If emission reductions from these actions were maximized by 2045, total emissions would still be approximately 1.1 million MT CO_2e based on preliminary estimates (see Figure 22). As a result, additional action will be needed to achieve the City's ambitious carbon neutrality goal. The primary emissions sources estimated to remain in 2045 include natural gas use in existing buildings, on-road vehicle emissions, operations at the city's energy industries, and off-road vehicles and equipment. New actions may be developed in future CAAP updates to reduce these emissions sources. Some current priority actions may also be strengthened to begin implementation sooner or increase estimated participation rates. New state legislation and programs may also be developed in the future to help address these remaining emissions sources in support of the state's long-term GHG targets.

Process For Selecting and Prioritizing Actions

Priority actions were identified and included based on the following factors:

- Contribution to achieving necessary GHG reductions
- Technical feasibility and City implementation capacity
- Public and stakeholder feedback
- Equity analysis
- Implementation costs

Public and stakeholder feedback played a prominent role in identifying both the priority and the additional actions. Broadly, common feedback themes included expanding transportation choices, increasing access to renewable electricity, reducing waste, reducing costs and preserving and enhancing affordability, and investments that would improve public health and overall quality of life.

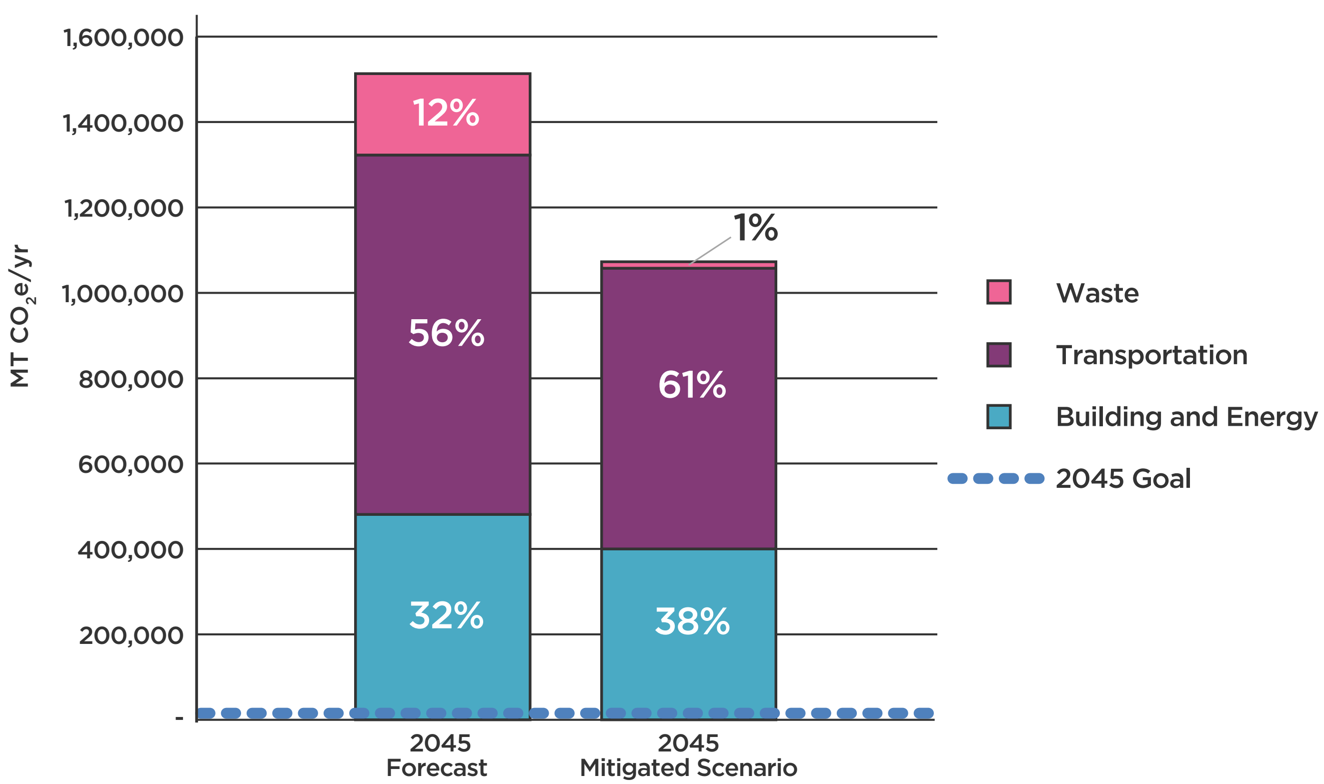
Public feedback also broadened the scope of issues examined in the CAAP process, most notably regarding the issue of oil and gas extraction in Long Beach. Issues related to oil and gas extraction were raised in a variety of public meetings and led to the City preparing an informational memorandum to evaluate at a high level the lifecycle emissions from the use of oil and gas extracted in Long Beach and to identify measures the City could take to address them. This was a focused, high level analysis of lifecycle oil intensity that leveraged the Oil Climate Index (OCI) methodology for assessing the lifecycle impacts of global oils. The evaluation did not include considerations about the economic benefits to the City from its oil production activities, local public health impacts, domestic energy security, human rights records, or other socio-political factors.

The Oil and Gas Memo includes a range of measures that the City could take to further address GHG emissions from extraction activities. The City has included all near-term measures in action BE-8. Additionally, some of the recommended medium and long-term measures aimed at reducing oil and gas consumption within the city, such as electrifying public and passenger vehicle transportation and pursuing energy efficiency upgrades of end-use appliances, are addressed in other mitigation actions in this chapter. The City has already made a number of investments to reduce GHG and air pollutant emissions and improve the environmental sustainability of extraction activities.

The Priority Mitigation Actions table lists the actions for each of the three sectors along with the estimated total GHG reductions. Appendix A describes the methodology used to estimate reductions for each sector, and the Implementation and Monitoring Chapter outlines the tools and process that will be utilized to monitor emissions reduction progress and identify adjustments that may be needed to ensure the City is on track to meet its 2030 CAAP targets. Each action identifies an implementation lead and partners, general timeline (short, medium, long) and City costs (low, medium, high), co-benefits, implementing subactions, and an equity strategy. In general, City operational costs and one-time costs associated with tasks such as updating ordinances and conducting studies are considered to be low while actions that include capital costs and/or significant ongoing operational costs range from medium to high. It is important to note that a number of actions with medium to potentially high cost ranges such as expanding and improving bikeway and pedestrian infrastructure or implementing the Port of Long Beach Clean Air Action Plan have primary objectives such as improving safety and air quality with GHG reductions as an important additional benefit. In other cases, such as municipal building energy and water audits, upfront implementation costs are likely to be outweighed by long-term energy and water savings.

The City has included a preliminary set of potential performance metrics associated with each action that will be considered in Appendix F. These will be used to measure implementation outcomes related to GHG reductions, co-benefits, and equity, and complement GHG monitoring as outlined in the Implementation and Monitoring Chapter.

Figure 22: 2045 Reduction Goal



BUILDING AND ENERGY ACTIONS

Reducing building energy use and using clean, renewable energy are necessary to meet the CAAP's 2030 targets. Electricity and natural gas use in residential and commercial buildings are responsible for about 25 percent of the emissions in the Long Beach GHG inventory. The electricity sector in California is rapidly evolving towards renewable energy. This evolution is the result of California's aggressive Renewables Portfolio Standard (RPS) as well as market and technology changes that are making renewables increasingly cost-competitive with fossil fuels. The RPS requires utilities to achieve a 33 percent renewables power mix by 2020, a 60 percent mix by 2030, and a 100 percent mix by 2045. One of the primary ways cities around the state are aiming to meet their near-term emissions reduction targets is to transition to 100 percent local consumption of renewable electricity before 2045. A renewable electricity transition will significantly reduce but not eliminate energy emissions from buildings because of the prevalence of natural gas in existing buildings. The use of renewable natural gas is also increasing but is not expected to reach levels that would allow for a similar replacement of traditional supplies with renewables. To make progress and ultimately achieve net carbon neutrality by 2045, natural gas emissions from existing and new buildings, which make up approximately 13 percent of the GHG inventory, must be addressed. Although energy-efficiency improvements in buildings will reduce natural gas emissions and result in cost savings for residents and businesses, it will ultimately be necessary to transition from all natural gas uses to electricity in both existing buildings and new buildings.

The core focus of building energy actions is on transitioning Long Beach to renewable energy and increasing energy efficiency in existing and new residential, commercial, and municipal buildings. Energy-efficient buildings that are powered by clean, renewable energy will also improve outdoor and indoor air quality, improve overall comfort, and provide utility cost savings, which are important co-benefits for residents and businesses. This section includes the action (BE-8) incorporating the Oil and Gas Memo's suite of near-term measures to address emissions associated with local oil and gas extraction. The City will work to ensure that key populations, such as low-income households, renters, and communities most impacted by climate change, are prioritized in the implementation of these actions.

BE Building + Energy

Goal: Long Beach buildings are energy-efficient and our communities run on affordable, renewable electricity

GHG Reductions 247,700 MT CO_2e

OBJECTIVES	NO.	ACTIONS
Transition to a carbon-free, more resilient electricity system	BE-1	Provide access to renewably generated electricity
	BE-2	Increase use of solar power
	BE-3	Promote community solar and microgrids
Increase the energy efficiencyof existing buildings/facilities	BE-4	Develop a residential and commercial energy assessment and benchmarking program
	BE-5	Provide access to energy efficiency financing, rebates, and incentives for building owners
	BE-6	Perform municipal energy and water audits
Ensure new buildings are low-carbon or carbon-neutral	BE-7	Update building codes to incentivize electric new residential and commercial buildings
Reduce emissions from local oil and gas extraction	BE-8	Implement short-term measures to reduce emissions related to oil and gas extraction

BE-1 Provide Access to Renewably Generated Electricity

Explore and pursue various options to increase the community's access to renewable electricity that exceeds the State's Renewables Portfolio Standard in the near-term.

Implementation Lead: City Manager; Office of Sustainability; Energy Resources
Partners: Utilities (Southern California Edison and/or a Community Choice Aggregation utility)
Timeline: Short
Potential Cost Level: Low to High

Description

The City will explore options for increasing the community's access to and utilization of renewable electricity to exceed the State's Renewables Portfolio Standard (RPS) of 60 percent by 2030. At the utility level, there are a few options available to increase local use of clean electricity. Currently, Southern California Edison (SCE) offers its Green Rate program to residential and commercial customers that want to voluntarily purchase 50 percent or 100 percent clean electricity. It is important to also note that SCE has committed to an 80 percent carbon free energy supply by 2030, along with other actions to meet and exceed the State's GHG reduction goals.

Alternatively, the City could establish its own Community Choice Aggregate (CCA) or join an existing one such as the Clean Power Alliance (CPA), which would automatically enroll customers in receiving up to 100 percent of their electricity from cleaner energy sources. CCAs are programs that allow local governments to procure power on behalf of their residents, businesses, and municipal accounts from an alternative supplier while still receiving transmission and distribution service from their existing utility provider. Similar to SCE's existing Green Rate program, members have tiered rate options based on their desired share of renewable energy, however data shows that CCAs, which are "opt-out" (where clean electricity is the default option), have much higher rates of participation in clean electricity usage compared to SCE's existing "opt-in" program.

Electricity use contributed more than 20 percent of Long Beach's total community emissions in 2015, so reducing electricity-related emissions is critical to the CAAP. To demonstrate leadership, the City will commit to 100 percent clean electricity for all municipal accounts. The City will then evaluate how it can best facilitate communitywide participation in clean electricity use. Since SCE's renewable portfolio in 2030 is anticipated to exceed state requirements, GHG reductions may be comparable to the reductions that could be achieved by a CCA. The City will monitor SCE's progress toward its 80 percent carbon free energy supply goal and consider this when assessing future renewable electricity programs.

Co-benefits:

- ✓ Improved air quality
- ✓ Grid resilience, if energy storage is an added element

Implementing Actions

BE-1.1: Continue to assess the risks and benefits associated with joining a CCA such as through updated feasibility studies taking into account local electricity emissions factors from SCE.

BE-1.2: Develop a comprehensive economic impact analysis to understand the full benefits and costs of joining or developing a CCA and investing CCA revenues in local community climate projects.

BE-1.3: Work with SCE to collect Green Rate participation information and promote SCE Green Rate enrollment.

BE-1.4: Purchase 100 percent renewable electricity for all municipal accounts.

Equity Strategy

Ensure that local programs funded through increased use of renewably generated electricity benefit low-income communities most impacted by climate change including a focus on job creation, job training, and workforce development.

Existing Program: Citywide Solar

The City has a Solar Energy Power Purchase Agreement to install 10 solar arrays at various City-owned properties, including the Long Beach Gas & Oil Headquarters, Airport Garage, and the Public Works Yard. Together these solar arrays will generate 6,069 kilowatts of solar energy, decreasing the City's energy costs while reducing its carbon footprint through the use of renewable energy.

BE-2

Increase Use of Solar Power

Incentivize and facilitate an increase in solar power infrastructure installation and usage.

Implementation Lead: City of Long Beach Office of Sustainability
Partners: Pacific Gateway Workforce Innovation Network; SCE; GRID Alternatives
Timeline: Medium
Potential Cost Level: Low to Medium

Description

To increase the use of renewable power in Long Beach, the City will promote increased installation of solar power infrastructure in buildings across the city and in municipal projects. According to Google Project Sunroof, a solar calculator from Google that estimates every rooftop's solar potential, only 2 percent of Long Beach's solar potential is being used for solar. Although there can be a substantial upfront cost associated with solar installation, a variety of rebate, incentive, alternative financing (such as power purchase agreements), and grant programs exist. Moreover, in addition to environmental benefits, the financial savings from solar power over time can cover the costs of solar installation.

GRID Alternatives, a California-based nonprofit organization, has assisted low-income communities and communities of color in Long Beach in getting affordable solar power while creating solar jobs. A frequent barrier to solar installation is aging and damaged roofs. To safely install solar panels, roofs that are damaged or nearing the end of their life span must be replaced.

Equity Strategy

Identify and maximize use of resources to provide solar installation at a free or reduced cost for the low-income communities most impacted by climate change in Long Beach. Partner with the Pacific Gateway Workforce Innovation Network and/or other workforce entities to increase solar power infrastructure installation and usage in the community while expanding local green job development opportunities

Co-benefits:

- ✓ Reduced household costs associated with energy consumption
- ✓ More equitable access to the economic benefits of solar energy
- ✓ Local job creation in installation of solar infrastructure

Implementing Actions

BE-2.1: Assess solar installation trends by housing typology, neighborhood, and use of incentive program to understand strengths and

BE-2.2: Identify, assess, and reduce any barriers to solar installation due to the City's building permit or zoning requirements.

BE-2.3: Require that municipal projects include solar infrastructure installation to the maximum extent feasible.

BE-2.4: Partner with SCE to explore options for supporting increased installation and use of solar power.

BE-2.5: Partner with GRID Alternatives and other community partners to encourage and promote free and reduced-cost solar installation options for low-income or qualified households.

BE-2.6: Partner with local workforce and economic development entities such as Pacific Gateway Workforce Innovation Network and educational institutions like Long Beach Community College and Long Beach Unified School District (LBUSD) to identify and create job training and workforce development programs in emerging green industry sectors for the communities most impacted by climate change.

BE-3 Promote Community Solar and Microgrids

Leverage partnerships and private developers to expand participation in community solar programs. Identify optimum locations and funding mechanisms for implementing microgrid pilot projects.

Implementation Lead: City of Long Beach Office of Sustainability; Disaster Preparedness and Emergency Communications
Partners: SCE; Harbor Department
Timeline: Medium
Potential Cost Level: Low

Description

Community solar refers to local solar systems shared by multiple community subscribers. Community solar programs provide access to the benefits of solar energy for renters, residents of multifamily properties, and other customers for whom rooftop solar installations are not an option.

Local solar development can also be used to increase community resilience during utility grid outages through development of microgrids. A microgrid is a localized energy grid powered by on-site energy sources that can disconnect from the traditional utility grid to operate autonomously. This means that during outages or other times of crisis, customers and critical facilities connected to the microgrid still receive power, increasing resilience and energy independence. The Port of Long Beach is implementing a microgrid pilot project that will serve as learning lab for the technology. The City will monitor the results of the Port's microgrid project and analyze other opportunities for microgrids, with a focus on critical facilities that require power during emergencies, such as fire stations and hospitals.

Equity Strategy

Promote community solar opportunities that can benefit the low-income communities most impacted by climate change. Locate microgrid projects associated with support services in the neighborhoods most impacted by climate change to promote community resilience by augmenting the energy supply during disasters and other interruptions in service.

Co-benefits:

- ✓ Reduced household costs associated with energy consumption
- ✓ Increased and more equitable access to the economic benefits of solar energy
- ✓ Local job creation in installation of solar and microgrid infrastructure
- ✓ Increased backup power for critical facilities during utility grid outages

Implementing Actions

BE-3.1: Partner with SCE to increase participation in its community solar program, which connects customers with solar developers on projects in their community.

BE-3.2: Monitor the results of the Port microgrid project to inform potential future projects.

BE-3.3: Identify potential partnerships, funding, or financing sources for microgrids.

BE-3.4: Promote microgrid development to private agencies and organizations in Long Beach and work with applicants to minimize permitting barriers, where possible.

BE-3.5: Identify critical facilities that require power during emergencies, such as fire stations and hospitals, as candidates for a microgrid project.

BE-4 Develop a Residential and Commercial Energy Assessment and Benchmarking Program

Develop an energy assessment and benchmarking program for commercial and residential properties to identify opportunities for energy efficiency and evaluate options to increase energy efficiency retrofits.

Implementation Lead: City of Long Beach Office of Sustainability; Development Services Department
Partners: Pacific Gateway Workforce Innovation Network
Timeline: Short
Potential Cost Level: Low

Description

The City will establish its own residential and commercial energy assessment and benchmarking program to assess the consumption of electricity and natural gas used to power appliances and lights, produce hot water, and heat and cool rooms in residential and commercial buildings throughout the city. This is important because the building sector represents 45 percent of the greenhouse gas (GHG) emissions in the city. As part of program development, the City will evaluate whether to go beyond the requirements of Assembly Bill (AB) 802 and require energy benchmarking for buildings that are smaller than 50,000 square feet. The City will also evaluate and define any additional energy assessment requirements or incentives for commercial and residential properties, including time-of-sale and time-of-rent energy disclosure requirements for all residential and commercial properties.

Opportunities to leverage existing resources and partnerships, such as the City of Long Beach Office of Sustainability's Residential Direct Install Program and the Pacific Gateway Workforce Innovation Network, will be evaluated and integrated into the program to increase the number of certified Home Energy Rating System (HERS) raters in the community and expand local green job development opportunities. Given that approximately 60 percent of Long Beach residents currently live in rental housing, the City will need to work with landlords and property management companies to ensure energy assessments are prioritized improvements in rental housing units, so that more residents can experience the cost savings and housing quality benefits associated with improved energy efficiency.

Co-benefits:

- ✓ Reduced household and business costs associated with energy consumption
- ✓ Local job creation in energy audits and efficiency improvements

Implementing Actions

BE-4.1: Establish a program to comply with AB 802 and investigate a residential and commercial energy assessment program.

BE-4.2: Implement a pilot program for residential and commercial energy assessment to identify potential energy savings opportunities.

BE-4.3: Identify opportunities to leverage existing resources and partnerships to help expand local workforce development.

BE-4.4: Explore opportunities to require audits and time-of-sale and/or time-of-rent energy and other utility use disclosures for residential and commercial buildings.

BE-4.5: Partner with local workforce and economic development entities such as the Pacific Gateway Workforce Innovation Network and educational institutions like Long Beach Community College and LBUSD to identify and create job training and workforce development programs in emerging green industry sectors for the communities most impacted by climate change.

Equity Strategy

To remove barriers to participation, develop targeted engagement programs and explore options for subsidies or benefits for the low-income communities most impacted by climate change. Ensure that improvements are not a precursor to rent hikes and evictions through robust anti-displacement strategies. Partner with the Pacific Gateway Workforce Innovation Network and/or other workforce entities to increase the number of certified HERS raters in the community while expanding local green job development opportunities.

BE-5 Provide Access to Energy Efficiency Financing, Rebates, and Incentives for Building Owners

Identify funding sources to increase energy efficiency improvements in the community's existing building stock and develop an outreach strategy to promote opportunities to all segments of the community.

Implementation Lead: Energy Resources Department; Economic Development Department; City of Long Beach Office of Sustainability
Partners: SCE; Southern California Regional Energy Network (SoCalREN)
Timeline: Short
Potential Cost Level: Low

Description

In order to provide access to energy efficiency financing, rebates and incentives, the City will develop a building energy resource center that helps residents and businesses identify financing or rebate opportunities and estimate cost savings. While the City does not provide funding directly, it will take an active role in cataloguing and promoting the various rebate and assistance programs available to residents and businesses in Long Beach, such as those offered through the property assessed clean energy (PACE) program, SCE, and SoCalREN. It will also seek to identify new or additional programs that are or could be accessible to residents, businesses, and building owners. Engagement activities will include creating energy resource kiosks in certain City facilities, such as libraries, and partnering with community-based organizations, business improvement districts, and other stakeholders to spread this information. This action is critical because the vast majority of GHGs from the building sector come from older, less energy-efficient buildings, since new buildings must be built to much higher energy efficiency standards with today's technology.

Equity Strategy

Develop targeted engagement programs, including programs for the low-income communities most impacted by climate change, to remove barriers to participation. Track participation based on these factors to measure and increase utilization by targeted communities.

Co-benefits:

- ✓ Reduced household and business costs associated with energy consumption
- ✓ Local job creation in efficiency improvement installation

Implementing Actions

BE-5.1: Develop a building energy resource center to provide residents and businesses with information on available rebates, financing options, and technical assistance programs.

BE-5.2: Implement an engagement campaign that increases awareness of financial and technical assistance options for all segments of the community, including the translation of materials into Spanish, Khmer, and Tagalog.

BE-5.3: Establish data-sharing processes with SoCalREN, SCE, and other agencies to track participation in energy efficiency rebate/finance programs, and estimate annual energy savings.

BE-5.4: Identify and/or seek out new or additional energy efficiency programs that are or could be accessible to residents, businesses, and building owners.

BE-5.5: Partner with local workforce and economic development entities such as the Pacific Gateway Workforce Innovation Network and educational institutions like Long Beach Community College and LBUSD to identify and create job training and workforce development programs in emerging green industry sectors for the communities most impacted by climate change.

Existing Program: Civic Center Energy and Water Efficiency

City Hall and the Port Headquarters meet LEED (Leadership in Energy and Environmental Design) standards through sustainable features and practices, including energy-efficient cooling and design that allows natural light into the buildings. The new City Hall consumes 25 percent of the energy of the old City Hall. The Civic Center produces its own renewable energy with roof top photovoltaic panels on the Billie Jean King Main Library that generate 930 kilowatt-hours of solar energy, which is enough electricity for 119 average homes. The Civic Center site captures rainwater and stores it in an underground cistern that is used to irrigate landscaping.

BE-6 Perform Municipal Energy and Water Audits

Establish a municipal building/facility energy and water audit program, establish targets for decreasing annual energy use, and track progress.

Implementation Lead: City Manager; City of Long Beach Office of Sustainability; Public Works Department

Partners: SCE; SoCalREN; Long Beach Parks, Recreation and Marine; Library; Health and Human Services Department

Timeline: Short

Potential Cost Level: Low

Description

The City will undertake actions to continue to increase efficient energy and water use in its buildings. These will include establishing a municipal building energy and water audit program and developing a schedule to produce a complete evaluation of energy and cost-saving opportunities across the City's building portfolio. Energy audits will be required every 5 years along with operational improvements to optimize energy efficiency. Targets to decrease annual energy use and make progress towards those targets will be tracked and made publicly available.

California has set a target to double cumulative energy efficiency in electricity and natural gas end uses by 2030 (Senate Bill [SB] 350). Energy efficiency in buildings is a core focus of California's efforts to achieve this goal. Though a very small proportion of citywide emissions, increased efficiency at City facilities will reduce the City's carbon footprint while eventually saving taxpayer dollars through reduced utility costs. In addition, increased efficiency will likely improve thermal comfort for City employees.

Equity Strategy

Develop local hire goals and strategies, where feasible, to facilitate increased economic opportunity through municipal energy and water audits. Prioritize audits to take place first in the low-income communities most impacted by climate change.

Co-benefits:

- ✓ Reduced City costs associated with energy consumption
- ✓ Reduced City water consumption

Implementing Actions

BE-6.1: Conduct energy and water audits of all City-owned or City-leased buildings and facilities

BE-6.2: Establish a municipal energy benchmarking efficiency policy that includes efficiency targets.

BE-6.3: Incorporate energy and water audits into Facilities Conditions Assessments.

BE-6.4: Maximize to the extent feasible the attainment of green building standards that improve energy and water efficiency in municipal projects.

BE-6.4: Partner with local workforce and economic development entities such as Pacific Gateway Workforce Innovation Network and educational institutions like Long Beach Community College and LBUSD to identify and create job training and workforce development programs in emerging green industry sectors for the communities most impacted by climate change.

BE-7 Evaluate Building Codes to Incentivize Electric New Residential and Commercial Buildings

Identify and implement building energy code options to establish incentives and/or requirements for all electric residential and commercial buildings.

Implementation Lead: Department of Planning and Building
Partners: Undefined
Timeline: Short
Potential Cost Level: Low to Medium

Description

Because cities and counties across the state have recognized the importance of reducing emissions in new buildings, at least 50 have adopted building codes that exceed or reach beyond these standards. While these "reach codes" vary by jurisdiction, they generally focus on encouraging or requiring building electrification, installation of electric vehicle (EV) infrastructure, and/or solar installation. The City will evaluate a range of reach code components, including those that would incentivize and/or require buildings to include increased EV readiness and/or infrastructure and be solar-ready and/or have solar installations. The City will also conduct an analysis of the cost-effectiveness of reach code components and engage stakeholders to inform reach code development.

Reducing and eventually eliminating GHG emissions from new residential and commercial buildings is an important component in achieving both the CAAP's 2030 target and the City's aspirational goal of net carbon neutrality by 2045. Even as existing buildings move to using renewable electricity, new buildings that incorporate natural gas would result in substantial emissions (and further carbon lock-in). In addition to reducing carbon emissions, a move toward all-electric buildings will also have beneficial public health impacts as a result of improved outdoor and indoor air quality. Requiring or incentivizing EV readiness and infrastructure will also support the transition from vehicles dependent on fossil fuels to those that run on clean, renewable electricity.

Co-benefits:

- ✓ Improved outdoor and indoor air quality
- ✓ Increased energy cost savings
- ✓ Improved public health

Implementing Actions

BE-7.1: Evaluate a range of reach code components that incentivize between 50 and 100 percent of all new commercial and residential buildings to be 100 percent electric, and conduct an analysis of the cost-effectiveness of various measures.

BE-7.2: Establish an outreach strategy to engage stakeholders in reach code development.

Equity Strategy

Pursue funding opportunities to help offset costs associated with energy-efficient electric buildings when constructing affordable housing in order to ensure an adequate supply of affordable housing.

BE-8 Implement Near-Term Measures to Reduce Emissions Related to Oil and Gas Extraction

Implement the suite of near-term measures included in the CAAP Oil and Gas Technical Memorandum to reduce oil and gas extraction emissions per the memorandum.

Implementation Lead: Energy Resources
Partners: Office of Sustainability; City Manager's Office; California Air Resources Board (CARB); South Coast Air Quality Management District SCAQMD)
Timeline: Medium
Potential Cost Level: Medium to High

Description

The City will implement the recommended short-term measures for reducing emissions related to oil and gas extraction, as outlined in the CAAP Oil and Gas Technical Memorandum and recommended by the City's Energy Resources Department. Under this action, the City will implement the seven upstream (i.e. extraction), midstream (i.e. oil refining), and downstream (i.e. transport to consumers and end use of fuel) near-term emissions reduction actions the Oil and Gas Technical Memorandum recommends and establish corresponding implementation strategies. The recommendations include a range of infrastructure, technology, reporting, and regulatory efforts. Generally, successful implementation of the near-term recommendations will require the City to identify strategies it can devise and pursue under its own authority, those it will need to pursue through existing and/or expanded partnerships with federal, state, and regional agencies that have regulatory authority, and those that it can partner on with the private sector. The CAAP also considers the GHG emissions reductions that will result from a 20 percent decrease in local oil production by 2030, as well as ongoing efforts to maximize renewable energy production opportunities at the City's oil fields, including development of solar photovoltaics and gravity energy storage in oil wellbores.

Although most oil and gas life cycle emissions occur downstream during fuel transport to consumers and in fuel end uses, this action is critical to reducing the City's overall carbon footprint, since life cycle emissions associated with drilling for oil and gas are roughly 2.7 times greater than the entire citywide 2015 production-based inventory for Long Beach.

Equity Strategy

Prioritize actions that would provide air quality and public health co-benefits to low-income communities most impacted by climate change.

Co-benefits:

- ✓ Improved air quality

Implementing Actions

BE-8.1: Establish strategies to implement the near-term actions recommended by the CAAP Oil and Gas Technical Memorandum to reduce oil and gas extraction emissions.

BE-8.2: Partner with regulatory agencies to share information and report on oil and gas extraction emissions.

BE-8.3: Develop and implement state and federal legislative agendas to help implement the developed strategies.

Existing Program: Synergy Oil Wetlands Restoration and Oil Consolidation Project

The Synergy Oil Wetlands Restoration and Oil Consolidation Project restores significant coastal wetlands habitat in Long Beach while improving the efficiency of local oil production by modernizing equipment and removing legacy wells to reduce their environmental impact.

TRANSPORTATION ACTIONS

The transportation sector is typically the largest source of GHG emissions at the state, regional, and local level. Decades of transportation policy and investment decisions in California – including in Long Beach – have produced a transportation system that is heavily dependent on fossil fuels and communities that are too reliant on single-passenger vehicles. In the last 15 years California has put in place regulations and policies and increased State funding to reduce transportation sector emissions through expanded public transit, the development of walkable communities, and a shift to cleaner passenger vehicles and freight networks. Despite these efforts, statewide transportation GHG emissions have been on the rise since the end of the Great Recession, primarily driven by an increase in passenger vehicle emissions. While reversing this trend requires action at all levels of government, cities have an important role to play in providing residents and businesses with real transportation choices that support a healthy climate and improved quality of life now and in the future.

The CAAP transportation actions incorporate current City efforts to reduce GHG transportation emissions and new efforts to achieve greater reductions. The San Pedro Bay Ports Clean Air Action Plan, the Long Beach Transit Systemwide Transit Analysis and Reassessment (STAR) Initiative to improve transit service, continued expansion of the City's bikeway and pedestrian networks, and increased housing and employment density along major transit corridors are existing efforts that not only have public health, mobility, and quality of life benefits but also reduce GHG emissions. New actions such as increasing rapid bus service, establishing bus-only lanes, and expanding electric-vehicle charging infrastructure will result in additional reductions.

T Transportation

Goal: Affordable, safe, carbon-free transportation choices connect all Long Beach communities to opportunity, clean air, and improved health

GHG Reductions 30,480 MT CO_2e

OBJECTIVES	NO.	ACTIONS
Decrease reliance on personal motor vehicles and increase transit, biking, andwalking trips	**T-1**	Increase the frequency, speed, connectivity, and safety of transit options
	T-2	Expand and improve pedestrian infrastructure citywide
	T-3	Increase bikeway infrastructure citywide
Shift to low- and zero-emissions vehicles to move people and freight	**T-4**	Implement the Port of Long Beach Clean Trucks Program
	T-5	Develop an Electric Vehicle Infrastructure Master Plan
Prioritize the development of transit-oriented neighborhoodswith a mix of jobs, services, and housing	**T-6**	Increase employment and residential development along primary transit corridors
	T-7	Update the Transportation Demand Management Ordinance
	T-8	Increase the density and mixing of land uses
	T-9	Integrate SB 743 planning with the CAAP process

T-1 Increase the Frequency, Speed, Connectivity, and Safety of Transit Options

Evaluate transit service and routes, and identify opportunities to increase to ridership by increasing the transit frequency, speed, connectivity, and safety.

Implementation Lead: Long Beach Transit
Partners: Los Angeles County Metropolitan Transportation Authority (Metro); other regional transit providers; Development Services Department; Public Works Department
Timeline: Medium
Potential Cost Level: Low to High

Description

Long Beach has ample public transit infrastructure and service, yet like many other cities in the U.S. most trips are taken by automobile. The Metro A Line has nine stations in Long Beach, and Long Beach Transit boasts more than 30 routes, including specialized options like the free downtown Passport bus, water taxis, the Museum Express, and the Galaxy/Chargers Express. Many areas of Long Beach also have service from Torrance Transit, Bellflower Bus, Los Angeles Department of Transportation (LADOT) Commuter Express, the Orange County Transportation Authority (OCTA), and Metro bus routes. When Long Beach individuals were asked about their primary mode of transportation as part of an online CAAP survey, 75 percent of respondents stated that driving alone remained their primary mode and cited three primary issues as barriers to increased transit usage: frequency of service, connectivity of routes, and safety. Increasing the frequency, speed, connectivity, and safety of transit options will encourage greater use of transit and decreased dependency on single-passenger auto trips.

Co-benefits:

- ✓ Increased access to key major destinations and job centers
- ✓ Increased air quality
- ✓ Increased safety and perception of safety

Equity Strategy

Improve transit services, prioritizing core and low-income transit riders

Implementing Actions

T-1.1: Collaborate with Long Beach Transit to advance the Systemwide Transit Analysis and Reassessment (STAR) Initiative goals and strategies (e.g., increase operating hours by 50 percent, reduce headways to 15 minutes on key routes and corridors).

T-1.2: Collaborate with Long Beach Transit, other transit providers, and the public to better understand origin and destination patterns for shorter trips that could be made by transit.

T-1.3: Collaborate with Long Beach Transit, other transit providers, and the public to better understand which destinations Long Beach residents would like to access by transit in order to inform future land use and transit planning.

T-1.4: Collaborate with transit providers to assess current bus routes and identify opportunities to create and/or enhance rapid bus and regional connector routes.

T-1.5: Pursue opportunities to increase rapid bus service and establish bus-only lanes (e.g., pursue federal and state transit funding to establish bus-only lanes).

T-1.6: Improve rider safety when making transit improvements (to include anti-bias training and de-escalation methods).

T-1.7: Collaborate with Long Beach Transit to prioritize riders with disabilities and "Dial-A-Lift" Access Service users in the Future Emerging Mobility Zones.

Existing Program: Metro A Line (Blue) and Long Beach Transit STAR Program

Metro recently completed a major renovation of the A Line (Blue) light rail between Downtown Los Angeles and Long Beach, improving service reliability and making station upgrades. The upgrades included installing interactive digital screens with real-time arrival information, maps, and service alerts. The City is also partnering on the Long Beach Transit STAR program to increase bus service and ridership. The City continues to work to improve first mile/last mile experiences for transit riders.

T-2 Expand and Improve Pedestrian Infrastructure Citywide

Ensure safe and convenient pedestrian infrastructure is provided citywide, including uninterrupted sidewalk connections, adequate lighting and visibility, shading, and safe intersections.

Implementation Lead: Public Works Department
Partners: Health and Human Services Department – Healthy Active Long Beach; Development Services Department; Long Beach Transit; Metro; nonprofit transportation organizations; and neighborhood groups
Timeline: Medium
Potential Cost Level: Medium to High

Description

Expanding and improving pedestrian infrastructure in neighborhoods can increase walking and reduce driving. Walkable neighborhoods are also generally safer for users of other modes, such as wheelchairs, bicycles, scooters, and public transit. People are less likely to walk in places that lack sidewalks or that have sidewalks that are uneven, too narrow, and lack Americans with Disabilities Act ramps and other amenities, such as safety infrastructure. Pedestrian infrastructure improvements should address those basic issues and can also include installing sidewalk amenities, such as street trees and other landscaping, lights, street furniture (e.g., benches, trash and recycling bins), and transit shelters. Pedestrian safety improvements can include streetlight crossings or designated bike lanes (to minimize biking and e-scooters on sidewalks). In addition, traffic-calming features like medians, bulb-outs, and curb extensions can discourage high-speed, cut-through traffic and result in safer routes for pedestrians.

Equity Strategy

Work with local neighborhoods, such as nonprofit, community and neighborhood organizations, to identify and prioritize areas for pedestrian infrastructure and safety enhancements. Seek resources that will support the City in advancing equity in pedestrian infrastructure.

Co-benefits:

- ✓ Increased public health benefits through active transportation and active lifestyles
- ✓ Decreased vehicle-pedestrian collisions, injuries, and deaths
- ✓ Improved local air quality
- ✓ Increased walkability, spurring economic development
- ✓ Increased development of neighborhood character

Implementing Actions

T-2.1: Implement the Mobility Element of the General Plan, the Communities of Excellence in Nutrition, Physical Activity, and Obesity Prevention (CX3) Pedestrian Plan, and the Downtown Transit-Oriented Development (TOD) Pedestrian Plan to achieve GHG emissions reduction targets from infrastructure investment and other efforts to encourage walkability and active transportation.

T-2.2: Leverage the development review and environmental review processes to implement pedestrian infrastructure improvements.

T-2.3: Integrate the financing, design, and construction of pedestrian facilities within other street projects to install pedestrian improvements alongside vehicle, transit, and bikeway improvements.

T-2.4: Ensure that all planning processes, such as neighborhood and specific plans, identify opportunities for pedestrian improvements.

T-2.5: Pursue funding opportunities, including the California Department of Transportation's Active Transportation Grants and cap-and-trade revenue programs, for development of pedestrian infrastructure.

T-2.6: Identify infrastructure gaps in neighborhoods not analyzed in the City's other pedestrian plans, and develop pedestrian improvement plans accordingly.

T-3

Increase Bikeway Infrastructure Citywide

Expand the bikeway system and associated infrastructure throughout the city in order to encourage safe and convenient use of active and sustainable travel modes.

Implementation Lead: Public Works Department
Partners: Long Beach Bike Share; e-scooter companies; nonprofit transportation organizations
Timeline: Medium
Potential Cost Level: High

Description

Expansion of bikeway infrastructure creates active mobility networks and helps ensure rider safety for healthy, nonpolluting, and low-cost forms of transportation. Improvements that expand bikeway infrastructure can include bike lanes multimodal facility improvements; e-scooter, e-bike, and micro-mobility charging infrastructure; and education and engagement for active transportation riders and drivers alike to encourage safe road behavior. Investments in bikeway infrastructure can also help address first mile/last mile challenges (i.e., getting to and from transit stations and stops).

Co-benefits:

- ✓ Improved local air quality
- ✓ Increased public health benefits from active transportation and active lifestyles
- ✓ Reduced transportation expenses
- ✓ Increased safety
- ✓ Increased transit use

Equity Strategy

Assess existing and planned bikeway infrastructure to ensure equitable distribution based on CalEnviroScreen and other environmental justice indicators. Increase accessibility of active transportation and micromobility options for low-income individuals by working with providers and by exploring subsidies and specialized programs.

Implementing Actions

T-3.1: Implement the Mobility Element of the General Plan and the Bicycle Master Plan to achieve GHG emissions reduction targets from infrastructure investment and other efforts to encourage active transportation and micromobility use.

T-3.2: Leverage the development review and environmental review processes to implement bikeway infrastructure improvements.

T-3.3: Integrate the financing, design, and construction of bikeway infrastructure into other street projects to expand bikeways alongside vehicle and transit improvements.

T-3.4: Seek funds from federal agencies, state departments, Metro, Long Beach Measure A, and private foundations to increase bikeway infrastructure and facilities.

T-3.5: Conduct community outreach and education to encourage safe driving, bicycling and other active transportation, and micromobility user behavior.

T-3.6: Prioritize human-powered trips in facility design while assessing and accommodating emerging technologies and their potential benefits.

T-3.7: Monitor travel mode patterns through surveys (e.g., the City's annual bicycle, pedestrian, and e- scooter count) and/or travel studies sponsored by the Southern California Association of Governments (SCAG) to assess opportunities for greater mode shifts.

T-3.8: Explore options to incentivize or require emerging technology companies to achieve a more sustainable product life cycle, such as by reducing electronic waste and investing in bikeway infrastructure.

Existing Program: Bikeshare Program and Promoting Multimodal Transportation

Long Beach has 165 miles of bike lanes, including nine protected bike lanes and four bike boulevards. Launched in 2016, the City's bikeshare program now boasts 40,841 members. The bikeshare program includes partnerships that offer low-cost memberships to college students. As of July 2020, there have been 237,069 total trips taken, resulting in an estimated reduction of 566,497 pounds of carbon.

T-4 Implement the Port of Long Beach Clean Trucks Program

Implement the Port of Long Beach Clean Trucks Program, which is described in the San Pedro Bay Ports Clean Air Action Plan, to reduce the GHG emissions associated with goods movement through trucks serving the Port of Los Angeles and Port of Long Beach.

Implementation Lead: Harbor Department
Partners: Terminal operators
Timeline: Ongoing
Potential Cost Level: High

Description

In 2017, the Mayors of the City of Los Angeles and City of Long Beach committed to zero emissions by 2035 for on-road drayage trucks serving the ports in both cities. Trucks are a significant source of emissions at the ports. According to the ports' 2017 Clean Air Action Plan Update, port trucks contribute 23 percent of the total NOx emissions, making them the second largest source of NOx emissions at the ports. Furthermore, port trucks are the largest contributor of port-related GHG emissions, representing 40 percent of total port-wide GHG emissions. The Clean Trucks Program was adopted in 2007 to phase out the oldest, dirtiest trucks serving port terminals between 2 and 6 years in advance of the State Drayage Truck Rule. Beginning in 2008, the ports banned pre-1989 trucks; that ban was followed by a progressive ban on all trucks that did not meet 2007 emissions standards by 2012.

The Port of Long Beach and Port of Los Angeles Clean Trucks Program reduced air pollution from on-road drayage trucks by more than 90 percent in a little over 3 years. Implementation of the ports' Clean Trucks Program is estimated to result in a 10 percent reduction in diesel heavy-duty truck emissions by 2030.

Co-benefits:

- ✓ Improved air quality
- ✓ Improved public health

Implementing Actions

T-4.1: Collaborate with the Port to ensure implementation of the Clean Trucks Program to reduce GHG emissions while maximizing air quality emissions reductions.

T-4.2: Collaborate with the Ports, regulatory agencies, industry stakeholders and others to identify and pursue grants, financial incentives, bulk purchasing, and other opportunities to transition to a zero- and near-zero-emissions truck fleet and drayage system that does not place an undue burden on truck drivers or other relevant stakeholders.

T-4.3: Collaborate with the Ports to support a path to zero emissions.

T-4.4: Collaborate with the Port to further reduce shipping-related emissions through use of 100% emissions-free cargo handling equipment by 2030 and implementation of state's shore power regulation for at-berth vessels.

Equity Strategy

Focus on improvements that provide the most direct air quality benefits to neighborhoods in close proximity to and most impacted by port-related emissions.

T-5 Develop an Electric Vehicle Infrastructure Master Plan

Develop an EV infrastructure plan that aligns with county-wide efforts to guide investment and policy decisions that will result in a distributed network of EV chargers to incentivize and facilitate EV ownership and use.

Implementation Lead: Public Works Department; Development Services Department
Partners: City of Long Beach Office of Sustainability; SCE; Los Angeles County
Timeline: Short
Potential Cost Level: Low

Description

To date, California has been a leader in EV adoption. In 2019, EV and plug-in hybrid sales constituted nearly 8 percent of all cars sold in the state. In Long Beach, on-road emissions are the largest source of total emissions. Expanding EV use is a core transportation sector GHG reduction strategy facilitated by ensuring clean electricity is available to recharge EVs. An EV Infrastructure Master Plan guides investment and policy decisions that result in a distributed network of EV chargers. A plan analyzes the numerous technology and ownership options for charging stations, considers location and network density needs, and analyzes case studies from other jurisdictions that have been successful in removing barriers to broad installation. A plan will also establish the policies for EV charging related to zoning, curbside charging, and workplace charging. Finally, it will account for infrastructure projects for EVs in the City fleet.

Equity Strategy

Provide equitable access to EV infrastructure by installing charging stations and providing EV car sharing in low-income areas and neighborhoods impacted by poor air quality and by pursuing low-cost or no-cost EV car-sharing options for income-qualified residents.

[1] https://www.latimes.com/business/story/2019-12-01/electric-vehicle sales-in-california-on-the-rise-but-is-it-enough-to-reach-the-5-million-goal-by-2030

Co-benefits:

- ✓ Improved air quality
- ✓ Reduced urban heat from decreased vehicle waste heat

Implementing Actions

T-5.1: Develop an EV Infrastructure Master Plan in coordination with residents and other key stakeholders to better understand needs, locations, and opportunities to further reduce barriers to EV use in the city.

T-5.2: Continue to analyze and update zoning and building code requirements for EV charging infrastructure and readiness to maximize EV infrastructure availability and usage.

T-5.3: Develop pilot projects, as needed, to install charging stations (e.g., increasing at-home charging opportunities in neighborhoods with constrained properties), facilitate EV car sharing, and pursue other initiatives to facilitate EV use.

T-5.4: Collaborate with SCE on the Charge Ready program to expand the network of publicly accessible EV charging stations at municipal facilities.

T-5.5: Pursue EV infrastructure projects that maximize the proportion of the City fleet that is EV.

T-5.6: Coordinate with Los Angeles County on the EV infrastructure plan.

T-5.7: Pursue funding opportunities to pilot an EV car-sharing program, install charging stations, and implement other initiatives to facilitate EV use.

T-5.8: Collaborate with the Port regarding potential convenient charging points for trucks as part of the development of the EV Infrastructure Master Plan.

Existing Program: Green City Fleet

The City of Long Beach Fleet Services has been recognized for its green fleet of City-owned vehicles. The City's alternative fuel vehicles include vehicles powered by compressed natural gas, electric, hybrid, liquefied natural gas, biodiesel, and propane. In addition, the City and Long Beach Transit have made significant investments in electric buses and other vehicles.

Existing Program: Citywide Electric Vehicle Charging

The City is partnering with Southern California Edison through the Charge Ready Program to install electric infrastructure for charging stations at public and City fleet locations. From 2018 to 2020, the City installed 140 electric vehicle (EV) charging ports at public and City fleet locations. By the end of 2020, 65 more charging ports are expected to be installed. In addition, 160 Long Beach residents have received EV chargers through the City's EV Charger Giveaway Program.

T-6 Increase Employment and Residential Development along Primary Transit Corridors

Identify land use and/or zoning changes to expand TOD opportunities along the city's primary transit corridors. Pursue strategies to increase affordable housing in these areas.

Implementation Lead: Development Services Department
Partners: Economic Development Department; Gateway Council of Governments; SCAG; neighborhood groups
Timeline: Long
Potential Cost Level: Low

Description

People's ability to rely on transit as a primary mode of transportation depends largely on their network of destinations and whether they can be easily reached through transit. Helping address this challenge are TOD neighborhoods, which provide a mixture of housing, office, retail, and other amenities integrated into a walkable neighborhood served by high-quality transit, typically rail or high-frequency bus service. TOD neighborhoods are critical for reducing VMT. Affordable, transit-accessible housing can increase transit ridership while reducing combined housing and transportation costs for residents, especially for low-income populations that typically use transit at higher rates than the general population. Long Beach can capitalize on its strong transit network, which will continue to improve, and its many distinctive neighborhoods. Through the 2019 General Plan Update, the City is encouraging a greater mix of land uses near transit lines and stations. Through SB 375, California requires the creation of regional plans to reduce per capita VMT and prioritize transit and transit-oriented development. Cities play a key role in these efforts. TOD policies also put the City on more competitive footing for California's Affordable Housing Sustainable Communities grant funding as well as cost-saving housing policies like AB 987 and SB 743, which can speed TOD and reduce the cost of housing for consumers.

Equity Strategy

Maximize opportunities for affordable housing development and employment uses near transit to improve the accessibility of low income residents to jobs, and combine this strategy with renter protections to prevent displacement of low-income residents.

Co-benefits:

- ✓ Improved air quality
- ✓ Increased transit ridership
- ✓ Reduced vehicle miles traveled (VMT)
- ✓ Increased economic development and increased tax base
- ✓ Increased affordable housing
- ✓ Increased walkability

Implementing Actions

T-6.1: Evaluate projects through the development review process, based on consistency with the goals of the General Plan's Land Use Element and Mobility Element to maximize opportunities for higher-density, mixed-use, transit-oriented, walkable infill development.

T-6.2: Strengthen incentives for affordable housing development near transit and expand renter protections to prevent displacement of low-income residents near transit.

T-6.3: Incentivize development projects to include land uses for which residents must take regular trips, such as grocery stores, pharmacies, or restaurants.

T-6.4: Disincentivize driving through a variety of strategies, including reducing or eliminating parking requirements, establishing parking maximums, increasing density allowances, and removing or reducing height restrictions along transit corridors, as feasible.

T-6.5: Locate businesses and job centers along transit corridors to facilitate the use of public transit for commuter trips.

T-6.6: Continue to integrate land use and transportation planning goals and initiatives that demonstrate consistency with both the SCAG Regional Transportation Plan/Sustainable Community Strategy and the City's General Plan Land Use Element, which create complete neighborhoods and reinforce regional transit planning objectives.

T-6.7: Explore options to enhance renter protections to prevent displacement of low-income residents near transit.

T-7 Update the Transportation Demand Management Ordinance

Update and implement a transportation demand management (TDM) ordinance that encourages travel by transit, vanpool/carpool, and bicycle.

Implementation Lead: Public Works Department; Development Services Department
Partners: Metro; transit providers; building managers; Business Improvement Districts
Timeline: Medium
Potential Cost Level: Low

Description

Transportation demand management ordinances require development projects over a certain size or qualifying threshold to implement strategies for reducing single-occupancy vehicle trips anticipated from the development project, while TDM programs incentivize or improve access to alternative transportation modes, such as transit, walking, biking, and carpooling. Strategies include, but are not limited to, supplying or incentivizing transit passes and rideshare and carpool programs, and the inclusion of physical amenities such as bike parking. The ordinances generally apply to larger residential and commercial projects that have the most potential for single-occupant vehicle trip reduction. Cities with effective TDM ordinances generally combine strong trip reduction incentives and/or requirements and robust monitoring to ensure that those reductions materialize.

Equity Strategy

Ensure equitable access to TDM benefits, including cost savings and increased affordable transportation options, for low-income individuals and those most impacted by climate change. Seek opportunities to expand TDM benefits beyond those traditionally served (people working for large employers, large residential and commercial developments).

Co-benefits:

- ✓ Improved efficiency of existing transportation infrastructure
- ✓ Reduced traffic congestion and air pollution
- ✓ Reduced transportation cost burden for residents and employees
- ✓ Improved public health through increased physical activity (i.e., biking and walking)

Implementing Actions

T-7.1: Define requirements for a TDM ordinance update, using evidence-based strategies that reduce single-occupant vehicle trips. These strategies include preferential carpool/vanpool parking, bicycle parking, and shower facilities and locker rooms; trip reduction plans; transit-supportive infrastructure development; and similar strategies.

T-7.2: Apply TDM strategies to new non-residential development that exceeds an established size threshold (e.g., 25,000 gross square feet) and new large multifamily developments (e.g., more than 50 units). Include a VMT reduction target and monitoring mechanisms for development, subject to the updated ordinance.

T-7.3: Partner with large employers, institutions, and community-based organizations to promote existing resources from Metro and Long Beach Transit, including trip-planning resources for transit, biking, and ridesharing, existing incentive programs for employers, and incentives for employees, such as the Regional Guaranteed Ride Home Program.

T-7.4: Subsequent to adoption of the ordinance update, develop a method for collecting data and tracking the effectiveness of TDM measures in reducing VMT and GHG emissions.

T-8 Increase Density and the Mixing Of Land Uses

Use the City's land use authority to increase development density particularly near transit, and provide a mix of land uses, such that residents and employees in the city can easily access goods, services, and entertainment via transit or active transportation modes.

Implementation Lead: Development Services Department
Partners: Developers
Timeline: Long
Potential Cost Level: Low

Description

To promote sustainable neighborhoods, the City will identify and designate select areas for increased development density leading to mixed-use, transit-oriented, walkable neighborhoods that meet community needs. Neighborhoods with a diverse mix of jobs and housing will improve the overall jobs/housing balance and help lower VMT by providing households with the opportunity to live and work in the same area. These neighborhoods will be consistent with General Plan's land use designations and design standards, which permit increased density near transit areas. Reduced parking requirements and shared off-street parking will also be pursued in transit-oriented neighborhoods.

Promoting sustainable neighborhoods encourages residents to access stores, healthy foods, and community services without a car. Inherently, sustainable neighborhoods mitigate GHG emissions by making residents less dependent on fossil-fueled vehicles and by lowering overall VMT.

Co-benefits:

- ✓ Improved public health through less dependency on auto trips for short trips to goods, services, and entertainment
- ✓ Increased pedestrian activity that spurs economic development in commercial mixed-use areas
- ✓ Increased number of vibrant, complete communities with nearby access to places to live, work, and shop

Implementing Actions

T-8.1: Develop a zoning code that is consistent with the General Plan place types and that designates additional TOD and mixed-use development areas.

T-8.2: Implement regulations to reduce parking requirements in transit-oriented neighborhoods and allow shared off-street parking for mixed-use projects.

T-8.3: Adopt policies and strategies to preserve and increase the supply of affordable housing and prevent displacement.

T-8.4: Work with large institutions such as California State University, Long Beach to include an adequate mix of uses within their campuses and near transit whenever possible.

Existing Program: Planning for Density and a Greater Mix of Uses

Locating housing near jobs and increasing density and the mix of uses along transit corridors are actions that help reduce GHG emissions from one of the largest contributing sectors – transportation. The updated Land Use Element of the General Plan, adopted in 2019, is an example of these efforts.

Equity Strategy

Ensure that the low-income communities most impacted by climate change benefit from investments in affordable housing incentives, rent protection, and anti-displacement policies.

T-9 Integrate SB 743 Planning with the CAAP Process

Evaluate the effectiveness of VMT reductions resulting from SB 743 compliance in achieving the City's GHG reduction target.

Implementation Lead: Development Services Department
Partners: Long Beach Transit; Metro; other transit providers; bike share providers; schools
Timeline: Short
Potential Cost Level: Low

Description

Senate Bill 743 creates a process to change the way that transportation impacts are analyzed under the California Environmental Quality Act (CEQA). It requires that transportation impacts of development projects be assessed using a VMT metric rather than a Level of Service (LOS) metric. State guidance also recommends a threshold of significance such that if a project would result in per capita VMT that is in excess of 15 percent below the regional average, it should then mitigate that VMT. VMT mitigation or reductions in VM could be funded directly by the project sponsor, or a central authority could collect an in-lieu fee to then fund the mitigation. Research suggests that VMT reduction is highly context-sensitive and depends on many local factors. Some of the more cost-competitive VMT reduction strategies include subsidized transit passes, bike share facilities, and employer-based "fair commuting" programs that charge fees for single-occupancy vehicle commuting and give rebates for using more sustainable modes of transportation.

Co-benefits:

- ✓ Reduced traffic congestion and air pollution
- ✓ Reduced transportation cost burden for residents and employees
- ✓ Increased funding for transit passes and other amenities to support low-income populations

Implementing Actions

T-9.1: Evaluate the effectiveness of new VMT thresholds, metrics, and mitigations as the City's updated Transportation Impact Analysis (TIA) guidelines are implemented.

T-9.2: Monitor what types of mitigation strategies are working in other cities that could apply in the Long Beach context to reduce emissions and meet aligned City objectives.

T-9.3: Consider strategies to fund the implementation of VMT mitigation strategies, such as collecting in lieu fees and participating in a regional mitigation bank program.

T-9.4: Evaluate VMT mitigations and adjust as needed to maximize effectiveness on an ongoing basis.

Equity Strategy

Ensure that VMT reduction strategies benefit core and low-income transit riders, such as by providing reduced public transit fares and expanding affordable transportation options.

WASTE ACTIONS

Solid waste disposal creates emissions when organic waste, such as food scraps, yard trimmings, and paper and wood products, is buried in landfills and decomposition occurs that emits methane. Methane from landfill waste disposal is responsible for approximately 6 percent of the city's GHG inventory.

The City, along with its franchise waste haulers, is responsible for collecting solid waste from homes and businesses. The portion of waste that the City collects is processed at the Southeast Resource Recovery Facility (SERRF), where it is sorted to remove additional recyclables and then incinerated to generate electricity. Through this process, SERRF helps to avoid landfill emissions and extends the operational life of regional landfills, while also providing energy recovery that can offset the additional use of non-renewable energy sources for electricity generation. SERRF generates enough power each year to supply 35,000 residential homes with electricity and has reduced the volume of solid waste entering landfills by more than 4 million cubic yards.

To address the city's solid waste emissions comprehensively, the CAAP includes waste actions directed at services provided by the City and by private waste haulers. These actions include ensuring compliance with State waste regulations, which set requirements for different property types, and expanding community-wide participation in organic waste collection.

W

Waste

Goal: Long Beach is a zero-waste city

GHG Reductions 116,680 MT CO_2e

OBJECTIVES	NO.	ACTIONS
Materials that can be recycled are recycled	W-1	Ensure compliance with state law requirements for multifamily and commercial property recycling programs
	W-2	Develop an organic waste collection program for City-serviced accounts
Collect all organic waste for composting or clean energy generation	W-3	Partner with private waste haulers to expand organic waste collection community-wide
	W-4	Identify organic waste management options

W-1 Ensure Compliance with State Law Requirements for Multifamily and Commercial Property Recycling Programs

Adopt a mandatory commercial recycling ordinance that includes enforcement mechanisms to ensure that on-site recycling collection is provided at multifamily and commercial properties and that the City is in compliance with state laws.

Implementation Lead: Public Works Department - Environmental Services Bureau
Partners: Franchise waste haulers; property management companies; Code Enforcement; Business License Division
Timeline: Short
Potential Cost Level: Low to Medium

Description

Diverting waste from landfills through recycling can reduce downstream GHG emissions from organic materials (e.g., office paper, cardboard). It can also reduce upstream emissions from all recycled materials through decreasing demand for new raw materials and avoiding emissions associated with their extraction/harvesting, processing, manufacturing, and transportation. According to CalRecycle, the commercial sector (including multifamily residences) generates nearly three-quarters of the total solid waste in California, and much of that disposed waste is readily recyclable.

California enacted AB 341 to require on-site recycling services at commercial and multifamily properties (five or more units). The legislation requires jurisdictions to implement education, outreach, and monitoring for businesses to make them aware of the recycling requirements and their compliance options. To enhance compliance with the legislation, some cities have adopted mandatory commercial recycling ordinances to enforce state law.

Co-benefits:

- ✓ Extended landfill operating life
- ✓ Increased beneficial reuse of recycled products

Implementing Actions

W-1.1: Adopt a mandatory commercial and multifamily recycling ordinance that codifies the requirements of AB 341, which mandates on-site recycling services at commercial and multifamily properties (five or more units) and includes local enforcement mechanisms.

W-1.2: Continue to conduct outreach to commercial and multifamily properties about state law and implementing City ordinances.

W-1.3: Develop technical assistance for properties found to be out of compliance with the recycling diversion requirements.

W-1.4: Implement a program to audit compliance and monitor attainment of recycling diversion goals.

Equity Strategy

Ensure equitable access to recycling services and potential benefits such as cost savings by developing multilingual outreach materials and conducting targeted outreach to local businesses and low-income and multifamily tenants.

W-2 Develop an Organic Waste Collection Program for City-Serviced Accounts

Develop an organic waste collection program and educational campaign for properties serviced by the City to divert organic waste from landfills.

Implementation Lead: Public Works Department - Environmental Services Bureau
Partners: Waste facilities
Timeline: Medium
Potential Cost Level: Low to Medium

Description

Organic waste is an important emissions source in Long Beach, as it is in the rest of the state, where it decomposes in landfills to generate methane gas. Organic waste includes food scraps and compostable paper (like pizza boxes and used coffee filters) as well as yard waste trimmings. Based on CalRecycle data, approximately 45 percent of the residential waste stream in Southern California consists of organic materials, including food waste (21 percent) and yard waste (11 percent). Diverting these items from landfills can help reduce GHG emissions and can prolong the operable life of a landfill. There are several organic waste management options, including composting to produce soil amendments for use in residential, commercial, and agricultural applications, or anaerobic digestion to produce a low-carbon biofuel.

California has already defined a regulatory framework to reduce these emissions in support of statewide GHG targets. Senate Bill 1383 defines specific organic waste targets to help reduce the impact of short-lived climate pollutants in the state, such as methane. The bill sets a target to achieve a 50 percent reduction in statewide organic waste disposal below 2014 levels by 2020, and a 75 percent reduction by 2025. It also requires a residential organics diversion program by 2022.

Existing Program: SERRF

Since 1988, the City of Long Beach has incinerated waste to generate electricity at its Southeast Resource Recovery Facility (SERRF), located on Terminal Island at the Port of Long Beach. The SERRF processes waste from single-family residences and most small businesses in Long Beach, and also accepts waste from other private haulers and nearby jurisdictions.

Co-benefits:

- ✓ Increased beneficial resuse of waste products
- ✓ Increased development of local renewable energy (e.g., biofuels)

Implementing Actions

W-2.1: Work with stakeholders to design an organic waste collection program for City-serviced properties to meet California's organic waste disposal goals and requirements.

W-2.2: Develop a pilot program for smaller multifamily and commercial properties serviced by the City to identify challenges and solutions to implementation of an organics collection program.

W-2.3: Continue to educate residents and businesses about the benefits of organic waste diversion, through efforts such as free composting workshops.

W-2.4: Adopt citywide goals for organic waste reduction and adopt an enforcement mechanism into the Long Beach Municipal Code to support state requirements.

W-2.5: Conduct a waste characterization study, among other future studies, that can be used to evaluate progress in organics diversion.

W-2.6: Monitor implementation of SB 1826, SB 1383, and all applicable state laws.

Equity Strategy

Ensure equitable access to organic waste services and potential benefits such as cost savings by developing multilingual outreach materials and conducting targeted outreach to low-income residents.

W-3 Partner With Private Waste Haulers to Expand Organic Waste Collection Community-Wide

Adopt a mandatory commercial and multifamily organic waste collection ordinance and partner with the City's franchise waste haulers to ensure organics collection service is provided community-wide.

Implementation Lead: Public Works Department - Environmental Services Bureau
Partners: Franchise waste haulers; Public Works Department - Environmental Services Bureau; property management companies
Timeline: Short
Potential Cost Level: Low to Medium

Description

In Long Beach, franchise waste haulers provide collection services to many of the City's multifamily and commercial properties, and the City provides waste collection services to the remaining properties. Once a mandatory commercial and multifamily organic waste collection ordinance is adopted, City staff will ensure compliance with state law and increase participation in organics collection programs among all privately serviced properties. The City will continue to provide information on the Long Beach Recycles website to assist businesses and multifamily property managers in complying with the requirements of applicable laws.

Senate Bill 1383 defines specific targets for organic diversion and outlines the state's implementation strategy. As part of this strategy, California enacted AB 1826 to require businesses that exceed solid waste disposal thresholds to recycle their organic waste. The bill also set green waste disposal thresholds for multifamily residential properties (five or more units).

Co-benefits:

- ✓ Increased beneficial reuse of waste products
- ✓ Increased development of renewable energy (e.g., biofuels)
- ✓ Compliance with state laws

Implementing Actions

W-3.1: Adopt a mandatory commercial and multifamily organic waste collection ordinance that codifies state law and includes an enforcement mechanism.

W-3.2: Conduct outreach to businesses and multifamily properties to ensure they understand organic waste diversion requirements as they are adopted, and to support the specific targets and target years of SB 1383.

W-3.3: Conduct a waste characterization study, among other future studies, that can be used to evaluate progress in organics diversion.

W-3.4: Develop technical assistance for properties found to be out of compliance with the organic waste diversion regulations.

Equity Strategy

Ensure equitable access to organic waste services and potential benefits such as cost savings by developing multilingual outreach materials and conducting targeted outreach to local businesses and low-income and multifamily residential tenants.

W-4 Identify Organic Waste Management Options

Evaluate organic waste collection and processing options, including composting, mulching, and anaerobic digestion, and develop a plan to implement feasible options.

Implementation Lead: Development Services Department; Public Works Department—Environmental Services Bureau

Partners: Regional waste processing facilities; other local governments; franchise waste haulers

Timeline: Long

Potential Cost Level: Low

Description

The State of California established methane reduction targets for short-lived climate pollutants in several economic sectors. These included specific targets to reduce statewide disposal of organic waste. The targets can be achieved by reducing food waste generation and by diverting organic waste away from landfills to other types of treatment (e.g., composting, anaerobic digestion). Managing organic waste through anaerobic digestion can also help offset fossil fuel use through production of biogas, which can be used to produce heat and/or electricity, support process heating at the digester facility, power alternative-fuel vehicles, or be injected into natural gas pipelines for use in homes and businesses. The City will explore opportunities for processing organic waste in collaboration with other agencies, waste haulers, and other relevant partners.

Co-benefits:

- ✓ Increased beneficial resuse of waste products
- ✓ Increased development of local renewable energy (e.g., biofuels)
- ✓ Reduced transportation emissions through localized processing

Implementing Actions

W-4.1: Evaluate options for processing organic waste in Long Beach, such as composting, mulching, and anaerobic digestion facilities.

W-4.2: Collaborate with other agencies to identify potential locations for organic waste processing facilities and share more information with interested parties, including how to navigate the permitting process.

W-4.3: If a facility is identified and ultimately established, the City will work to update waste hauler contracts and ensure that organic waste is hauled to locally sited facilities.

W-4.4: The City will continue to minimize the use of green waste as alternative daily cover and instead will include the use of inert materials that minimize the generation of GHG emissions.

Equity Strategy

Ensure equitable access to organic waste services and potential benefits such as cost savings. Evaluate the siting of an organic waste facility through an environmental justice lens.

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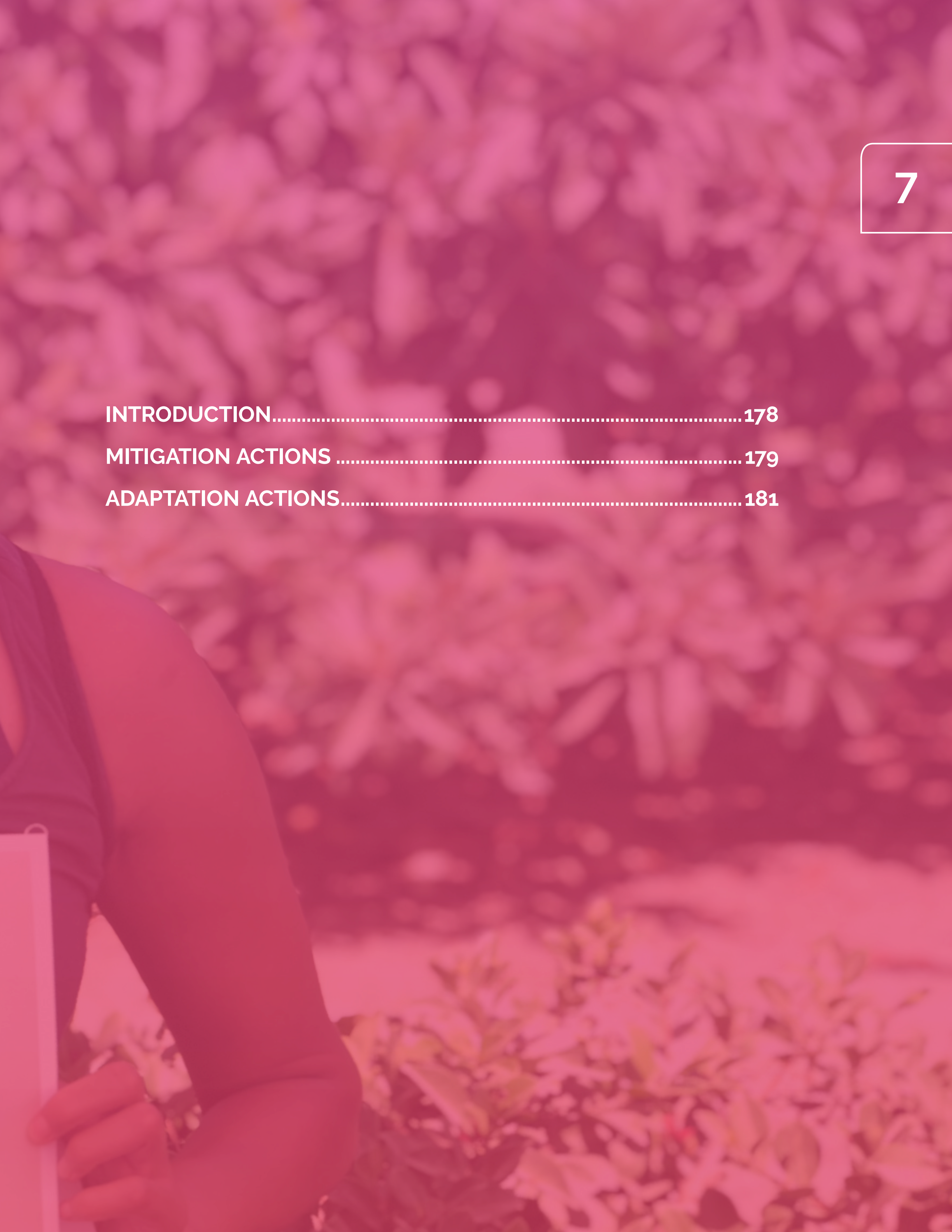
7

City Leadership and Funding



7

INTRODUCTION

The City recognizes that for the CAAP to be successful, the City must both set up a governance structure that facilitates implementation of the CAAP and demonstrate leadership by integrating climate action into its operations and internal culture, public engagement, and financial decision-making processes.

Several of the CAAP adaptation and mitigation actions in Chapters 4 and 6 include implementation components defining City leadership roles. One notable example is the City's commitment to transition municipal buildings and facilities to 100 percent renewable electricity (BE-1) in the short term. Another is the City's commitment to perform energy and water audits (BE-6) in existing facilities and perform subsequent efficiency upgrades. The City has identified additional efforts, described below, that demonstrate its leadership and commitment to supporting the overall implementation of the CAAP and integrating sustainability and climate resilience into all facets of the City's operations while promoting economic resilience and job creation. These efforts will include actions such as engaging and providing education to internal staff and the general public; transitioning to net-zero municipal buildings, transitioning the City vehicle fleet to low- and zero-carbon vehicles; transitioning to zero-carbon cargo handling equipment at the Port; integrating sea level rise considerations into plans and policies; incorporating green infrastructure into city projects and properties; pursuing funding for urban greening, cooling centers, and a myriad of other programs that protect against air quality and extreme heat climate impacts and advance equity goals; and seeking opportunities to create jobs and train residents in emerging green technologies.

City Funding and Investment

The City seeks to align its expenditures with CAAP actions and objectives. In recognition of the level of funding and investment that will be needed to implement the CAAP in the coming years, the City aims to establish a funding strategy that details the City's approach to integrating mitigation and adaptation considerations in the allocation of existing funds and when seeking and securing new funding sources. More specifically, City actions around funding will focus on identifying opportunities to better align the annual city budget, Capital Improvement Program, and other expenditures with CAAP actions and objectives. The City will also pursue new revenue sources for implementing CAAP actions by working across departments and with other public agencies, as appropriate, to successfully compete for grants and by studying options to increase local revenue and identify other financing mechanisms. This effort will include securing funding for both the staff needed to successfully implement the CAAP and dedicated staff to advance CAAP policies and programs. A more detailed discussion and specific implementing actions are outlined below.

Commitment to Job Creation and Training

The City seeks to reduce greenhouse gas (GHG) emissions while promoting a prosperous local economy and creating green jobs, particularly for those who are most impacted by climate change. Actions that reduce community-wide GHG emissions also present opportunities to make investments in infrastructure. By investing in developing quality jobs locally and adopting new low-carbon technologies, the City can facilitate new sources of green job growth within the city. The City will seek opportunities to partner with local workforce and economic development entities, such as the Pacific Gateway Workforce Innovation Network, and educational institutions, such as Long Beach City College and Long Beach Unified School District (LBUSD), on identifying and creating job training and workforce development programs in emerging green industry sectors for the communities most impacted by climate change. The City will work with the local business community to identify emerging green technology opportunities in energy, transportation, land use, and general goods and services, and will facilitate connections with local job training and workforce development programs. Increasing local job opportunities will support a prosperous local economy and reduce the need for city residents to commute long distances to employment centers outside the city. Specific implementing actions are outlined in more detail below.

City Initiatives

The City will implement a range of mitigation and adaptation actions to support the overall implementation of CAAP. Specific mitigation actions are organized below by the three main sectors—transportation, building and energy, and waste—that generate the City's GHG emissions. The mitigation actions are followed by adaptation actions that are organized by each of the four primary climate stressors—extreme heat, air quality, drought, and sea level rise and flooding.

MITIGATION ACTIONS

Transportation

The City of Long Beach has more than 5,300 employees who need to get to and from work, and operates a large vehicle fleet to support City activities. The City will identify and implement strategies to provide employees with transportation choices that reduce reliance on single-occupancy vehicles to get to and from work and reduce and eventually eliminate GHG emissions from City-owned vehicles. To ensure that this approach will be carried forward, the City will:

- Evaluate the effectiveness of existing incentives and requirements in place to manage transportation demand among employees and identify improvements to increase transit usage, walking and biking, and other options that will reduce employee commute-related vehicle miles traveled.
- Continue to explore and expand telecommute options that reduce the need for City staff to commute.
- Identify and implement a strategy to reduce and eliminate GHG emissions from the City fleet through a requirement to replace fossil-fueled vehicles with electric vehicles. Where there are no cost-effective electric vehicle replacements, whenever feasible, the City will prioritize alternative-fuel vehicles that run on renewable fuels. Where possible, smaller vehicles will be purchased that achieve more miles to the gallon and kilowatt-hour.
- Identify opportunities to replace City off-road vehicles and equipment with zero- or low-carbon alternatives, including at the Port and Airport.
- Ensure that City events with food include vegetarian and local food options.

Building + Energy

The City's recently completed Civic Center complex showcases the City's leadership in sustainable building design. Through this and other similar projects and its commitment to 100 percent carbon-free municipal energy, the City can reduce emissions and energy use, and achieve cost savings.

To ensure that this approach will be carried forward, the City will:

- Ensure that new municipal buildings are net-zero facilities constructed in accordance with the most up-to-date green building standards; to the extent feasible, the City will also apply these standards to the rehabilitation of existing municipal facilities when upgrades are undertaken.
- Purchase 100 percent renewable electricity for all municipal accounts (see BE-1).
- Establish a municipal building/facility energy and water audit program with targets for decreasing annual energy and water use, and track progress (see BE-6).
- Require that municipal projects include solar infrastructure installation to the maximum extent feasible.
- Develop a guidance tool to help City projects incorporate mitigation and adaptation measures.
- Develop partnerships with education and jobs and workforce development entities, such as the Pacific Gateway Workforce Innovation Network, Long Beach City College, and LBUSD, to train and create jobs for residents in sectors that reduce the GHGs associated with buildings and energy use. These jobs could include conducting energy and water audits, installing solar and microgrid infrastructure, and installing other efficiency improvements for which rebates or other incentives might be offered.

Waste

The City will continue to reduce and divert waste from its own facilities and waste collection network, and will build the capacity of key stakeholders and the general public to divert waste.

- To ensure that this approach will be carried forward, the City will:
- Audit existing public waste receptacles citywide to identify and resolve issues that lead to litter, such as overfilling or receptacles that do not contain waste effectively.
- Establish and execute a plan to install waste recycling, landfill, and composting receptacles at all City properties along with information that educates staff and the public about their benefits and how to use them.
- Conduct waste audits and public education at multifamily and commercial properties to grow awareness of the City's efforts to divert waste.

ADAPTATION ACTIONS

Extreme Heat

In addition to its efforts to expand and enhance the urban forest cover under EH-05, the City will pursue other projects and programs to address extreme heat, and will:

- Identify and prioritize projects at City-owned properties in environmental justice communities that will provide additional public benefits, such as enhanced green spaces and cooling centers that reduce the urban heat island effect and otherwise mitigate climate impacts, and will consult with community residents on project designs.
- Pursue funding to enhance and expand parks and green space, particularly parks and green space in those communities that are most vulnerable to extreme heat and air quality climate impacts and that lack sufficient access to parks and green space.

Air Quality

A reduction in air pollution will be a significant co-benefit of the City's efforts to reduce GHG emissions as well as to reduce extreme heat impacts under the CAAP. In addition, the City will:

- Identify other opportunities to improve air quality data by collaborating with the Ports of Long Beach and Los Angeles, the South Coast Air Quality Management District, the California Air Resources Board, and the U.S. Environmental Protection Agency to evaluate the need for expanding or improving the existing air quality monitoring network and data.
- Phase out City-owned fossil-fuel-powered lawn and garden equipment and establish requirements for vendors contracted by the City to do the same.

Drought

The City will seek to address drought by incorporating green infrastructure, recycled water and greywater, and rainfall capture into existing and new facilities. The City will:

- Implement green infrastructure technologies in City-owned properties to increase stormwater capture and serve as demonstration projects for community education.
- Incorporate greywater for irrigation into new City-owned properties, when possible, and evaluate the potential for incorporating greywater use in existing buildings as part of facility retrofits.
- Install rain barrels or cisterns at City-owned properties both to diversify the water supply and serve as demonstration projects for community education, such as community events to decorate rain barrels to be installed at various City-owned properties. Use the captured rainfall for irrigation purposes whenever possible.

Sea Level Rise and Flooding

The City will identify and pursue partnerships to continue to understand and respond to the latest climate science and its potential effects on sea level rise and related impacts:

- Participate in forums and collaborate with academic institutions to ensure that City staff stay current on climate science.
- Collaborate with federal, state, and regional agencies to identify approaches and resources that can be used to pursue adaptation strategies that are more regional in nature.
- Work with federal, state, and regional partners to explore and pursue funding and other solutions related to sea level rise adaptation.
- Consider flooding and sea level rise impacts in capital improvement plans and adaptive strategies, as appropriate.

Ongoing CAAP Education, Outreach, and Engagement

The City will engage in a range of education and outreach activities to communicate the importance of climate action at all levels: individual, organizational, City and regional. Some actions the City will take related to this objective are:

- Establish and execute an internal citywide communications and training framework to increase awareness of and support for climate action and the CAAP, and promote greater understanding of staff responsibilities and the importance of cross-departmental collaboration to achieve successful implementation.
- Develop and execute a strategy to grow public awareness of the CAAP and spur engagement in its implementation by all members of the public, especially those populations and entities that have the resources to take actions that effectively reduce climate impacts.
- Develop targeted education and outreach campaigns to raise awareness about individual actions the public can take to improve energy efficiency and reduce waste and reliance on the automobile as part of the collective effort to reduce GHG emissions and minimize climate impacts.
- Collaborate with LBUSD and other public agencies to identify opportunities to incorporate climate education and climate action into the education curriculum or other educational activities, and to identify funding needed for implementation.

Funding and Investment

To successfully implement climate mitigation and adaptation plans, cities must strategically identify and pursue new funding and financing sources and tools. As the need for climate action has become more urgent, the number of funding programs and tools and the total resources available have proliferated. However, demand for this growing but limited pool of resources is also accelerating. Major funding sources such as the California Climate Investments Program, which has allocated more than $12 billion to GHG reduction projects since 2013, mostly through competitive grants, are highly sought after. While grants are important, a more comprehensive funding and financing approach should also include components such as evaluations of potential local funding mechanisms and alignment of existing funding resources and practices with mitigation and adaptation goals.

Upon adoption of the CAAP, the City will begin work on an integrated funding and financing strategy to support implementation of the CAAP. The City will identify opportunities to improve the alignment of existing City funding and financing resources with mitigation and adaptation actions. The annual city budget and the Capital Improvement Program will integrate consideration of mitigation and adaptation actions and objectives in both strategic improvements to the City's existing infrastructure and one-time projects designed to address important community needs. Climate mitigation and adaptation will also be integrated into the programming of other funding sources, such as Community Development Block Grants. In addition, the City will identify grant opportunities for potential funding of plans, studies, programs, and infrastructure investments. In each process, the City will prioritize those projects and programs that have the greatest potential to include mitigation and adaptation actions while also addressing environmental justice, equity concerns, and opportunities to invest in youth and the green economy.

In the medium term, the City will evaluate ways to increase local funding and financing options for investing directly in programs and infrastructure while also leveraging grants and outside funding. Regarding sea level rise, for example, some local funding sources might include special flood districts, transient occupancy taxes, and bonds that can be dedicated to flood protection within a defined area.

In making these decisions, the City will consider funding sources and their availability, community input, and the cost of inaction. Specifically, the City will:

- Evaluate the City's annual budget, Capital Improvement Program and other funding sources to identify opportunities to integrate implementation of climate mitigation and adaptation into projects, with an emphasis on investing in projects that improve infrastructure in and the health of the low-income communities disproportionately impacted by climate change to ensure that investments improve equity for the people in those communities.
- Identify available grant opportunities to fund CAAP implementation and prioritize investments in the low-income communities most impacted by climate change.
- Assess the political and financial feasibility of different local funding mechanisms through a process that engages potentially impacted stakeholders.
- Identify financing mechanisms for adaption strategies in coastal areas of the city that are funded by impacted landowners and/or other private funding sources to minimize public subsidy of impacts in "high opportunity areas."[i]
- Explore the feasibility of funding additional dedicated staff who may be required to successfully implement the CAAP.

[i] California Department of Housing and Community Development Department "High Opportunity Areas" Map

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Performance and Monitoring


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8

INTRODUCTION

The CAAP is a living document, and its greenhouse gas (GHG) reduction estimations reflect a moment in time. As the City begins implementing the plan, new information will become available and previous assumptions will change. This chapter describes how the City will track progress toward the CAAP GHG target and adjust course as needed over time.

IMPLEMENTATION MONITORING AND REPORTING

The CAAP can be monitored in two ways, with each providing different information on implementation progress. A top-down approach will show how total emissions are trending compared to the City's GHG target. A bottom-up approach will provide more granular insight into how individual actions are performing compared to their corresponding assumptions in the CAAP. The City can use one or both approaches in its future monitoring efforts, depending on the resources available and the information needed at the time.

If plan monitoring shows the City is not on track to achieve its GHG target as assumed, the City will take action to expand participation in the existing CAAP actions (e.g., some actions in Chapter 5 include implementation steps to strengthen the action if the assumed reductions are not occurring), develop new actions that can provide additional GHG reductions, and/or evaluate new State of California legislation that could result in local GHG reductions. The following sections present a framework for plan monitoring and updates.

Top-Down Emissions Monitoring

A top-down monitoring approach can be achieved using future community-wide inventories or can follow a more streamlined approach based on collecting the most important activity data related to the quantified CAAP actions. Both approaches will help identify high-level trends in community emissions to understand if total emissions are on track toward the target and/or if individual emissions sectors are trending toward the target.

Comprehensive Community Inventory

The City will update the production-based community-wide GHG inventories every 2 years to track total GHG emissions from all sources within the community. To the extent feasible, these inventories will follow consistent methodologies to support direct comparison with prior inventory results and establish information on community emissions trends and changes within the various sectors and subsectors. During years in which a community GHG inventory is not developed, the City will prepare a municipal GHG inventory.

Primary Emissions Source Tracking

The City will collect a primary set of data to support tracking of several emissions sources annually. The table below lists the emissions sources to be tracked as part of this top-down monitoring approach, along with the corresponding activity data (e.g., vehicle miles traveled [VMT], kilowatt-hours [kWh] of electricity consumed), data sources, and monitoring approach. These sources combined represent approximately 98 percent of the 2015 base-year emissions. Staff can collect the energy, waste, and oil data annually with relative ease. However, the VMT values used in the GHG inventory come from the Southern California Association of Governments' (SCAG's) regional travel model, which is updated on an approximately 4- to 5-year cycle, so the frequency of monitoring based on this top-down approach will be limited to the frequency of model updates. Other data sources may be available to help support transportation sector monitoring in the year between SCAG model updates. For example, Google's Environmental Insights Explorer may be useful in harnessing "big data" to understand the city's transportation emissions on a year-to-year basis and in supporting a cost-effective analysis that is automatically updated by Google annually. This process can be used as a verification or backup to the comprehensive GHG inventories that the City will prepare on a regular basis.

Table 10: Top-down Action Monitoring Process

Emissions Source	Data Needed	Data Source	Monitoring Approach
Electricity	Community-wide electricity consumption and electricity emissions factor	Southern California Edison	Compare against CAAP implementation assumption forecasts; review sector-specific actions if activity data are not following the target trend line
Natural Gas	Community-wide natural gas consumption	City of Long Beach Energy Resources Department	
Oil/Gas Extraction	Barrels of oil extracted in the city	City of Long Beach Energy Resources Department	
Transportation	Daily vehicle miles traveled	Southern California Association of Governments or "big data" providers	
Landfill Waste Disposal	Total tons of waste disposed of in landfills (diversion of recycling and organics)	California Department of Department of Resources Recycling and Recovery (CalRecycle)	

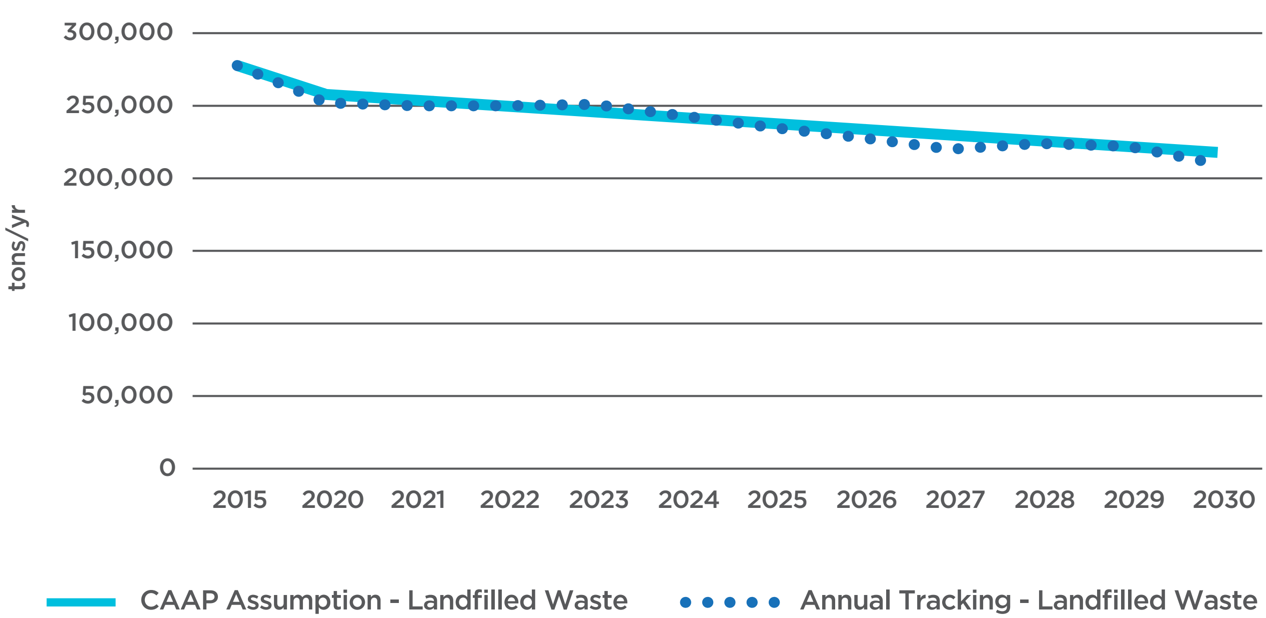
The graph below shows how the volume of waste disposed in landfills, for example, can be used to show trends in comparison to the forecasted landfill waste disposal estimates. The solid line represents the activity data trend assumed in the CAAP analysis, while the dotted line represents what annual monitoring results could look like. Progress is unlikely to occur in a linear fashion and straying from the trend line in 1 or 2 years might not signify a need for corrective action. However, consistent patterns of missing the CAAP assumption trend line or missing by a significant magnitude will alert City staff that an additional review of the corresponding CAAP actions is necessary (see the Bottom-Up Emissions Monitoring section).

It is possible that some individual emissions sources could underperform compared to assumptions, while others could overperform. If certain actions or emissions sectors are falling behind their assumed trajectory, the community may still be on track toward the overall GHG target. Future community-wide inventories will show how the city's total emissions trend compares to the CAAP target.

Top-Down Monitoring Schedules

- **Focused emissions source monitoring –** Annual
  - Electricity consumption (kWh) Electricity emissions factor (lbs CO_2e/MWh)
  - Natural gas consumption (therms)
  - Oil extraction (barrels)
  - Solid waste sent to landfills (tons)
  - On-road vehicle travel, if "big data" are available (VMT or metric tons of carbon dioxide equivalent)
- **Community inventory monitoring –** Every 2 years (community and municipal inventories prepared in alternate years)
  - All emission sources from the 2015 base-year inventory

Figure 23: Example Top-Down Monitoring Figure



Bottom-Up Emissions Monitoring

If the top-down monitoring shows an emissions source is off track for GHG target achievement, the City can review individual actions that address the emissions source to determine which, if any, are falling behind in implementation. This bottom-up monitoring approach can then help identify which individual actions are falling short of their implementation assumptions. When tracking individual actions, the City will consider what the primary goal of the action is intended to be as it relates to GHG reductions and will then select one or more performance metrics to monitor that outcome. The City has developed a list of potential implementation tracking metrics for each CAAP mitigation action. The list can serve as a starting point for bottom-up monitoring and the table below.

Tracking specific performance metrics can also help clarify how the City can modify its implementation approach to improve action outcomes. Depending on the overall emissions trends in the community, the City may choose to revise specific actions to increase their GHG reductions (e.g., through additional incentives or with new regulations) or may determine that the current set of actions are performing to the extent feasible and that new actions are needed to further reduce emissions. These corresponding plan updates are described in the following section.

Table 11: Example Implementation Tracking Metrics

Mitigation Action	Primary Metrics	Data Sources	Additional Metrics	Data Sources
T-1: Increase frequency, speed, connectivity, and safety of transit options	Percent increase in ridership on Long Beach Transit, Metro Blue Line, and regional transit routes	• Long Beach Transit • LA Metro • Partnering transit agencies	• Long Beach Transit • LA Metro • Partnering transit agencies	• Long Beach Transit
W-3: Partner with private waste haulers to expand organic waste collection community-wide	Tons of organic waste collected from commercial and multifamily properties	• Long Beach Transit • LA Metro • Partnering transit agencies	• Percent compliance at commercial and multi-family properties	• Waste haulers

8

Performance and Monitoring

Plan Updates

The CAAP must be adapted over time to incorporate new GHG reduction technologies and strategies, new financing mechanisms to support implementation, and changes in State or federal legislation. The CAAP will also be updated in response to monitoring results if emissions are not trending toward the City's adopted GHG target. In this case, the City will assess the implications of new scientific findings, explore new emission reduction technologies or changes to existing CAAP actions, and modify the plan accordingly to help the City get back on track toward meeting its GHG target.

As part of regular CAAP updates, the City will incorporate major changes in plan assumptions or new information, which can include:

- future GHG inventory results,
- emissions forecast updates,
- important new or revised statewide policies (e.g., an increased timeline for Renewables Portfolio Strategy implementation, new adopted GHG targets), and/or
- new or revised CAAP actions and/or implementation strategies.

CAAP updates will occur approximately every 5 years and can be scheduled to align with other City milestones, such as General Plan updates to the Land Use and Mobility Elements or budgetary cycles. If regular monitoring shows the CAAP is on track toward the GHG target, then CAAP updates may not be necessary. The City will also develop a comprehensive CAAP update following the current 2030 target year to provide greater analysis of the actions and implementation steps necessary to achieve the City's 2045 carbon neutrality goal.

Plan Update Schedule

- Every 5 years, as needed
- Plan update for any post 2030 targets

Other Inventory Monitoring

The City also evaluated consumption-based emissions and oil and gas extraction life cycle emissions in the CAAP to provide additional lenses through which the city's contribution to global emissions can be understood. These inventories are not directly related to the City's adopted GHG target that is evaluated in the CAAP. However, the City may update these additional inventories for informational purposes, as appropriate. Both inventories are dependent, at least in part, on inputs from models that may not be updated on a regular basis, including the CoolCalifornia household carbon footprint calculator and the Oil Climate Index global oil assessment, and this lessens the usefulness of annual inventory updates. However, the City will continue to monitor both models for major updates or other enhancements that could provide additional information to the Long Beach emissions context. And as part of stakeholder engagement around CAAP implementation, the City will promote readily available tools for residents and local businesses to help them evaluate their individual carbon footprints and identify personal actions to reduce consumption-based emissions.

Adaptation Action Monitoring

Adaptation actions do not (usually) have a GHG emission reduction associated with them, and determining what needs to be measured to demonstrate the impact of adaptation action is not always straightforward. While it is possible to monitor the level of activity related to the rollout of an adaptation action (such as increase in the number of accessible cooling centers in the city), it will often be necessary to wait for a disruptive event before the true performance can be tested (such as determining the number of users of cooling centers and the number of heat-related admissions to hospitals during extreme heat events). The City has also developed a list of potential implementation tracking metrics for each adaptation action (see Appendix F). As actions are implemented, specific metrics will be selected and tracked to enable the City to assess its overall reduction in vulnerability to climate stressors and/or ability to adapt.

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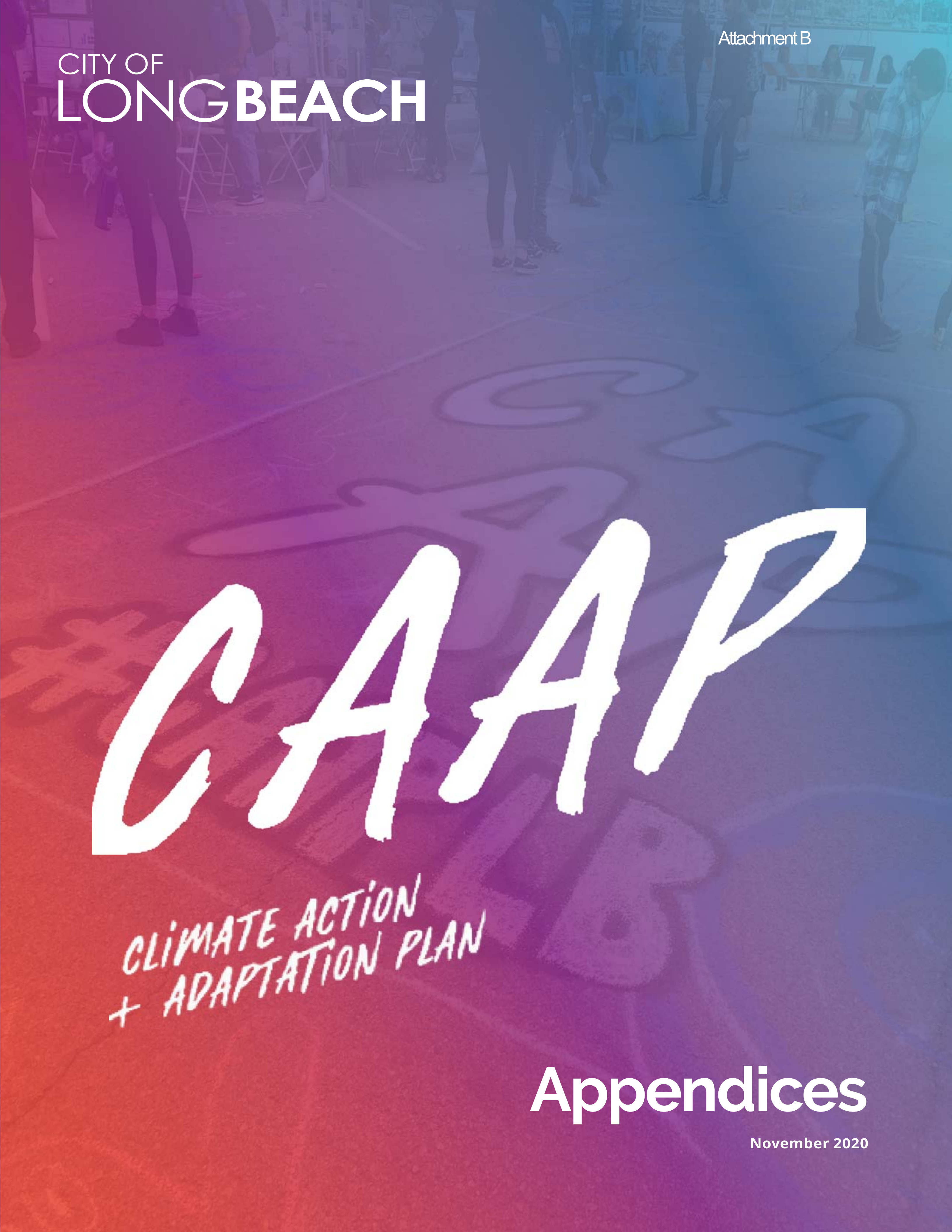
To request this information in an alternative format or to request a reasonable accommodation, please contact the Development Services Department at longbeach.gov/lbds and 562.570.3807. A minimum of three business days is requested to ensure availability; attempts will be made to accommodate requests with shorter notice.



Attachment B

CITY OF LONG BEACH

CAAP

CLIMATE ACTION + ADAPTATION PLAN

Appendices

November 2020

Appendix A Greenhouse Gas Inventory Methodology and 2030 Reduction Target Pathway

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APPENDIX A

Appendix A – Greenhouse Gas Inventory Methodology and 2030 Reduction Target Pathway

PART I – GHG INVENTORY METHODOLOGY

This section presents the calculation methodologies, data sources, and assumptions used to prepare the 2015 GHG inventory. It is organized by emissions sector and subsector. The intent of this section is to provide documentation to guide preparation of future annual inventories to maintain direct comparisons from one year to the next.

Wherever necessary, the project team used the following global warming potential (GWP) factors from the UN International Panel on Climate Change (IPCC) Fifth Assessment Report to convert various greenhouse gases into carbon dioxide equivalent units (CO_2e):

- CO_2 = 1
- CH_4 = 28
- N_2O = 265

STATIONARY ENERGY

Residential Buildings (I.1), Commercial & Institutional Buildings and Facilities (I.2), Manufacturing Industries & Construction (I.3), and Agriculture, Forestry and Fishing Activities (I.5)

The Residential, Commercial/Institutional, Industrial, and Agriculture/Forestry/Fishing subsectors includes the use of electricity and natural gas by these building types or activities within the city boundary.

I.1.1 – FUEL COMBUSTION

Data Sources
Table 1 identifies the sources for fuel consumption activity data and emissions factors. Long Beach Gas & Oil Department (LBGO) provided aggregated natural gas activity data, and an LBGO-specific emissions factor was used to calculate emissions.

Table 1: Stationary Fuel Consumption Data Sources

Description	Source	Units
Natural Gas Consumption by End-Use Category	LBGO[1]	therms / year
Natural Gas – Emission Factor	LBGO[2]	MT / therm

[1] City of Long Beach, 2015. Greenhouse Gas Report to California Air Resources Board
[2] ibid

Calculation Methodology
LBGO provided annual natural gas consumption data within the city boundary by end use category (e.g., residential, commercial and institutional, industrial).

The natural gas activity data was multiplied by an LBGO-specific emissions factor for carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) after standardizing units to calculate total emissions as metric tons of carbon dioxide equivalent (MT CO_2e).

Assumptions
No natural gas use was identified for the agriculture/forestry/fishing subsector. If this type of activity did occur within the City in 2015, the corresponding natural gas use was likely incorporated within the commercial or industrial data from LBGO.

I.1.2 – ELECTRICITY

Data Sources
As shown in Table 2, Southern California Edison (SCE) provided electricity consumption data for 2015 sorted by rate category, and a 2015-specific emissions factor.

Table 2: Residential Electricity Data Sources

Description	Source	Units
Electricity Consumption by Rate Category (residential and non-residential)	SCE	kWh / year
SCE – Emissions Factor	SCE	MT / MWh
Estimates of the proportion of non-residential electricity consumption by sector (commercial, industrial, and agricultural)	SCE	percent

Calculation Methodology
SCE provided activity data by rate category (residential and non-residential) but was unable to break down non-residential electricity consumption into sub-categories due to aggregation requirements to protect data privacy. Instead, SCE provided the estimated proportion of non-residential electricity consumption by sector (commercial, industrial, and agricultural) based on historic energy usage.

The project team used this information to calculate estimates of electricity consumption by sector for 2015. The resulting electricity consumption values were multiplied by the SCE emission factors for CO_2, CH_4, and N_2O after standardizing units to calculate total emissions as MT CO_2e.

Assumptions
The project team calculated commercial energy consumption from total non-residential energy consumption based on an estimate provided by SCE based on historic energy usage. This method assumes that the proportion of non-residential electricity consumption attributable to the commercial sector in 2015 is similar to historic patterns.

This subsector includes emissions identified as agriculture based on the SCE information used to allocate the total non-residential electricity data. If energy use was erroneously allocated to agricultural activity within the city boundary, there would be no net change to total electricity emissions results as SCE provided activity data describing total non-residential electricity use; allocation to different end uses (e.g., commercial, industrial) was performed to follow GPC guidance as closely as possible.

Energy Industries (I.4)

The Energy Industries subsector includes the combustion of natural gas and other stationary fuels by energy-related industrial facilities within the city boundary that are engaged in petroleum refining and electricity generation activities, although the latter is not included in the Basic reporting framework (see note in I.4.4 below).

I.4.1 Emissions from Fuel Combustion

Data Sources

Table 3 shows the data sources for activity data and direct emissions reporting used to estimate emissions in this subsector. For the Thums gas and oil field, activity data on fuel consumption was collected from the EPA Flight Database for diesel and natural gas. Data for the Tidelands facility (also called the West Wilmington Field) was not available in the EAP Flight Database, so the project team referred to the CARB industrial emissions database, which provided direct emissions data but not activity data for specific fuel types or uses/activities.

Table 3: Emissions from Fuel Combustion at Refineries

Description	Source	Units
Emissions by GHG from operations at the Thums gas and oil field by fuel type and source	EPA Flight Database[3]	MT / year
Emissions from the Tidelands facility (fuel supplier CO2e)	CARB[4]	MT CO_2e / year
Natural Gas – Emission Factors	EPA[5]	MT / scf
Diesel – Emission Factors	EPA[6]	MT / gallon

Calculation Methodology

Activity data for fuel consumed at the Thums facility was provided in the EPA database and multiplied by corresponding emissions factors from the EPA. For the Thums facility, emissions data from the EPA Flight Database was broken out by greenhouse gas, fuel type, and source.

Activity data for the Tidelands facility was unavailable and the project team used emissions data from the CARB industrial database instead. This information was not broken out by fuel type. The project team inferred that the emissions were from natural gas combustion and back calculated natural gas activity data using the EPA natural gas emissions factor.

Assumptions

Emissions for the Tidelands facility were reported in the CARB industrial database as fuel-supplier emissions and emitter emissions. For purposes of the community inventory, the fuel-supplier emissions were assumed to represent natural gas provided to the facility by SCE since LGBO reported that it does not supply natural gas to the Tidelands facility. This would make the natural gas consumed at Tidelines an additional volume of natural gas from that reported by LBGO and represented elsewhere in the

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[3] US Environmental Protection Agency (EPA), 2015. Facility Level Information on Greenhouse Gases Tool (FLIGHT). Available: <https://ghgdata.epa.gov/ghgp/main.do#>

[4] California Air Resources Board, 2015. Annual Summary of 2015 Greenhouse Gas Emissions Data Reported to the California Air Resources Board. Available: < https://ww2.arb.ca.gov/mrr-data>

[5] US Environmental Protection Agency (US EPA), 2015. Emissions Factors for Greenhouse Gas Inventories. Available: <https://www.epa.gov/sites/production/files/2015-11/documents/emission-factors_nov_2015.pdf>

[6] ibid

inventory (e.g., I.1, I.2, I.3), meaning the inclusion of this emissions source is not double-counting emissions reported elsewhere in the inventory. In the absence of additional information on what caused the emitter emissions, the project team assumed they resulted from process emissions (e.g., equipment leaks, pneumatic devices, etc.) at the Tidelands facility. These emissions are reported in subsector I.8.

I.4.4 Emissions from Energy Generation Supplied to the Grid

Emissions from energy generation supplied to the grid are reported as a territorial emissions source and not included in the Basic or Basic+ reporting frameworks. However, the City of Long Beach has calculated this emissions source to provide a more complete analysis of emissions sources in the city. The data sources and methodology for these calculations are provided below.

Note also that this sector includes emissions associated with waste incineration at the Southeast Resources Recovery Facility (SERRF) – these emissions are reported here and not in solid waste (III.3) because the waste is incinerated to produce electricity that is consumed by SCE customers. SCE electricity consumed by residents and businesses in Long Beach is already included in the Stationary Energy sector under I.1.2, I.2.2, and I.3.2.

Data Sources

Table 4 shows the source of activity data and emissions factors used in this subsector. In most cases, facility-level emissions data was gathered from the EPA Flight Database, CARB, and other sources. Emissions in this subsector represent fuel use at facilities engaged in electricity generation and co-generation activities.

Table 4: Energy Generation Data Sources

Description	Source	Units
Natural gas combustion for electricity generation from LBGO	LGBO	therms / year
Landfill gas combustion for electricity generation at Haynes facility	EPA Flight Database[7]	scf / year
Natural gas combustion for electricity generation from SoCalGas at Haynes facility	EPA Flight Database[8]	mmbtu / year
Natural gas combustion for electricity generation from SoCalGas at AES Alamitos facility	EPA Flight Database[9]	MT CO_2 / year
MSW combustion from SERRF for electricity generation	EPA Flight Database[10]	MT CO_2e / year
MSW combustion from SERRF for electricity generation	City of Long Beach[11]	tons of MSW / year (2015)
Natural gas combustion for electricity generation from SoCalGas at NRG Energy	CARB[12]	MT CO_2e / year

[7] US Environmental Protection Agency (EPA), 2015. Facility Level Information on Greenhouse Gases Tool (FLIGHT). Available: <https://ghgdata.epa.gov/ghgp/main.do#>
[8] ibid
[9] ibid
[10] ibid
[11] 2015 waste incineration volume is confidential data. Personal communication between Al Foley at City of Long Beach and Joshua Lathan of AECOM on September 6, 2017.
[12] California Air Resources Board, 2015. Annual Summary of 2015 Greenhouse Gas Emissions Data Reported to the California Air Resources Board. Available: < https://ww2.arb.ca.gov/mrr-data>

Description	Source	Units
Natural Gas – Emission Factor	LBGO[13]	MT / therm
Natural Gas – Emission Factor	EPA[14]	MT / scf

Calculation Methodology

The project team used facility-level emissions data reported in the EPA Flight Database and the EPA natural gas emissions factor to back calculate activity data for natural gas consumed for electricity generation at the AES Alamitos facility (operated by SoCalGas). The project team used activity data directly reported in the EPA Flight Database for natural gas consumed for electricity generation at the Haynes facility (operated by SoCalGas). The project team used facility-level emissions data reported in the EPA Flight Database and the EPA landfill gas emissions factor to back calculate landfill gas activity data used in electricity generation at the Haynes facility.

The project team used emissions data reported by CARB and the EPA natural gas emissions factor to back calculate activity data for natural gas used in electricity generation at the NRG Energy facility.

LBGO provided activity data and an emissions factor for natural gas used in electricity generation at LBGO facilities.

The project team derived a per ton emissions factor to calculate emissions from electricity generation at the SERRF facility. The emissions factor was calculated based on 2015 SERRF emissions reported in the EPA FLIGHT database divided by a known volume of waste incinerated at SERRF in 2015. This calculation provided an estimated emissions factor expressed as MT CO_2e/metric ton of incinerated waste. The emissions factor was multiplied by activity data representing the total waste from Long Beach incinerated at the SERRF facility in 2015 to calculate MT CO_2e.

Fugitive Emissions from Oil and Natural Gas Systems (I.8)

The Fugitive Emissions subsector includes emissions resulting from activities at the City's Thums and Tidelands oil and natural gas facilities.

I.8.1 Oil and Gas Well Fugitive Emissions

Data Sources

Data on emissions for the Thums and Tidelands facilities were obtained from the sources listed in Table 5 below.

Table 5: Oil and Gas Well Fugitive Emissions Data Sources

Description	Source	Units
Emissions from the Thums facility by source and type	EPA Flight Database[15]	MT / year
Emissions from the Tidelands facility (emitter CO_2e)	CARB[16]	MT CO_2e / year

[13] City of Long Beach, 2015. Greenhouse Gas Report to California Air Resources Board
[14] US Environmental Protection Agency (US EPA), 2015. Emissions Factors for Greenhouse Gas Inventories. Available: <https://www.epa.gov/sites/production/files/2015-11/documents/emission-factors_nov_2015.pdf>
[15] US Environmental Protection Agency (EPA), 2015. Facility Level Information on Greenhouse Gases Tool (FLIGHT). Available: <https://ghgdata.epa.gov/ghgp/main.do#>
[16] California Air Resources Board, 2015. Annual Summary of 2015 Greenhouse Gas Emissions Data Reported to the California Air Resources Board. Available: < https://ww2.arb.ca.gov/mrr-data>

Calculation Methodology
Emissions data for the Thums facility broken out by greenhouse gas and by emissions source was obtained from the EPA Flight Database. The project team converted emissions from CO_2 and CH_4 into MT CO_2e for each source. Flaring was reported separately from leaks from atmospheric tanks, compressors, and other equipment. Note that fuel combustion associated with the Thums facility is reported in I.4.1.

Emissions data for the Tidelands facility were not available in the EPA Flight Database. Instead, emissions data presented in MT CO_2e were obtained from the CARB industrial database and recorded directly in the CIRIS inventory file.

TRANSPORTATION

On-Road Transportation (II.1)

The on-road transportation subsector includes exhaust-related GHG emissions from on-road vehicles operating within the City of Long Beach. The City's on-road transportation emissions are estimated using outputs from the Southern California Association of Governments (SCAG) origin-destination travel model. The outputs used in the inventories were developed to align with the origin-destination methodology, which allocates vehicle trips and their corresponding vehicle miles traveled (VMT) to cities based on the starting and ending point of each trip. Under this methodology, a city would include VMT occurring within its boundaries based on the following distribution:

- **Internal-Internal trips**: 100% of trips that start and end in the city are included
- **Internal-External and External-Internal trip**: 50% of trips that start or end in the city are included
- **External-External trips**: Trips that do not start or end in the city (i.e., pass through travel) are excluded

II.1.1 Fuel Combustion from On-road Transportation

Data Sources
Table 6 shows the sources for VMT data and vehicle fuel emissions factors used in this subsector. City-specific data on vehicle trips was collected from the SCAG travel demand model and was further analyzed with data outputs from the California Air Resources Board (ARB) mobile source emissions model (EMFAC) to estimate emissions factors by vehicle type.

Table 6: On-road Transportation Data Sources

Description	Source	Units
Daily VMT by Vehicle Class, Fuel Type, and Speed Bin for the City of Long Beach (2012 and 2016)	SCAG Regional Travel Demand Model[17] (run by AECOM)	VMT / day
VMT and Fuel Consumption by Vehicle Type, Fuel Type, and Speed Bin for the South Coast Air Basin	California Air Resources Board EMFAC2014 Web Database[18]	VMT / day gallons / year

[17] Southern California Association of Governments, 2011. Transportation Demand Models. Available: <http://www.scag.ca.gov/DataAndTools/Pages/TransportationModels.aspx>
[18] California Air Resources Board. EMFAC2014 Web Database, v1.0.7. Available: <https://www.arb.ca.gov/emfac/2014/>

Description	Source	Units
Emission Rates by Pollutant by Vehicle Type, Fuel Type, and Speed Bin for the South Coast Air Basin	California Air Resources Board EMFAC2014 Web Database[19]	grams / mile

The project team developed VMT estimates for the city using the SCAG Regional Travel Demand model. As the model does not generate outputs for 2015, the project team used outputs for 2012 and 2016 to interpolate VMT values for 2015. Daily VMT values were converted to annual values using an annual traffic conversion factor of 347.

Per the origin-destination methodology, all VMT associated with internal-internal trips were included in the inventory, and 50% of VMT from internal-external and external-internal trips were included in the inventory. All external-external trips were omitted from the inventories.

Fuel consumption and emissions factors for 2015 were obtained from ARB's mobile emissions model, EMFAC. EMFAC2014 was the current EPA-approved version of the EMFAC model at the time of inventory analysis, and is a mobile source emissions model for California that provides daily VMT, fuel consumption (gallons/day), and emissions factors (grams/mile), by air basin, vehicle type, operational year, and speed bin.

Outputs from the SCAG travel demand model and EMFAC2014 were provided in 5 mph speed bins. Although both datasets used in this analysis were separated into vehicle categories, the vehicle types in EMFAC2014 model are different (and more granular) than the vehicle classes in the SCAG model. To apply fuel efficiency and emission rate data from EMFAC2014 to the city-specific VMT data from the SCAG model, the project team assigned vehicle types from EMFAC2014 to the vehicle classes in the SCAG model according to the classifications shown in Table 7.

Table 7: Vehicle Category Reclassification

SCAG Model Vehicle Class	EMFAC2014 Vehicle Type
Light Duty Vehicles	LDA
Light Duty Trucks	LDT1, LDT2, LHDT1, LHDT2
Medium Duty Trucks	MDV
Heavy Duty Trucks	T6 (all subtypes), T7 (all subtypes except T7 Ag)
Not Included	All Other Buses, MH, Motor Coach, OBUS, PTO, SBUS, T7 Ag

Note: Several vehicle types from EMFAC2014 (i.e., All Other Buses, MH, Motor Coach, OBUS, PTO, SBUS, T7 Ag) were excluded from the fuel efficiency and pollutant emission rate calculations because they did not apply to the vehicle classes in the SCAG model. However, this approach had no impact on annual VMT calculations because VMT values were generated from the SCAG model, as opposed to EMFAC2014.

[19] ibid

Calculation Methodology

Calculating Fuel Mix of VMT by Vehicle Class

VMT from vehicles in the same vehicle class that consume different fuel types are recorded separately in the final inventory and have different emissions factors applied. The SCAG model does not distinguish between fuel type, so it was necessary for the project team to determine the proper ratio of VMT driven by gasoline, diesel, and electric vehicles in each vehicle class. VMT ratios by vehicle class and fuel type were calculated from the EMFAC2014 outputs at the Air Basin level, and then applied to the city-specific VMT data to allocate the SCAG VMT data by vehicle fuel type. Once separated, emissions from diesel and gasoline vehicles were calculated as Scope 1 emissions in this section using the same method.

Emissions associated with electric vehicles were not calculated under this subsector. Because SCE did not provide activity data specifically on electric vehicle charging, electricity consumption associated with electric vehicles is assumed to be embedded in residential and commercial electricity consumption from SCE, which is reported in inventory sectors I.1.2 and I.2.2.

Fuel Consumption by Vehicle Class by Speed Bin

Fuel efficiencies were calculated using EMFAC2014 data by dividing daily VMT by daily fuel consumption for each combination of vehicle type and speed bin. To convert the fuel efficiency values from EMFAC2014 to SCAG vehicle classes, the project team averaged the fuel efficiency values of each EMFAC2014 vehicle type within a SCAG vehicle class (see Table 7 for vehicle type comparisons across models). The results were then multiplied by VMT values to generate annual gallons of fuel consumed by vehicle class by speed bin.

Emissions by Vehicle Class by Speed Bin

Emissions factors in grams per mile for CO_2, N_2O, and CH_4 were calculated by vehicle class by speed bin using EMFAC2014 emissions rate data. EMFAC2014 provides emissions rates for a variety of pollutants and greenhouse gases, including CO_2, NO_X (all nitrous oxides) and TOG (total organic gases, including CH_4). The project team isolated CH_4 and N_2O using methods recommended by CARB.[20] Methane was isolated by multiplying TOG emissions factors for both gas and diesel by 0.0408. For gasoline, N_2O was isolated by multiplying NO_X emissions rates by 0.0416. For diesel, N_2O was calculated by summing the total daily gallons of diesel consumed by vehicle class by speed bin, multiplying each value by 0.3316 to calculate the total grams of N_2O emitted, and then dividing the results by daily VMT to arrive at emissions factors in grams per mile for each vehicle class and speed bin. Next, the speed bin and vehicle class-specific emissions factors were multiplied by annual VMT in each speed bin/vehicle class combination to generate emissions in metric tons for 2015 for each of the three greenhouse gases.

Composite Activity Data and Emissions Rates by Fuel Type

Individual emissions factors for all vehicle types and speed bins were combined into weighted emissions factors for each greenhouse gas that represent all vehicle classes and speed bins weighted by VMT within the city. That is, emissions factors for vehicle classes that represent a higher percentage of VMT were weighted according to their relative VMT proportion and within vehicle classes; emissions factors for speed bins that represent a higher percentage of VMT were also weighted according to their relative VMT proportion.

Finally, VMT for all vehicle classes were summed (gasoline and diesel separately) resulting in a total annual VMT activity value for each fuel type, to which the composite emissions factors for each

[20] California Air Resources Board, 2013. Frequently Asked Questions. Available: <https://www.arb.ca.gov/msei/emfac2011-faq.htm#emfac2011_web_db_qstn07>

greenhouse gas were applied to calculate annual emissions for each greenhouse gas. As elsewhere in the inventories, the individual greenhouse gases were converted to CO_2e using GWP coefficients from the IPCC 5th Assessment.

Assumptions

The SCAG Transportation Demand Model does not calculate VMT for urban buses by speed bin, but instead outputs them as an aggregate value. All calculations described above (fuel efficiencies, emission rates, etc.), when performed on the urban buses vehicle class, were not carried out individually by speed bin. Therefore, calculations for the urban bus category are less granular and may have a higher margin of error.

The SCAG Travel Demand Model does not separate urban bus VMT by trip type. For all other vehicle classes, the model separates internal-internal trips, internal-external and external-internal trips, and external-external trips. Although it is recommended by ARB and the GPC to include all internal-internal trips, 50% of internal-external trips, and exclude all external-external trips, for urban buses this distinction was not possible, and instead all VMT from urban buses were included in the inventories. Therefore, VMT and the corresponding emissions from urban buses are likely over-estimated in the inventory as it relates to the city's responsibility for urban bus emissions per the origin-destination methodology.

Railways (II.2)

The Railways subsector includes the use of electricity and diesel fuel to operate passenger rail and freight rail services within the city.

II.2.1 Fuel Combustion from Railway Transportation

Data Sources

Table 8 presents the data sources used to estimate railway fuel consumption and fuel emissions factors. The calculations used a combination of track length and route schedules, with emissions factors for different locomotive types.

Table 8: Diesel Consumption from Rail Transportation Data Sources

Description	Source	Units
Freight Rail Routes	Caltrans GIS Data Library[21]	GIS Data
National Diesel Locomotive – Emissions Factor	US EPA Emissions Factors for Locomotives[22]	grams / gallon
Energy Density of Diesel by Locomotive Type	US EPA Emissions Factors for Locomotives[23]	Brake horsepower hour / gallon
Energy Consumption of Locomotives by Service Provider in the South Coast Air Basin	Port of Long Beach Air Emissions Inventory[24]	MWh

[21] California Department of Transportation (Caltrans), 2013. California Rail Network. Available: <http://www.dot.ca.gov/hq/tsip/gis/datalibrary/>
[22] US Environmental Protection Agency (US EPA), 1997. Emissions Factors for Locomotives. Available: <nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=P1001Z8C.TXT>
[23] ibid

Description	Source	Units
Total BNSF Fuel Use by Locomotive Type	BNSF[25]	gallons
Total Union Pacific Fuel Use by Locomotive Type	Union Pacific[26]	gallons

Calculation Methodology

The most detailed activity data available for Union Pacific and BNSF trains operating in the city was provided by the South Coast Air Basin and expressed as energy consumption of locomotives by operator. These values were converted to gallons of diesel and then downscaled from the air basin level to the City of Long Beach.

The energy densities of diesel locomotives depend on locomotive type (long haul/freight vs. switching), so the first step in this process was to calculate the total fuel use of each operator by locomotive type. Fuel use by locomotive type was converted to energy consumption by locomotive type using energy density data from US EPA. From this, the system-wide ratio of line-haul energy consumption to switching energy consumption was calculated for each operator and then applied to the air basin-level energy consumption data. This allowed the different energy densities for locomotive types to be applied to more accurately convert energy consumption to gallons of diesel consumed by each operator within the air basin.

Caltrans GIS data of freight rail lines was used to determine the percent of the air basin's freight rail network mileage that is located within the city. This ratio was used to downscale the total gallons of diesel consumed at the air basin level to the city. Finally, default national emissions factors for diesel from the US EPA were used to estimate emissions in CO_2e.

Assumptions

Default national emission factors for diesel locomotives from EPA were used to estimate emissions. This assumes that locomotive fleets operating within the City of Long Beach emit at rates similar to the national average.

II.2.2 Electricity Consumed in the City for Railways

Data Sources

Table 9 presents the data sources for railway electricity use and emission factors. Electricity consumption data was provided by LA Metro, and electricity emissions factors were collected from utility companies that provide electricity to the Blue Line.

[24] Port of Long Beach, 2015. Annual Air Emissions Inventory. Available: <http://polb.com/civica/filebank/blobdload.asp?BlobID=13555>

[25] BNSF Railway Company, 2015. Class I Railroad Annual Reports. Available: <http://www.bnsf.com/about-bnsf/financial-information/pdf/14R1.pdf>

[26] Union Pacific Railroad, 2013-2017. Class I Railroad Annual Reports. Available: <https://www.up.com/cs/groups/public/@uprr/@investor/documents/investordocuments/pdf_uprr_r-1_03312015.pdf>

Table 9: Electricity Consumption from Rail Transport Data Sources

Description	Source	Units
Metro Rail Route Lines GIS Data	LA Metro GIS Data[27]	GIS
Electricity Consumption of Metro Rail by Line by Utility	LA Metro	MWh
LADWP – Emissions Factor	LADWP	lbs / MWh
SCE – Emissions Factor	SCE	t / MWh

Calculation Methodology
Activity data for the entire Metro Railway system was provided by transit line and electric utility company. To isolate electricity consumed within the city, the project team used Metro Rail GIS data to calculate the ratio of the Blue Line that is within the city limits. This ratio was multiplied by total electricity consumption for the Blue Line, and the results were summed by electricity utility provider. Utility-specific emissions factors were then applied to convert from MWh to CO_2e.

Assumptions
The method of isolating Long Beach-specific electricity consumption from system-wide consumption assumes that energy use is uniform across all portions of a transit line.

Waterborne Navigation (II.3)

The Waterborne Navigation subsector includes the consumption of diesel fuel to operate harbor craft and oceangoing vessels hoteling as a result of activity at the City's port. Note that the City estimated waterborne navigation emissions in its total inventory but did not include this source within the jurisdictional inventory that is evaluated in the CAAP; see CAAP Chapter 5 for further detail on this distinction.

II.3.1 – Fuel Combustion for Waterborne Navigation Occurring in the City

Data Sources
As shown in Table 10, the Port of Los Angeles Air Emissions Inventories provided the activity data and emissions factor data to calculate emissions in this subsector.

Table 10: Waterborne Navigation Data Sources

Description	Source	Units
Emissions by Vessel Type (Oceangoing vessels - hoteling, oceangoing vessels – transit and maneuvering, and harbor craft)	Port of Long Beach Air Emissions Inventory 2015[28]	MT CO_2e / year

[27] Los Angeles Metropolitan Transportation Authority (LA METRO), 2017. LA Metro Rail GIS. Available: <https://developer.metro.net/introduction/gis-data/download-gis-data/>
[28] Port of Long Beach, 2015. Annual Air Emissions Inventory. Available: < http://polb.com/civica/filebank/blobdload.asp?BlobID=13555>

Calculation Methodology
The Port of Long Beach annual Air Emissions Inventories provide estimates of GHG emissions in MT CO_2e split into oceangoing vessels (hoteling), oceangoing vessels (transit and maneuvering), and harbor craft.

These emissions estimates were calculated by the Port of Long Beach based on methodologies described in detail in the Port's 2015 Air Emissions Inventory. The project team used these emissions estimates directly in the City's inventory. Oceangoing vessels – transit and maneuvering are not included in the Basic reporting framework but are included in the Basic+ inventory results provided in the CAAP.

Assumptions
All harbor craft emissions were included as Scope 1, assuming that the majority of harbor vessel operations occur within the city limits. For purposes of the community emissions inventory, all 'transit' and 'maneuvering' operation-related emissions were allocated to Scope 3 assuming most of these operations occur outside the city limits. This assumption has no impact on the CAAP analysis since all waterborne vessel emissions were excluded from the jurisdictional inventory for GHG target analysis purposes.

Aviation (II.4)

The Aviation subsector includes emissions associated with the operations of ground service equipment and generators at Long Beach Airport. Note that emissions associated with transboundary airplane trips are not included in the Basic reporting framework and are therefore not included here. Emissions associated with electricity or natural gas consumption are not included here because they are already captured in the SCE and LBGO activity data recorded in I.2.

II.4.1 Emissions from Fuel Combustion for Aviation Occurring in the City

Data Sources
Table 11 presents the sources for activity data and emissions factors used to calculate emissions associated with ground service equipment and generators. Activity data from Long Beach Airport was combined with a regional off-road diesel emissions factor and a national EPA aviation gasoline emissions factor.

Table 11: Aviation Emissions Occurring Inside the City Data Sources

Description	Source	Units
Fuel consumption by fuel and equipment type	Long Beach Airport	gallons
Aviation Gasoline – Emissions Factor	EPA[29]	MT / gallon
Off-road Diesel – Emissions Factor	California Air Resources Board Off-road Model	MT / gallon

Calculation Methodology
The activity data provided by Long Beach Airport for diesel and aviation gasoline was multiplied by corresponding emissions factors to convert gallons of fuel consumed to MT CO_2e.

[29] US Environmental Protection Agency (US EPA), 2015. Emissions Factors for Greenhouse Gas Inventories. Available: <https://www.epa.gov/sites/production/files/2015-11/documents/emission-factors_nov_2015.pdf>

Off-road Transportation (II.5)

The Off-road Transportation subsector includes emissions associated with off-road vehicles and equipment used in construction, transport refrigeration, light commercial, industrial, and lawn and gardening operations.

Data Sources

Data for construction, light commercial, industrial, and lawn and gardening equipment were obtained from the California Air Resources Board OFFROAD2007 model, which provides county-level emissions factors for off-road equipment.[30] OFFROAD2007 uses multiple factors and indicators to estimate and project off-road equipment activity levels. This includes, but is not limited to, population, statewide rules and regulations, academic studies, growth forecasts, existing ARB reporting systems (e.g., Diesel Off-Road On-Line Reporting System [DOORS]), and non-compliance estimates.[31] Activity data from OFFROAD2007 is provided separately for gasoline, diesel, and LPG in gallons per year (gal/yr).

Calculation Methodology

To scale the results of OFFROAD2007 from county-level emissions data to values more representative of emissions generated within the city, the project team collected demographic indicators from the American Communities Survey (ACS) 2011-2015 5-Year Estimates for both the City of Long Beach and the County of Los Angeles.[32,33] These values were used to generate multipliers for converting county-level values to city-level values. ACS data includes a breakdown of the number employees by job sector within a given geography. Job sector-specific multipliers were generated from employment data to improve the precision of the calculations, where possible. For emissions sources that are not job sector-specific, such as lawn and gardening equipment, the project team applied a multiplier based on population. For example, in 2015, 4.7% of the County's manufacturing jobs were located within the City of Long Beach, so the countywide industrial equipment emissions value generated by OFFROAD2007 was multiplied by 0.047 to estimate industrial equipment emissions in the city. Table 12 shows the demographic indicators used to downscale the county-wide OFFROAD2007 emissions.

Table 12: County to City Multiplier Sources by Off-road Equipment Class

Off-road Equipment Class	Multiplier Source (ACS 5-Year Estimates)
Industrial Equipment	Employees in the Manufacturing Sector
Light Commercial Equipment	Employees in the Wholesale Trade and Retail Trade Sectors
Transport Refrigeration Units	Population
Lawn and Garden Equipment	Population
Construction and Mining Equipment	Population

[30] CARB. 2006 (December). Off-Road Emissions Inventory. Available: <http://www.arb.ca.gov/msei/offroad/offroad.htm>.
[31] Additional information regarding the assumptions and factors used to estimate OFFROAD activity levels can be found at: <http://www.arb.ca.gov/msei/categories.htm>
[32] U.S. Census Bureau, 2009-2013, 2010-2014, 2011-2015, 2012-2016, and 2013-2017 American Community Survey 5-Year Estimates. Selected Economic Characteristics (Table DP03). Available: <https://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=ACS_16_5YR_DP03&prodType=table>
[33] U.S. Census Bureau, 2009-2013, 2010-2014, 2011-2015, 2012-2016, and 2013-2017 American Community Survey 5-Year Estimates. Total Population (Table B01003). Available: <https://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=ACS_16_5YR_B01003&prodType=table>

The downscaled activity data for gasoline, diesel, and LPG consumption were then multiplied by their corresponding emissions factors from the OFFROAD2007 model to convert gallons of fuel consumed to MT CO_2e.

WASTE

Solid Waste Disposal (III.1)

The Solid Waste Disposal subsector includes methane emissions that occur as a result of the anaerobic decomposition of waste disposed in landfills. Emissions in this sector were calculated using the methane commitment method described in the GPC.

Data Sources

The project team obtained solid waste disposal data from City staff. The data included short tons of solid waste generated within the city organized by the final waste processing facilities used in 2015. Waste processing facilities included multiple landfills throughout California, incineration facilities, and use of alternative daily cover (ADC).

Landfill methane capture efficiency rates were collected from the EPA FLIGHT database, where reported, and were otherwise assumed to be 75% at landfills where no EPA FLIGHT data was available. The result is different methane capture rates used in the emissions calculations based on where the city's waste was sent. Data for total waste disposed to landfills is provided in Table 13. The landfill methane capture rates are provided in Table 14.

Table 13 – Waste Disposed by Waste Type

Landfill Facility	Disposal Type	Short Tons
American Avenue Disposal Site	Landfill	0.02
Kettleman Hills - B18 Nonhaz Co-disposal	Landfill	0.9
Lamb Canyon Sanitary Landfill	Landfill	0.9
Chemical Waste Management, Inc. Unit B-17	Landfill	2.1
Lancaster Landfill and Recycling Center	Landfill	46.4
Victorville Sanitary Landfill	Landfill	85.2
Savage Canyon Landfill	Landfill	107.5
San Timoteo Sanitary Landfill	Landfill	781.5
Antelope Valley Public Landfill	Landfill	858.9
McKittrick Waste Treatment Site	Landfill	1,479.8
Mid-Valley Sanitary Landfill	Landfill	2,923.8
Chiquita Canyon Sanitary Landfill	Landfill	3,352.4
Simi Valley Landfill & Recycling Center	Landfill	12,495.2
Azusa Land Reclamation Co. Landfill	Landfill	21,124.2
Prima Deshecha Sanitary Landfill	Landfill	22,503.5

Landfill Facility	Disposal Type	Short Tons
Olinda Alpha Sanitary Landfill	Landfill	26,645.0
El Sobrante Landfill	Landfill	30,330.2
Sunshine Canyon City/County Landfill	Landfill	57,267.5
Frank R. Bowerman Sanitary Landfill	Landfill	97,700.1
Subtotal	**Landfill**	**277,704.9**
Lancaster Landfill and Recycling Center	ADC	443.5
Simi Valley Landfill & Recycling Center	ADC	908.8
Antelope Valley Public Landfill	ADC	1,206.2
El Sobrante Landfill	ADC	128,994.4
Subtotal	**ADC**	**131,552.9**
Commerce Refuse-To-Energy Facility	Incineration	436.8
Southeast Resource Recovery Facility (SERRF)	Incineration	196,599.5
Subtotal	**Incineration**	**197,036.3**

Source: City of Long Beach 2017

Table 14 – Waste Disposed by Waste Type

Landfill Facility	Methane Collection Rate	Source
American Avenue Disposal Site	75.00%	Default assumption
Kettleman Hills - B18 Nonhaz Co-disposal	75.00%	Default assumption
Lamb Canyon Sanitary Landfill	74.00%	EPA FLIGHT
Chemical Waste Management, Inc. Unit B-17	75.00%	Default assumption
Lancaster Landfill and Recycling Center	75.00%	Default assumption
Victorville Sanitary Landfill	74.83%	EPA FLIGHT
Savage Canyon Landfill	75.00%	EPA FLIGHT
San Timoteo Sanitary Landfill	75.00%	Default assumption
Antelope Valley Public Landfill	75.00%	Default assumption
McKittrick Waste Treatment Site	75.00%	Default assumption
Mid-Valley Sanitary Landfill	76.68%	EPA FLIGHT
Chiquita Canyon Sanitary Landfill	75.00%	Default assumption
Simi Valley Landfill & Recycling Center	74.90%	EPA FLIGHT
Azusa Land Reclamation Co. Landfill	75.00%	Default assumption
Prima Deshecha Sanitary Landfill	75.00%	Default assumption
Olinda Alpha Sanitary Landfill	75.00%	Default assumption
El Sobrante Landfill	74.87%	EPA FLIGHT

Landfill Facility	Methane Collection Rate	Source
Sunshine Canyon City/County Landfill	87.65%	EPA FLIGHT
Frank R. Bowerman Sanitary Landfill	75.00%	Default assumption

Calculation Methodology

The equations and inputs associated with the methane commitment methodology are presented below, followed by additional data items used to estimate the city's solid waste emissions.

The project team applied equations 8.1, 8.3, and 8.4 from the GPC (shown on the following pages).

Equation 8.1: Degradable organic carbon (DOC)

DOC = (0.15 x A) + (0.2 x B) + (0.4 x C) + (0.43 x D) + (0.24 x E) + (0.15 x F) + (0.39 x G) + (0.0 x H) + (0.0 x I) + (0.0 x J) + (0.0 x K)	
A	= Fraction of solid waste that is food
B	= Fraction of solid waste that is garden waste and other plant debris
C	= Fraction of solid waste that is paper
D	= Fraction of solid waste that is wood
E	= Fraction of solid waste that is textiles
F	= Fraction of solid waste that is industrial waste
G	= Fraction of solid waste that is rubber and leather
H	= Fraction of solid waste that is plastics
I	= Fraction of solid waste that is metal
J	= Fraction of solid waste that is glass
K	= Fraction of solid waste that is other, inert waste

Source: Default carbon content values sourced from IPCC Waste Model spreadsheet, available at: http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/5_Volume5/V5_2_Ch2_Waste_Data.pdf
Note: GPC Equation 8.1 includes factors A-F; AECOM added factors G-K using the default DOC content in % of wet waste from the same IPCC Waste Model spreadsheet referenced in the source above.

Equation 8.3: Methane commitment estimate for solid waste sent to landfill

CH_4 emissions = $MSW_x \times L_0 \times (1\text{-}f_{rec}) \times (1\text{-}OX)$		
Description		**Value**
CH_4 emissions	= Total CH4 emissions in metric tons	Computed
MSW_x	= Mass of solid waste sent to landfill in inventory year, measured in metric tons	User input (see Table 13)
L_0	= Methane generation potential	See Equation 8.4 Methane generation potential
f_{rec}	= Fraction of methane recovered at the landfill (flared or energy recovery)	User input (see Table 14)
OX	= Oxidation factor	0.1 for well-managed landfills; 0 for unmanaged landfills

Source: Adapted from *Revised 1996 IPCC Guidelines for National Greenhous Gas Inventories*

The project team used the following values in Equation 8.3 for the city's calculations:

- MSW_x = see Table 13
- f_{rec} = see Table 14
- OX = 0.1

Equation 8.4: Methane generation potential, L_0

L_0 = $MCF \times DOC \times DOC_F \times F \times 16/12$		
Description		**Value**
L_0	= Methane generation potential	Computed
MCF	= Methane correction factor based on type of landfill site for the year of deposition (managed, unmanaged, etc., fraction)	Managed = 1.0 Unmanaged (≥ 5 m deep) = 0.8 Unmanaged (<5 m deep) = 0.4 Uncategorized = 0.6
DOC	= Degradable organic carbon in year of deposition, fraction (tons C / tons waste)	See Equation 8.1
DOC_F	= Fraction of DOC that is ultimately degraded (reflects the fact that some organic carbon does not degrade)	Assumed equal to 0.6
F	= Fraction of methane in landfill gas	Default range 0.4-0.6 (usually taken to be 0.5)
16/12	= Stoichiometric ratio between methane and carbon	n/a

Source: *IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (2000)*

The project team used the following values in Equation 8.4 for the city's calculations:

- MCF = 1.0
- DOC_F = 0.6
- F = 0.5

Waste Characterization

The project team estimated landfill waste composition for the 2015 GHG inventory based on CalRecycle's statewide waste characterization studies. The 2015 inventory results are based on CalRecycle's *2014 Disposal-Facility-Based Characterization of Solid Waste in California* report. Per the 2014 report, CalRecycle's side-by-side analysis of the 2008 and 2014 study results identified an unexpected anomaly in the distribution of waste per sector (i.e., residential, commercial, and self-hauled). The report states that CalRecycle was obtaining additional data to verify the 2014 report results. In the interim, the 2014 report presents two sets of data: one reflecting the 2014 calculated sector percentages, and the other based on the 2008 report sector percentages. The project team averaged the reported results for use in the GHG inventory.

The CalRecycle study estimates the percentage of different materials in California's waste stream. The project team referred to Table 7: Composition of California's Overall Disposed Waste Stream to determine the distribution of waste by the material types included in Equation 8.1. Table 15 shows the results of this data sorting,

Table 15: Waste Characterization – Selected Materials Categories

Material	2008 Sector Percentages	2014 Sector Percentages	2008 and 2014 Average	Material Categories/Sub-types from CalRecycle Reports[1]
Paper	18.1%	18.5%	18.3%	Paper category plus Gypsum Board sub-type from Inerts and Other category
Textiles	5.6%	5.8%	5.7%	Textiles and Carpet sub-types from Other Organic category
Food	16.5%	18.1%	17.3%	Food sub-type from Other Organic category
Garden and Park	10.6%	11.8%	11.2%	Leaves and Grass, Prunings and Trimmings, Manures, and Remainder/Composite Organics sub-types from Other Organic category
Wood	15.5%	13.6%	14.6%	Lumber sub-type from Inerts and Other category and Branches and Stumps sub-type from Other Organic category
Rubber and Leather	0.1%	0.1%	0.1%	Tires sub-type from Special Waste category
Plastics	10.4%	10.4%	10.4%	Plastic category
Metal	3.1%	3.1%	3.1%	Metal category
Glass	2.5%	2.5%	2.5%	Glass category

Material	2008 Sector Percentages	2014 Sector Percentages	2008 and 2014 Average	Material Categories/Sub-types from CalRecycle Reports[1]
Other	17.7%	16.1%	16.9%	Electronics category, Household Hazardous Waste (HHW) category, Mixed Residue category, Inerts and Other category (minus Lumber and Gypsum Board sub-types), and Special Waste category (minus Tires sub-type)
Total [2]	**100.1%**	**100.0%**	**100.1%**	

[1] *2014 Disposal-Facility-Based Characterization of Solid Waste in California,* CalRecycle 2015. Prepared by Cascadia Consulting Group. Available online at: <http://www.calrecycle.ca.gov/Publications/Documents/1546/20151546.pdf>. Adapted by AECOM 2017.

[2] Totals do not sum to 100% due to rounding in the CalRecycle report.

Assumptions

Use of the CalRecycle waste characterization report assumes that waste generated in the city has a similar composition to waste generated in the state as a whole. The project team conservatively assumed that 100% of ADC waste was green waste and allocated the tonnage to the Garden and Park material category and corresponding DOC factor. It is likely that some or all of the ADC waste was inert materials that would not decompose to generate landfill emissions, and therefore the city's solid waste emissions could be lower than estimated in the inventory. New ADC tracking data provided by CalRecycle that was unavailable during inventory preparation can be used in future inventories to better understand the portion of the city's ADC waste that includes green waste.

Incineration and Open Burning (III.3)

The Incineration and Open Burning subsector (referred to as incineration elsewhere in this report) includes carbon dioxide, methane, and nitrous oxide emissions that result from the incineration of waste at the Commerce Refuse-to-Energy Facility, which is located outside the city limits. Emissions from the Southeast Resource Recovery Facility (SERRF), which is located within Long Beach, are calculated and reported separately in the Emissions from Energy Generation Supplied to the Grid subsector (I.4.4).

Data Sources

The project team obtained data on waste incineration from staff at the Long Beach Environmental Services Bureau. The data provided included short tons of solid waste incinerated at one of two incineration facilities (i.e., Commerce Refuse-to-Energy Facility and Southeast Resource Recovery Facility [SERRF]).

Table 16: Wastewater Incineration Data Sources

Description	Source	Units
Emissions from waste incinerated at the SERRF facility	EPA Flight Database[34]	MT / year
Total municipal solid waste incinerated at the SERRF facility	City of Long Beach[35]	st / year
Municipal solid waste from Long Beach incinerated at the Commerce facility	CalRecycle[36]	st / year

Calculation Methodology

Waste incineration facility emissions factors were calculated based on 2015 SERRF emissions reported in the EPA FLIGHT database divided by a known volume of waste incinerated at SERRF in 2015. This calculation provided an estimated emissions factor expressed as MT CO_2e/metric ton of incinerated waste. This emissions factor was multiplied by activity data representing the total waste from Long Beach incinerated at the Commerce facility in 2015 to calculate MT CO_2e for this subsector in lieu of a Commerce facility-specific emissions factor.

Assumptions

Waste incineration emissions factors could vary among the two incineration facilities. The data needed to estimate different incineration emissions factors was not publicly available at the time of inventory preparation, and incineration represents a minor emissions source in the City's total inventory so the project team does not believe this data gap would have a material impact on inventory results. Further, the Commerce facility was closed in 2018 and will not appear in future city inventories.

Wastewater Treatment and Discharge (III.4)

The Wastewater Treatment and Discharge subsector includes nitrous oxide emissions from the portion of wastewater going to the LB Water Reclamation Plant that is generated by Long Beach (III.4.1) and nitrous oxide and methane emissions from the portion of wastewater going to the Joint Water Pollution Control Plant (located in Carson, CA) that is generated in Long Beach (III.4.3).

Data Sources

Table 17 presents the sources for activity data used to calculate wastewater emissions.

Table 17: Wastewater Sector Emissions Activity Data Sources

Description	Source	Units
Daily nitrogen load from effluent discharge for the Long Beach Water Reclamation Plant	LACSD[37]	kg nitrogen / day
Daily nitrogen load from effluent discharge for the Joint Water Pollution Control Plant	LACSD[38]	kg nitrogen / day
Service populations for the Long Beach Water Reclamation	LACSD[39]	population

[34] US Environmental Protection Agency (EPA), 2015. Facility Level Information on Greenhouse Gases Tool (FLIGHT). Available: <https://ghgdata.epa.gov/ghgp/main.do#>
[35] 2015 waste incineration volume is confidential data. Personal communication between Al Foley at City of Long Beach and Joshua Lathan of AECOM on September 6, 2017.
[36] CalRecycle, 2015. CY 2015 Electronic Annual Reporting.
[37] Sanitation Districts of Los Angeles County (LACSD), 2015. Long Beach Water Reclamation Plant NPDES Annual Monitoring Report.
[38] Los Angeles County Sanitation Districts (LACSD), 2015. Joint Water Pollution Control Plant NPDES Annual Monitoring Report.

Description	Source	Units
Plant and Joint Water Pollution Control Plant		served
Percentage of Long Beach population served by each plant	Long Beach Water Department[40]	percent
Volume of digester gas produced at the Joint Water Pollution Control Plant; methane content of biogas; details on onsite or offsite use	LACSD[41]	cubic feet / year

Calculation Methodology

Wastewater generated in the city is treated by two wastewater treatment plants: the Long Beach Water Reclamation Plant and the Joint Water Pollution Control Plant. Both plants treat wastewater from other cities as well, so only a portion of the emissions associated with these plants is attributable to Long Beach.

GHG emissions from both plants occur in the form of N_2O from nitrogen loads in treated effluent discharge and nitrification/denitrification processes during treatment. Furthermore, the Joint Water Pollution Control Plant also produces digester gas, the incomplete combustion of which (onsite or offsite) results in CH_4 emissions.

The project team received data on daily nitrogen loads from effluent discharge, which were used to estimate N_2O emissions using a standard equation from the ICLEI Local Government Operations Protocol (LGOP). Similarly, data on the population served by each treatment facility were used in a separate standard equation from the LGOP to estimate emissions from nitrification/denitrification processes.

Data on total biogas generation and the corresponding methane content at the Joint Water Pollution Control Plant were used in a standard LGOP equation to estimate fugitive methane emissions. All standard equations contain default conversion factors and other constants such as days per year, which are specified in the LGOP.

As emissions were initially calculated at the facility scale for both treatment plants, and the service population of the plants includes communities outside of Long Beach, emissions were downscaled to the city using a ratio of total City of Long Beach-specific service population to the total service population.

Assumptions

As the treatment process at the Long Beach Water Reclamation Plant is aerobic, no methane emissions are assumed to be generated at that facility.

[39] Los Angeles County Sanitation Districts (LACSD), 2012. Clearwater Program Master Facilities Plan.
[40] Estimates provided by Jinny Huang from Long Beach Water Department via phone on December 28, 2017.
[41] Los Angeles County Sanitation Districts (LACSD), 2015. Joint Water Pollution Control Plant NPDES Annual Monitoring Report.

PART II – 2030 REDUCTION TARGET PATHWAY

The CAAP evaluated a 2030 GHG target that was established to demonstrate consistency with the state's adopted 2030 GHG target (i.e., 40% below 1990 levels by 2030), and CAAP actions were defined to demonstrate a feasibly reduction pathway toward target achievement. While the CAAP does also include a 2045 carbon neutrality goal and high-level estimates of the City's potential progress toward that the goal, this appendix focuses on describing the assumptions and calculation methodology used to demonstrate 2030 target achievement in the CAAP.

Table 18 summarizes the GHG reductions by action that provide the City's pathway to 2030 target achievement. The remainder of this section provides quantification details for each action listed below to document assumptions related to action implementation and sources of information to support future CAAP monitoring and updates. GHG reductions have been rounded to the nearest tens value and the green highlighted values within each action section correspond to the GHG reductions shown in the table below. The CAAP reflects the sector-level reductions total shown here.

Table 18 – Quantified CAAP Actions

CAAP Action	2030 GHG Reductions (MT CO_2e/yr)
BUILDING + ENERGY ACTIONS	**247,700**
BE-1 Provide access to renewably generated electricity	188,960
BE-2 Increase use of solar power	3,880
BE-6 Perform municipal energy and water audits	13,120
BE-8 Implement short-term measures to reduce emissions related to oil and gas extraction	41,740
TRANSPORTATION ACTIONS	**30,480**
T-1 Increase the frequency, speed, connectivity and safety of transit options	5,230
T-4 Implement the Port of Long Beach Clean Trucks Program	25,250
WASTE ACTIONS	**116,680**
W-1 Ensure compliance with state law requirements for multifamily and commercial property recycling programs	45,340
W-3 Partner with private waste haulers to expand organic waste collection community-wide	39,730
W-4 Identify organic waste management options	31,610
TOTAL CAAP REDUCTIONS	**394,860**

Some action quantification methodologies refer to the demographic forecasts used to estimate the city's BAU emissions scenario. The relevant demographic information is documented in Table 19.

Table 19 – City of Long Beach Demographic Forecasts

	2012	2015	2016	2020	2030	2035
Population	466,255	468,911	469,796	478,346	480,424	481,463
Employment	153,154	155,402	156,900[1]	165,800	172,297	175,546
Service Population	619,409	624,312	626,696	644,146	652,721	657,009

Notes:
Service population = population + employment
Values for 2012, 2016, 2020, and 2035 provided to AECOM by City of Long Beach, Table LU-8: Population, Household and Employment Growth
Values for 2015 and 2030 interpolated
[1] Employment data is for 2017

Clean Electricity Grid Options

The general quantification approach used to evaluate emissions reductions from actions that would reduce electricity use or offset it with carbon-free energy sources is presented in the section below.

Overarching Methodology

The CAAP evaluated the GHG reduction potential that would result from implementation of SCE's commitment to provide 80% carbon-free energy by 2030, as well as the additional net emissions reductions that would occur from voluntary participation in SCE's Green Rate program.

Potential emissions reductions were estimated according to the following equation:

Emissions Reduction = (Business-as-Usual Emissions) – (Mitigated Scenario Emissions)

The primary inputs supporting calculations for the above equation include activity data (e.g., MWh of electricity use) and emissions factors (e.g., MT CO_2e/MWh). Each component of the equation is described below.

Business-as-Usual (BAU) Emissions Scenario

Activity Data

BAU emissions were calculated based on the 2030 electricity activity data forecasts that underpin the CAAP's GHG emissions forecasts. These were developed for three subsectors: residential, commercial, and industrial electricity accounts. 2030 forecasts were calculated using growth indicators to estimate how the 2015 base year inventory might change by the CAAP's 2030 target year. Residential activity data was projected using city population forecasts and the commercial and industrial activity data was projected using city employment forecasts. Population and employment forecast information was collected form the SCAG 2016 Regional Transportation Plan/Sustainable Community Strategy and provided to AECOM by the City of Long Beach in August 2018 (see Table 19). CAAP action BE-6 separately estimates the GHG reduction potential from a City commitment to purchase renewable electricity for all municipal accounts by 2030. The community inventory did not separately evaluate municipal GHG emissions, however the City did prepare a 2015 municipal operations inventory from which municipal electricity activity data was collected for purposes of evaluating GHG reduction potential. This activity data was subtracted from the communitywide electricity data for commercial accounts provided by SCE in order to avoid double counting emissions reduction potential. Table 20 presents the city's 2015 and 2030 electricity activity data.

Table 20 – Electricity Activity Data

Energy Sub-sector	2015 (MWh)	2030 (MWh)
Residential	813,346	833,316
Commercial	678,407	872,200
Municipal	108,264	108,264
Industrial	1,409,718	1,562,987

Note: Values are rounded; for purposes of community emissions planning, no activity data growth was assumed for municipal electricity accounts from 2015-2030.

Emissions Factor

In the CAAP forecasts, BAU emissions were calculated using an estimated SCE 2030 electricity emissions factor that assumes compliance with the state's Renewables Portfolio Standard (RPS). The RPS requires SCE to procure 60% RPS-eligible sources by 2030. In the CAAP 2015 base year, SCE's electricity came from the energy source mix shown in Table 21. The project team estimated a 2030 mix that assumes compliance with the RPS requirements (i.e., 60% eligible renewable sources), with the remainder of energy provided by unspecified sources of power. This scenario represents a conservative estimate based on the 2015 energy mix by allocating the full 40% of non-RPS energy to the potentially highest emissions option in use in the 2015 base year. It is a conservative approach in that it results in an estimated emissions factor that is greater (i.e., more carbon intensive) than other scenarios could provide. For example, if SCE maintains its large hydroelectric and nuclear power sources through 2030 and provides 60% RPS-eligible energy sources, then only 32% of energy would need to come from unspecified sources.

Table 21 – SCE Electricity Mix

Energy Source	2015 SCE Power Mix (Actual)[1]	2030 SCE Power Mix (Estimated)[2]
Eligible Renewable	25%	60%
Coal	-	-
Large Hydroelectric	2%	-
Natural Gas	26%	-
Nuclear	6%	-
Other	-	-
Unspecified Sources of Power	41%	40%
Total	**100%**	**100%**

Source:
[1] California Energy Commission. 2015 SCE Power Content Label.
[2] Estimated by AECOM.

At the time of emissions forecast analysis, an unspecified energy source emissions factor of 0.428 MT CO_2e/MWh was collected from the California Air Resources Board[42] to evaluate the estimated 2030 SCE emissions factor. When applied to the estimated energy mix shown above, the resulting weighted emissions factor for SCE's estimated 2030 electricity portfolio is 0.1712 MT CO_2e/MWh, as shown in Table 22.

[42] CARB Unofficial Electronic Version of the Regulation for the Mandatory Reporting of Greenhouse Gas Emissions. Available online: https://ww3.arb.ca.gov/cc/reporting/ghg-rep/regulation/mrr-2018-unofficial-2019-4-3.pdf?_ga=2.85289563.330032031.1594773045-55257910.1560365597

Table 22 – 2030 Estimated Electricity Emissions Factor

Energy Sources	2030 Energy Mix	Emissions Factor ($MT\ CO_2e/MWh$)	$MT\ CO_2e/MWh$
Eligible Renewable	60%	0	0
Unspecified Sources of Power	40%	0.428	0.1712
Total	**100%**	**-**	**0.1712**

The estimated 2030 emissions factor was combined with the estimated 2030 activity data to calculate the BAU electricity emissions scenario (see Table 23).

Table 23 – 2030 BAU Electricity Emissions Scenario

Energy Sub-sector	2030 (MWh)	2030 Emissions Factor ($MT\ CO_2e/MWh$)	2030 BAU Emissions ($MT\ CO_2e$)
Residential	833,316	0.1712	142,664
Commercial	763,936	0.1712	130,786
Municipal	108,264	0.1712	18,535
Industrial	1,562,987	0.1712	267,583
Subtotal	**3,268,504**		**559,568**

MITIGATED EMISSIONS SCENARIO

The mitigated scenario was developed with participation estimates and/or goals for the different electricity focused CAAP actions to calculate what amount of future electricity demand would be achieved in a manner that differs from the BAU scenario. The calculations and assumptions are presented below.

BE-1 PROVIDE ACCESS TO RENEWABLY GENERATED ELECTRICITY

SCE-Provided 2030 Electricity Emissions Factor

In September 2020, SCE provided City staff with its estimated 2030 electricity emissions factor that aligns with the utility company's long-term carbon free energy source commitments. The 2030 factor provided by SCE has a lower emissions intensity (i.e., $MT\ CO_2e/MWh$) than the 2030 emissions factor used in the BAU emissions forecast analysis presented in the previous section. The result is that if SCE does achieve its proposed 2030 electricity factor, the City will experience even greater electricity emissions reductions than currently estimated in the BAU scenario. The net additional reductions from use of this new 2030 emissions factor were calculated based on the difference between the 2030 BAU forecast scenario and one in which SCE does achieve its proposed 2030 emissions factor.

PARTICIPATION ASSUMPTIONS

Because this scenario was analyzed as an alternative to the current BAU emissions forecast scenario, this action was quantified to assume that all Long Beach SCE customers would receive electricity with the provided 2030 emissions factor, unless they participate in the SCE Green Rate program or a solar PV installation program. Therefore, participation in this action is assumed to be 100%.

EMISSIONS FACTORS

SCE provided City staff with a proposed replacement 2030 electricity emissions factor of 0.1192 MT CO_2e/MWh, which is referenced throughout the remainder of this section.

SCE Green Rate Program

For purposes of the CAAP analysis, a scenario was evaluated in which the City of Long Beach encourages voluntary participation in the existing SCE 100% Green Rate program through which residential and commercial electricity customers fund solar energy development with 100% of their energy use. Participation in this program would provide a net GHG reduction beyond implementation of SCE's 80% carbon-free commitment described above.

PARTICIPATION ASSUMPTIONS

A review of the Sacramento Municipal Utility District's (SMUD) 2017 Annual Report[43] shows that 74,000 customers participated in the Greenergy program that provides 100% renewable electricity (comparable to SCE's 100% Green Rate program). The report notes that SMUD had 628,952 customer contracts in 2017 and 1,500,000 total customers. The report is unclear if the Greenergy participation reference to 74,000 customers uses that term in the same way as the total customer metric is reported, or if it more closely reflects the number of customer accounts. The different interpretations result in a Greenergy participation rate in 2017 that ranges from 4.9% to 11.8%.

For purposes of the CAAP, voluntary participation in the SCE Green Rate program was assumed to reach 10% by 2030 for residential and commercial customers (industrial customers were not included in this assumption). This could either be viewed as an approximate doubling of participation in SMUD's comparable program from 2017 (which would provide a decade of CAAP implementation to achieve that participation rate) or achieving slightly less participation than SMUD experienced in its comparable program in 2017.

Based on the stated participation assumptions above, Table 24 shows the resulting 2030 electricity demand by sub-sector and SCE rate program option.

Table 24 – Energy Demand Estimate by SCE Rate Option

Energy Sub-sector	2030 (MWh)	SCE Green Rate Participation	SCE Green Rate Energy Demand (MWh)	SCE Non-Green Rate Energy Demand (MWh)
Residential	833,316	10%	83,332	749,985
Commercial	763,936	10%	76,394	687,543
Municipal	108,264	0%	-	108,264
Industrial	1,562,987	0%	-	1,562,987

EMISSIONS FACTORS

As described above, the assumption is that participation would be in the 100% Green Rate program, which has an emissions factor of 0.0 MT CO_2e/MWh. The portion of electricity demand that is not covered by the 100% Green Rate program (as shown in Table 24) would be provided by SCE at its committed 2030 electricity rate of 0.1192 MT CO_2e/MWh.

[43] SMUD, *2017 SMUD Annual Report*. Available online: https://www.smud.org/-/media/About-Us/Reports-and-Statements/2017-Annual-Report/2017-Annual-Report.ashx

Mitigated Scenario Emissions

The combination of activity data shown in Table 24 with the emissions factors described above result in the mitigated scenario emissions shown in Table 25.

Table 25 – Mitigated Scenario Electricity Emissions

Energy Sub-sector	SCE Green Rate Energy Demand (MWh)	SCE 100% Green Rate Emissions Factor (MT CO_2e/yr)	SCE Non-Green Rate Energy Demand (MWh)	SCE Non-Green Rate Emissions Factor (MT CO_2e/yr)	Total Emissions (MT CO_2e/yr)
Residential	83,332	0.0	749,985	0.1192	89,408
Commercial	76,394	0.0	687,543	0.1192	81,964
Municipal	-	0.0	108,264	0.1192	12,906
Industrial	-	0.0	1,562,987	0.1192	186,328
Subtotal	**159,725**	**-**	**3,108,779**	**-**	**370,605**

The estimated reduction resulting from implementation of this action is calculated based on the difference between the BAU and mitigated scenarios and total approximately 188,960 MT CO_2e/yr (see Table 26).

Table 26 – Emissions Reduction

Energy Sub-sector	BAU Scenario Emissions (MT CO_2e/yr)	Mitigated Scenario Emissions (MT CO_2e/yr)	Emissions Reductions (MT CO_2e/yr)
Residential	142,664	89,408	53,256
Commercial	130,786	81,964	48,822
Municipal	18,535	12,906	5,628
Industrial	267,583	186,328	81,256
Total	**559,568**	**370,605**	**188,960**

Note: Total reduction value has been rounded for use in the CAAP.

BE-2 Increase Use of Solar Power

Participation Assumptions

Based on a review of Google's Project Sunroof dashboard, the City of Long Beach currently has 1,469 roofs with solar PV installations and a maximum coverage potential of 91,992 roofs (see Table 27). Therefore, approximately 2% of candidate roofs currently have solar. Project Sunroof also estimates that the average system size in Long Beach is 6.8 kW DC with 476 square feet of coverage, producing 10,400 kWh AC per year.

Table 27 – Long Beach Solar PV Data

	Value	Unit
Maximum Coverage Potential	91,992	Roofs
Existing Coverage	1,469	Roofs
% Current Coverage	2%	% of candidate roofs
Per Roof Estimates	6.8	kW DC
Average System Size	476	sq ft
Average Electricity Generation	10,400	kWh AC per year

Source: Google Project Sunroof for City of Long Beach, accessed February 2020

This action assumes that 5% of Long Beach's candidate roofs will have solar installations by 2030; or approximately double the current coverage. This means that more than 3,100 new solar systems would be installed, generating approximately 32,500 MWh of carbon-free electricity (see Table 28). To avoid double counting emissions reductions, this value of carbon-free electricity can be compared to the amount of electricity demand estimated in 2030 that will not be provided through the SCE Green Rate program (see Table 25). The net additional carbon-free energy provided through action BE-2 is approximately 1% of that total remaining energy demand.

Table 28 – Solar Action Implementation Assumptions

	Value	Unit
Roof Coverage by 2030	5%	%
New Installations	3,131	New Roofs
Generation per roof	10,400	kWh AC per year
Total Generation per year	32,562,400	kWh AC per year
Total Generation per year	32,562.40	MWh
BAU Scenario Electricity EF	0.1192[1]	MT CO_2e/MWh
Mitigated Electricity EF	0	MT CO_2e/MWh

[1] This emissions factor corresponds to the SCE 2030 commitment to provide 80% carbon-free electricity; see Action BE-1 description for further information.

EMISSIONS FACTORS

The electricity generated from solar PV systems is a carbon-free energy source for community CAAP planning purposes. The energy provided by these systems would offset purchases of SCE electricity. As shown above, Action BE-1 already estimates the GHG reductions associated with implementation of SCE's 80% carbon-free commitment by 2030. Therefore, this action is calculated to show the net marginal GHG reductions that result from avoiding using of SCE's 2030 electricity.

MITIGATED SCENARIO EMISSIONS

This action would provide net GHG reductions totaling 3,880 MT CO_2e/yr, as shown in Table 29.

Table 29 – Emissions Reduction

Action Electricity Generation (MWh)	BAU Scenario Emissions (MT CO_2e/yr)	Mitigated Scenario Emissions (MT CO_2e/yr)	Emissions Reductions (MT CO_2e/yr)
32,562	3,880	-	**3,880**

BE-6 Perform municipal energy and water audits

PARTICIPATION ASSUMPTIONS

Energy Efficiency
The City regularly takes action to implement energy efficiency improvements as part of standard business operations. The Public Works Department provided information on the primary electricity savings from efficiency improvement programs implemented since 2015, which were quantified for inclusion in the CAAP GHG reduction estimates:

- Street and park light retrofits – 1,538,927 kWh/yr
- Houghton Community Center window upgrades – 295 kWh/yr

The Public Works Department also committed to a reduction in natural gas use within City buildings and facilities of 5% below 2015 base year levels by 2030.

Renewable Energy Development
Public Works staff also provided information on the City's solar PV development programs, including use of power purchase agreements to implement additional solar installations. Table 30 shows the solar installation capacities evaluated in this CAAP action; this table also includes a 1 MW commercial solar program planned for installation by the Energy Department at Pier A West.

Table 30 – Municipal Solar Development Projects

Solar Location	kW Size
ECOC	238.5
Main Health Dept. Building	656
Public Works Yard	668
East Division Police Sub-Station	176
LBGO Headquarters	851
Airport Parking Garage (Lot B)	736
City Place Lot A	216
City Place Lot B	280
City Place Lot C	150
Pike Parking Structure	539
Aquarium Parking Structure	524
Convention Center	2,800
Pier A West	1,000
Total	**8,834.5**

The project team used the PV Watts calculator estimate the approximate electricity generation potential of the City's solar projects shown above. The calculation was performed using the default assumptions within the calculator based on the Long Beach Airport Garage location. Based on these assumptions, the City's 8,834.5 MW of solar development could generate 14,50,584 kWh/yr.

In addition to the solar development projects listed above, the Public Works Department is implementing two battery storage projects totaling 1,685 MWh of storage, and the Energy Department is evaluating and piloting gravity well potential energy storage systems at wellbore sites within the City's oil fields. Neither of these additional actions were included within this action evaluation but could demonstrate additional GHG reduction potential in future CAAP updates.

100% Carbon-Free Electricity

In CAAP action BE-1, the City has committed to purchasing 100% renewable electricity for all municipal accounts by 2030. The GHG quantification shown here assumes that all remaining municipal electricity demand following energy efficiency programs and solar development projects will be offset through participation in the SCE Green Rate program. Note that the action BE-1 quantification inputs above do not include municipal participation in the Green Rate program. GHG reductions related to 100% renewable municipal electricity are included here to illustrate all municipal energy reductions together.

Table 31 summarizes the BAU and mitigated scenario inputs for this action. The municipal energy demand is based on the City's 2015 municipal operations GHG inventory and assumes for CAAP action planning purposes that municipal energy demand does not increase in the future; municipal emissions are represented in inventory sector I.2, as described in Part I of this appendix, and therefore their potential emissions growth was included within the commercial sector energy growth forecasts.

Table 31 – BAU and Mitigated Scenario Inputs

BAU Scenario Energy Demand

	Value	Units	Emissions Factor	Unit	MT CO_2e
Electricity	108,264	MWh	0.1192	MT CO_2e/MWh	12,906
Natural Gas	787,878	therms	0.00532	MT CO_2e/therm	4,190
Subtotal	-	-	-	-	17,097

Mitigated Scenario - Energy Savings

	Value	Units	Emissions Factor		MT CO_2e
			BAU	Mitigated	
Solar Development	14,508	MWh/yr	0.1192	-	1,729
Energy Efficiency - electricity	1,539	MWh/yr	0.1192	-	183
Energy Efficiency - natural gas	39,394	therms	0.0053	-	210
Renewable Electricity Purchase	92,217	MWh/yr	0.1192	-	10,993
Subtotal					**13,116**

Emissions Factors

To avoid double counting with GHG reductions estimated in action BE-1, the electricity savings and solar development potential were multiplied by the SCE 2030 emissions factor that corresponds to its 80% carbon-free energy commitment. The natural gas emissions factor was derived from the 2015 municipal operations GHG inventory, dividing natural gas emissions by reported therms consumption.

Mitigated Scenario Emissions

Table 32 shows the mitigated scenario emissions and allocates the GHG reductions to energy efficiency, solar energy development, and carbon-free electricity purchases.

Table 32 – Mitigated Scenario Emissions by Source

Reductions Source	MT CO_2e
Energy Efficiency	393
Solar PV Development	1,729
Carbon-free Electricity Purchase	10,993
Subtotal	**13,116**

BE-8 Implement short-term measures to reduce emissions related to oil and gas extraction

Participation Assumptions

The Long Beach Energy Department committed to decrease oil production 20% below 2018 production volumes by 2030. In 2018, 11,158,706 barrels of oil (bbl) were produced in the city. This commitment would result in a 2030 production volume of 8,926,965 bbl. The CAAP emissions forecasts had assumed that 2018 production levels would remain constant based on year-over-year production declines. This was a conservative approach in that production has already been decreasing, but the forecasts did not assume continued declines beyond the last year for which empirical data was available at the time of analysis (i.e., 2018).

Emissions Factors

To estimate GHG reductions associated with decreased oil production, the project team calculated a per barrel emissions factor based on the 2015 GHG inventory oil industry emissions divided by the 2015 production volume. The emissions sub-sectors included in this analysis include I.4.1 and I.8.1 (see Part I of this appendix for further information).

Mitigated Scenario Emissions

Table 33 shows the inputs used to quantify this action.

Table 33 – Oil and Gas Emissions per Barrell

	Value	Unit
2015 Oil Production	13,321,018	bbl
2015 Oil-related Emissions	249,139	MT CO_2e/yr
2015 Emissions per Barrel	0.019	MT CO_2e/bbl
2030 Oil Production – BAU	11,158,706	bbl
2030 Oil Production – Mitigated	8,926,965	bbl
2030 Oil Production Reduction	2,231,741	bbl
2030 GHG Reductions	**41,740**	**MT CO_2e/yr**

T-1 Increase the frequency, speed, connectivity and safety of transit options

Participation Assumptions

This action assumes that implementation of transit system and ridership improvements will result in a 1% VMT reduction below 2030 BAU levels for light duty vehicles (gas and diesel).

Emissions Factors

Reductions from this action were calculated using the same methodology used to estimate GHG emissions for sub-sector II.1 On-Road Transportation. The project team re-ran the emissions forecast calculations based on VMT values that included a 1% reduction in gas and diesel VMT for light duty vehicles. Refer to Part I of this appendix for further detail on the on-road emissions quantification methodology.

Mitigated Scenario Emissions

As with the electricity actions described above, GHG reductions from this action were calculated as:

Emissions Reduction = (Business-as-Usual Emissions) – (Mitigated Scenario Emissions)

See Table 34 for outputs from this on-road emissions model analysis. This action is estimated to result in reductions of approximately 5,230 MT CO_2e/yr.

Table 34 – Action Quantification Inputs

	Value	Unit
VMT Reduction – LDV – gas and diesel	1	1%
2030 BAU – LDV Gasoline	2,390,410,729	VMT/yr
2030 BAU – LDV Diesel	25,468,434	VMT/yr
2030 BAU – LDV Gasoline and Diesel	522,835	MT CO_2e/yr
2030 Mitigated – LDV Gasoline	2,366,506,622	VMT/yr
2030 Mitigated – LDV Diesel	25,213,750	VMT/yr
2030 Mitigated – LDV Gasoline and Diesel	517,607	MT CO_2e/yr
Reduction	**5,228**	**MT CO_2e/yr**

T-4 Implement the Port of Long Beach Clean Trucks Program

Participation Assumptions

This action is based on implementation results for the Port of Long Beach Clean Trucks Program. The Clean Air Action Plan estimates GHG reductions from this action could range from 10-46% in 2031. The project team conservatively estimated the low-end of this range for use in quantifying GHG reductions.

The 2015 CAAP inventory did not have granular enough information from the on-road travel model to isolate VMT associated with Port truck activity. The project team used the diesel heavy-duty vehicle (HDV) on-road category as a proxy for Port trucking activity. The ratio of HDV VMT from the Port's 2015 Air Emissions Inventory was compared to the CAAP on-road VMT data to help scale the emissions reduction estimates. As shown in Table 35, the comparison of HDV VMT in these two inventories shows the Port value is approximately 8.2% lower than that assumed based on the community-wide on-road inventory. Since this action is quantified as a reduction in future GHG emissions, the community-wide diesel HDV emission were extracted from the on-road emissions inventory and normalized by multiplying by -8.2%. A 10% reduction in the 2030 diesel HDV emissions was then calculated to estimate the reduction potential of this action.

EMISSIONS FACTORS

The calculations were based on the emissions from the CAAP GHG inventory and forecasts. See Part I of this appendix for further information on how on-road emissions were calculated.

Table 35 – Action Quantification Inputs

	VMT	MT CO_2e/yr	
		2015	2030
Port Inventory - Diesel HDV on-road emissions	151,857,117	256,283	-
Community Inventory - Diesel HDV on-road emissions	164,234,998	230,181	274,876
Ratio (Port/Community Inventory)	-8.2%	-	-8.2%
Scaled Diesel Emissions (Estimate of Port's diesel HDV emissions in community inventory)	-	-	252,471
Clean Trucks Program – GHG Reduction Potential	-	-	10%
GHG Reductions	-	-	**25,250**

ADDITIONAL PORT EMISSIONS CONSIDERATIONS

In addition to the Clean Trucks Program quantified above, the Port of Long Beach has committed to achieve 100% emissions-free cargo handling equipment (CHE) by the year 2030. The city's 2015 GHG inventory estimated off-road vehicle and equipment emissions based on ARB's OFFROAD model (the most up to date program at the time), which did not include emissions associated with CHE. ARB's current offroad emissions model, Orion, does include CHE emissions, so future GHG inventories can accurately reflect this emissions source. The Port's 2015 Air Emissions Inventory estimated that CHE emissions totaled nearly 127,000 MT CO_2e/yr. The Port's ongoing GHG reduction actions will serve to fully reduce this emissions source by the 2030 CAAP target year.

The Port will also implement ARB's Ocean-Going Vessels At-Berth Regulation that will result in reduced fuel use by certain vessel types when at-berth in the Port of Long Beach. ARB has estimated that implementation of this regulation will result in emissions reduction totaling approximately 100,500 MT CO_2e/yr at the Port of Long Beach

Neither of these GHG reduction values is included in the CAAP's target achievement pathway because they both represent emissions sources that are not included in the city's jurisdictional production inventory. However, both actions demonstrate the ongoing commitment of the Port of Long Beach to identify and implement programs and actions that will reduce GHG emissions and improve local air quality.

T-5 Develop an Electric Vehicle Infrastructure Master Plan

Long Beach Airport is implementing programs to increase use of electric ground service equipment (GSE) to reduce emissions from gasoline- and diesel-powered equipment. Sufficient data was unavailable during CAAP development to estimate potential future reductions from these efforts. However, the Airport's 2031 BAU Emissions Inventory report estimates emissions from GSE will total approximately 2,559 MT CO_2e/yr. Future CAAP updates will monitor implementation of vehicle and equipment electrification programs citywide to understand if additional GHG reductions are occurring beyond those currently estimated within this appendix.

SOLID WASTE CALCULATIONS

The solid waste actions are calculated based on the methane commitment methodology equations described in the Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GPC), and replicated in Part I of this appendix. Specifically, the calculations follow Equation 8.3, and use the same default factors as described in Part I. The methodological descriptions of the actions included below describe the process for calculating other inputs needed in the GPC equation. Please refer to Part I of this appendix for a full description of the methane commitment method and its corresponding equations and default assumptions.

The solid waste disposal data from 2015 was used to estimate landfill disposal amounts by facility in 2030 (see Table 36). AECOM used the 2015 disposal data shown in Table 14 and converted from short tons to metric tons for use in the preceding equations. The rate of disposal, expressed as metric tons per service population (MT/SP), where service population is residents plus employees, was calculated based on 2015 values, and held constant to estimate future disposal values in the emissions forecasts.

Table 36 – Landfill Waste Disposal Forecasts

Year	Short Tons (ST)	Metric Tons (MT)	Service Population (SP) [3]	MT/SP [4]
2015	409,258 [1]	371,273 [2]	624,312	0.595
2030	-	388,167 [5]	652,721	0.595

Source: AECOM 2018

Notes: Service population (SP) = population and jobs

[1] See Table 13, landfill plus ADC volume

[2] 1.0 short ton = 0.9072 metric tons

[3] See Table 19 for demographic data sources

[4] Calculated for 2015 as MT/SP, and held constant for 2030

[5] Calculated as SP * (MT/SP)

For CAAP action planning purposes, the volume of waste disposal was further disaggregated into single-family residential, multi-family residential, commercial, and ADC. Table 37 shows the breakdown by land use type and treatment destination. The project team used the CalRecycle Waste Characterization Web Tool – Residential Waste Stream Data Export tool to evaluate the contribution of single-family and multi-family waste in Long Beach (values shown in Table 37). Single-family residential waste collected in the city is sent to SERRF for incineration; multi-family residential waste is sent to regional landfills as shown in Table 13. The project team then derived the commercial portion of the waste stream by subtracting the multi-family residential value from the total volume sent to landfills in 2015.

Table 37 – Landfill Waste by Type and Destination

CalRecycle Land Use Splits	Tons (ST)	Tons (MT)	Destination	Landfill Waste Ratio
Single-family Residential	71,963	65,284	SERRF	-
Multi-family Residential	49,413	44,827	landfill	12%
Commercial	228,292	207,103	landfill	56%
ADC	131,553	119,343	landfill - ADC	32%
Total (non SFR city hauled)	409,258	371,273	-	100%

The corresponding landfill waste ratio was applied to the total 2030 disposal forecast (see Table 36). Table 38 shows the modeled 2030 disposal tonnage by land use and type for use in the CAAP action quantification.

Table 38 – 2030 Landfill Waste Estimates

Land Use Splits	Disposal Value (landfill or ADC)	Units
Multi-family Residential	46,867	tons (MT)
Commercial	216,527	tons (MT)
ADC	124,773	tons (MT)
Total	388,167	tons (MT)

W-1 Ensure compliance with state law requirements for multifamily and commercial property recycling programs

PARTICIPATION ASSUMPTIONS

This action would increase paper and cardboard recycling in the multi-family residential and commercial waste streams to reduce waste in these categories 75% below the 2030 estimated levels.

EMISSIONS FACTORS

To model emissions reductions, separate multi-family residential and commercial hypothetical landfill profiles were developed. This allowed each CAAP action to be applied differently based on land use type. The same methane commitment calculation inputs were used as described in Part I of this appendix. A weighted landfill methane collection factor was calculated based on the estimated 2030 waste disposal volume by landfill facility and the methane collection rates shown in Table 14. The resulting weighted methane collection rate was 77.61% for landfills that received Long Beach waste in 2015.

MITIGATED SCENARIO EMISSIONS

Tables 39 and 40 show the modeled 2030 multi-family and commercial landfill emissions by waste type based on the methane commitment methodology calculations described in Part I. The total landfill waste weight by composition correspond to the values shown in Table 38. This action would divert 75% of the paper/cardboard waste tonnage away from landfills, and therefore avoid 75% of these estimated future emissions. Reductions would total 7,461 MT CO_2e/yr from the multi-family sector, and 37,873 MT CO_2e/yr from the commercial sector; total reductions from this action are estimated to be approximately 45,340 MT CO_2e/yr.

Table 39 – 2030 Multi-family Residential Landfill Emissions

Waste Type	Landfill Waste Composition (Weight)	DOC Content in Waste	GHG Emission (Methane)	GHG Emission (MT CO_2e)
Paper/Carboard	11,019	40.0%	355	9,949
Textiles	3,785	24.0%	73	2,050
Food	11,609	15.0%	140	3,931
Garden and Park	5,268	20.0%	85	2,378
Wood	2,228	43.0%	77	2,163
Rubber and Leather	0	39.0%	0	0
Plastics	5,162	0.0%	0	0
Metal	1,657	0.0%	0	0
Glass	1,402	0.0%	0	0
Other	4,736	0.0%	0	0
Total	**46,867**		**731**	**20,470**
W-1 Paper/Cardboard Reduction				
75%				**7,461**
W-3 Food / Garden and Park / Wood Reduction				
75%				**6,354**

Table 40 – 2030 Commercial Landfill Emissions

Waste Type	Landfill Waste Composition (Weight)	DOC Content in Waste	GHG Emission (Methane)	GHG Emission (MT CO_2e)
Paper/Carboard	55,930	40.0%	1,803	50,498
Textiles	9,751	24.0%	189	5,282
Food	53,648	15.0%	649	18,164
Garden and Park	25,225	20.0%	407	11,388
Wood	15,409	43.0%	534	14,956
Rubber and Leather	48	39.0%	2	42
Plastics	26,210	0.0%	0	0
Metal	7,662	0.0%	0	0
Glass	4,910	0.0%	0	0
Other	17,732	0.0%	0	0
Total	**216,527**		**3,583**	**100,330**
W-1 Paper/Cardboard Reduction				
75%				**37,873**
W-3 Food / Garden and Park / Wood Reduction				
75%				**33,381**

W-3 Partner with private waste haulers to expand organic waste collection community-wide

PARTICIPATION ASSUMPTIONS

This action would increase organic waste diversion in the multi-family residential and commercial waste streams to reduce waste in these categories 75% below the 2030 estimated levels.

Note that a similar action is included in the CAAP for single-family residential waste (action W-2). However, single-family waste is processed at SERRF and its corresponding GHG emissions are excluded from the CAAP for GHG target achievement purposes (see Part I of this appendix for further information on this). Therefore, GHG reductions are not estimated for W-2 since the corresponding emissions are not included in the jurisdictional production inventory.

EMISSIONS FACTORS

The same approach to action quantification as described in W-1 was taken for this action.

MITIGATED SCENARIO EMISSIONS

Tables 39 and 40 included above with action W-1 also highlight the reductions associated with this action. Each table shows a GHG reduction value from diverting 75% of the food, garden and park, and wood waste tonnages away from landfills, therefore avoiding 75% of these estimated future emissions. Reductions would total 6,354 MT CO_2e/yr from the multi-family sector, and 33,381 MT CO_2e/yr from the commercial sector; total reductions from this action are estimated to be approximately 39,730 MT CO_2e/yr.

W-4 Identify organic waste management options

PARTICIPATION ASSUMPTIONS

This action would ensure that 50% of ADC disposal volume by 2030 consists of non-green waste materials to avoid landfill emissions generation from organic material. It assumes the remainder of ADC waste would be composed of inert materials that would not generate landfill emissions.

EMISSIONS FACTORS

To model emissions reductions, a separate hypothetical ADC landfill profile was developed, as with action W-1 and W-3 described above. The same methane commitment calculation inputs were used as described in Part I of this appendix. A weighted landfill methane collection factor was calculated based on the estimated 2030 waste disposal volume by landfill facility and the methane collection rates shown in Table 14 for those facilities that received ADC waste in 2015. The resulting weighted methane collection rate was 74.87% for landfills that received Long Beach ADC waste in 2015.

As described in Part I of this appendix, the project team conservatively assumed that 100% of ADC waste disposed by the city was green waste and therefore allocated the tonnage to the garden and park material category and corresponding DOC factor. It is likely that some or all of the ADC waste was inert materials that would not decompose to generate landfill emissions, and therefore the city's solid waste emissions could be lower than estimated in the inventory and forecasts. New ADC tracking data provided by CalRecycle that was unavailable during inventory preparation shows that a relatively minor portion of Long Beach's ADC consists of green waste. Based on the *2018 CalRecycle Disposal Reporting System Green Material Alternative Daily Cover Tonnages by Jurisdiction* report, only 13.37 tons of Long Beach ADC volume was identified as green waste. This represents 0.01% of the reported 2015 ADC volume from the city. Therefore, this action's assumption that 50% of ADC waste would be non-green waste materials by 2030 is highly plausible and still a reflects a conservative estimation of the corresponding GHG reductions from this action (i.e., since nearly 100% ADC emissions reductions might be supported given the very low current use of green waste as an ADC material by the city).

MITIGATED SCENARIO EMISSIONS

Table 41 shows the modeled 2030 ADC landfill emissions by waste type based on the methane commitment methodology calculations described in Part I. The total landfill waste weight by composition correspond to the values shown in Table 38. This action would divert 50% of the garden and park waste tonnage away from landfills, and therefore avoid 50% of these estimated future emissions. Reductions would total approximately 31,610 MT CO_2e/yr.

Table 41 – 2030 ADC Landfill Emissions

Waste Type	Landfill Waste Composition (Weight)	DOC Content in Waste	GHG Emission (Methane)	GHG Emission (MT CO_2e)
Paper/Carboard		40.0%	0	0
Textiles		24.0%	0	0
Food		15.0%	0	0
Garden and Park	124,773	20.0%	2,258	63,217
Wood		43.0%	0	0
Rubber and Leather		39.0%	0	0
Plastics		0.0%	0	0
Metal		0.0%	0	0
Glass		0.0%	0	0
Other		0.0%	0	0
Total	124,773		2,258	**63,217**
W-4 Garden and Park Waste Reduction – ADC Green Waste				
50%				**31,609**

Appendix B Adaptation and Mitigation Actions - Additional Context

ADAPTATION ACTIONS

This section provides additional context for each of the adaptation actions found in Chapter 4.

EXTREME HEAT ACTIONS

Action Number	Action Title	Additional Context
EH-1	**Increase presence of cool roofs and cool walls**	Cool roofs are required under the California Green Building Code if the building is to achieve Tier 1 or Tier 2 compliance. However, under Part 6 of the Energy Code, any building will get compliance credits against the baseline building if it has a cool roof. Both the City and County of Los Angeles have made cool roofs mandatory for new and replaced residential roofs. Growing a vegetative layer (plants, shrubs, grasses, and/or trees) on a rooftop can also act as a cool roof, providing insulation to the building below. Due to seismic considerations, these green roofs, which can be heavy due to thick layers of substrate material, can only be sited on steel-reinforced buildings and are significantly more costly than cool roofs. As a result, cool roofs are generally accepted as a more cost-effective approach to reducing the heat island effect than green roofs, but both options should be allowed based on the local context. Despite this, green roofs can potentially offer important co-benefits, such as increased green space and local food production, which can be especially important in low-income communities that lack access to both. It is expected that candidate buildings in these communities may not be able to support green roofs; however, the City will conduct a study to assess the feasibility of green roofs in these areas.
EH-2	**Increase the presence of reflective streets, cool surfaces, and shade canopies**	One effort that is generally reflective of this approach is already underway. The City received a Southern California Association of Governments grant for the Washington Neighborhood to engage the community in the development of an urban greening and cool street plan that will include recommendations for cool street design standards and an implementation and funding framework. LBUSD is also installing solar shade structures over parking lots and playgrounds at school sites. Pilot cool street projects in the city of Los Angeles and elsewhere in the world have been well received. Since hotter temperatures result in more ozone and smog formation, installation of cool pavement is an effective way to improve local air quality. Children are particularly vulnerable to respiratory disease due to poor air quality, and so targeting playgrounds for cool pavement applications could deliver important public health benefits. Likewise, parking lots are a cost-effective location for cool pavement, since slow vehicle speeds mean that the reflective coating will have a longer durability on parking lots than it would on high-volume, high-speed streets that receive more wear-and-tear. As long as the reflectivity of the cool street does not exceed 50 percent, glare has not proven to be an issue of concern.

EH-3	**Enhance and expand urban forest cover and vegetation**	Long Beach's 2016 Draft Urban Forest Management Plan[i] includes goals and policies to protect, preserve, and enhance Long Beach's urban forest. The plan led to the development of the Urban Forestry Program, a collaboration between neighborhood associations, community groups, and the Neighborhood Services Bureau, which uses Federal Community Development Block Grant and State Funds to plant trees across the city. Since the 2016 plan was enacted, the Urban Forest Program has planted 10,000 trees across Long Beach.[ii] The City will continue to implement the Urban Forest Management Plan, which includes a goal to ensure the fair provision and distribution of urban forest services. This action also entails increasing the urban forest citywide by an additional 20,000 trees. A healthy urban forest and vegetation can reduce urban heat island conditions. They can also reduce the runoff augmenting existing stormwater management systems, and thereby increase system capacity during intense storm events and improve water quality. Particular emphasis should be placed in selecting drought-tolerant plants or California natives, whose benefits include reducing the urban heat island effect, increasing habitat due to the large canopy they offer fauna, providing drought-tolerant habitat, and establishing quickly and requiring little water once established.
EH-4	**Install additional water fountains and take other actions to increase public access to water**	As average temperatures and the number of extreme heat days and warm nights increase over the coming decades, an accessible public water supply will become increasingly important. At parks, schools, public buildings, and other facilities, water fountains are a valuable public resource for improved public health. This approach of installing public water fountains and engaging in public education surrounding plastic pollution has been adopted in other cities (e.g., the "Refill London" campaign in the United Kingdom). Plastic pollution remains in the environment and eventually finds its way into rivers, wetlands, and oceans, where it has long-term negative impacts on ecosystems and organisms. The negative impacts from plastic bottles are not just limited to pollution. Manufacturing and recycling plastic bottles also requires substantial energy and produces GHG emissions. In addition, despite sustained efforts to increase recycling rates, the vast majority of plastic bottles end up in landfills and the natural environment. In contrast, the Long Beach Water Department delivers high-quality water at the tap or water fountain at a fraction of the cost (and carbon footprint) of bottled water and safeguards water quality by continuously sampling and testing the city's drinking water throughout the water distribution system.

EH-5	**Identify future vulnerability potential for power outages related to extreme heat and develop plans to prevent such outages**	Actions to enhance resiliency to be considered could include the creation of microgrids focused on vulnerable and/or critical areas to allow localized electricity service to continue in the event of an outage. The City could also work with SCE to expand their current efforts on expanding energy storage. SCE is planning to connect almost 750 megawatts of energy storage to the grid by 2024, which would provide reliable backup systems for power outages. This program also focuses on expanding renewable energy storage by providing incentives for low-income customers that are already a part of their multifamily solar programs. This would both reduce strain on the grid and provide reliable power to vulnerable communities. In July 2015, high temperatures may have been a factor in equipment failures that caused two powers outages in downtown Long Beach. These outages left thousands of residents and businesses without power for days and stranded people without medical devices, refrigeration, air conditioning or elevator service during a period of high temperatures. This was particularly challenging for seniors living in high-rise apartments (KPCC 2015[iii]). Since 2015, SCE has been involved in national efforts to accelerate the development of and investment in technologies, practices, and policies that will create a more resilient energy system. As a part of these efforts, SCE analyzed its system, using future climate models to better understand how to prepare for changes in its environment.
EH-6	**Enhance and expand accessibility of cooling centers**	There are 13 community centers and 12 libraries in Long Beach, with 15 cooling centers in the most disadvantaged areas (CalEnviroScreen). In the Long Beach CAAP survey, 58.5 percent said they remained indoors during heat advisories and 29 percent of respondents said they visited air-conditioned areas such as cooling centers or malls. Certain populations, such as the homeless, outdoor workers, older adults, young children and infants, pregnant women, and people with chronic illnesses, are more susceptible to warmer temperatures and heat-related illnesses. In order to protect these populations, a strong and expansive network of cooling centers is important to making Long Beach more adaptive and resilient to the threat of extreme heat.
EH-7	**Provide bus shelter amenities**	There are public and private funding options for these improvements. For example, Long Beach Transit has used some of its Low Carbon Transit Operations Program, which is funded by cap-and-trade revenues, to upgrade bus stops and shelters. Advertising companies will often install and maintain street furniture in exchange for the right to place advertisements on them at little or no cost to cities. Residents and businesses may request, through their City Council office, that bus stop amenities be installed.

AIR QUALITY ACTIONS

Action Number	Action Title	Additional Context
AQ-1	**Incentivize installation of photocatalytic tiles**	There are a growing number of photocatalytic tile products on the market. These are increasingly embedded into cool-roofing products, representing an opportunity to actively reduce air pollution and temperatures. The City will actively pursue grant funding options to incentivize installation of these tiles and will prioritize neighborhoods and communities near the Port and the I-710 corridor that are heavily impacted by air pollution. Several of California's cap-and-trade programs prioritize funding projects in disadvantaged and low-income communities that reduce energy use and GHGs from building end uses. Integration of photocatalytic products into building energy efficiency projects, affordable housing developments, and similar projects could result in meaningful air quality co-benefits. In addition, in response to AB 617 (the Community Air Protection Program), air districts are tasked with working with identified impacted communities to identify projects to reduce exposure to air pollution. In 2018, West Long Beach (extending all the way to Cherry Avenue) was selected as one of the initial focus communities. The City will support the inclusion of photocatalytic tiles in projects located in areas of the city that are heavily impacted by pollution. This will include collaborating with SCAQMD, community partners, developers, and other stakeholders to identify projects that could become a component of projects that seek to more holistically address GHG and/or air quality emissions reductions with other amenities such as solar. In addition, the City will work with SCAQMD to quantify air pollutant reductions for any projects that implement photocatalytic tiles.
AQ-2	**Encourage urban agriculture practices that reduce air quality pollution**	Educational and training opportunities for drought-tolerant urban agriculture may be conducted in conjunction with the Lawn-to-Garden program and may include holding free urban gardening workshops at community gardens, such as the gardens at the Michelle Obama and Mark Twain libraries. Education and outreach could include demonstration plots, soil conservation practice trainings, drip tape irrigation trainings, and other materials on relevant urban agriculture water conservation practices. These trainings could also be expanded to other locations in the city, especially to low-income areas to allow for more equitable attendance.

AQ-3	**Support the development of the Long Beach Airport Sustainability Plan**	Long Beach Airport is working on a Sustainability Plan that will include an evaluation of areas where the airport can improve existing programs or introduce new programs. Longer term, as technologies evolve, there is likely to be an increasing number of opportunities to support the integration of electric airplanes into Long Beach Airport's fleet. Regional flights are expected to be the strongest candidates for integration. For longer flights requiring jet fuel planes, the City will work with airlines to further promote their existing carbon offset programs
AQ-4	**Electrify small local emitters, such as lawn and garden equipment, outdoor power equipment, and others**	At least 50 cities across the state already have some sort of regulation on lawn and garden equipment. Small off-road engines are spark-ignition engines that produce less than 19 kilowatts gross power (and less than 25 horsepower). They are primarily used for lawn, garden, commercial utility, and other outdoor power equipment. Unfortunately, small off-road engines that use gasoline or diesel contribute greatly to local air pollution. According to CARB, in 1 hour, a traditional lawn mower can emit as much smog-forming pollution as the best-selling passenger car driven 300 miles – approximately the distance from Los Angeles to Las Vegas. A traditional leaf blower in 1 hour of operation emits smog-forming pollution comparable to driving about 1,100 miles, which is approximately the distance from Long Beach to Denver. Local governments, commercial landscapers, school districts, colleges, nonprofits, and residents are eligible to participate in the SCAQMD Electric Lawn and Garden Equipment Incentive and Exchange Program and Residential Lawn Mower Rebate Program. One equivalent operable gasoline- or diesel-powered piece of lawn and garden equipment must be scrapped to receive incentive funding to purchase an electric-powered equipment. Furthermore, SCAQMD is prioritizing funding in disadvantaged communities (CalEnviroScreen). The City can also apply for incentives to transition its own fleet of equipment. In addition, the City will identify strategies to accelerate the transition in disadvantaged communities and assist landscaping workers to transition with a reasonable cost. A voucher program would be one example of such a strategy.
AQ-5	**Work with LBUSD to support school bus electrification**	The negative effects of using diesel-powered school buses are well documented. Pollution levels inside school buses are greatly affected by the bus's own exhaust and early childhood exposure to higher concentrations of particulate matter affects lung development and can cause respiratory health effects later in life. Transitioning diesel-powered buses to electric power will have positive, long-term public health impacts for children.

		There is a significant amount of funding available from state sources such as the Hybrid Voucher Incentive Program and the Volkswagen Mitigation Environmental Trust (administered through CARB), Prop 39: School Bus Replacement Program (administered through the California Energy Commission) and the Carl Moyer Program and AB 617 Community Air Protection Funds (administered through SCAQMD). The eligible costs for these funds include lower emission or zero-emission school buses, electric charging infrastructure, and workforce training and development. Most of the programs prioritize disadvantaged communities (CalEnviroScreen).
AQ-6	**Implement the San Pedro Bay Ports Clean Air Action Plan**	The Port of Long Beach is a major hub for global, national, and regional trade. Port emission sources include ocean-going ships, harbor craft, cargo equipment, trains, and trucks. While these sources have historically relied on diesel fuel, there is an increasing number of options that are available and being deployed to reduce both GHG and air quality emissions. These include plugging ships into shore power while they are docked, reducing ship speeds, encouraging clean and alternative-fuel trucks, using more efficient locomotives, furthering the use of hybrid and electric cargo equipment and harbor craft, increasing energy efficiency and renewable power generation, investing in infrastructure to increase efficient movement of cargo, and continuing implementation of a Clean Trucks Program. The Ports of Los Angeles and Long Beach originally adopted the San Pedro Bay Ports Clean Air Action Plan in November 2006 and updated the plan in 2010. Since its adoption, the plan has guided aggressive strategies that have been effective in reducing air pollution from port-related sources. In June 2017, Mayor Eric Garcetti of the City of Los Angeles and Mayor Robert Garcia of the City of Long Beach announced a joint declaration for creating a zero-emissions goods movement future – with ultimate goals of zero emissions for cargo handling equipment by 2030 and zero emissions for on-road drayage trucks serving the ports by 2035.

DROUGHT ACTIONS

Action Number	Action Title	Additional Context
DRT-1	**Continue development and implementation of water use efficiency programs and implement additional water conservation programs**	Long Beach is located in the semi-arid region of Southern California, which relies on imported water, delivered via a process that uses 20 percent of the state's electricity. Conserving water and increasing water use efficiency is imperative to reducing costs and resource usage now, while increasing water supply sustainability and resiliency for the future. In an effort to increase water use efficiency, the State of California enacted AB 1668 and SB 606 in 2018, bills that emphasize the efficiency of water use and efforts to maximize existing water supplies. The legislation sets an initial limit for indoor water use of 55 gallons per person per day in 2022 and gradually drops to 50 gallons per person by 2030. This legislation is not imposed upon individual citizens, but instead upon urban water suppliers. The Water Resources Plan helps Long Beach move forward with water use efficiency programs that will ensure the 2030 target is met. Existing water use efficiency programs will change to help increase
DRT-2	**Enhance outreach and education related to water conservation**	The City has made significant strides through the initiation of a number of programs to respond to drought and meet and exceed state water use efficiency targets. This includes successful public outreach and education efforts to residents and businesses to conserve water. It also includes programs such as the L2G program, which provides incentives to transform lawns to drought-resistant gardens. In addition, the Long Beach Water Department has a user friendly, interactive website that features a variety of water conservation educational materials and programming that can be further built upon to enhance the use of various water conservation opportunities. Long Beach has water restrictions and seasonal watering day rules in effect. As noted in DRT-1, AB 1668 and SB 606 set limits on per capita daily water use that are gradually reduced over time. Although these limits are imposed on the water suppliers' end users, such as households and businesses that have a role to play in reducing water consumption. Education about choices and behaviors can go a long way to meeting citywide water conservation goals. Water conservation also has meaningful cost savings potential that will continue to be a core part of the Long Beach Water Department's ongoing efficiency outreach and education.

DRT-4	**Expand usage of recycled water and greywater for non-potable use**	The City's Water Reclamation Plant recycles up to 25 million gallons of wastewater per day for reuse. The water is used at more than 60 sites for uses such as irrigation, replenishment of groundwater supply and protection from saltwater intrusion, and repressurization of oil-bearing strata off the coast. Water that is not used is discharged to Coyote Creek. To establish a more diverse and sustainable water supply, the City will identify ways to increase the supply and use of recycled water. The City could expand upon the "Laundry to Landscape" pilot program that took place in 2012-2013 for greywater irrigation from washing machines. Proposition 68, Measure W, and Proposition 3 include funding that is potentially available for water infrastructure. Rebates and incentives are available through MWD.
DRT-5	**Incorporate increased rainfall capture and other actions to maximize local water supplies and to offset imported**	Some California cities have or are modifying construction codes to require new commercial developments to use recycled water from rainwater harvesting for irrigation and toilets. In addition, several California municipalities are harvesting rooftop rainwater for direct on-site indoor uses in city facilities, such as toilet and urinal flushing. California municipalities are also diverting water from the storm drain pipes and storing and treating the water for irrigation of adjacent park landscaping and for toilet flushing. Currently, residential rebates for rain barrels are available to Long Beach residents through the MWD. In addition, the City of Long Beach Office of Sustainability offers free classes on rainwater harvesting.

SEA LEVEL RISE AND FLOODING ACTIONS

Action Number	Action Title	Additional Context
FLD-1	**Update the floodplain ordinance**	As a participant in the FEMA National Flood Insurance Program, the City already enforces a minimum design standard for the base flood elevation for first floor building elevations (Chapter 18.73 [Flood-Resistant Design and Construction] of the City's Building Code). Many areas of the city adjacent to the coastline, inlets, or canals are currently located in FEMA-designated flood hazard areas. The Harbor District, neighborhoods surrounding Alamitos Bay, Belmont Shore, Lower Westside, and the Shoreline Marina are identified as vulnerable to a 100-year flood event based on existing conditions. Areas of the city identified as vulnerable to a 500-year flood event are significantly more expansive, and they include North Long Beach, Sunrise, Hamilton, Freeway Circle, Upper Westside, Arlington, Marina Pacifica, El Dorado South, South of Conant, Lakewood Village, and Los Altos neighborhoods. Although building codes can improve the chances that a structure will survive an extreme storm, additional regulation may be necessary to ensure adequate flood protection for the area. In updating the Floodplain Ordinance, addressing the city's flood risks will be emphasized, and regulations and programs to promote long-term flood resilience for buildings located in the floodplain will be introduced. The updated ordinance will include incentives for building owners to invest in resiliency improvements by either meeting or exceeding flood-resistant construction standards, even when they are not required by FEMA or the City's Building Code. Incentives will include City-led pursuits of FEMA grants to subsidize floodproofing and elevating properties as well as the removal of regulatory obstacles to incorporate resiliency standards in design. The City will consider recommending accommodation strategies, such as elevation, before construction of hard protective structures. This precautionary approach will help make buildings safer in the long term, and will thus decrease the risk of future property damage. By exceeding minimum FEMA floodplain requirements, the City may also reduce flood insurance premiums through FEMA's Community Rating System.
FLD-2	**Incorporate sea level rise language into citywide plans, policies, and regulations**	Mainstreaming sea level rise adaptation into planning and decision-making processes requires a coordinated, citywide effort. However, most decision-making responsibilities are allocated to specific functional areas or departments and follow relatively codified procedures, particularly where specialized knowledge is required. In general, city planning documents fall into two high-level categories: overarching planning documents and design guidelines. To help meet the City's goal of enhancing resilience to future climate conditions, language addressing sea level rise

		impacts will be added to both types of documents. Overarching documents, such as the General Plan, are high level and focus on the City's priorities. It is particularly important to influence overarching plans that aim to enhance the capacity and performance of operations and assets, often with a longer-term, strategic perspective. These documents provide an opportunity to introduce, coordinate, and generate knowledge, and to present a vision of long-term resilience. Design guidelines, such as design standards for capital projects, are detailed and provide guidance to technical practitioners. Existing building codes and minimum design standards are primarily based on historical weather data that do not account for changing climate conditions, such as the increasing frequency and magnitude of coastal flood events. Updating design criteria to consider future sea level rise conditions is a critical step toward integrating resilience as a core principle into the design of City infrastructure and facilities. Updating prevailing design guidelines, standards, and specifications allows the City to evaluate the risk tolerance of city assets and guides project design. Prioritizing the updating of design guidelines is particularly important to ensure opportunities to influence the construction or major renovation of assets with a long design life (e.g., bridges, stormwater infrastructure, seawalls, etc.).
FLD-3	**Establish a flood impacts monitoring program**	The flood impacts monitoring program can play an important role in monitoring the physical impacts of flooding over time, the associated costs, and the effectiveness of existing adaptation strategies, and in identifying the need for new adaptation strategies. In addition, the citizen monitoring component will connect residents with city officials and emergency managers, providing a firsthand look at flood risks throughout the city. This uploaded data collected by residents can be geolocated and added to a map interface that is viewable by the public. During the event, the real-time data are useful for emergency managers and may improve response times. Following the event, the City can review the information to address flooding hot spots and to monitor the effectiveness of implemented flood adaptation strategies.
FLD-4	**Incorporate adaptation into City lease negotiations**	The City will leverage its position as a lessor to incentivize and/or require adaptation actions for tenants who use City-owned buildings or land through lease agreements. Because some City-owned properties are located in areas vulnerable to flood exposure, adding flood adaptation requirements into lease negotiations will provide enhanced flood resilience for tenants and may avoid adverse environmental impacts. City leases also provide a vehicle

		to include adaptation strategies that will address extreme heat, air quality, and drought, and achieve GHG reduction co-benefits. A guidance document will be developed to assist City staff in understanding the key terms used to evaluate future climate impacts and in making informed decisions regarding lease permits. Project examples and an internal checklist for staff reviewing applications will also be included.
FLD-5	**Update the City's existing Stormwater Management Plan**	The Stormwater Management Plan includes an inventory of stormwater assets, field investigations, hydraulic modeling, and recommendations for capital improvements and expanded inventory data collection and maintenance programs. Its stated primary purpose is to protect water quality by preventing pollutant discharges to receiving waters. Updating the Stormwater Management Plan will include developing an up-to-date hydrological and hydraulic model of the City's major watersheds that includes new information regarding changes in climate and rising tides. This will help the City better understand how its infrastructure will perform under changing storm scenarios. The updated Stormwater Management Plan will also evaluate the invert elevations of stormwater outfalls located in tidally influenced areas and the existing capacity of the system to convey and drain excess stormwater.
FLD-6	**Conduct citywide beach stabilization study**	The goal of evaluating multiple scenarios for beach nourishment is to determine an effective adaptive management approach in dealing with spatial alongshore variation and high erosion or deposition that routinely occurs in nourished beaches. Ideally, a beach nourishment project will respond to seasonal changes in wave and current conditions, but is designed so the shoreline fluctuations remain relatively stable for the duration of the project design life. However, nourishment material is dynamic by nature, will be affected by large storm events and changing water levels, and will require periodic maintenance.
FLD-7	**Review and conduct studies of combined riverine/ coastal flooding and increased severity of rainfall events on watershed flooding**	While existing 100-year floods occurring along the primary riverine waterways in Long Beach are contained within their channels by existing levees, overtopping risk could be exacerbated in the future by a combination of sea level rise and increased intensity of precipitation. With more intense precipitation events projected as a result of climate change, increased peak flows into major drainage channels (the Los Angeles River, Los Cerritos Channel, and the San Gabriel River) could cause overtopping of levees that were previously adequate. In addition, as sea levels increase, the zone of tidal influence will move further up the channels. If a major precipitation event coincides with a high tide, floodwaters will not be able to discharge the channels as quickly, which could result in overtopping at the riverine/coastal interface.

		Reliable modeling on how riverine floodplains will be impacted by changes in extreme precipitation patterns and sea level rise does not exist for Long Beach. For this CAAP, asset exposure to riverine flooding was assessed based on location within FEMA's
FLD-8	**Enhance dunes**	Sand dunes are formed naturally when sand or sediment blown by wind accumulates against an obstacle, generally vegetation. Healthy dune systems rely on the root systems of dune grasses and other vegetation to maintain their shape. Currently, the City of Long Beach operates a beach grooming program along Belmont Shore Beach. While grooming helps maintain the pristine appearance of the beach, flattening the sand each day prevents dunes from forming naturally, and clearing the buildup of seaweed deprives beach vegetation of an important source of nutrients. Due to the lack of natural dunes, the City currently engineers sand berms each year to provide protection for adjacent communities from seasonal swells. However, because these berms do not have vegetation holding them together, they are eroded by tides and wave action each year and need to be replaced. By implementing a comprehensive active dune enhancement program as part of an adaptive management approach that includes actions such as beach nourishment, the City will enable the growth of sand dunes as natural coastal protection along beaches that do not have a bluff behind them. The City will pursue dune options that are best suited for the physical characteristics of the shoreline. For example, the southeastern tip of Alamitos Peninsula is characterized by a narrow beach that currently experiences significant seasonal erosion and may not be wide enough to support a natural dune. Alternative options (e.g., a hybrid dune/revetment feature and sand management strategies to keep sand in place) will be considered for this location.
FLD-9	**Inventory and flood-proof vulnerable sewer pump stations**	One of the City's priorities in the coming years will be enhancing the adaptive capacity of its wastewater infrastructure to increase the system's resilience to flood damage. Many of the City's pump stations are located in or near areas at risk of flood exposure and power outages, such as Belmont Shore and Naples, and areas around the Shoreline Marina in downtown. Pump stations rely on an uninterrupted power supply to maintain operation. A power failure may cause sewage overflows and backups may result. Because the likelihood of flooding will increase over time with sea level rise, the City will implement protective measures through capital projects to reduce flood damage for pump stations identified as vulnerable to future flood conditions. As an initial step, the City will perform a detailed inventory of all pump stations identified as vulnerable to future flooding. The inventory will include updated information for critical electrical

		and mechanical components (e.g., elevation, condition, age) and entryway elevations that could serve as a flood pathway. For pump stations identified as vulnerable to flooding, the City will implement protective measures (such as floodproofing techniques and adding emergency generators to ensure uninterrupted power) through capital projects to reduce flood damage for pump stations identified as vulnerable to future flood conditions. Flood adaptation strategies are likely to vary for each pump station, depending on local conditions (e.g., space constraints, cost-effectiveness, station criticality, projected flood depth). Potential floodproofing strategies may include the following: elevating pump housing entryways, sealing the building and entryways to projected flood depth, elevating electrical equipment, or replacing an existing pump with a submersible pump. All vulnerable pump stations should also be equipped with a flood-proof backup generator to maintain operability even during storm-induced power outages. If floodproofing techniques are not possible due to the configuration or location of components, the entire pump station may need to be relocated.
FLD-10	**Relocate/ elevate critical infrastructure**	To maintain essential assets and services for the economy, society, and health of the public, the City will identify critical assets vulnerable to sea level rise and either relocate them or incorporate protective adaptation measures to ensure assets can continue to maintain their functionality. The Ocean Protection Council's March 2018 State of California Sea Level Rise Guidance recommended consideration of the H++ scenario, subsequent studies on urban/ riverine flooding recommended by the CAAP, and other identified relevant emerging information will be used to assess each facility's exposure to flooding, including the expected timing of flood risk. For example, facilities such as the fire stations in the Harbor District and in Belmont Shore and police stations in West Long Beach that need to remain in operation during or immediately following a flood event may be flood-proofed using a temporary barrier that is deployed prior to the storm event to provide protection of the facility during the storm. Other facilities such as Naples Bayside Academy and Charles F Kettering Elementary may also incorporate barriers, consider elevating or relocating the school, improve site stormwater drainage capacity, or raise electrical equipment in anticipation of future exposure. In cases where it is not feasible to relocate critical facilities outside of the flood vulnerability area, the City will prioritize regrading facility access roads so that they are above the projected flood elevation. As an added precaution, all critical facilities located in areas vulnerable to future flooding will be required to complete a continuity plan that describes appropriate design interventions necessary to maintain operation during or after flood events.

FLD-11	**Elevate riverine levees**	Based on the results of FLD-07 (a study of increased watershed flooding due to climate change), portions of existing levees adjacent to the City's channels and rivers (Los Angeles River, Los Cerritos Channel, and San Gabriel River) may need to be elevated or modified to provide enhanced flood protection. Consequences assessed should include the number of residents and businesses, as well as critical facilities and transportation assets within each flood path. Multipurpose infrastructure can also improve the urban ecosystem and enhance living conditions for local communities. Complementary riverine modification projects may also include channel widening or watershed restoration, which would likely further enhance habitats and recreation co-benefits.

MITIGATION ACTIONS

This section provides additional context for each of the mitigation actions found in Chapter 6.

BUILDING AND ENERGY ACTIONS

Action Number	Action Title	Additional Context
BE-1	**Provide access to renewably generated electricity**	Reducing electricity-related emissions is a primary strategy for achievement of the State's GHG targets, and is implemented through California's Renewables Portfolio Strategy (RPS). An option available for reducing electricity-related emissions is joining the local CCA program's CPA, which consists of Los Angeles and Ventura Counties and numerous other cities. Community Choice Aggregates purchase clean power for members, while traditional utilities, such as SCE, deliver it. Similar to SCE's Green Rate, members have tiered rate options based on their desired share of renewable energy; however, data show that CCAs have much higher rates of participation in clean electricity usage, since clean electricity is set as the default. In addition to utility-scale options, Action BE-2 discusses building-scale solar energy development and Action BE-3 promotes community solar.
BE-2	**Increase use of solar power**	Solar power is the conversion of energy from sunlight into electricity. It offers a renewable form of power that is plentiful, particularly in Southern California. Solar power technology has been a key aspect of the City's transition toward cleaner energy. The Civic Center produces its own renewable energy with rooftop photovoltaic panels that can generate 930 kWh/yr. In 2008, the Long Beach Airport installed six solar trees that track sun movement to produce electricity, generating 15,000 kWh/yr. A citywide solar power purchase agreement will facilitate solar installation of 5 MW at 10 City-owned facilities.
BE-3	**Promote community solar and microgrids**	In addition to the utility-scale clean electricity options described in Action BE-1, the City can also facilitate development of local solar energy systems through community solar and microgrid projects. Customers contract directly with the developers for their desired solar energy subscription amount, and SCE applies a bill credit for its share of the project's monthly output. In addition to partnering with SCE to increase participation in its community solar program, the City can also promote participation through information sharing and sign-up drives at City-sponsored events to collect the contact information of interested residents on behalf of the solar developers. The City can work directly with solar developers to identify local opportunity sites and remove permitting barriers within the City's control. Based on the results of the Port microgrid project, the City will analyze opportunities for other microgrid systems in Long Beach. The analysis will consider the location of existing and planned

		renewable energy systems and critical facilities that require power during emergencies, such as hospitals. The City will also explore development of community resilience hubs (community centers), where solar and battery storage can be installed to ensure neighborhood residents have a location where they can access electricity during power outages or other emergencies.
BE-4	**Develop a residential and commercial energy assessment and benchmarking program**	Beginning in June of 2019, under AB 802 California began requiring all commercial and multifamily buildings over 50,000 square feet to perform energy benchmarking. Benchmarking will allow for the comparison of energy performance of a single building over time, relative to similar buildings or to a specific energy code. This can be used effectively to identify opportunities to improve energy efficiency. Some cities such as Berkeley have established energy assessment and benchmarking programs that go beyond AB 802, combining annual energy benchmarking with regular energy assessments for larger buildings and requiring regular energy assessments for smaller buildings and homes. Improving building energy efficiency can reduce utility costs for residents and businesses, and can minimize the size requirements for on-site renewable energy systems. Energy assessments can help homeowners, property managers, and business owners understand which upgrades will provide the greatest energy savings and what payback period to expect. If sufficient GHG reductions are not being achieved from combined CAAP actions, the City will develop a mandatory retrocommissioning ordinance designed to fill the emissions reduction gap. Opportunities to leverage existing resources and partnerships into the program will be evaluated and integrated into the program, such as the Office of Sustainability's Residential Direct Install Program for disadvantaged communities, which will include home energy assessments performed by City-approved HERS raters. The City will partner with the Pacific Gateway Workforce Innovation Network and other related parties to increase the number of certified HERS raters in the community and to expand local green job development opportunities.
BE-5	**Provide access to energy efficiency financing, rebates, and incentives for building owners**	Residents and businesses in Long Beach have access to a variety of rebates and other funding sources to help offset upfront costs for building energy efficiency improvements. SCE and Energy Upgrade California provide rebates for energy-efficient appliances, insulation, smart thermostats, and more. When funding was available, the City's Energy Resources Department provided residential customers with information and assistance to access energy rebates when performing whole-house energy

		conservation projects. SoCalREN provides technical assistance and financing options to single-family, multifamily, and commercial buildings. PACE financing is also available for property owners to make permanent upgrades for building energy and water efficiency or to install renewable energy systems and repay improvement costs as an assessment on their property tax bill.
BE-5	**Provide access to energy efficiency financing, rebates, and incentives for building owners**	Residents and businesses in Long Beach have access to a variety of rebates and other funding sources to help offset upfront costs for building energy efficiency improvements. SCE and Energy Upgrade California provide rebates for energy-efficient appliances, insulation, smart thermostats, and more. When funding was available, the City's Energy Resources Department provided residential customers with information and assistance to access energy rebates when performing whole-house energy conservation projects. SoCalREN provides technical assistance and financing options to single-family, multifamily, and commercial buildings. PACE financing is also available for property owners to make permanent upgrades for building energy and water efficiency or to install renewable energy systems and repay improvement costs as an assessment on their property tax bill.
BE-6	**Perform municipal energy and water audits**	Local governments are not required to increase energy efficiency in municipal buildings, but efforts to do so will help California to achieve its emissions reduction goals and achieve cost savings. The City has partnered with SCE and SoCalREN, a service of the County of Los Angeles, to complete high-level energy audits and comparative energy analyses of City facilities. The City's overarching goal for these efforts is to identify and prioritize energy efficiency improvements.
BE-7	**Update building codes to incentivize electric new residential and commercial buildings**	Moving away from natural gas is critical because it is primarily made up of methane, a super pollutant that is 84 times more effective at trapping heat in the atmosphere than CO2 over the short term. Cooking with natural gas has been shown to lead to severe indoor air quality degradation that has strong negative health impacts. Beginning in 2020, under the California Building Energy Efficiency Standards, new single-family and small multifamily buildings will be required to meet zero net energy standards. In 2030, this requirement will be extended to commercial buildings and mid- and high-rise residential buildings. The City will evaluate building codes to incentivize electric new residential and commercial buildings. If sufficient GHG reductions are not being achieved from combined CAAP actions, the City will develop a mandatory building reach code designed to fill the emissions reduction gap.

BE-8	**Implement measures to reduce emissions related to oil and gas extraction**	Short-term measures for reducing emissions related to oil and gas extraction, as outlined in the CAAP Oil and Gas Technical Memorandum, are critical to reducing the City's overall GHG emissions profile. In 2015, 13.3 million barrels of crude oil and 5.1 million MCF (thousand) of natural gas were extracted in Long Beach. This resulted in an estimated 8.3 million metric tons of CO2e in life cycle emissions, which is effectively 2.7 times greater than the City's 2015 production-based inventory. Approximately 91 percent of these emissions occur downstream and midstream as a result of refining and transporting to consumers and end users of fuel, while the remaining 9 percent consists of upstream emissions associated with extraction (5 percent) and natural gas life cycle emissions (4 percent). It is estimated that 99 percent of the natural gas produced in Long Beach is combusted, and 1 percent escapes as fugitive emissions through leakage. In addition, the CAAP Oil and Gas Technical Memorandum contains a number of the long-term actions that are addressed in part through the existing mitigation actions included in this CAAP. These are intended to put Long Beach on a path to reduce and eventually eliminate oil and gas consumption in the city. They include transportation electrification, building energy use reduction and increased energy efficiency, and City advocacy for policies and regulations that reduce oil and gas consumption beyond Long Beach.

TRANSPORTATION ACTIONS

Action Number	Action Title	Additional Context
T-1	**Increase the frequency, speed, connectivity, and safety of transit options**	In addition to evaluating opportunities within its own service area, the City will work with Long Beach Transit to explore options to improve and expand regional connector routes to key destinations. Examples of regional connector routes from Long Beach to key destinations include: the temporary Metro 860 express shuttle from Downtown Long Beach to Downtown Los Angeles, the Long Beach Transit/UCLA Westwood Commuter Shuttle, the LAX Flyway, and FlixBus/Greyhound buses to Las Vegas, San Francisco, and San Diego. The City will also collaborate on STAR's Future Emerging Mobility Zones, where on-demand service using smaller vehicles serves the needs of customers and can prioritize the disabled and those who currently use the "Dial-A-Lift" access services. Mobility zones are planned to be located near the Del Amo and Artesia Blue Line Stations, around Bellflower and Lakewood, and in the vicinity of Long Beach Towne Center and California State University, Long Beach. Identification and implementation of customer safety enhancements, done alongside increasing frequency and connectivity of transit options, will be important, especially since many Long Beach survey respondents identified not feeling safe on transit as a barrier to their ridership. Safety improvements could include lighting at stops, bus video monitors, and signage that provides riders with emergency contact and "what to do" information. In addition, the presence of trained social workers on public transit lines is one way to support the homeless population and reduce minor crime violations.
T-2	**Expand and improve pedestrian infrastructure citywide**	The City has taken many steps to improve pedestrian infrastructure. In 2013, it approved the General Plan's Mobility Element; in 2016, it approved the Downtown and TOD Pedestrian Master Plan; and in 2017, it approved the CX3 Pedestrian Plan. The City also worked with Metro to produce the Blue Line First/Last Mile: A Community-Based Process and Plan, which was adopted in 2018. All of these plans are appendices to the Mobility Element. While three of these plans focus on specific areas of Long Beach, the City will take a more comprehensive approach and develop a citywide Pedestrian Master Plan that incorporates street design standards from each plan. In addition, pedestrian improvements within parks also play an important role in creating a complete pedestrian network and ensuring that all Long Beach residents have access to high-quality park space within a 10-minute walk.

T-3	**Increase bikeway infrastructure citywide**	The City of Long Beach has taken many steps to improve its bicycle and e-scooter infrastructure. In 2017, the City adopted its Bicycle Master Plan as an appendix to the General Plan Mobility Element. The plan outlines the City's efforts to expand its 141 miles of existing bikeways, establish and expand its bike share program, and increase bicycle parking across the city. The success of these efforts has been noticed, as Long Beach has been recognized in past years as one of the most bike-friendly cities in the U.S. With the rise of e-scooters since 2018, the City has worked extensively with e-scooter companies to increase mobility for short-distance travel.
T-4	**Implement the Port of Long Beach Clean Trucks Program**	As detailed in the San Pedro Bay Ports' 2017 Clean Air Action Plan Update, the Ports had never undertaken a program that was so transformational to a sector of the port industry; however, numerous challenges arose with implementing the Clean Trucks Program. There were many concerns with the ability of the trucking sector to take on the costs of upgrading its equipment and uncertainty as to the availability of enough clean trucks to meet the operational needs of the Ports. Drayage is a low-margin industry and many of the truck owners were not well positioned to invest in newer, more expensive trucks. The high cost of new technology is beyond what most drivers can afford. During the previous Clean Trucks Program, a widespread drayage industry practice was for licensed motor carriers to purchase the trucks and lease them to drivers, with lease deductions taken directly from the payments to the drivers. Some have argued that this practice was highly successful for achieving the rapid replacement of trucks. However, numerous drivers have complained, that these expenses and deductions left little remaining to cover living expenses. It is critical that the drivers, the motor carrier companies, the Ports, the goods movement industry, cargo owners, agencies, and legislators all work together on solutions to address this problem so that transitioning to a sustainable cleaner truck fleet and drayage system does not place an undue burden on any particular party. In March 2020, the commissioners of both of the San Pedro Bay Ports approved a \$20 fee per 40-foot loaded shipping container to be paid by cargo owners, including retailers and manufacturers, and agreed that the fees would go into a fund to help truckers switch to cleaner vehicles.
T-5	**Develop an Electric Vehicle Infrastructure Master Plan**	The City can facilitate development of EV charging infrastructure to further support broad adoption of this technology. As a first step, Long Beach Sustainability recently received a SCAG planning grant to develop an EV study. After an initial study of existing conditions,

		the SCAG grant will deliver a plan that provides Long Beach-specific guidelines for EV infrastructure deployment after the implementation of an outreach and marketing strategy to engage the community in plan development. It will address multifamily dwellings, workplaces, fleets, commercial and public sites, and fast charging stations in strategic locations. The Plan will also identify policy recommendations for prioritized locations for and quantity of charging infrastructure, needed investment, and a timeline for deployment. Implementation of this action can also include the development of EV car shares at affordable housing sites or a broader EV car share pilot program with incentives for low-income participants. The Cities of Los Angeles and Sacramento implemented similar programs with cap-and-trade grant funding. This would allow all members of the community to share in the benefits of improved air quality from increased EV use.
T-8	**Increase density and the mixing of land uses**	According to the U.S. Census American Community Survey (2018), 75 percent of Long Beach residents drive alone, 9 percent carpool, 6 percent use public transit, and 2.5 percent walk to get to and from work. Seventy-five percent of the respondents to the CAAP survey also indicated that driving is their dominant transportation mode for all trips, but also indicated a strong preference for walkable, bikeable neighborhoods. Promoting sustainable neighborhoods encourages residents to access stores, healthy foods, and community services without a car. Inherently, sustainable neighborhoods mitigate GHG emissions by making residents less dependent on fossil-fueled vehicles and by lowering overall VMT. Moreover, state regulations such as SB 375 push regional and local jurisdictions to strategically implement regional allocation of housing needs and regional transportation planning coordinated together to further reduce GHG emissions. Reduced and shared parking offer a number of potentially important benefits, including a reduction in commercial and housing development costs, which can lead to more affordable housing options, increased walkability, and increased development near transit.
T-9	**Integrate SB 743 planning with the CAAP process**	Research studies funded by SCAG, Metro, and CARB have explored various VMT mitigation strategies to determine which strategies are most effective.

WASTE ACTIONS

Action Number	Action Title	Additional Context
W-1	**Ensure compliance with state law requirements for multifamily and commercial property recycling programs**	The Public Works Department - Environmental Services Bureau provides recycling collection as part of the refuse services it provides to all single-family residential accounts in the city and to the multifamily and commercial accounts the bureau services. The City's private waste haulers provide recycling collection to customers that sign up for the service, and they communicate with impacted customers about the requirements of AB 341 and how they can achieve compliance. The City also provides information on the Long Beach Recycles website about AB 341 and tips for compliance. In accordance with state regulations, the City and private haulers will continue to conduct commercial recycling outreach to provide technical assistance on establishing recycling programs for properties that are out of compliance.
W-3	**Partner with private waste haulers to expand organic waste collection community-wide**	As described in Action W-2, diverting organic waste from landfills is an important strategy in achieving California's GHG emissions reduction target. Senate Bill 1383 defines specific targets for organic diversion and outlines the State's implementation strategy. As part of this strategy, California enacted AB 1826 to require businesses that exceed solid waste disposal thresholds to recycle their organic waste. As of January 1, 2019, businesses producing 4 cubic yards or more of solid waste per week are required to arrange for organic waste recycling services for food waste, green waste, landscape and pruning waste, nonhazardous wood waste, and food-soiled paper. AB 1826 also set green waste disposal thresholds for multifamily properties (five or more units). As of April 1, 2016, multifamily properties that generate 8 or more cubic yards of green waste (e.g., landscaping, pruning, wood waste) must implement organic waste diversion strategies. Franchise waste haulers provide collection services to many of the city's multifamily and commercial properties, while the City provides waste collection services to the remaining properties. In accordance with AB 1826, the City will continue to provide information on the Long Beach Recycles website to assist businesses and multifamily property managers in complying with the law's requirements.
W-4	**Identify organic waste management options**	Actions W-1 and W-2 will result in increased organic waste collection and management in the future. The City will collaborate with other agencies, such as Los Angeles County, to identify potential locations for organic waste treatment facilities to handle future waste volumes and avoid the use of landfills due to capacity issues. The City will then work to support and share this information with potential parties willing to go through the permitting process. If a

		facility is identified and ultimately established in Long Beach, the City will work to update waste hauler contracts and ensure that organic waste is hauled to locally sited facilities, which will help reduce transportation emissions. Currently, the City identifies organic waste collection requirements for its franchise waste haulers to ensure a high-quality level of service community-wide. These requirements include providing information to the City on the collection of organic waste. To support implementation monitoring, the City will continue to work with its franchise waste haulers to measure and report the amount of organic waste collected and to track its treatment by method or facility.

[i] https://ufmptoolkit.net/wp-content/uploads/2016/03/LongBeachUFMP.pdf
[ii] http://www.lbds.info/neighborhood_services/neighborhood_improvement/urban_forestry_program.asp
[iii] KPCC 2015. "SoCal Edison says mismanagement led to Long Beach outages."

CITY OF
LONG BEACH

Appendix C
Long Beach Vulnerability Assessment

AECOM

C

APPENDIX C

Climate Change Vulnerability Assessment Results

Long Beach Climate Action and Adaptation Plan

FINAL | November 12, 2018

C

APPENDIX C

Table of Contents

Section 1. **Introduction**

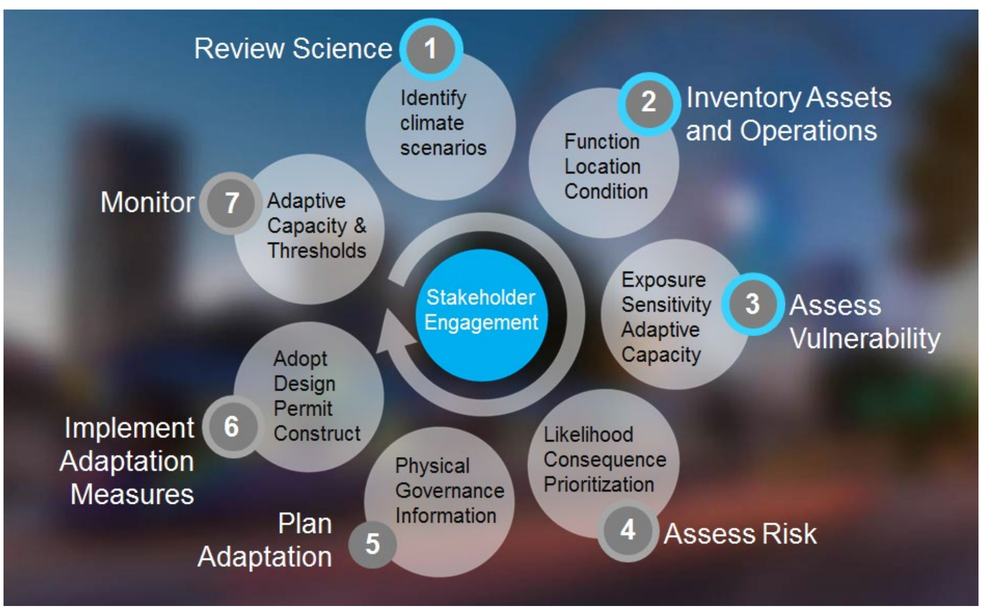
1.1 Purpose of the Vulnerability Assessment

The purpose of the vulnerability assessment is to understand to what extent climate stressors will impact various assets in Long Beach in order to prioritize in the development of adaptation strategies, as well as to inform decision making for future capital investment.

This assessment analyzed the vulnerability of assets to several climate stressors: Sea level rise (SLR) and coastal flooding, riverine flooding, extreme heat, drought, and poor air quality. The SLR and Coastal Flooding assessment was done with a relatively greater level of detail compared to other stressors given the detailed modeling available, the high level of risk in Long Beach, and the level of detail needed to understand the potential impacts of sea level rise and coastal flooding. Generally, more detailed data was available on City-owned assets, so they were assessed in greater detail. However, privately-owned assets, such as buildings and energy infrastructure were assessed at a high level.

Climate adaptation planning typically follows a cyclical process. This report represents steps one, two and three of the adaptation process depicted in Figure 1. The results of this assessment will inform the development of adaptation strategies in the next phase of the project.

Figure 1: Climate Adaptation Planning Process



1.2 Organization of the Assessment

Section 2: This chapter describes the methodology of the assessment.

Section 3: This chapter summarizes the data collection process and asset inventory.

Section 4: This chapter describes the SLR mapping methodology used in the assessment and the results of a subarea assessment of SLR exposure.

Section 5 to 12: These chapters present the findings from the vulnerability assessment by asset sector.

Section 2. **Vulnerability Assessment Methodology**

This section outlines the approach and methodology for the climate vulnerability assessment component of the Long Beach Climate Action and Adaptation Plan. The climate vulnerability assessment is based on an assessment of exposure, sensitivity, and adaptive capacity for critical[1] physical assets and vulnerable populations. The purpose of the vulnerability assessment is to understand which assets and populations are the most vulnerable in order to prioritize those assets and communities for adaptation strategy development in the next phase of the project.

2.1 Sea Level Rise and Coastal Flooding Assessment Methodology

2.1.1 Exposure

The exposure assessment for SLR and coastal flooding considered permanent inundation from the daily high tide and temporary flooding from the annual king tide and 100-year coastal storm conditions (100-year storm surge).

- Timeframes: As required by AB 691, timeframes include 2030, 2050 and 2100.
- Projection Scenarios: 11, 24, 37, and 66 inches, based on National Research Council (NRC) 2012 report on West Coast SLR (described in greater detail below).
- Mapping source: U.S. Geological Survey Coastal Storm Modeling System (CoSMoS)[2]

<u>Sea Level Rise Projection Scenarios</u>

Up until recently, the state of California utilized the National Research Council (NRC) 2012 sea level rise projections as best available science in state policy and guidance. In 2017, a new study was released by Griggs et al. (2017) with updated SLR projections for the California coast. The Griggs study informed the

[1] Critical assets are those that are important in providing core services and functions of City departments.
[2] CoSMoS, a Coastal Storm Modeling System created by the USGS, is a source for wave run up, sea level rise, and shoreline change modeling data.

development of the Ocean Protection Council's (OPC) new sea level rise guidance document that was adopted in March 2018.

OPC developed future sea level rise projections at each tide station along the California coast. Table 1 presents sea level rise projections for Los Angeles. The OPC study incorporated a range of global emissions scenarios ranging from aggressive emissions reductions to no emissions reductions through end of century.

Table 1. Sea Level Rise Projections at Los Angeles, CA from OPC (2018)

Year (Emissions Scenario)	Inches Above 1991-2009 Mean Sea Level (in)			
	Median (50% probability of exceedance)	Likely Range (67% percent likely range)	1-In-20 Chance (5% probability of exceedance)	1-In-200 Chance (0.5% probability of exceedance)
2030	4	2 to 6	7	8
2050	8	6 to 12	14	22
2100 (low emissions)	16	8 to 25	36	65
2100 (very high emissions)	26	16 to 38	49	80

Source: OPC (2018)

Not only were the OPC (2018) SLR projections not yet available at the time of the vulnerability assessment, but the SLR projections from NRC (2012) show higher potential SLR for near-term planning horizons (2030 and 2050). Given the differences in projections, it was determined that for the sake of being conservative in developing a plan to preserve life and property, that the more aggressive forecast should be utilized. To understand the implications of a worst-case scenario, and to include a factor of safety, particularly for critical assets, the high-end of the NRC (2012) SLR range was selected for each planning timeframe. This rationale aligns with the State Guidance from the Ocean Protection Council (2011) and California Coastal Commission (2015). Because there is increased uncertainty (wider ranges of SLR) after 2050, both the projection (mid-range) and high-range magnitudes were selected to guide planning for 2100. In addition, including the mid-range 2100 allows for a range of SLR scenarios to better understand thresholds for exposure of assets or subareas of the city.

Table 2: Sea Level Rise Projections for Los Angeles, CA from NRC (2012)

Year	Southern California	
	Projection	Range
2030	5.8 ± 2.0 in	4.6 – 11.8 in
2050	11.2 ± 3.5 in	5.0 – 23.9 in
2100	36.7 ± 9.8 in	17.4 – 65.6 in

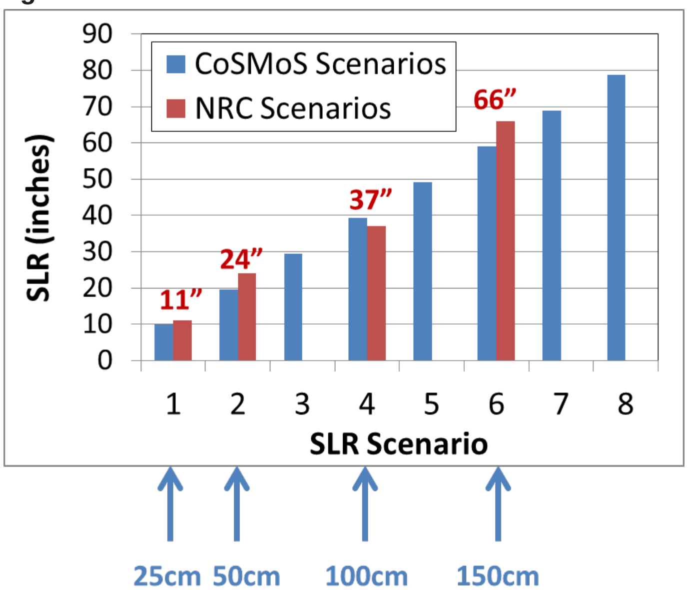
Source: NRC (2012)

In summary, the following SLR scenarios were adopted for use in this study and Figure 2 shows how these scenarios align with the available SLR mapping layers from CoSMoS, which are measured in centimeters.

- 11 inches for year 2030 (high-range) or year 2050 (mid-range) = 25 cm SLR CoSMoS scenario*
- 24 inches for year 2050 (high-range) = 50 cm SLR CoSMoS scenario
- 37 inches for year 2100 (mid-range) = 100 cm SLR CoSMoS scenario
- 66 inches for 2100 (high-range) = 150 cm SLR CoSMoS scenario

*Note that the 25 cm (11 inches) CoSMoS scenario exceeds the projected amount of SLR for 2030 for both the NRC (2012) and OPC (2018) projections; however, it is the lowest SLR scenario available from the CoSMoS modeling and was therefore selected to evaluate near-term SLR impacts in Long Beach.

Figure 2: CoSMoS and NRC Sea Level Rise Scenarios



2.1.2 Sensitivity

Sensitivity of physical assets (buildings, facilities, infrastructure, etc.) was assessed using a qualitative approach based on asset types. Assets that are found to not be exposed to sea level rise and coastal flooding are not assessed for sensitivity. Table 3 provides the criteria for the sensitivity ratings, and further details regarding specific asset-type sensitivities are provided in the asset section.

Table 3: Sensitivity Rating Scale for Physical Assets

None	Low	Moderate	High
No impact to asset function	Asset impacted but still functional	Asset function temporarily compromised	Asset damaged and no longer functional

2.1.3 Adaptive Capacity

The adaptive capacity of physical assets was assessed using a qualitative approach by asset type. Table 4 provides the criteria for the sensitivity ratings, and further details regarding specific adaptive capacity considerations by asset-type are provided in the asset section.

Table 4: Adaptive Capacity Rating Scale for Physical Assets

High	Moderate	Low
Asset is easily repaired, modified, or relocated.	Asset may be repaired, modified or relocated, but with some challenges.	Asset may be repaired, modified, or relocated, but with significant challenges.

2.2 Riverine and Urban Flooding

Precipitation can generate flooding in two distinct ways. *Riverine flooding* occurs during extreme, regional rainfall events as rivers, creeks, and channels discharge excess water from an entire watershed. The Los Angeles and San Gabriel rivers drain much of the Los Angeles Basin and discharge into San Pedro Bay. This type of flooding could impact the City of Long Beach if high flows overtop and/or compromise the levees bordering these rivers. Precipitation can also generate localized *urban flooding* during high rainfall events if the City's local stormwater collection system is overwhelmed and cannot drain the excess stormwater. This type of flooding tends to be localized near storm drains and other stormwater collection system components.

Riverine Flooding

Reliable modeling on how riverine floodplains will be impacted by changes in seasonal and extreme precipitation patterns does not exist for Long Beach. Therefore, asset exposure to riverine flooding was assessed based on location within the Federal Emergency Management Agency's (FEMA) 100 and 500-year riverine floodplains, which were adopted in 2008.[3] With precipitation events projected to increase in intensity as a result of climate change, riverine flooding may increase. These FEMA floodplains serve as proxies for areas that may be at risk to increased exposure to riverine flooding in the future. Additional hydrologic and hydraulic analysis of watersheds and drainages that flow through Long Beach, accounting for future projected changes in precipitation, would be required to conduct a more detailed evaluation of future riverine flooding vulnerabilities.

Urban Flooding

Climate change and SLR can also exacerbate localized urban flooding if stormwater collection, conveyance, and discharge systems are not sized appropriately for future conditions precipitation. In addition, discharge of stormwater to tidally-influenced waters such as Alamitos Bay may be impeded by higher water levels in the future. The vulnerability of the stormwater system to climate change and SLR was evaluated at a high level in this assessment by identifying stormwater outfalls that discharge to

[3] Flood Insurance Rate Maps available here: http://www.longbeach.gov/pw/resources/engineering/flood-zone/

tidally-influenced waters; however, a more detailed assessment of potential flooding impacts within the streets and neighborhoods would be required to evaluate this hazard in more detail.

Sensitivity and adaptive capacity of physical assets were assessed in the same way as described above for SLR and Coastal Flooding.

2.3 Extreme Heat

The number of extreme heat days (over 95 ℉) in Long Beach per year is projected to increase from an average of four in the baseline period (1980-2000) to 11-16 days by mid-century and 11-37 by end-of century, depending on the emissions scenario (Sun et al. 2015). The impact of this change on both physical assets and on vulnerable populations was assessed qualitatively.

2.4 Drought

Climate change, through its impacts on precipitation and temperature, is predicted to increase the severity and length of future droughts statewide (CEC 2012). By the end of the century, all climatic models included in the California Climate Change Center's Third Assessment predict regional drying, primarily from decreased precipitation and compounded by warming (CEC 2012). The impact of drought on physical assets and vulnerable populations was assessed qualitatively.

2.5 Air Quality

Higher temperatures are expected to increase the frequency, duration, and intensity of conditions conducive to air pollution formation (CNRA 2014). Specifically, studies have shown that ozone concentrations increase when maximum daytime temperatures increase (Kleeman et al. 2010). Since climate models project higher temperatures in the future for Long Beach, a "climate penalty" exists for ground level ozone, which means that greater State and regional emissions controls will be needed to meet a given air quality standard. The impacts of poor air quality were assessed qualitatively for vulnerable communities only, as air quality does not have direct impacts on physical assets.

Section 3. **Asset Data Collection**

One of the first steps of the vulnerability assessment is to compile an inventory of the assets that are to be evaluated.

3.1 Data Collection Process

The first step in the asset inventory was a review of the departmental surveys to understand what assets Long Beach City departments consider critical to providing core services/functions. AECOM reviewed that list and developed an asset data request list for the City departments and collected publically available data for privately-owned assets, such as electricity assets and buildings. AECOM also reviewed publically available demographic data for vulnerable populations in Long Beach.

3.2 Sectors and Asset / Population Types

As summarized in Table 5, assets and populations were assessed across eight different sectors. Each sector focused on asset types of particular importance in Long Beach.

Table 5: Asset Sectors and Asset / Population Types

Sector	Asset / Population Types
Buildings and Facilities	City-Owned Buildings, Privately-Owned Buildings
Parks and Open Space	City Parks, Beaches, Wetlands, Marinas
Transportation	Roads, Bike Paths, Bridges
Energy	Substations, Transmission, Generation Facilities, Natural Gas Mains
Wastewater	Pump Stations, Sewer Main, Sewer Forced Main
Stormwater	Stormdrain Outfalls, Stormdrain Carriers, Stormwater Pump Stations
Potable Water	Potable Facilities, Potable Mains
Public Health	Vulnerable Populations

3.3 Port of Long Beach Harbor District

Because the Port of Long Beach has its owns climate adaptation plan and has its own governance body and revenue sources, this vulnerability assessment focuses on the parts of the City of Long Beach that are not within the Port of Long Beach Harbor District (Harbor District). As such, the asset inventory does not specifically include Port-assets. However, City-owned infrastructure, such as buildings and facilities, that are located within the Harbor Districts were included. While adaptation strategy development will generally focus on assets outside the Harbor District, coordination between the Harbor District and the City of Long Beach on climate adaptation will be an on-going priority.

Section 4. **Mapping Sea Level Rise and Coastal Flooding**

This section describes the SLR Mapping and analysis that was used to evaluate the exposure of assets to permanent inundation (daily high tide), frequent temporary flooding (annual king tide), and rare temporary flooding (100-year storm surge).

4.1 Sea Level Rise Mapping

Daily, Annual, and Extreme Coastal Water Levels

A description of the daily high tide, annual king tide, and 100-year storm surge water levels is provided below:

- **Daily high tide inundation.** There are two high tides each day of unequal height in Long Beach. A commonly used measure of the average high tide is referred to as mean higher high water (MHHW), which is the average elevation of the higher of the two high tides each day. MHHW represents the typical high tide elevation on a daily basis. Areas that are exposed to daily high tide inundation are considered to be "permanently inundated" because of the frequency at which they are flooded (daily).

- **Annual king tide flooding**. King tides are the largest annual tide events and occur several days each year when a spring tide coincides with the moon being in its closes position to the Earth. In Long Beach, king tide events are approximately 1.5 feet above the average daily high tide. They can cause flooding of low-lying coastal areas, particularly if coinciding with a storm event that elevates tides above normal levels. Assets that are exposed to king tide flooding are considered to be "frequently flooded" because they would be temporarily flooded two to three times each year.

- **100-year storm surge flooding.** The 100-year storm surge has a 1-percent chance of occurring in any given year. The 100-year storm surge event includes the effects of the astronomical tide, storm conditions (due to atmospheric pressure and meteorological effects), and precipitation. The influence of temporary flooding caused by wave runup is not included. Assets that are exposed to 100-year storm surge flooding are considered to be "rarely flooded" because they would be temporarily flooded only during very infrequently occurring extreme coastal storm events. The 100-year storm surge elevation is commonly used as an indicator to inform assessments of flood risk and includes the following components in Long Beach:

- **Sheltered embayments** (such as within Port of Long Beach and Alamitos Bay): inundation extents include high tide and storm surge inundation of the shoreline; runoff from larger watersheds is also included.
- **Open coast** (such as Long Beach): inundation extents include high tide and storm surge inundation of the shoreline and inundation caused by storm wave conditions (i.e., wave setup); temporary flooding caused by wave runup is not included.

SLR Mapping Layers

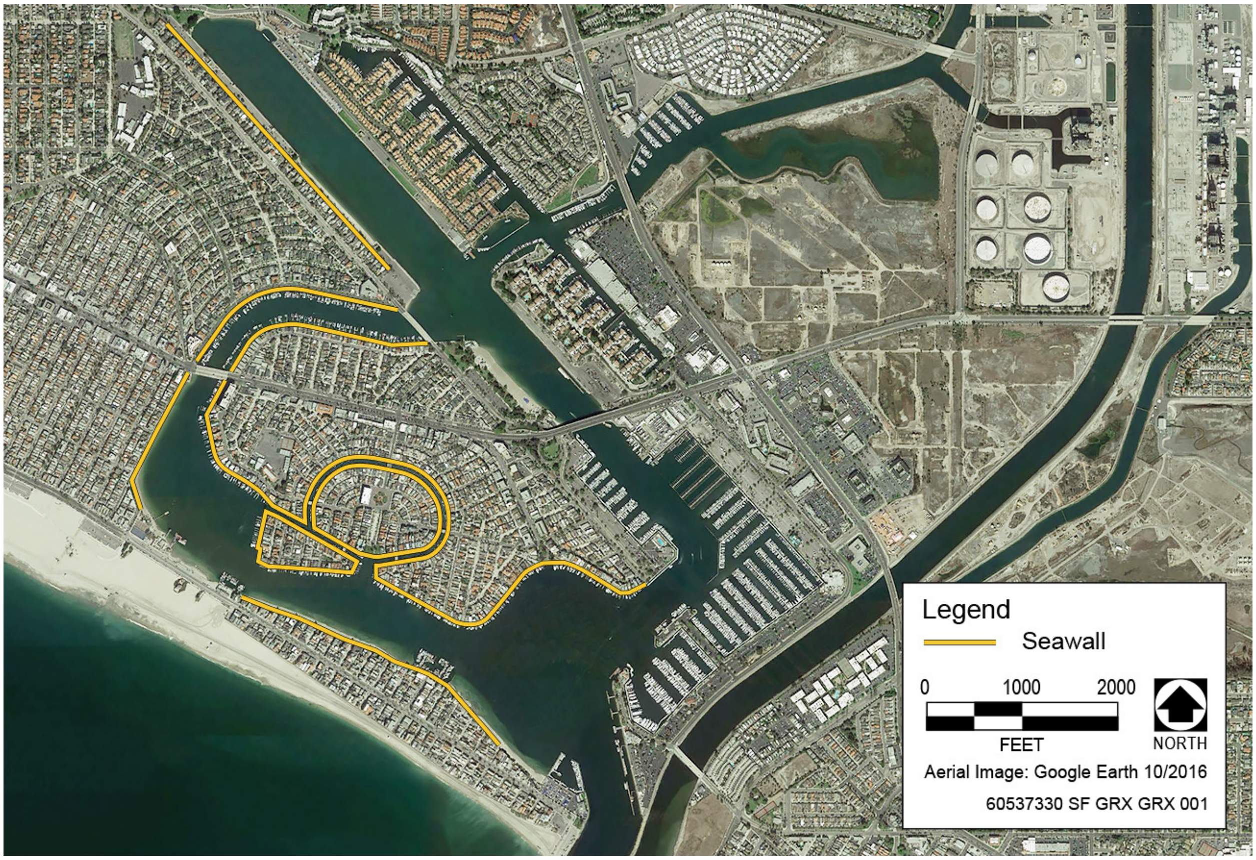
Coastal flooding layers from the CoSMoS 3.0 model results in southern California were used to evaluate asset exposure to temporary flooding events by annual king tides and 100-year storm surge events for each SLR scenario (see chapter 2 for more detail). Data layers can be viewed online through the Our Coast our Future[4] data viewer or downloaded through the USGS website.[5] SLR inundation layers and maps were not produced for permanent inundation scenarios as part of this assessment because Long Beach is not projected to be impacted by permanent inundation until higher amounts of SLR (greater than approximately 37" of SLR); however, the vulnerability analysis for each asset category includes discussion of permanent inundation impacts and asset sensitivity and adaptive capacity.

Limitations and Inundation Layer Revisions

The annual king tide and 100-year storm surge inundation layers developed by the USGS using the CoSMoS model provide a solid starting point to evaluate existing and future flood risk in Long Beach. It should be noted, however, that small-scale topographic features such as seawalls may not be accurately captured in the flood modeling and mapping. As a result, projected flooding in areas protected by seawalls may be overstated by the CoSMoS model. Areas protected by seawalls include the sheltered shorelines within Alamitos Bay, including Belmont Shore, Naples, and the Peninsula. To help address this issue, the SLR inundation mapping in these areas was modified as part of the vulnerability assessment by obtaining topography information on the crest elevation of the seawalls. Crest elevations were estimated by examining Lidar-based elevation data and field measurements of existing seawall heights relative to adjacent ground elevations. Approximate locations for seawalls within Alamitos Bay are shown in Figure 3. This information was used to update the SLR inundation maps to better reflect future flood risk in these areas by comparing the projected future water level scenarios for annual king tide and 100-year storm surge to the seawall elevations and removing low-lying areas of inundation located behind seawalls in cases where the typical elevation of the seawall exceeded the projected water level. Estimated seawall elevations were approximately 8 to 11 ft NAVD88.

[4] ourcoastourfuture.org
[5] https://walrus.wr.usgs.gov/coastal_processes/cosmos/socal3.0/

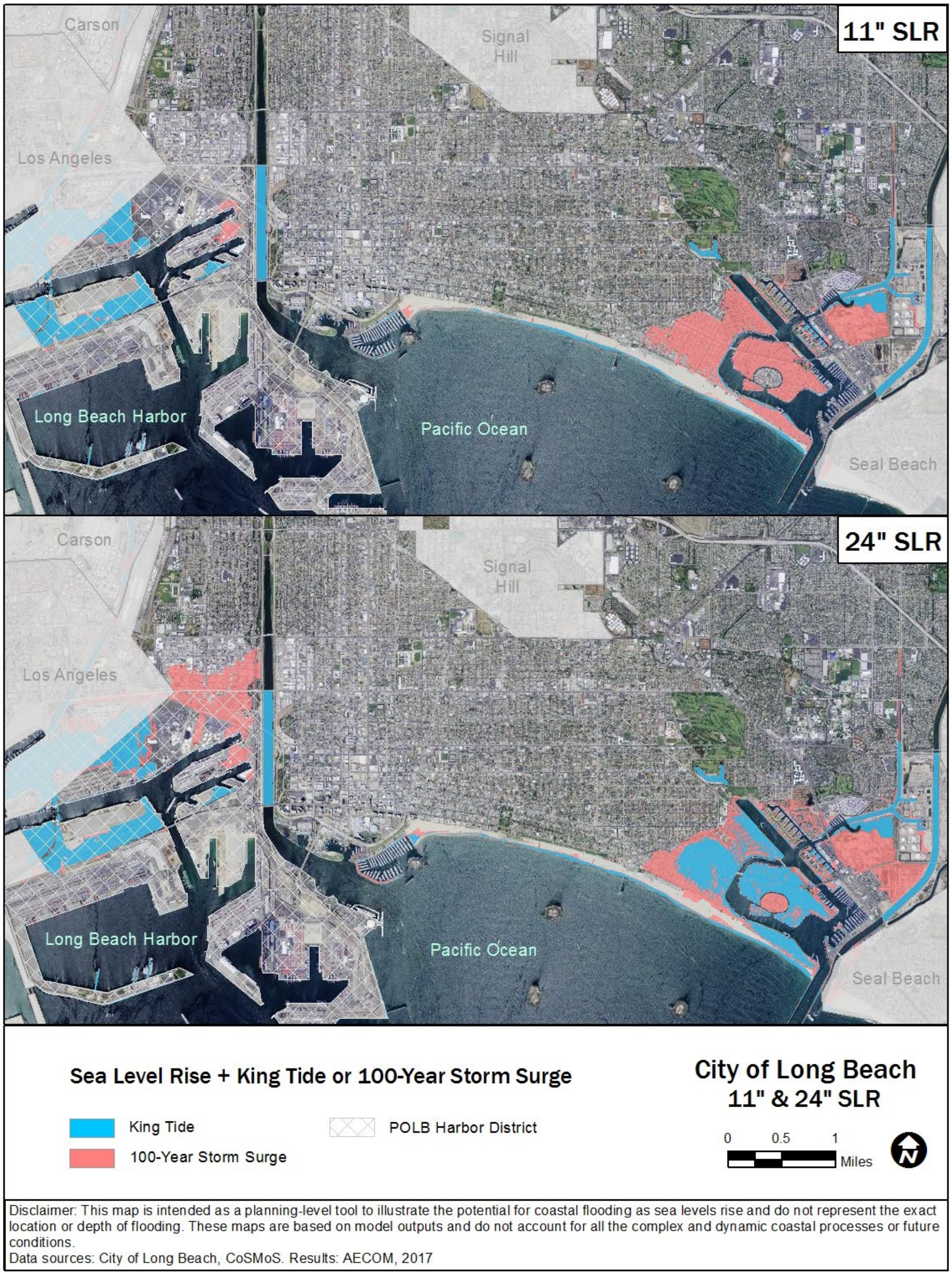
Figure 3: Approximate locations of Seawalls within Alamitos Bay



Sea Level Rise Mapping Results

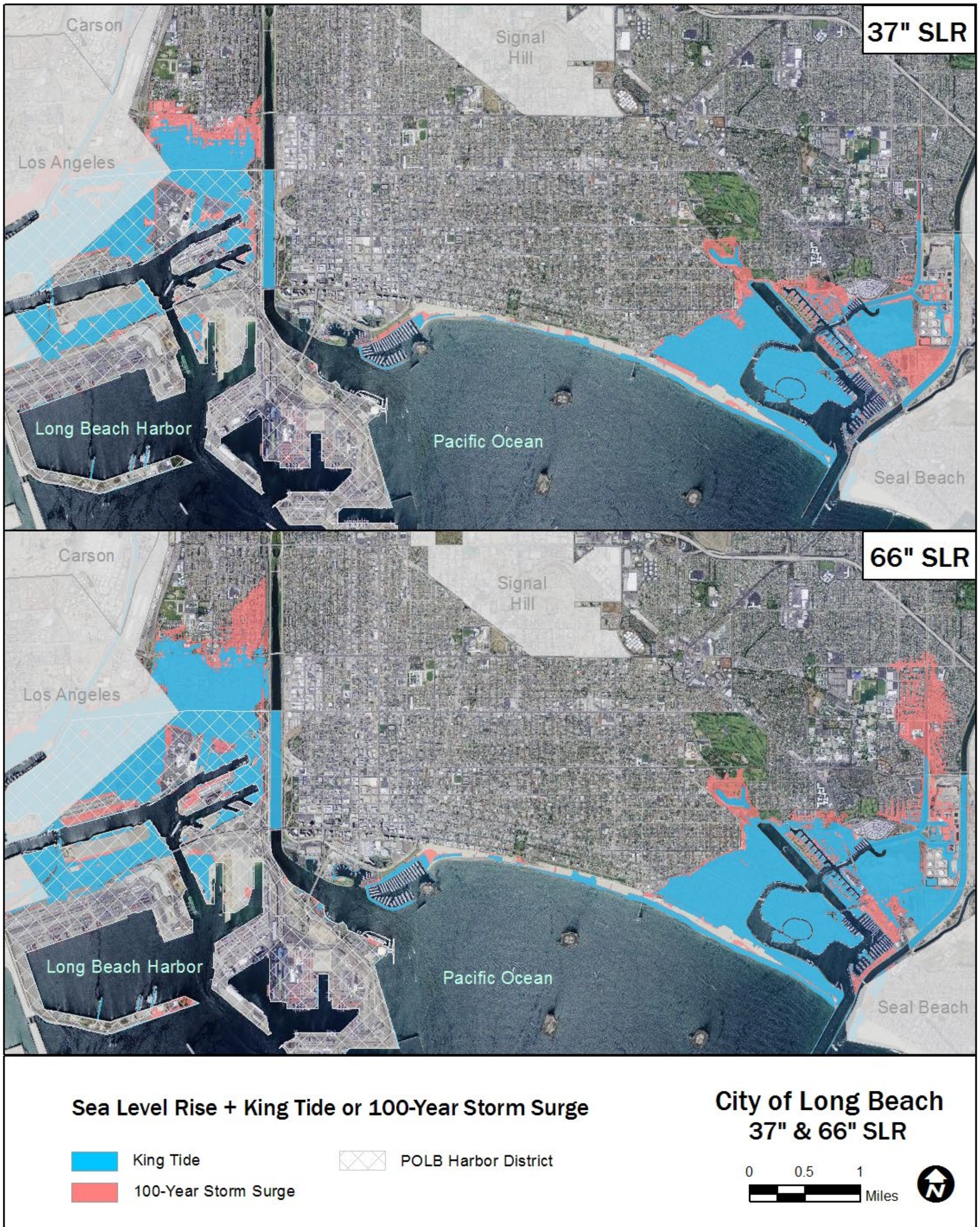
Figure 4 and Figure 5 show the results of the SLR mapping for Long Beach that was used in the exposure assessments described below. The maps show the projected extent of flooding for the King Tide and 100-year storm surge scenarios – both temporary flooding events that could impact Long Beach assets and communities in the near-term. Permanent inundation is not projected to occur within Long Beach until higher amounts of SLR (approximately the 37” SLR scenario) and was therefore not mapped in detail since the impacts of temporary flooding will be felt first and addressing these impacts would also address permanent inundation impacts as well. The flood extents shown in Figure 4 for the King Tide + 24” SLR scenario are similar to the permanent inundation extents that would occur for the daily high tide (MHHW) + 37” SLR scenario. Similarly, the flood extents shown in Figure 5 for the King Tide + 37” SLR scenario are similar to the permanent inundation extents that would occur for the daily high tide (MHHW) + 66” SLR scenario.

Figure 4: SLR Mapping Results for 11 and 24 Inches of SLR with King Tide and 100-Year Storm



Note: The flooding extents for the King Tide + 24" SLR scenario are similar to the daily high tide (MHHW) + 37" SLR scenario.

Figure 5: SLR Mapping Results for 37 and 66 Inches of SLR with King Tide and 100-Year Storm



Disclaimer: This map is intended as a planning-level tool to illustrate the potential for coastal flooding as sea levels rise and do not represent the exact location or depth of flooding. These maps are based on model outputs and do not account for all the complex and dynamic coastal processes or future conditions.
Data sources: City of Long Beach, CoSMoS. Results: AECOM, 2017

Note: The flooding extents for the King Tide + 37" SLR scenario are similar to the daily high tide (MHHW) + 66" SLR scenario.

4.2 Sea Level Rise and Coastal Flooding Subareas

The areas of exposure to SLR and Coastal Flooding in Long Beach can be divided into three different geographic areas: the Southeastern Subarea, Downtown Subarea, and Western Subarea. Figure 6 to Figure 8 were developed to better understand the various assets at risk in those areas and to support the development of neighborhood or district scale strategies that may help provide flood protection or build the resilience of multiple assets.

Figure 6 through Figure 8 show projected areas of temporary flooding due to King Tides with 11, 24, 37, and 66 inches of SLR. The summaries below provide a high-level overview of the areas of flooding and impacts to assets are discussed in greater detail in Sections 5 through 12.

Southeastern Subarea

As can be seen in Figure 6, the areas of darkest blue would be exposed to annual king tides earliest, with 11 inches of SLR. These areas include parts of Marina Pacifica, the Los Cerritos Wetlands Complex, and the Alamitos Bay shoreline of the Peninsula. There are no major roads exposed during this scenario, but the Bayshore Walk along the Peninsula is exposed. With higher levels of SLR, Belmont Shore, Naples, the Peninsula, and the Marina Pacifica area are projected to experience king tide flooding, including the beaches and parks that provide active recreation and boating access.

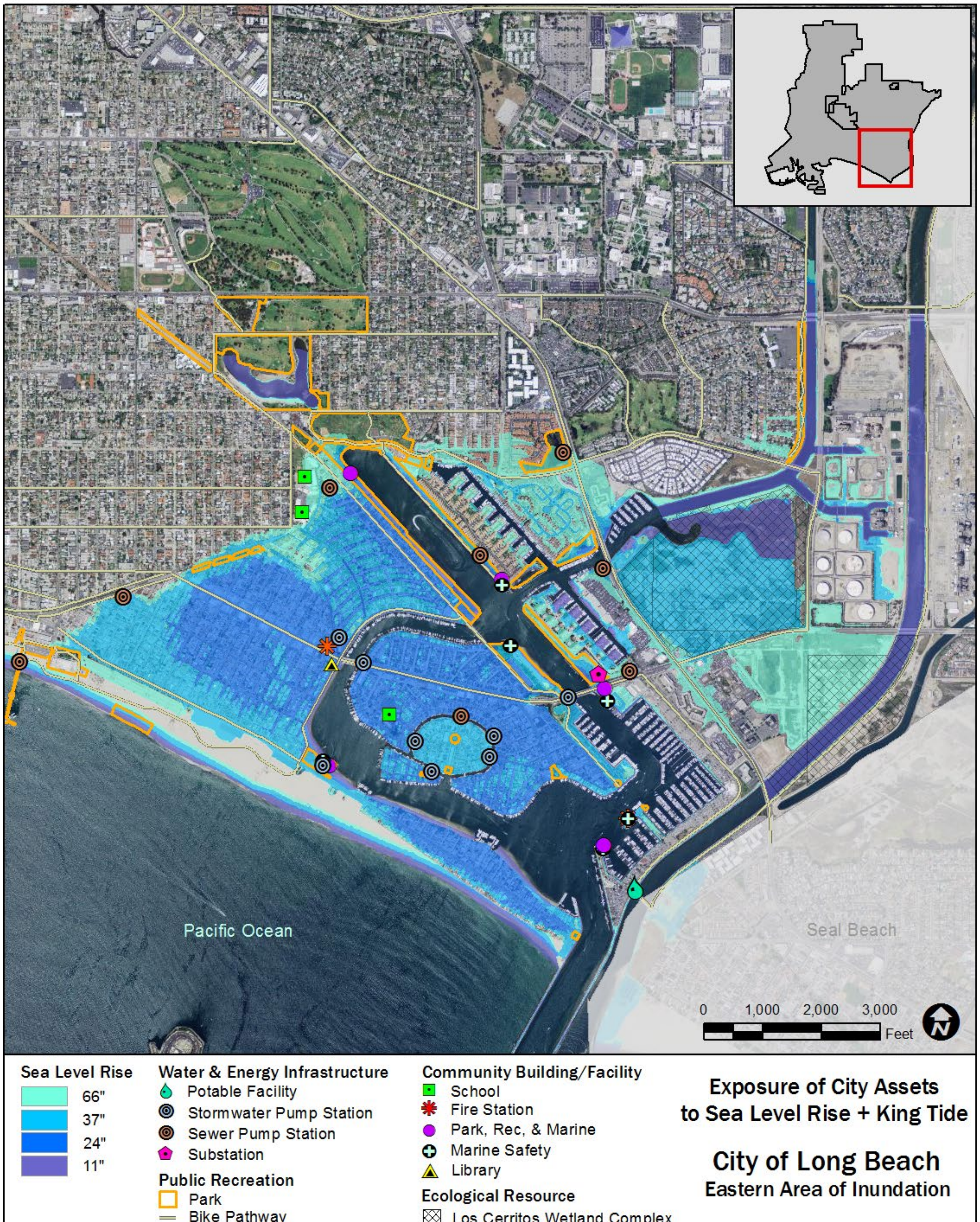
Downtown Subarea

As can be seen in Figure 7, in the Downtown Subarea, parts of the Shoreline Marina, Rainbow Harbor, and Golden Shore Marine Reserve are projected to be exposed to future annual king tides. The Golden Shore Marine Reserve is projected to be flooded by king tides combined with 11 inches of SLR. The edges of the Marina and Harbor start to experience king tide flooding at 11 inches and with higher levels of SLR, the pedestrian paths and parks also flood. Alamitos Beach also experiences king tide flooding, resulting in a narrowing of the beach, particularly with higher levels of SLR. Assets in this area that may be impacted include the Aquarium of the Pacific, and the bike path around Shoreline Marina, and the sewer lift stations associated with the comfort stations around the Marina.

Western Subarea

As can be seen in Figure 8, the Western Subarea, which is largely an industrial area, is not anticipated to experience flooding due to king tides until end-of-century (37 and 66 inches of SLR) and the flood pathways would likely come through the Harbor District area. Adaptation efforts by the Harbor District may provide flood protection benefits for West Long Beach, and on-going coordination between the Harbor District and City of Long Beach is recommended. Assets in West Long Beach that are at-risk include a potable water facility, two police facilities, and a Health Resource Center serving individuals experiencing homelessness. Within the Harbor District, there are also two potable facilities, a solid waste facility, and multiple fire stations.

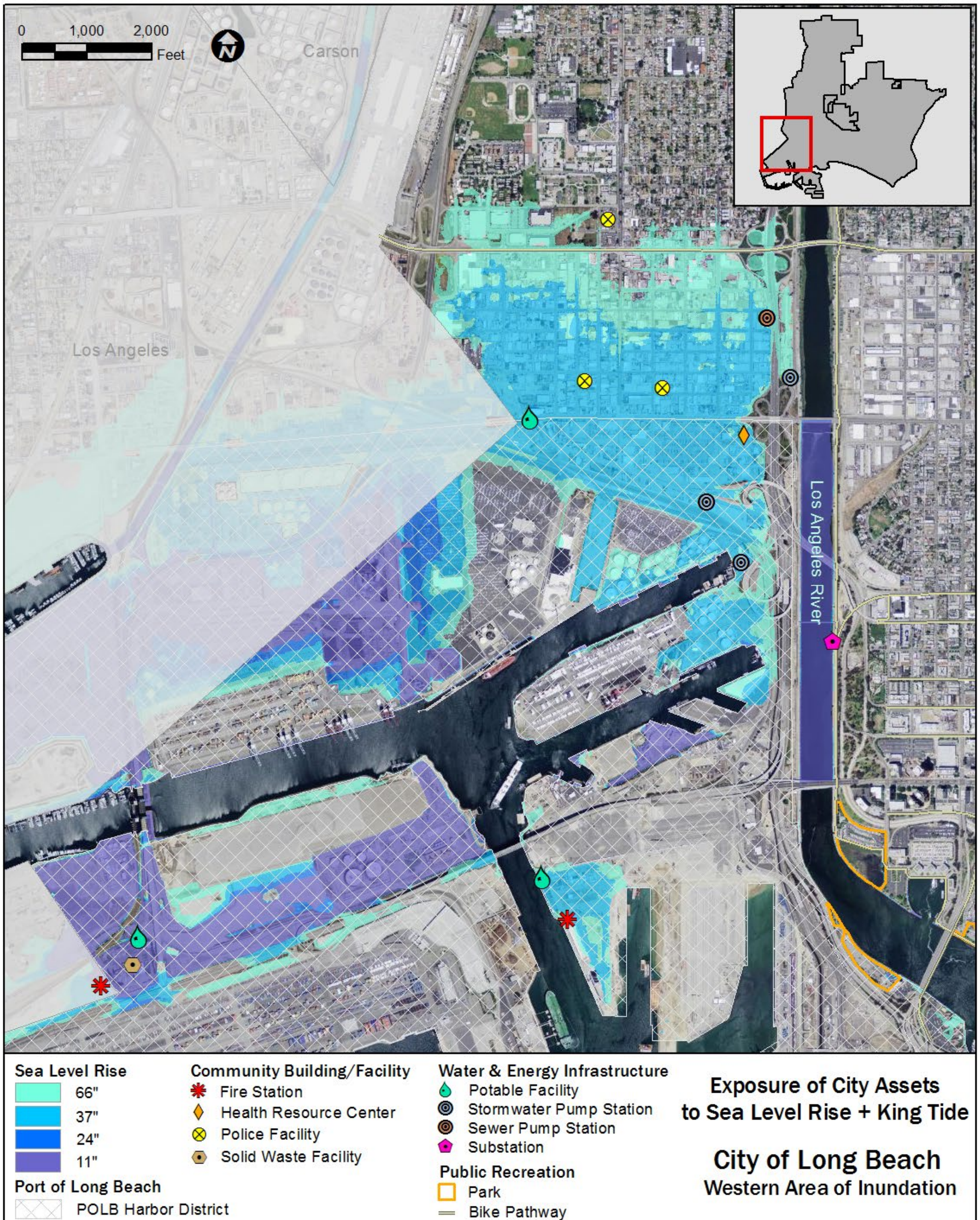
Figure 6: Exposure to SLR in the Southeastern Subarea



Disclaimer: This map is intended as a planning-level tool to illustrate the potential for coastal flooding as sea levels rise and do not represent the exact location or depth of flooding. These maps are based on model outputs and do not account for all the complex and dynamic coastal processes or future conditions.
Data sources: City of Long Beach, CoSMoS, Southern California Edison. Results: AECOM, 2017

Figure 7: Exposure to SLR in the Downtown Subarea

Figure 8: Exposure to SLR in the Western Subarea



Disclaimer: This map is intended as a planning-level tool to illustrate the potential for coastal flooding as sea levels rise and do not represent the exact location or depth of flooding. These maps are based on model outputs and do not account for all the complex and dynamic coastal processes or future conditions.
Data sources: City of Long Beach, CoSMoS, Southern California Edison. Results: AECOM, 2017

Section 5. **Vulnerability of Buildings and Facilities**

The Buildings and Facilities sector include two asset-types: City-owned buildings and facilities and privately-owned buildings. This section presents a summary of this sector's vulnerabilities to climate stressors.

Asset Overview

The Buildings and Facilities sector includes City-owned buildings and facilities and privately-owned buildings. Depending on the height and use, buildings may be constructed out of wood, masonry, concrete, and/or steel and glass. In addition to the building structure, this assessment considers their mechanical, electrical, and plumbing systems.

City-owned buildings and facilities include critical emergency response facilities, such as fire and police stations as well as buildings that serve vulnerable populations, such as health resource centers and schools. In addition to over 150 schools, there are over 160 City-owned buildings and facilities in Long Beach. Privately-owned buildings include residential, commercial, and industrial structures. Private hospital buildings were also assessed.

5.1 Sea Level Rise and Coastal Flooding

Exposure of City-Owned Buildings and Facilities

Table 6 shows that a total of 10 City-owned buildings and facilities are projected to be exposed to annual king tides with 11 inches of SLR. These buildings are located along the Alamitos Bay Marina or within the Harbor District. Two of these 10 buildings are fire stations, which are critical for emergency response. One of the fire stations is located in the Harbor District while the other fire station is located along the Alamitos Bay Marina (Figure 9).

A solid waste facility is also exposed to annual king tide flooding with 11 inches of SLR. This facility is the Southeast Resource Recovery Facility, which is owned by a joint powers agreement between the Sanitation Districts and the City of Long Beach and is located within the Harbor District. Several Marine Safety and Park, Recreation, & Marine facilities are also projected to be exposed to king tide flooding with 11 inches of SLR.

With 11 inches of SLR, in addition to the 10 buildings exposed to king tide events, seven additional buildings are projected to be exposed to the 100-year storm surge. These are a fire station, the Belmont

Shore Library, the Naples Bayside Academy, and four Marine Safety and Park, Recreation & Marine Facilities.

With 66 inches of SLR (2100 high-range), up to 26 City buildings are exposed to annual king tides and an additional 13 are projected to be exposed to the 100-year storm surge.

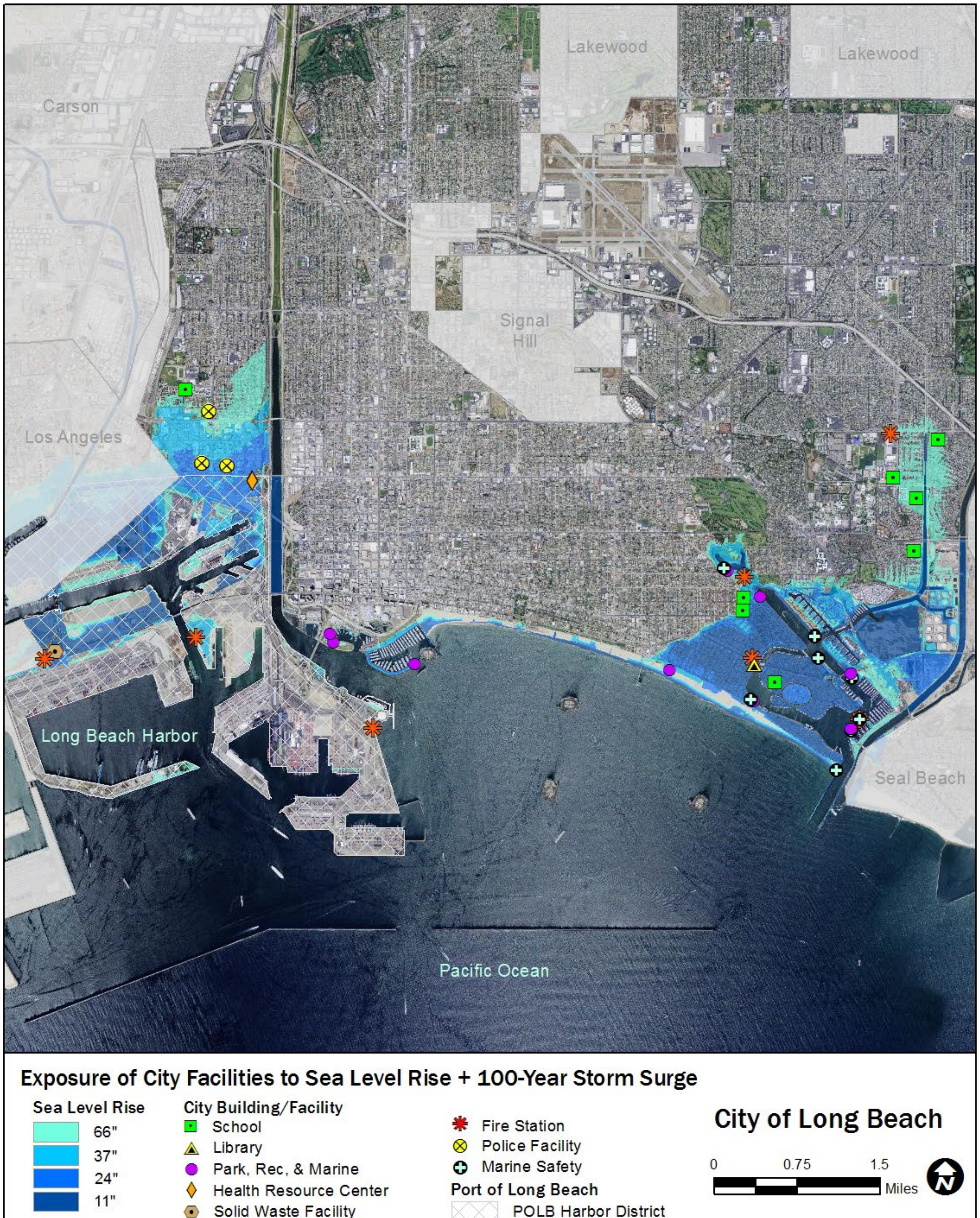
The City's Emergency Communications and Operations Center is not projected to be exposed to the studied levels of SLR and storm surge.

Table 6: Number of City Buildings and Facilities Exposed to Sea Level Rise and 100-year Storm Surge

	2030 (11" SLR)		2050 (24'' SLR)		2100 (37" SLR)		2100 (66" SLR)	
	Annual King Tide	Additional Exposure Due to Storm Surge	Annual King Tide*	Additional Exposure Due to Storm Surge	Annual King Tide*	Additional Exposure Due to Storm Surge	Annual King Tide	Additional Exposure Due to Storm Surge
Fire Station	2	1	3	1	4	1	4	3
Health Resource Center	0	0	0	1	1	0	1	0
Library	0	1	1	0	1	0	1	0
Marine Safety	3	2	5	0	5	3	6	2
Park, Rec, and Marine	3	2	4	1	5	3	7	2
Police Facility	0	0	0	2	2	0	3	0
Schools	0	1	1	2	3	0	3	5
Solid Waste Facility	1	0	1	0	1	0	1	0
Other	0	0	0	0	0	1	0	1
Total	**10**	**7**	**15**	**7**	**22**	**8**	**26**	**13**

*****Note: The exposed assets for the King Tide + 24" SLR scenario are similar to the daily high tide (MHHW) + 37" SLR scenario. The exposed assets for the King Tide + 37" SLR scenario are similar to the daily high tide (MHHW) + 66" SLR scenario.

Figure 9: Exposure of City Buildings to Sea Level Rise + 100 Year Storm Surge



Disclaimer: This map is intended as a planning-level tool to illustrate the potential for coastal flooding as sea levels rise and do not represent the exact location or depth of flooding. These maps are based on model outputs and do not account for all the complex and dynamic coastal processes or future conditions.
Data sources: City of Long Beach,CoSMoS. Results: AECOM, 2017

C

APPENDIX C

Exposure of Privately-Owned Buildings

With 11 inches of SLR, approximately 1.3 million square feet of buildings are projected to be exposed to annual king tides. Approximately half of these buildings are residential (624,100 square feet) and half are commercial (689,600 square feet). These buildings are primarily located in Marina Pacifica and along Shoreline Drive south of Ocean Boulevard. An additional 9.5 million square feet of buildings, primarily residential, are exposed to flooding from a 100-year storm surge with 11 inches of SLR. These buildings are primarily located in Naples Island, Belmont Shore, and the Peninsula.

Excluding buildings within the Harbor District, industrial buildings are not exposed to annual king tides until 37 inches of SLR, and none are exposed to the 100-year storm surge until 24 inches of SLR.

Without adaptation, by 2100, up to 17 million square feet of buildings are exposed to annual king tide flooding and an additional 4 million square feet are exposed to the 100-year storm surge.

No hospitals are projected to be exposed to the evaluated levels of SLR and storm surge.

Table 7: Square footage of Privately-Owned Buildings Exposed to Sea Level Rise and 100-year Storm Surge*

	2030		**2050**		**2100**		**2100**	
	(11" SLR)		**(24'' SLR)**		**(37" SLR)**		**(66" SLR)**	
	Annual King Tide	Added Exposure Due to Storm Surge	Annual King Tide*	Added Exposure Due to Storm Surge	Annual King Tide*	Added Exposure Due to Storm Surge	Annual King Tide	Added Exposure Due to Storm Surge
Residential	624,100	8,520,200	7,226,300	3,661,800	10,458,200	1,599,900	11,923,200	3,112,900
Commercial	689,600	930,500	1,106,800	741,900	1,875,200	698,800	2,189,900	837,400
Industrial	0	0	0	1,186,800	2,035,500	866,200	2,946,100	69,100
All others	0	117,300	112,800	48,500	165,200	17,000	185,000	3,700
Total	**1,313,700**	**9,568,000**	**8,445,900**	**5,639,000**	**14,534,100**	**3,181,900**	**17,244,200**	**4,023,100**

Note: Excludes buildings located in the Harbor District

*****Note: The exposed assets for the King Tide + 24" SLR scenario are similar to the daily high tide (MHHW) + 37" SLR scenario. The exposed assets for the King Tide + 37" SLR scenario are similar to the daily high tide (MHHW) + 66" SLR scenario.

Sensitivity and Adaptive Capacity of Buildings and Facilities

Buildings that are exposed to temporary floodwaters are likely to sustain damage to the building fabric and mechanical and electrical components. Buildings that are exposed to permanent inundation by daily high tides may lose functionality due to repeated flooding events and loss of access. Therefore, as illustrated in Table 8, buildings have high sensitivity to both permanent inundation and temporary flooding.

Buildings have moderate adaptive capacity to temporary flooding as flood proofing measures or elevating structures may be effective in protecting the structure even if access may be temporarily compromised. Buildings that are already located within the FEMA 100-year floodplain may already have some adaptive capacity built in due to floodplain regulations. However, for permanent inundation, only elevation or relocation of structures provide effective adaptation, but are more costly and challenging to implement than flood proofing of structures. If buildings are elevated, surrounding access modes, such as roads, driveways, and sidewalks would also need to be elevated to maintain access, pointing to the need for district or neighborhood-scale infrastructure solutions.

Table 8: Sensitivity and Adaptive Capacity of Buildings

	Sea Level Rise (Permanent Inundation)*	← **Rationale**	Sea Level Rise (Temporary Flooding)*	← **Rationale**
Sensitivity	High	Buildings cannot be accessed or used if permanently inundated.	High	Building fabric will be damaged with flooding. Wave energy and erosion could cause structural damage.
Adaptive Capacity	Low	Elevating or relocating buildings is difficult and costly.	Moderate	Flood proofing buildings is somewhat challenging.

*Note: Permanent inundation refers to inundation by the daily high tide (MHHW) and temporary flooding refers to flooding by the annual king tide or 100-year storm surge.

5.2 Riverine Flooding

In general, 100-year flood flows along the primary riverine waterways are contained within their channels by existing levees. Detailed modeling of the effect of SLR on riverine flood profiles was not conducted; however, such analysis could be conducted in the future to better understand combined riverine and coastal flood events within Long Beach. The list of buildings and facilities exposed to the FEMA 100-year storm is very similar to the 11 inches SLR + 100-year storm surge scenario described above. Figure 10 shows City-owned facilities, schools, and hospitals that are within the 100 and 500-year FEMA floodplain. Given the large extent of the 500-year floodplain, considerably more buildings and facilities are at-risk to that scenario, including two hospitals, 11 fire stations, one police station, and 96 schools.

The sensitivity and adaptive capacity considerations are similar to the temporary flooding (SLR + Storm Surge) described considerations above.

5.3 Extreme Heat

Given the projected increased in extreme heat events, buildings may require additional energy for cooling. Buildings without air conditioning or with insufficient air conditioning could be uncomfortable and potentially unsafe for occupants during extreme heat events. If electrical outages are caused due to area-wide brownouts, building heating and cooling could be disrupted, in addition to all other electronic systems.

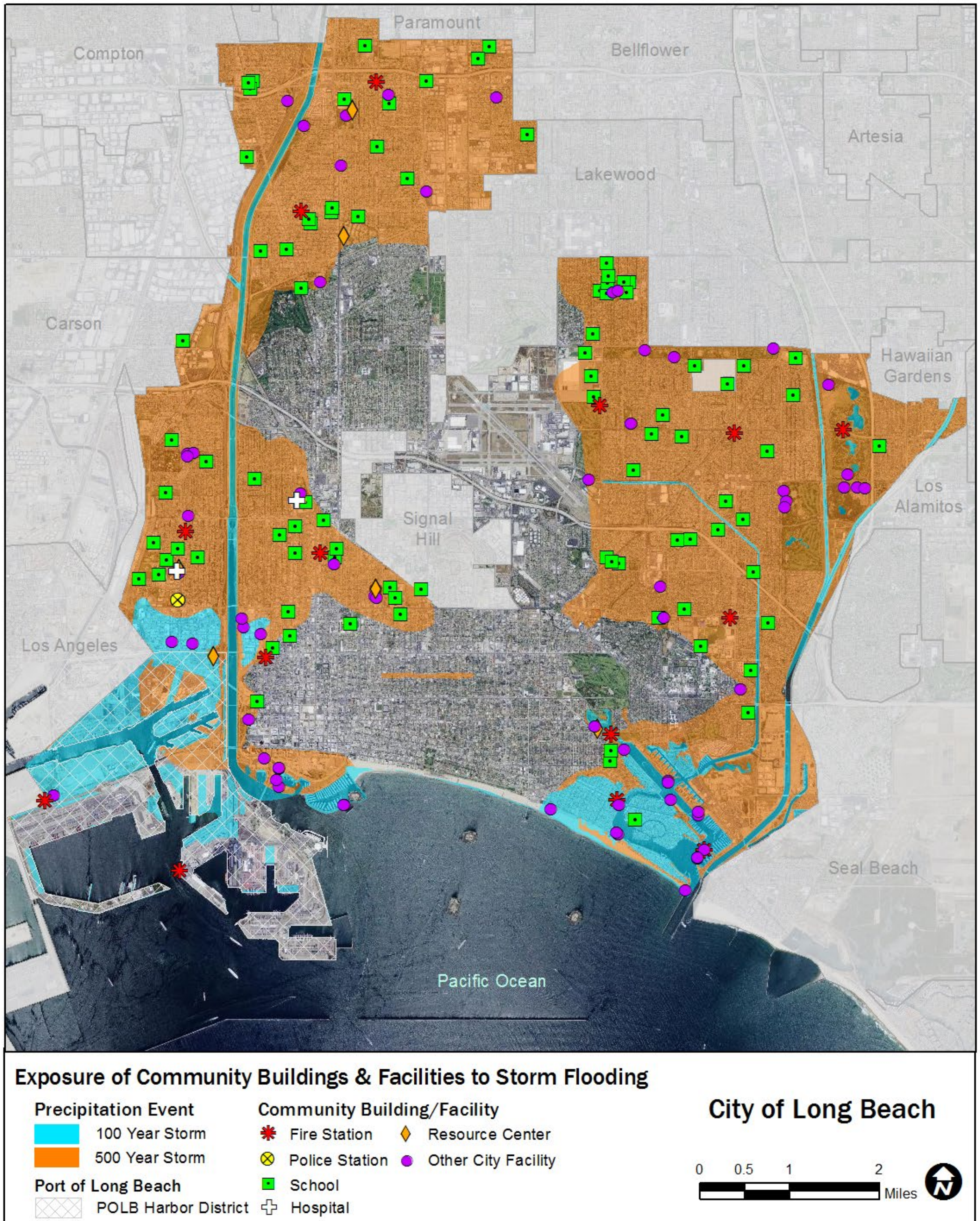
5.4 Drought

Under extreme conditions, foundations may be affected if the ground shrinks. This is most likely to happen with expansive soils that contain a large percentage of silt or clay. Damage to buildings may include cracks in the structure and sloping floors.

5.5 Vulnerability Summary for Buildings and Facilities

- With 11 inches of SLR, 10 City-owned buildings, 624,100 square feet of residential buildings, and 689,600 square feet of commercial buildings are projected to be exposed to annual king tides.
- No hospitals are projected to be exposed to the studied levels of SLR and 100-year storm surge.
- Several critical emergency response facilities are located in the 500-year floodplain.
- Buildings have high sensitivity and low adaptive capacity to permanent inundation. Buildings have high sensitivity and moderate adaptive capacity to temporary flooding (king tide, 100-year storm surge, and riverine flooding).
- Buildings may require additional energy for cooling due to an increase in extreme heat.

Figure 10: Exposure of Buildings and Facilities to Riverine Flooding



Disclaimer: This map is intended as a planning-level tool to illustrate the locations of FEMA designated flood hazard areas and do not represent the exact location or depth of flooding. These maps are based on model outputs and do not account for all the complex and dynamic riverine, coastal, or stormwater drainage processes or future conditions.
Data sources: City of Long Beach, FEMA. Results; AECOM, 2017

Section 6. **Vulnerability of Parks & Open Space**

The Parks and Open Space assets include City parks, beaches, and wetlands. These asset types are not mutually exclusive. For example, several City-owned parks feature wetlands and several beaches include parks. Assets that overlap different asset-types have been noted below.

6.1 Sea Level Rise and Coastal Flooding

City Parks

Asset Overview

The City of Long Beach has over 200 parks citywide. City parks range in type from active recreation parks with playgrounds, courts, playing fields, and/or boating facilities while others are more passive with lawns, paths and/or native habitat. Other parks are more urban and include hardscaped plazas or promenades. In addition to various types of landscaping sensitive to saltwater exposure, parks often include electrical components, such as lighting.

Exposure

With 11 inches of SLR, portions of 17 parks are projected to experience annual king tide flooding while an additional five are projected to experience temporary flooding due to 100-year storm surge (Table 9). Out of the 17 parks that are projected to be exposed to king tide flooding with 11 inches of SLR, one (Rosie's Dog Beach) is projected to be 50% exposed to flooding, three are projected to be 20% exposed, and the remaining parks are projected to be 10% or less exposed (Table 10).

In Southeast Long Beach, several parks are projected to be exposed to annual king tides by 2030. Active recreation parks include Marine Stadium, Leeway Sailing Center, Bayshore Playground, and Jack Nichol, and Rosie's Dog Beach. Urban parks with hardscaping include Belmont Pier and Plaza. Parks with native habitat include Jack Dunster Marine Reserve.

The Downtown Long Beach area also has several parks that are projected to experience annual king tide flooding with 11 inches of SLR. These are primarily passive recreation parks, featuring pedestrian paths and lawns, such as Rainbow Harbor Esplanade, Shoreline Aquatic, and Downtown Marina Mole. The Jack Dunster Marine Reserve features natural habitat for public recreation and education and is also projected to begin to experience flooding due to annual king tides when combined with 11 inches of SLR.

Table 9: Number of City-Owned Parks Exposed to Sea Level Rise Combined with King Tide and 100-year Storm Surge

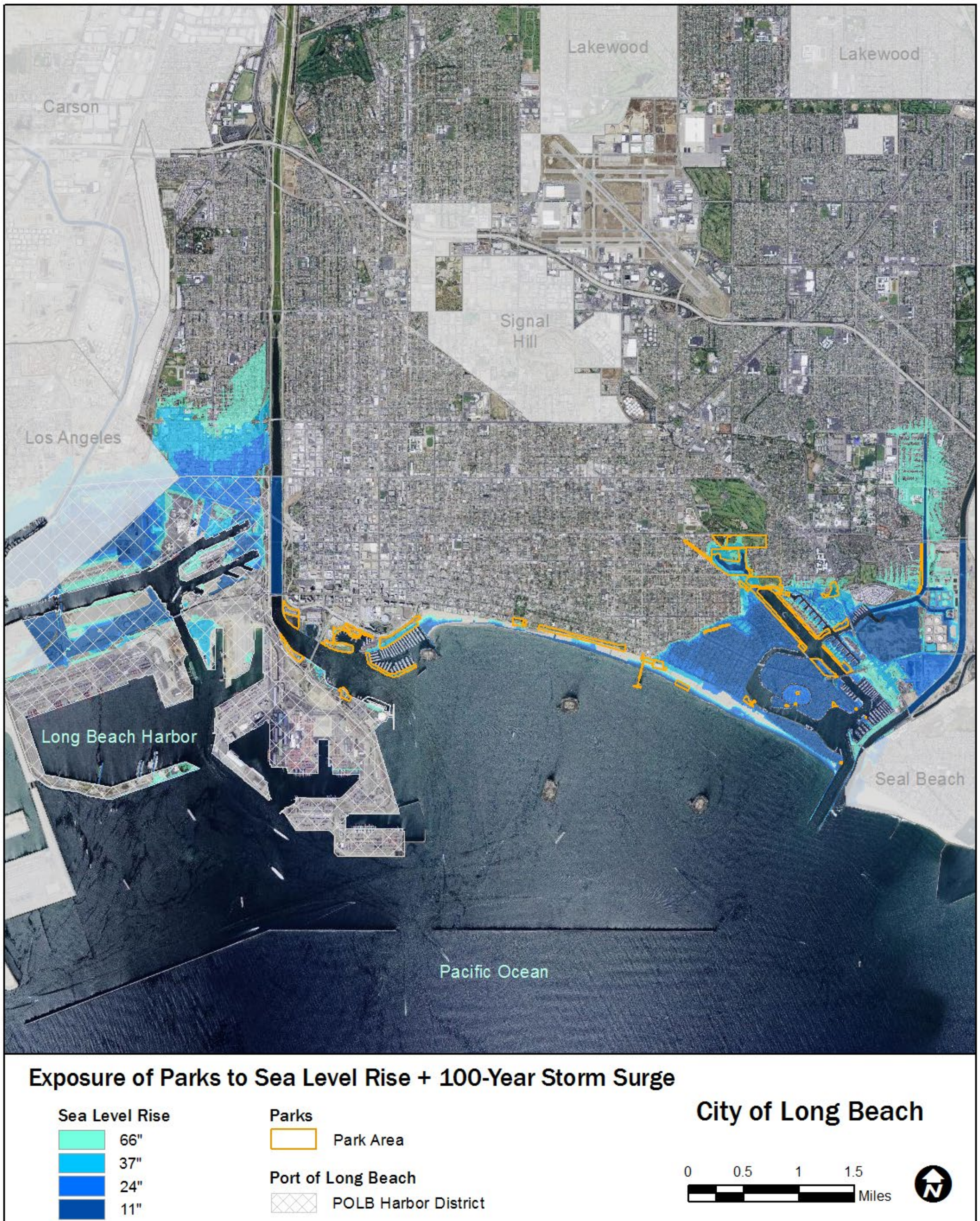
	2030 (11" SLR)		2050 (24'' SLR)		2100 (37" SLR)		2100 (66" SLR)	
	Annual King Tide	Additional Exposure Due to Storm Surge	Annual King Tide*	Additional Exposure Due to Storm Surge	Annual King Tide*	Additional Exposure Due to Storm Surge	Annual King Tide	Additional Exposure Due to Storm Surge
Number of Parks	17	5	20	8	31	7	36	5

***Note**: The exposed assets for the King Tide + 24" SLR scenario are similar to the daily high tide (MHHW) + 37" SLR scenario. The exposed assets for the King Tide + 37" SLR scenario are similar to the daily high tide (MHHW) + 66" SLR scenario.

Table 10: Percent of Park Area Exposed to Annual King Tide with 11 inches SLR

Park Name	**Percent** (rounded to nearest 10%)
Rosie's Dog Beach (Beach)	50%
Leeway Sailing Center	20%
Marine Stadium	20%
Maurice 'Mossy' Kent	20%
Downtown Marina Mole	10%
Harry Bridges Memorial Park At The Queen Mary	10%
Jack Dunster Marine Reserve (Wetlands)	10%
Marine Park (Mother's Beach)	10%
Alamitos At 72nd	Less than 5%
Alamitos Heights	Less than 5%
Belmont Pier And Plaza	Less than 5%
Davies Launch Ramp	Less than 5%
Golden Shore Marine Reserve (Wetlands)	Less than 5%
Jack Nichol	Less than 5%
Rainbow Harbor Esplanade	Less than 5%
Shoreline Aquatic	Less than 5%
South Shore Launch Ramp	Less than 5%

Figure 11: Exposure of Parks to Sea Level Rise + 100-Year Storm Surge



Disclaimer: This map is intended as a planning-level tool to illustrate the potential for coastal flooding as sea levels rise and do not represent the exact location or depth of flooding. These maps are based on model outputs and do not account for all the complex and dynamic coastal processes or future conditions.
Data sources: City of Long Beach, CoSMoS. Results: AECOM, 2017

Sensitivity and Adaptive Capacity

Parks have high sensitivity to permanent inundation because they cannot be accessed and function as a park when inundated, and therefore permanent inundation would result in loss of the park. Parks have moderate sensitivity to temporary flooding from king tides and storm surge as access to the park may be lost temporarily, and damage to landscaping, architectural, and electrical components is possible. Unless designed to be salt-water resistant, park landscaping is generally sensitive to salt-water exposure. However, when floodwaters recede, the park can be repaired, damaged vegetation replaced, and the park can be returned to use.

Parks have moderate adaptive capacity to permanent inundation, as it can be challenging to elevate or relocate a park. Elevating a large park would be particularly difficult given the amount of fill needed and the disruption/destruction to the existing vegetation. In addition, protecting or relocating mature trees is challenging. However, some parts of the parks could be converted to flooded landscapes and other parts of the park protected. Parks have high adaptive capacity to temporary flooding due to storm surge as modifications to landscaping, such as use of a salt tolerant planting palette, and flood proofing of architectural and electrical features may be possible to accommodate temporary flooding with minimal disruption.

Table 11: Sensitivity and Adaptive Capacity Ratings for Parks

	Sea Level Rise (Permanent Inundation)*	← Rationale	Sea Level Rise (Temporary Flooding)*	← Rationale
Sensitivity	High	Cannot function or be accessed if permanently inundated.	Moderate	Loss of access temporarily. Damage possible to landscaping, architectural, and electrical components.
Adaptive Capacity	Moderate	Somewhat challenging to elevate or relocate park. Portions of park could be sacrificed to floodwaters while others portions are elevated.	High	Modifications to landscaping (salt tolerant plant species) and architectural features available to accommodate temporary flooding.

*Note: Permanent inundation refers to inundation by the daily high tide (MHHW) and temporary flooding refers to flooding by the annual king tide or 100-year storm surge.

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APPENDIX C

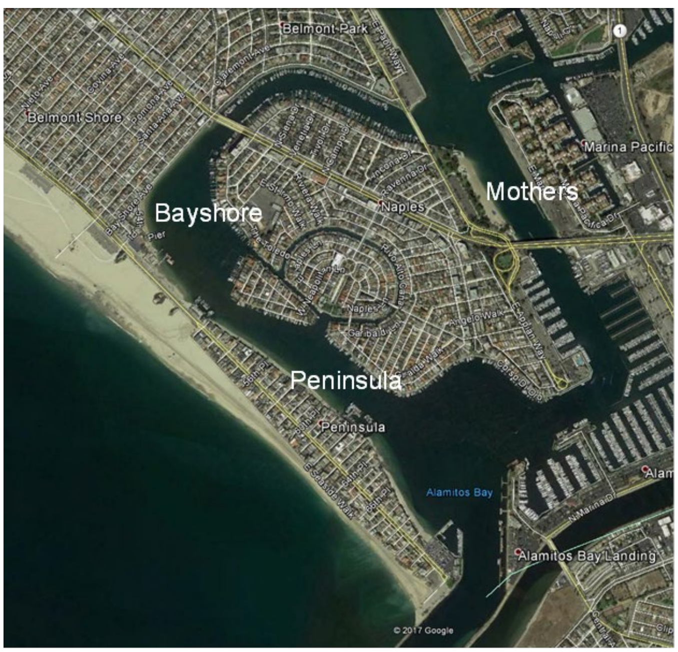
Beaches

Asset Overview

Long Beach has four open coast beaches: Alamitos, Junipero, Belmont, and Peninsula, which are shown in Figure 12. Long Beach has three beaches within Alamitos Bay: Bayshore, Peninsula, and Mothers, which are shown in Figure 12.

Figure 12: Open Coast Beaches

Figure 13: Alamitos Bay Beaches



Exposure

The exposure assessment for beaches focuses on beach width change at 11 inches (2030), 24 inches (2050), 37 inches (2100), and 66 inches (2100) of SLR. Change in beach width for open coast beaches was evaluated using CoSMoS 3.0 sandy shoreline projections for the “hold the line, no nourishment” scenario. Change in beach width for Alamitos Bay beaches was evaluated using permanent inundation projections obtained from the National Oceanic and Atmospheric Administration (NOAA) Sea Level Rise Viewer[6].

Beach width, as shown in Table 12, varies due to coastal dynamics and the presence of backshore features, such as parking lots that are built on the beach. When the sandy shoreline retreats up against a developed backshore feature, the beach width decreases to zero, and there is potential for complete loss of the sandy beach. Without interventions (such as beach nourishment), parts of Bayshore and Peninsula beaches in Alamitos Bay are projected to have zero width with 24 inches of SLR. All three Alamitos Bay beaches are projected to have zero width (complete loss) with 66 inches of SLR.

The open coast beaches are somewhat less susceptible to losses, but Junipero and Peninsula are projected to have zero width in some places (such as along beaches with backshore parking lots) under the 24 inches of SLR by 2050 scenario.

Table 12: Beach Exposure Assessment: Projected Beach Width

Beach	Existing Width (feet)	Projected Beach Width (feet)			
		2030 (11 "SLR)	2050 (24” SLR)	2100 (37” SLR)	2100 (66” SLR)
Open Coast					
Alamitos	200 to 400	250 to 500	200 to 400	150 to 400	50 to 300
Junipero	100 to 550	50 to 500	0 to 350	0 to 400	0 to 250
Belmont Shore	350 to 850	300 to 800	250 to 750	200 to 650	100 to 600
Peninsula	150 to 700	100 to 700	0 to 600	0 to 600	0 to 350
Alamitos Bay					
Bayshore	35 to 100	20 to 90	0 to 50	0	0
Peninsula	50 to 80	40 to 70	0 to 60	0 to 30	0
Mothers	110 to 160	95 to 145	85 to 120	75 to 105	0

Sensitivity and Adaptive Capacity

As described above, Long Beach generally has two different types of beaches: open coast and sheltered. Both types of beaches have high sensitivity to permanent inundation, as they cannot be used or function as beaches when underwater. They have moderate sensitivity to temporary flooding from king tides and storm surge. Although flooding, erosion, and debris may impair the use of the beach temporarily, the beach can return to functionality through natural recovery of sand and after repair and clean up.

[6] https://coast.noaa.gov/slr/; Accessed September 2018.

Beaches generally have low adaptive capacity to SLR for a number of reasons. Beaches in southern California typically have developed backshores (such as parking lots, roads, and homes), which impede the natural landward migration of the beach in response to SLR. In addition, the California coastline is generally sediment starved as a result of decades of reductions in sediment supply due to damming and coastal armoring, which trap sediment. As a result, beaches cannot respond to rising seas as they would under more natural conditions. Interventions such as sand re-nourishment are challenging and expensive. Open coast beaches have greater adaptive capacity than sheltered beaches because wave action and currents can help bring in new sand and redistribute it naturally to help the beach respond to SLR and recover from storm events. In contrast, the Alamitos Bay beaches are especially susceptible to SLR inundation because natural processes such as waves are less able to redistribute sediment within the sheltered embayment. Table 162 summarizes the sensitivity and adaptive capacity ratings for beaches.

Table 13: Sensitivity and Adaptive Capacity Ratings for Beaches

	Sea Level Rise (Permanent Inundation)*	← Rationale	Sea Level Rise (Temporary Flooding)*	← Rationale
Sensitivity	High	Cannot be used or accessed if permanently inundated.	Moderate	Flooding, erosion, and debris can impair use temporarily.
Adaptive Capacity	Low	Challenging and expensive to renourish beach. Backshore development impedes natural landward migration of beach.	Moderate	Sand eroded off the beach during storms can be transported onshore by waves and help beach recover from storm damage.

*Note: Permanent inundation refers to inundation by the daily high tide (MHHW) and temporary flooding refers to flooding by the annual king tide or 100-year storm surge.

Wetlands/Natural Habitats

Asset Overview

Wetlands in the City of Long Beach occur along the coastline, rivers and waterways, and in small scattered pockets amid developed areas. These present day wetlands are representative of remnant wetlands that historically occurred over much larger surface areas. Wetlands in Long Beach can be divided into freshwater wetlands and estuarine (part saline, part freshwater) wetlands. Riverine wetlands, a third category, are a combination of freshwater and estuarine wetlands, depending on the location in the river the wetland is, and whether it is upstream of the salt-zone (boundary line of tidal/salt water influence). Wetlands provide important habitat for wildlife and fish species. In addition to wildlife habitat, marshes provide coastal stability to reduce erosion, and act as nature's sponges to absorb rising tides and reduce wave energy during storm events. Marshes play an important role in carbon storage capacity, chemical nutrient uptake, and as biofiltration for pollutants that occur in surface water runoff, treating the water onsite before the pollutants spread.

There are six named wetland and natural area sites that are assessed in this evaluation: The Jack Dunster Marine Biological Reserve, the Golden Shore Marina Reserve, Los Cerritos Wetlands Complex, the San Gabriel River, the Los Angeles River, and the Colorado Lagoon. These wetlands can be divided into estuarine: Jack Dunster Marine Biological Reserve, Golden Shore Marina Reserve, and the lower stretches of the San Gabriel and the Los Angeles rivers; and freshwater: the Colorado Lagoon, and the upstream portions of the San Gabriel and Los Angeles rivers. Several additional wetlands occur throughout the City, such as the freshwater pond south of the Del Lago gated community at Loynes Drive and Highway 1, and east of Highway 1 in the Bixby Village Golf Course, along with the freshwater wetlands associated with the El Dorado Nature Center.

Exposure

With 11 inches of SLR, wetlands that occur from the coastline and harbors, upriver to the 405 on the Los Angeles River and upriver to the 605 on the San Gabriel River will be impacted. These include the estuarine wetlands associated with the Los Angeles River and the Port of Long Beach area, and the estuarine wetlands associated with the San Gabriel River and Alamitos Bay.

The Jack Dunster Marine Reserve estuarine wetlands will be exposed to annual king tide flooding with 11 inches of SLR. This area is an important remaining wetland habitat in the City of Long Beach because it is some of the last remaining wetland habitat and provides a suite of ecosystem services.

The Los Cerritos Wetlands Complex is composed of estuarine and freshwater wetlands. The northern portion of the complex north of East 2nd Street and consisting of estuarine and freshwater wetlands is exposed to SLR at 11 inches. South of East 2nd Street, in the Los Cerritos Wetlands Complex, freshwater wetlands are exposed to SLR at 66 inches. The freshwater pond south of the Del Lago gated community at Loynes Drive and Highway1 is exposed to annual king tide flooding at 66 inches.

The Colorado Lagoon is tidally connected to Marine Stadium through culverts under Marina Vista Park. An evaluation of SLR impacts within Colorado Lagoon was not possible because the CoSMoS model does not simulate flow through water control structures (such as culverts) and information on the tidal characteristics within the lagoon was not available. The Colorado Lagoon Restoration Project will remove the culverts and construct an open channel connection to Marine Stadium, introducing full tidal exchange. Components of the restoration project such as grading, foot bridge deck and supports, road crossings and elevations, etc. have been designed with considerations for SLR.

Sensitivity and Adaptive Capacity

Estuarine Wetlands

Estuarine wetlands in Long Beach have a high sensitivity to SLR (permanent inundation). As the sea level rises, these wetlands will become inundated with sea water, which will ultimately drown the vegetation if natural sedimentation is unable to keep pace with SLR. Little to no upslope undeveloped land cover is present for upslope migration. As a result these estuarine wetlands may transition to open water habitat over time. The response of estuarine wetlands to SLR is an area of active research and could be explored further to better understand their vulnerability to SLR.

Estuarine wetlands in Long Beach have a low adaptive capacity to SLR (permanent inundation) because little to no undeveloped areas exist up slope for marsh migration. As a result, these wetlands would likely convert to open water environments. At the Jack Dunster Marine Biological Reserve, adaptive capacity is increased by a floating breakwater, which reduces the erosive currents from the Los Cerritos Channel.

Estuarine wetlands are generally less sensitive to temporary flooding by king tides and 100-year storm surge because they can tolerate occasional temporary flooding events.

Freshwater Wetlands

Freshwater wetlands in Long Beach overall have a high sensitivity to SLR. These wetland types would likely convert to estuarine wetlands, because the freshwater-saltwater zone edge on the surface and in the ground water would move upstream as the sea level rises. Associated freshwater species, including vegetation and wildlife, would not sustain in a saltwater influenced environment because their salt tolerance would be exceeded.

Freshwater non-riverine wetlands have a low adaptive capacity to salt water intrusion.

Riverine Wetlands

Riverine wetlands have high sensitivity to SLR. The downstream estuarine portion of riverine wetlands have high sensitivity to sea level rise because they would become inundated and generally lack the open upslope landscape to migrate upslope. The upstream freshwater stretch of riverine wetlands has high sensitivity to SLR due to salt water intrusion.

Riverine wetlands have a moderate adaptive capacity to sea level rise because these areas are refreshed by upstream runoff. Storm surges will bring in salt but then the freshwater flows from upriver would rinse these areas, allowing them more adaptive capacity than the other isolated freshwater wetlands.

Table 14: Sensitivity and Adaptive Capacity Ratings for Wetlands

	Sea Level Rise (Permanent Inundation)*	← Rationale	Sea Level Rise (Temporary Flooding)*	← Rationale
Sensitivity	High	Vegetation would become regularly inundated. In a constrained urban environment, there is limited room for habitat migration.	Moderate	Erosion and debris can impair wetlands temporarily, but wetlands can tolerate occasional extreme storm flooding.
Adaptive Capacity	Low	In a constrained urban environment, there is limited room for habitat migration.	Moderate to High	Healthy wetlands can generally recover and regenerate following occasional extreme storm flooding.

*Note: Permanent inundation refers to inundation by the daily high tide (MHHW) and temporary flooding refers to flooding by the annual king tide or 100-year storm surge.

Marinas

Vulnerability Summary

Marina assets typically include boat slips, docks, showers and restrooms, pump out stations, fuel services, equipment supply stores, storage, and shipyard facilities. There are a number of public marinas along the Long Beach shoreline (such as the Alamitos Bay Marina and Long Beach Shoreline Marina) that may be impacted by sea level rise and elevated water levels in the future. Sailing, fishing, boating, and waterfront bars and restaurants are an important part of Long Beach's economy that could be impacted.

High water levels from king tides, storm surge, and sea level rise may impact marina operations in a number of ways. High tide events that overtop the marina shorelines may affect access to marina docks and boat slips. In addition, shoreline facilities such as showers, restrooms, and marina offices, etc. may be damaged by floodwaters. In addition, Long Beach Shoreline Marina is home to fire rescue, lifeguard rescue, and police boats. Higher water levels during extreme events could impact marine emergency response if these facilities are impacted. While most marina areas have floating docks and can therefore accommodate moderate water level fluctuations within their design range, during extreme water level events, docks may float off their pilings or gangways may become separated from docks and limit access.

During combined wave and high tide events, protective structures such as breakwaters may become less effective as waves overtop the crest of these structures and allow waves to enter protected areas. The Long Beach Shoreline Marina has an offshore detached breakwater and an attached breakwater at Grissom Island that could lose effectiveness in the future due to sea level rise unless their crest elevations are raised. There is also a breakwater within the Alamitos Bay Marina that could be overtopped by high tides and boat wakes during future high water level events as a result of sea level rise.

6.2 Riverine Flooding

Parks, beaches, and wetlands exposed to the FEMA 100-year storm is very similar to the 11 inches SLR + 100-year storm surge scenario described above. Figure 14 shows City-parks that are within the 100 and 500-year FEMA floodplain. Given the large extent of the 500-year floodplain, considerably more parks are at-risk to that event.

The sensitivity and adaptive capacity considerations for riverine flooding are similar the temporary flooding (SLR + Storm Surge) described considerations above.

6.3 Extreme Heat Events

Vegetation in Parks and Open Space may be impacted by extreme heat events, but parks are likely to remain operational. The use of additional irrigation and/or change of vegetation to heat and drought tolerant plants may reduce the impact of extreme heat. Extreme heat often coincides with periods of drought, so increased irrigation may not be a preferred option. Parks and Open Spaces may experience loss of some species that are not able to tolerate higher temperatures. Parks and Open Spaces, in particular beaches, may experience increased visitation during extreme heat days, which could put stress on associated facilities such as parking and waste management.

6.4 Drought

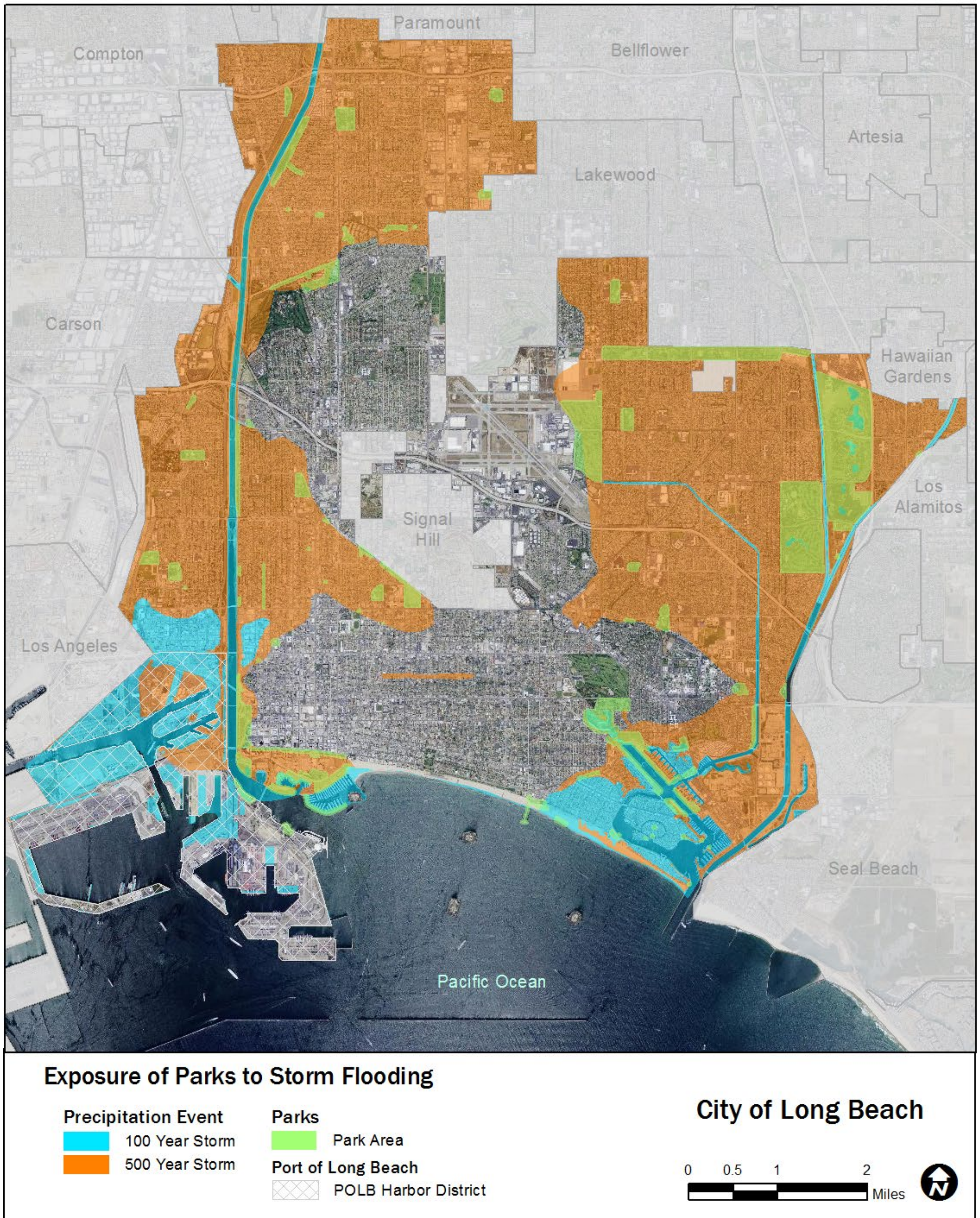
Vegetation in Parks and Open Space may be impacted by drought, but parks are likely to remain operational. The use of additional irrigation and/or change of vegetation to heat and drought tolerant plants may reduce the impact of drought. The use of irrigation may not be preferred as water restrictions may be in place during a drought. The use of non-potable water for irrigation may be a preferred option. Parks and Open Spaces may experience loss of some species that are not able to tolerate drought.

6.5 Vulnerability Summary for Parks and Open Space

- With 11 inches of SLR, portions of 17 parks are exposed to annual king tides. One of those parks is projected to have 50% of the park area flooded, three are projected to have 20% exposed, and the rest are projected to have 10% or less exposed.
- Although parks have high sensitivity to permanent inundation, they have moderate sensitivity and high adaptive capacity to temporary flooding due to king tides and storm surge.
- With 24 inches of SLR, there is potential for loss of portions of the Bayshore and Peninsula beaches within Alamitos Bay.
- Beaches in this highly urbanized context have high sensitivity and low adaptive capacity to permanent inundation. They have moderate sensitivity and moderate adaptive capacity to temporary flooding due to king tides and storm surge.

- The Jack Dunster Marine Reserve estuarine wetlands and the Los Cerritos Wetlands Complex north of East 2nd Street will be exposed to annual king tides with 11 inches of SLR.
- Vegetation in Parks & Open space may be impacted by extreme heat and drought, but functionality of the parks is unlikely to be impacted.

Figure 14: Exposure of Parks and Open Space to Riverine Flooding



Disclaimer: This map is intended as a planning-level tool to illustrate the locations of FEMA designated flood hazard areas and do not represent the exact location or depth of flooding. These maps are based on model outputs and do not account for all the complex and dynamic riverine, coastal, or stormwater drainage processes or future conditions.
Data sources: City of Long Beach, FEMA. Results: AECOM, 2017

Section 7. **Vulnerability of Transportation Assets**

The transportation asset sector includes roads, bike paths, and bridges.

7.1 Sea Level Rise and Coastal Flooding

Roads

Asset overview

Roads in Long Beach consist of highways, arterials, and neighborhood streets. Roads are constructed from asphalt or concrete. Roads also include lighting and other electrical equipment.

Exposure

With 11 inches of SLR, four miles of road are projected to be exposed to annual king tides. The majority of the roads that will be impacted at 11 inches are in the Long Beach Harbor District. Impacted roads in other areas are generally only slightly affected along portions in close proximity to existing water levels. Impacted areas include stretches of Seaside Freeway, Highway 47, Pier A Way and Carrac Avenue. These roads provide access to Port facilities, the NRG Power Station and other industrial operations. An additional 45 miles of road would be exposed to 100-year storm surge flooding with 11 inches of SLR.

Without adaptation, up to 98 miles of road could be exposed to annual king tide flooding by the end-of-century.

Table 15: Miles of Roads Exposed to Sea Level Rise and 100-year Storm Surge

	2030 (11" SLR)		**2050 (24'' SLR)**		**2100 (37" SLR)**		**2100 (66" SLR)**	
	Annual King Tide	Additional Exposure Due to Storm Surge	Annual King Tide*	Additional Exposure Due to Storm Surge	Annual King Tide*	Additional Exposure Due to Storm Surge	Annual King Tide	Additional Exposure Due to Storm Surge
Roads (miles)	4	45	41	32	74	16	89	27

***Note: The exposed assets for the King Tide + 24" SLR scenario are similar to the daily high tide (MHHW) + 37" SLR scenario. The exposed assets for the King Tide + 37" SLR scenario are similar to the daily high tide (MHHW) + 66" SLR scenario.

Sensitivity and Adaptive Capacity

As described in Table 15 below, roads that are permanently inundated cannot be used, as vehicles will not be able to navigate them and inundation would lead to degradation of the road and subgrade. As such, roads are highly sensitive to permanent inundation. Roads are moderately sensitive to temporary flooding by king tides or 100-year storm surge. They could be used as normal other than when temporary flooding occurs over a certain depth depending on vehicle clearance (for example cars have lower clearance than emergency vehicles). It should be noted, however, that over time, temporary flooding could lead to erosion and degradation of the roadway, thus requiring additional maintenance above a baseline amount in order to maintain functionality.

In terms of adaptive capacity, roads have low ability to change in response to permanent inundation, as the cost of elevating or relocating a road is high. Roads have more adaptive capacity when it comes to temporary flooding because, while challenging, measures can be taken to temporarily flood-proof the road, such as inflatable flood barriers. In addition, temporarily re-routing traffic because of flooding is also an option, drawing on the redundancies within the road network. In evaluating both sensitivity and adaptive capacity, several nuances should be considered. For one, low inundation depths on a temporary basis may affect the functionality of a road in only very minor ways. In such a scenario, there could be little impact other than a slow-down of traffic, making the road's sensitivity to temporary flooding only minor. Similarly, the adaptive capacity of the road system might be high if a road that experiences temporary flooding is a minor road and if there are other roads in the system that provide essentially the same function.

Table 16: Sensitivity and Adaptive Capacity of Roads

	Sea Level Rise (Permanent Inundation)	← Rationale	Sea Level Rise (Temporary Flooding)	← Rationale
Sensitivity	High	Roads cannot be used if permanently inundated.	Moderate	Roads would not be usable during flood events but would return to normal once the flooding subsides. Erosion damage possible.
Adaptive Capacity	Low	Elevating or relocating roads is difficult and costly.	Moderate	Temporary flood proofing for storm events is somewhat challenging.

*Note: Permanent inundation refers to inundation by the daily high tide (MHHW) and temporary flooding refers to flooding by the annual king tide or 100-year storm surge.

Bikeways

Asset Overview

Bikeways include Class I, II, and III bikeways. Class I are separated from the street or highway. Class II is a striped lane on a street, and Class III provides for shared use with motor vehicle traffic and is identified by signage. Bikeways are important for providing safe travel for bicyclists.

Exposure

With 11 inches of SLR, one mile of bikeway is projected to be exposed to annual king tides and an additional three miles are projected to be exposed 100-year storm surge flooding. The main bikeway that will be exposed to annual king tides with 11 inches of SLR is along Boathouse Lane next to the Jack Dunster Marine Biological Reserve (see Figure 6).

Sections of the bike path along the Alamitos, Junipero, and Belmont Shore Beaches would experience inundation at 37 inches of SLR (see Figure 6 and Figure 7).

The bike path around the Shoreline Marina is projected to experience inundation at 37 inches of SLR (see Figure 7).

Table 17: Miles of Bike Paths Exposed to Sea Level Rise and 100-year Storm Surge

	2030 (11" SLR)		**2050 (24'' SLR)**		**2100 (37" SLR)**		**2100 (66" SLR)**	
	Annual King Tide	Additional Exposure Due to Storm Surge	Annual King Tide*	Additional Exposure Due to Storm Surge	Annual King Tide*	Additional Exposure Due to Storm Surge	Annual King Tide	Additional Exposure Due to Storm Surge
Bike paths (miles)	1	3	3	4	6	5	10	5

*****Note: The exposed assets for the King Tide + 24" SLR scenario are similar to the daily high tide (MHHW) + 37" SLR scenario. The exposed assets for the King Tide + 37" SLR scenario are similar to the daily high tide (MHHW) + 66" SLR scenario.

Sensitivity and Adaptive Capacity

Bike paths are highly sensitive to permanent inundation because inundation would result in permanent loss of use of the bike path. Bike paths are moderately sensitive to temporary flooding events as the paths can be used once flood waters recede. In exposed areas, wave action associated with a coastal storm event could damage bike paths, especially if the concrete path is built on a surface that is prone to erosion, such as sand.

In terms of adaptive capacity, depending on the length and width of the path, as well as the material it is made of, bike paths have some amount of adaptive capacity in both permanent and temporary flooding contexts. An adaptive measure focused on elevating the bike path certainly has costs associated with it, especially if such a measure requires bringing in materials from afar and / or laying new pavement surface, but bike paths tend to be relatively narrow, which means that the cost of elevating a bike path would be low in comparison to, for example, raising a road. Relocating bike paths as an adaptation measure also has costs associated with it, but if a suitable alternate road or surface is readily available, relocating the path could be as simple and cheap as painting markers in the new lane and putting up signage.

Table 18: Sensitivity and Adaptive Capacity of Bike paths

	Sea Level Rise (Permanent Inundation)*	← Rationale	Sea Level Rise (Temporary Flooding)*	← Rationale
Sensitivity	High	Cannot be used if regularly flooded.	Moderate	Path could not be used during temporary flooding event. Storm surge could damage or destroy paths.
Adaptive Capacity	Moderate	Elevating or relocating paths is somewhat challenging.	Moderate	Elevating or floodproofing paths is somewhat challenging.

*Note: Permanent inundation refers to inundation by the daily high tide (MHHW) and temporary flooding refers to flooding by the annual king tide or 100-year storm surge.

Bridges

Asset Overview

Bridges are made primarily of concrete and are comprised of distinct components such as approaches, a deck, a superstructure, and sub-structure (including piers). They may also have auxiliary equipment such as streetlights and other electrical and mechanical components, and often support some utility crossings. Some bridges are owned by the City and others are owned by the State Department of Transportation (Caltrans). There are over 120 City-owned and over 110 State-owned bridges citywide. The bridges asset data used in this assessment is from Caltrans, which generally identifies the location of the bridge approach. This tends to represent the lowest part of the bridge.

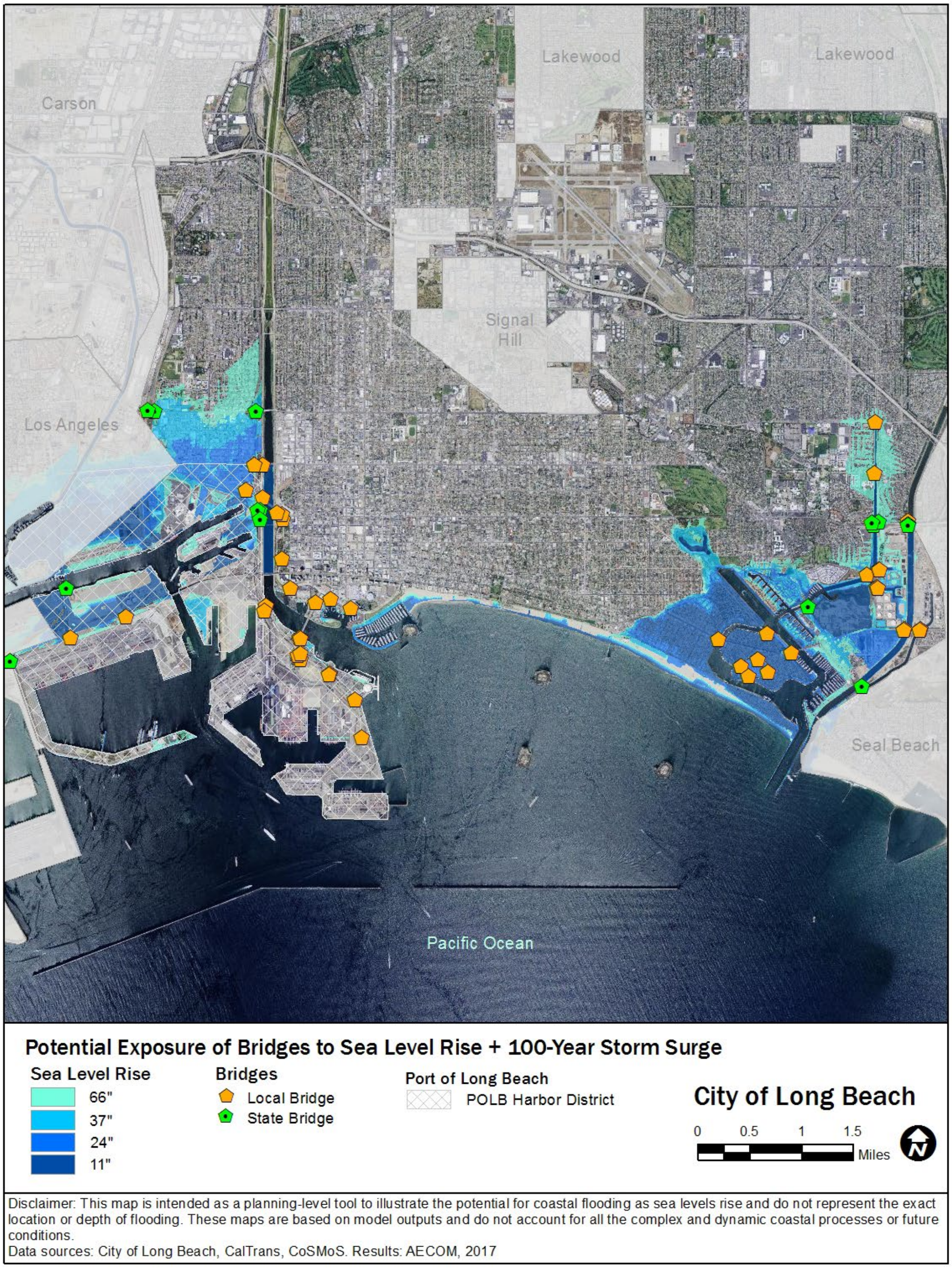
Exposure

The available bridge data represents single points approximately located at the bridge approaches. Because this data is not detailed enough to accurately assess flood impacts to bridges, a simplified approach was taken to identify bridges that may be exposed to future flood hazards. A 500-foot search radius was applied to the highest SLR scenario (66" SLR + storm surge) to assess which bridges are within a zone of vulnerability and would benefit from further analysis to evaluate exposure to future sea level rise-related inundation and flooding. 44 local bridges and 16 state bridges were identified within this SLR vulnerability area (Table 19). More detailed asset data and further analysis is required to identify which of these will be potentially impacted at each SLR scenario – for example, by comparing projected future water levels to bridge deck or soffit elevations and reviewing structural design plans to evaluate sensitivity to marine floodwaters. This level of analysis would require a comprehensive dataset of structural details related to the bridge design, which was not feasible to compile or evaluate as part of this study

Table 19: Number of Bridges Within 500 Feet Buffer of 66" of Sea Level Rise Plus 100-year Storm Surge

	Number of Bridges Within 500ft of 66" SLR + 100-year Storm Surge (2100)	
	Local Bridges	State Bridges
Bridges	44	16

Figure 15: Potential Exposure of Bridges to Sea Level Rise and Storm Surge



Note: Map identifies local and state bridges located within 500 foot buffer zone of the 100-year storm surge plus 66" SLR flooding area.

Sensitivity and Adaptive Capacity

Bridge components can exhibit different kinds of sensitivities to permanent inundation and temporary flooding and the extent of sensitivities depends on the depth of inundation and the elevation of components. For example, inundation or flooding of bridge approaches and decks could cause service disruption to on-road vehicular and pedestrian traffic as traffic would need to be rerouted. If the overtopping is shallow and isolated to the approach, traffic would have to slow down to use the bridge, but the bridge might be otherwise unaffected.

Other potential impacts of inundation or flooding on decks include debris overflow and pavement damage. Continuous exposure to salt water by permanent inundation could lead to more rapid degradation of bridge components (such as pavement and reinforcing steel), thus requiring an additional level of maintenance. In particular, salt water could infiltrate electrical and mechanical components of traffic control/signal boxes and cause immediate or latent damage through degradation and corrosion. Scouring and erosion (washout) around the bridge abutments or piers due to storm events could also compromise the bridge.

Some of the affected bridges span water channels that are used by recreational and commercial vessels. Depending on the extent of SLR and storm surge event, the water level may rise to a point where high mast vessels don't have adequate clearance to pass underneath the bridges.

The sensitivity of bridges to permanent inundation is high. The sensitivity of bridge approaches and decks to temporary flooding is moderate as the bridge could potentially return to normal operation once the floodwaters recede.

In terms of adaptive capacity, adapting a bridge approach or deck to permanent inundation would require rebuilding and elevating it, which is quite costly. As such, bridges are considered to have low adaptive capacity to permanent inundation. Bridges have slightly higher adaptive capacity to temporary flooding because, in addition to potentially elevating the approaches and touchdowns, there are options for flood-proofing the components that would be inundated. Furthermore, the overall transportation system that includes these bridges offers limited redundancies or alternative routes if the bridges were to go out of service, particularly if other routes are similarly vulnerable to SLR and storm surge.

Table 20: Sensitivity and Adaptive Capacity of Bridges

	Sea Level Rise (Permanent Inundation)*	← Rationale	Sea Level Rise + Storm Surge (Temporary Flooding)*	← Rationale
Sensitivity	High	Access likely to be impacted permanently; scouring and erosion likely.	Moderate	Access likely to be impacted temporarily. Scouring and erosion likely.
Adaptive Capacity	Low	Elevating bridges is difficult and costly.	Moderate	Elevating bridges is costly. Temporary floodproofing is somewhat challenging.

*Note: Permanent inundation refers to inundation by the daily high tide (MHHW) and temporary flooding refers to flooding by the annual king tide or 100-year storm surge.

7.2 Riverine Flooding

The transportation assets exposed to the FEMA 100-year storm is very similar to the 11 inches SLR + 100-year storm surge scenario described above. Given the large extent of the 500-year floodplain, considerably more transportation events are at-risk of exposure to flooding in that scenario. Over 600 miles of road are located in the 500-year floodplain.

The sensitivity and adaptive capacity considerations for riverine flooding are similar to the temporary flooding (SLR + Storm Surge) considerations described above.

7.3 Extreme Heat

The number of extreme heat days (over 95℉) in Long Beach per year is projected to increase from an average of four in the baseline period (1980-2000) to 11-16 days by mid-century and 11-37 by end-of century, depending on the emissions scenario (Sun et al. 2015). Based on a report completed by the United States Department of Transportation, it is estimated that the risk of asphalt pavement softening increase when temperatures remain over 100 °F without cooling at night, particularly in areas with high truck traffic (USDOT 2012). Asphalt pavement softening may result in damage. If electrical outages were caused due to area-wide brownouts, traffic signals and streetlights could be affected, temporarily disrupting traffic movement.

7.4 Drought

Under extreme conditions, paving materials may be affected if the ground shrinks. This is most likely to happen with expansive soils that contain a large percentage of silt or clay. Damage to transportation assets may include cracks and warping of pavement. Subsidence due to the extraction of groundwater from an aquifer faster than it can be recharged can also damage transportation assets.

7.5 Vulnerability Summary for Transportation Assets

- With 11 inches of SLR, 4 miles of road and 1 mile of bikeway are projected to be exposed to annual king tides.
- Transportation assets generally have high sensitivity and low adaptive capacity to permanent inundation, but moderate sensitivity and moderate adaptive capacity to temporary flooding. However, bikeways may have high sensitivity to temporary flooding if they are constructed on a land that could be prone to erosion from storm surge, such as on a sandy beach or river levee (a condition that exists in Long Beach).
- 44 local bridges and 16 state bridges are located in an area that could potentially be exposed to a 100-year storm surge event with 66” of SLR.
- Extreme heat may result in an increase in damage due to asphalt pavement softening, particularly in areas of high truck traffic.

Section 8. **Vulnerability of Energy Assets**

The Energy asset sector includes Generation Facilities, Transmission Lines, Electrical Substations, and Natural Gas Mains.

Asset Overview

Long Beach has over 200 miles of transmission lines citywide. They are owned and operated by Southern California Edison. Transmission lines carry high voltage power from generation facilities to substations. They are most often carried on overhead lines.

Long Beach has approximately 42 substations citywide. They are owned and operated by Southern California Edison. Substations serve to transform electricity from the high voltage transmission network to the lower voltage distribution network. They consist of electrical equipment and may be on a pad outdoors or within a structure.

Long Beach has three generation facilities. The NRG Long Beach Generating Station is located in the Harbor District and is owned and operated by NRG. Hayes Generating Facility, located East of the San Gabriel River, is owned and operated by the Los Angeles Department of Water and Power. The Alamitos Energy Station, located West of the San Gabriel River, is owned and operated by AES California. It is being redeveloped and is anticipated to include improvements that would make it more resilient to sea level rise.

Long Beach also has several smaller storage containers and over 900 miles of natural gas mains citywide. They are owned and operated by the Long Beach Energy Resources Department and deliver natural gas to homes and businesses. Natural gas mains are located underground.

8.1 Sea Level Rise and Coastal Flooding

Exposure

With 11 inches of SLR, the NRG Generating Station is projected to be exposed to annual king tides. During a 100-year storm event with 11 inches of SLR, the Alamitos Generating Station would also be exposed, although it is being redeveloped.

One substation is projected to be exposed to annual king tide with 11 inches of SLR. It is called “Seabright” and is located near the Los Angeles River. With 66 inches of SLR, the “Marina” substation is projected to be inundated. It is located near the Davies Boat Launch in Alamitos Bay.

With 11 inches of SLR, eight miles of transmission lines could be exposed to annual king tides. While transmission lines are generally carried on overhead lines, the bases of the transmission towers supporting the lines may be exposed. They may not have been designed for regular inundation, which could cause access issues for maintenance purposes.

With 11 inches of SLR, one mile of natural gas mains would be exposed to annual king tide flooding with an additional 25 miles exposed during a 100-year storm surge with 11 inches of SLR.

Table 21: Energy Sector Assets Exposed to Sea Level Rise and 100-year Storm Surge

	2030 (11" SLR)		2050 (24'' SLR)		2100 (37" SLR)		2100 (66" SLR)	
	Annual King Tide	Added Exposure Due to Storm Surge	Annual King Tide*	Added Exposure Due to Storm Surge	Annual King Tide*	Added Exposure Due to Storm Surge	Annual King Tide	Added Exposure Due to Storm Surge
Generation Facilities (number)	1	1	1	1	2	0	2	0
Electrical Substations (number)	1	0	1	1	1	2	2	2
Transmission Lines (miles)	8	0	9	3	13	2	15	5
Natural Gas Mains (miles)	1	25	21	19	41	11	53	21

*****Note: The exposed assets for the King Tide + 24" SLR scenario are similar to the daily high tide (MHHW) + 37" SLR scenario. The exposed assets for the King Tide + 37" SLR scenario are similar to the daily high tide (MHHW) + 66" SLR scenario.

Sensitivity and Adaptive Capacity

Energy infrastructure has high sensitivity to permanent inundation and temporary flooding, as extensive damage to electrical components is possible even with temporary exposure to salt water. Overhead transmission lines are generally not exposed to SLR, but if the base of the tower was not designed for permanent or temporary exposure to salt water, it could result in damage and problems with access for maintenance. Natural gas mains, which are underground pipes could be damaged by erosion or high groundwater.

The adaptive capacity of energy infrastructure to permanent inundation is generally moderate to low as elevating or relocating infrastructure is difficult and costly. Although still very costly to elevate, smaller pieces of energy infrastructure (e.g. substations) generally have higher adaptive capacity than large pieces of infrastructure, (e.g. generating facilities). Adaptive capacity for temporary flooding is somewhat higher and flood proofing mechanisms could help protect infrastructure at a lower cost.

Table 22: Sensitivity and Adaptive Capacity of Energy Assets

	Sea Level Rise (Permanent Inundation)	← Rationale	Sea Level Rise (Temporary Flooding)	← Rationale
Sensitivity	High	Cannot operate if inundated	High	Electric power systems may be damaged or destroyed from exposure to water.
Adaptive Capacity	Low	Elevating or relocating energy infrastructure is difficult and very costly.	Moderate	Elevating energy infrastructure is very costly. Flood proofing energy infrastructure, especially large assets, is somewhat challenging.

*Note: Permanent inundation refers to inundation by the daily high tide (MHHW) and temporary flooding refers to flooding by the annual king tide or 100-year storm surge.

8.2 Riverine Flooding

The transportation assets exposed to the FEMA 100-year storm are very similar to the 11 inches SLR + 100-year storm surge scenario described above. Given the large extent of the 500-year floodplain, considerably more energy assets are at-risk of exposure to flooding in that scenario. For example, an estimated 26 substations are located in the 500-year floodplain.

The sensitivity and adaptive capacity considerations for riverine flooding are similar to SLR + 100-year storm surge described in the considerations above.

8.3 Extreme Heat

Extreme heat events may result in higher electricity demand. At the same time, during extreme heat events electricity supply may be reduced due to reduced hydropower output and reduced transmission line and power plant efficiency. As a result, there is an increased risk of demand exceeding supply, which could result in area-wide brownouts or blackouts.

8.4 Drought

Generation facilities are sensitive to the loss of cooling water supply. The loss of hydropower generation during a drought may result in a greater reliance on fossil fuel powered energy generation, such as the generating facilities located in Long Beach.

8.5 Vulnerability Summary for Energy Assets

- With 11 inches of SLR, 1 generation facility, 1 substation, 8 miles of transmission lines, and 1 mile of natural gas mains are projected to be exposed to annual king tide flooding.
- Energy assets generally have high sensitivity and low adaptive capacity to permanent inundation. They have high sensitivity and moderate adaptive capacity to temporary flooding.
- Extreme heat may increase energy demand and could result in brownout if demand exceeds supply.

Section 9. **Vulnerability of Stormwater Assets**

The stormwater assets assessed include storm drain outfalls and storm drain carriers.

Asset Overview

Stormwater assets are part of the urban drainage system that conveys stormwater away from buildings and streets into pipes, channels, and finally through outfalls into water bodies, such as the ocean, bay or rivers. Storm drain carriers include pipes and open channels. There are over 440 miles of storm drain carriers in the city. Storm drain outfalls are the discharge point from the carrier to a body of water. There are over 400 storm drain outfalls citywide in Long Beach. Stormwater pump stations are used to pump away large volumes of water to prevent flooding. There are 55 stormwater pump stations in Long Beach.

9.1 Sea Level Rise and Coastal Flooding

Exposure

With 11 inches of SLR, 18 storm drain outfalls may be exposed to annual king tides. An additional five may be exposed to 100-year storm surge flooding. It should be noted that this is a preliminary assessment of potential exposure and more detailed analysis would need to be conducted to determine exact elevations of outfalls with respect to projected sea level rise and the outfall conditions, such as whether they have backflow prevention devices. Exposure of outfalls to SLR could result in stormwater flooding upstream as the outfall is blocked from discharging, and water backs up into the drainage system. Many of the storm drain outfalls that would be exposed earliest are around Alamitos Bay (which drain Belmont Shore and Marina Pacifica) and along the Los Cerritos Channel. Other outfalls that would be exposed earliest are around the mouth of the Los Angeles River and Queensway Bay (which drain the downtown area).

With 11 inches of SLR, one stormwater pump station may be exposed to annual king tides. This pump station is located on the northeastern side of Naples Island at E 2nd Street. An additional six may be exposed to 100-year storm surge flooding. Five of these are located around Naples Island and Belmont Shore.

Exposure of storm drain carriers to sea level rise reduces their capacity and can cause upstream flooding. Approximately 1 mile of storm drain carriers are projected to be exposed at 11 inches of SLR. An additional 14 miles would be exposed to 100-year storm surge flooding with 11 inches of SLR. Overland flooding of buried storm drain carriers can saturate soils and lead to increased infiltration into stormwater pipes or flooding of catch basins and reduce conveyance capacity.

Table 23: Stormwater Assets Exposed to Sea Level Rise and 100-year Storm Surge

	2030 (11" SLR)		2050 (24'' SLR)		2100 (37" SLR)		2100 (66" SLR)	
	Annual King Tide	Added Exposure Due to Storm Surge	Annual King Tide*	Added Exposure Due to Storm Surge	Annual King Tide*	Added Exposure Due to Storm Surge	Annual King Tide	Added Exposure Due to Storm Surge
Storm Drain Outfalls (number)	18	5	23	13	30	13	39	28
Stormwater Pump Stations (number)	1	6	5	4	10	2	11	3
Storm Drain Carriers (miles)	1	14	12	17	29	10	38	11

*****Note: The exposed assets for the King Tide + 24" SLR scenario are similar to the daily high tide (MHHW) + 37" SLR scenario. The exposed assets for the King Tide + 37" SLR scenario are similar to the daily high tide (MHHW) + 66" SLR scenario.

Sensitivity and Adaptive Capacity

Stormwater infrastructure has high sensitivity to permanent inundation as it can result in a permanent loss of drainage capacity near the coast. Stormwater infrastructure has moderate sensitivity to temporary flooding due to storm surge as there is a temporary loss of drainage capacity near the coast during the event, but the infrastructure can continue to function when floodwaters recede.

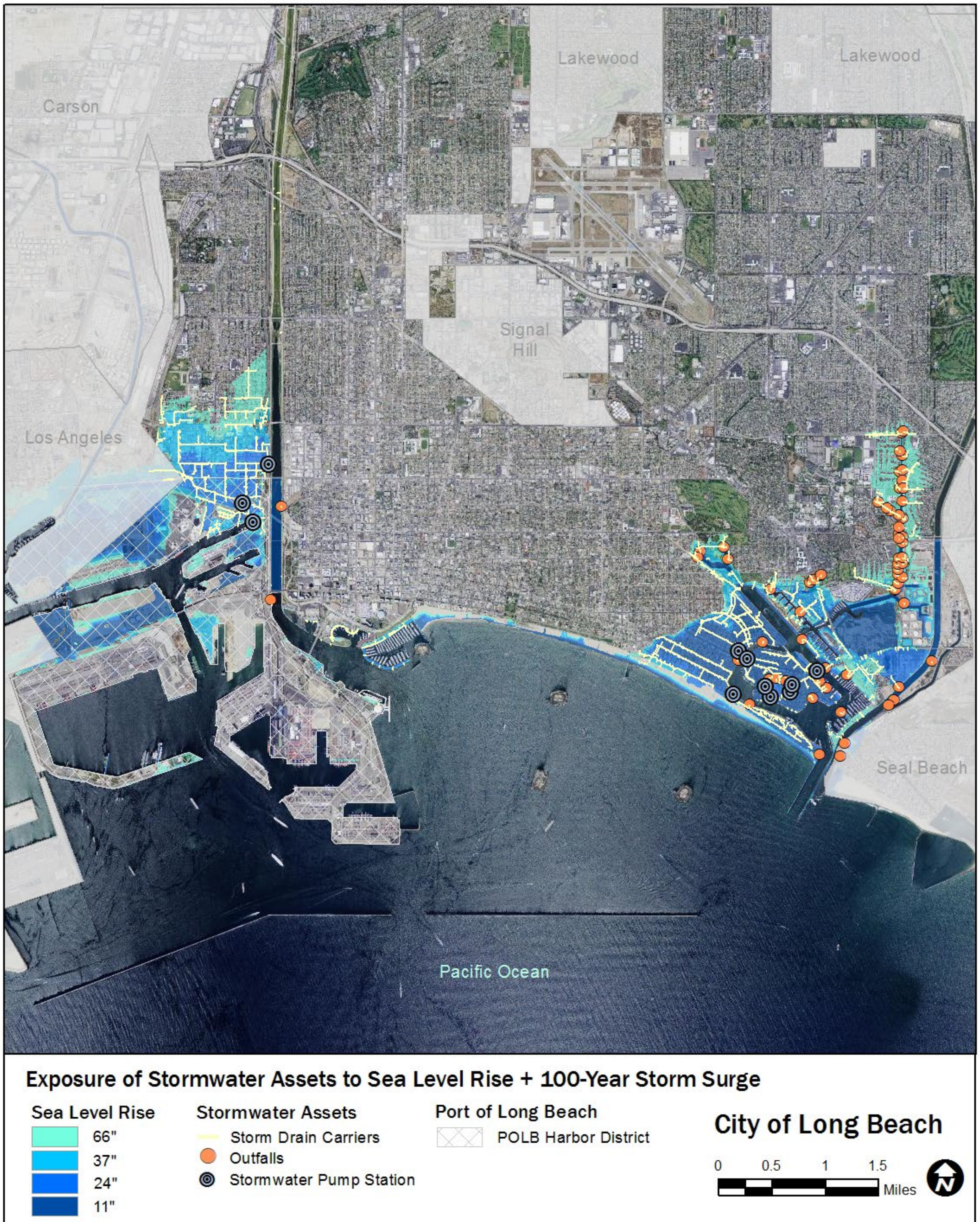
Stormwater infrastructure has low adaptive capacity to permanent inundation due to SLR as replacing or modifying (e.g. enlarging the drainage capacity) is somewhat challenging, particularly in a constrained urban environment. Stormwater infrastructure has better adaptive capacity to temporary flooding events as, in addition to modifying the infrastructure, devices such as backflow preventers can help in a temporary flood event.

Table 24: Sensitivity and Adaptive Capacity of Stormwater Infrastructure

	Sea Level Rise (Permanent Inundation)*	← Rationale	Sea Level Rise (Temporary Flooding)*	← Rationale
Sensitivity	High	Permanent loss of stormwater infrastructure capacity near the coast	Moderate	Temporary loss of stormwater infrastructure capacity near the coast.
Adaptive Capacity	Low	Elevating or modifying stormwater infrastructure is challenging.	Moderate	Elevating or modifying stormwater infrastructure is somewhat challenging for storm events. Backflow prevention can be useful for temporary flood conditions.

*Note: Permanent inundation refers to inundation by the daily high tide (MHHW) and temporary flooding refers to flooding by the annual king tide or 100-year storm surge.

Figure 16: Exposure of Stormwater Assets to Sea Level Rise + 100-year Storm Surge



Disclaimer: This map is intended as a planning-level tool to illustrate the potential for coastal flooding as sea levels rise and do not represent the exact location or depth of flooding. These maps are based on model outputs and do not account for all the complex and dynamic coastal processes or future conditions.
Data sources: City of Long Beach, CoSMoS. Results: AECOM, 2017

9.2 Riverine Flooding

The stormwater assets exposed to the FEMA 100-year storm is very similar to the 11 inches SLR + 100-year storm surge scenario described above. Given the large extent of the 500-year floodplain, considerably more stormwater assets are at-risk to that event. There are over 200 stormdrain outfalls located in the 500-year floodplain that could potentially be impacted.

The sensitivity and adaptive capacity considerations for riverine flooding are similar to the temporary flooding considerations described above. An increase in intense precipitation events could case increase flooding due to impacts on the stormwater system, particularly if an intense rainfall event is coupled with SLR or a high tide event, such as a King Tide. It is recommended that additional studies are carried out that model the impacts of combined SLR, storm surge, and heavy storm events on the stormwater system and flooding impacts. As an example, the Port of Long Beach studied the combined impacts of SLR, storm surge, and precipitation based flooding from the Dominguez Channel. The modeling found that under extreme conditions, more intensive riverine storm storms coupled with SLR could cause the Dominguez Channel to overtop its banks, resulting in extensive flooding to Port infrastructure.

9.3 Extreme Heat

No direct impacts.

9.4 Drought

No direct impacts.

9.5 Vulnerability Summary for Stormwater Assets

- With 11 inches of SLR, 18 storm drain outfalls, 1 stormwater pump station, and 1 mile of storm drain carriers are projected to be exposed to annual king tides.
- Stormwater assets generally have high sensitivity and low adaptive capacity to permanent inundation. They have moderate sensitivity and moderate adaptive capacity to temporary flooding (king tide or 100-year storm surge).
- Additional modeling needed to understand the potential flooding impact from combined SLR, storm surge, and riverine flooding events.

Section 10. **Vulnerability of Wastewater Assets**

The wastewater assets assessed include wastewater treatment plants, sewer pump stations, sewer forced main, and sewer gravity mains.

Asset Sector Overview

The wastewater system conveys wastewater from homes and businesses to a wastewater treatment plant for treatment then discharge. The majority of wastewater in Long Beach is treated at the Joint Water Pollution Control Plant, which is located in Carson. Because this plant is not located in Long Beach, its vulnerability could not be assessed as part of this study. SLR impacts to this plant would cascade to the entire wastewater system, so further study of the vulnerability of this plant is recommended. The remaining portion of the City's wastewater is delivered to the Long Beach Reclamation Plant of the Los Angeles County Sanitation Districts, which is located in Long Beach (7400 Willow Street). Where needed, pump stations move wastewater to higher elevations so that they can be transported by gravity flow (in sewer mains) to the wastewater treatment plant. Force mains convey wastewater under pressure to higher elevations from the downstream pump stations.

10.1 Sea Level Rise and Coastal Flooding

Exposure

With 11 inches of SLR, no sewer pump stations are projected to be exposed to annual king tides by 2030. However, with 11 inches of SLR, four pump stations are projected to be exposed to 100-year storm surge flooding. Three of these pump stations are owned by Long Beach Water Department and are located in the southeastern subarea (Marine Stadium, Belmont Shore, and Naples Island), and one is owned by the Parks, Recreation and Marine Department and is located at Shoreline Marina. With 66 inches of SLR, up to 15 pump stations are projected to be exposed to annual king tides.

With 11 inches of SLR, approximately 220 feet of force main and 280 feet of sewer mains are anticipated to be exposed to annual king tide flooding. These are located primarily around Naples Island and Marina Pacifica. By late century with 66 inches of SLR, up to 52 miles of sewer mains and five miles of force mains could be exposed to annual king tides.

The Long Beach Reclamation Plant is not exposed to the evaluated levels of SLR and storm surge.

Table 25: Wastewater Assets Exposed to Sea Level Rise and 100-year Storm Surge

	2030 (11" SLR)		2050 (24'' SLR)		2100 (37" SLR)		2100 (66" SLR)	
	Annual King Tide	Added Exposure Due to Storm Surge	Annual King Tide*	Added Exposure Due to Storm Surge	Annual King Tide*	Added Exposure Due to Storm Surge	Annual King Tide	Added Exposure Due to Storm Surge
Pump Stations (number)	0	4	2	8	9	6	14	3
Force Mains (miles)	<1	2	2	2	4	0	4	2
Gravity Mains (miles)	<1	24	18	21	40	12	52	20

*****Note: The exposed assets for the King Tide + 24" SLR scenario are similar to the daily high tide (MHHW) + 37" SLR scenario. The exposed assets for the King Tide + 37" SLR scenario are similar to the daily high tide (MHHW) + 66" SLR scenario.

Sensitivity and Adaptive Capacity

Wastewater assets have moderate sensitivity to temporary flooding. The mains are closed systems, so they have low sensitivity to temporary flooding. However, pump stations have high sensitivity to temporary flooding because they are often underground and/or located at low elevations and include electrical and mechanical components that can be damaged with exposure to saltwater. Flood damage to the pump stations could result in sewage backflows into homes or businesses, or wastewater overflow onto surface streets.

Wastewater assets have high sensitivity to permanent inundation. Permanent inundation could result in infiltration into the sewer system that could reduce capacity and impact operations. In addition, saturation of the ground due to higher sea levels could result in displacement and potential damage to pipes. Temporary flooding of pump stations may render them inoperable due to damage to mechanical and electrical components and loss of access.

Wastewater assets have moderate adaptive capacity to temporary flooding. Electrical equipment could be elevated and a redundant generator could be provided if located at a higher elevation or a separate storage area. In addition, temporary flood proofing measures, such as sandbags, could be employed.

Wastewater assets have low adaptive capacity to permanent inundation as both the equipment and adjacent ground would need to be elevated to maintain both operations and access.

Note: Wastewater treatment plants have high sensitivity to SLR, but Long Beach's treatment plant is not located within the areas anticipated to be exposed by the of sea level rise and storm surge studied, and the Joint Water Pollution Control Plant is located outside of Long Beach, and further study is recommended.

Table 26: Sensitivity and Adaptive Capacity of Wastewater Assets*

	Sea Level Rise (Permanent Inundation)*	← Rationale	Sea Level Rise (Temporary Flooding)*	← Rationale
Sensitivity	High	Cannot operate if regularly inundated. Electrical components particularly sensitive. Access would be impaired.	Moderate	Storm damage could temporarily impair functionality, particularly electrical components. Access impaired temporarily.
Adaptive Capacity	Low	Elevating the surrounding ground to allow for access could be expensive and challenging.	Moderate	Elevating electrical components and providing redundant power source could allow for continued operation during temporary flooding. Flood proofing measures could be used.

*Note: Permanent inundation refers to inundation by the daily high tide (MHHW) and temporary flooding refers to flooding by the annual king tide or 100-year storm surge.

Excludes treatment plants as the Long Beach Reclamation Plant is not located within the areas anticipated to be exposed by the levels of SLR and storm surge studied and the Joint Water Pollution Control Plant is located outside of Long Beach and therefore out of the scope of this study.

10.2 Riverine Flooding

The wastewater assets exposed to the FEMA 100-year storm is very similar to the 11 inches SLR + 100-year storm surge scenario described above. Given the large extent of the 500-year floodplain, considerably more wastewater assets are at-risk to that scenario. Over 20 wastewater pump stations and the Long Beach Reclamation Plant are located in the 500-year floodplain.

The sensitivity and adaptive capacity considerations for riverine flooding are similar to the temporary flooding considerations described above.

10.3 Extreme Heat

Extreme heat events may cause minor increase in odor impacts. In addition, if electrical outages result from area-wide brownouts, sewer pumps will be disrupted, unless they are connected to backup generators.

10.4 Drought

Not direct impact, but reduced water usage decreases flows into the wastewater system, increasing sewer cleaning needs and system corrosion.

10.5 Vulnerability Summary for Wastewater

- With 11 inches of SLR, approximately 220 feet of force main and 280 feet of sewer mains are anticipated to be exposed to annual king tide flooding. These are located primarily around Naples Island and Marina Pacifica.
- Wastewater assets generally have high sensitivity and low adaptive capacity to permanent inundation (annual king tide). They have moderate sensitivity and moderate adaptive capacity to temporary flooding (king tide and 100-year storm surge).
- The Joint Water Pollution Control Plant is located outside of Long Beach city limits, and further study of climate change vulnerabilities is recommended.

Section 11. **Vulnerability of Potable Water Assets**

The potable water assets assessed include potable facilities, mains, and hydrants.

Asset Sector Overview

The Long Beach Water Department oversees the infrastructure that provides potable water to Long Beach homes and businesses through a system that includes a treatment plant, reservoirs, tanks, and interconnections (facilities), and main lines (mains). Potable mains are in most cases underground. Hydrants supply water for firefighting purposes.

11.1 Sea Level Rise and Coastal Flooding

Exposure

With 11 inches of SLR, one potable facility (an interconnection) is projected to be exposed to annual king tides. It is located in the Harbor District and is an interconnection with the Los Angeles Department of Water and Power (LADWP) (see Figure 8). With 66 inches of SLR, four potable facilities could be exposed to annual king tides. These facilities are also interconnections with the City of Seal Beach Water District, LADWP, and the Harbor Department. The Groundwater Treatment Plant is not exposed to the studied levels of SLR and storm surge.

With 11 inches of SLR, 1 mile of potable mains are anticipated to be exposed to annual king tides and an additional 25 miles are projected to be exposed to 100-year storm surge flooding.

With 11 inches of SLR, four hydrants are anticipated to be exposed to annual king tides and an additional 213 are projected to be exposed to 100-year storm surge flooding. By late-century with 66 inches of SLR, nearly 500 hydrants may be exposed to annual king tides.

Table 27: Potable Assets Exposed to Sea Level Rise and 100-year Storm Surge

	2030 (11" SLR)		2050 (24'' SLR)		2100 (37" SLR)		2100 (66" SLR)	
	Annual King Tide	Added Exposure Due to Storm Surge	Annual King Tide*	Added Exposure Due to Storm Surge	Annual King Tide*	Added Exposure Due to Storm Surge	Annual King Tide	Added Exposure Due to Storm Surge
Potable Facilities (Number)	1	0	1	1	3	1	4	0
Potable Mains (Miles)	1	25	21	21	42	14	56	24
Hydrants (Number)	4	213	160	204	359	135	493	19

***Note**: The exposed assets for the King Tide + 24" SLR scenario are similar to the daily high tide (MHHW) + 37" SLR scenario. The exposed assets for the King Tide + 37" SLR scenario are similar to the daily high tide (MHHW) + 66" SLR scenario.

Sensitivity and Adaptive Capacity

Potable water assets have moderate sensitivity to temporary flooding. The potable water system is a closed and pressurized system, so damage to mains is unlikely. However, facilities, such as interconnections, may include electrical and mechanical equipment that can be damaged with exposure to saltwater.

Potable water assets have high sensitivity to permanent inundation. Prolonged exposure to saltwater could result in corrosion of the pipes. Given the pressurized system, buoyancy of the pipes and intrusion of salt water through cracks or joint connections are less of an issue. However, if there is a break in the system, then contaminated water could be pulled in. In addition, inundation could result in impaired access for maintenance and repairs.

Potable water assets are not likely to be damaged with temporary flooding, but the difficulty of accessing the assets for maintenance and repair may reduce their functionality and could result in safety issues. If the depth of inundation is high enough, access to hydrants may be impaired, which would hinder firefighting efforts.

Potable water assets have moderate adaptive capacity to temporary flooding (king tide and storm surge) as flood proofing sensitive assets is possible. Potable water assets have low sensitivity to permanent inundation, as elevating the surrounding ground or relocating water assets is costly and challenging.

Table 28: Sensitivity and Adaptive Capacity of Potable Water Assets

	Sea Level Rise (Permanent Inundation)*	← Rationale	Sea Level Rise (Temporary Flooding)*	← Rationale
Sensitivity	High	Access impaired if permanently inundated; potential water safety issues.	Moderate	Damage to mains unlikely, but damage to electrical and mechanical components of pump stations possible.
Adaptive Capacity	Low	Elevating or relocating potable water assets is costly and challenging.	Moderate	Flood proofing water supply infrastructure is somewhat challenging for storm surge events.

*Note: Permanent inundation refers to inundation by the daily high tide (MHHW) and temporary flooding refers to flooding by the annual king tide or 100-year storm surge.

11.2 Riverine Flooding

The potable assets exposed to the FEMA 100-year storm is very similar to the 11 inches SLR + 100-year storm surge scenario described above. Given the large extent of the 500-year floodplain, considerably more potable water assets are at-risk in that scenario. Over 20 potable water facilities are located in the 500-year floodplain.

The sensitivity and adaptive capacity considerations for riverine flooding are similar the temporary flooding considerations described above.

11.3 Extreme Heat

No direct impacts, but extreme heat may result in higher water use for irrigation. If electrical outages result from area-wide brownouts, pumps will be disrupted, unless they are connected to backup generators.

11.4 Drought

The provision of water services could be compromised due to reduced water supply. Conservation measures and the development of alternative water sources, such as recycled water for non-potable uses, can reduce the impact.

11.5 Vulnerability Summary for Potable Water Assets

- One potable facility (an interconnection), 1 mile of mains, and 4 hydrants are projected to be exposed to annual king tides with 11 inches of SLR.
- Over 20 potable facilities are located in the 500-year floodplain
- Potable water assets have high sensitivity and moderate adaptive capacity to both permanent inundation and temporary flooding.
- Drought may impact the provision of water services due to constrained water supply.

Section 12. **Public Health**

The Public Health asset sector focuses on vulnerable populations.

Overview

More coastal flooding, increased extreme heat events, and worsened air quality may negatively affect human health. While all people are vulnerable to the impacts of climate change, the degree of vulnerability is a function of demographic, socio-economic, health, and place-based conditions that influence an individual or community's sensitivity to environmental change. Factors, such as age, race, income, and existing health conditions affect the ability of an individual to prepare, respond, and recover from an extreme weather event or climate stressor. Low-income communities and communities of color are particularly susceptible to natural disasters. Long Beach is very diverse, which is a source of strength, vibrancy, and resiliency. However, it has also has racial and economic disparities that are manifested spatially across the City. The following are some key considerations with regards to vulnerable populations in Long Beach.

<u>Communities of Color</u>

A high proportion of Long Beach residents identify as non-white or Hispanic/Latino. As of the 2010 census, the population is 41 percent Hispanic / Latino, 13 percent Black or African American, 13 percent Asian, and 1 percent Native Hawaiian or Pacific Islander (CLB 2013). These communities may experience health disadvantages. For example, the Black or African American community in Long Beach has the highest rates of hospitalization for heart disease, diabetes, and asthma compared to other races/ethnicities (CLB 2013).

Although all the four major racial and ethnic groups are represented in each zip code, certain populations are concentrated in certain parts of the City. Hispanics or Latinos represent nearly 50 percent or greater of the total population in North, West Central and Southwest Long Beach. The greatest concentration of Black or African Americans are in the North, West Central and Southwest neighborhoods. The greatest concentration of Asians are in the West Central and Southwest neighborhoods (CLB 2013).

<u>Age</u>

Elderly populations can be more vulnerable to extreme weather and climate stressors. They may be less able to evacuate as a higher proportion do not drive and may rely on public transportation. They may also have pre-existing health conditions that can be exacerbated by climate stressors. In Long Beach, almost 40 percent of people over the age of 65 report a disability compared to 10 percent of the overall Long Beach population. Approximately 9.3 percent of the Long Beach population is over the age of 65, which is slightly lower than the County of Los Angeles and State of California. Southeast, West Central, and East Long Beach have a higher percentage of older adults compared to other parts of the City (CLB 2013).

Language

The inability to speak English well can affect an individual's ability to communicate with service providers and make use of preparedness, response, and recovery resources. In Long Beach, 34 percent of households speak Spanish at home and 10 percent speak Asian or Pacific Islander Languages at home. In Long Beach, English proficiency varies by age with people over the age of 65 most likely to report speaking English "not well" or "not at all" (38 percent) (CLB 2013).

Income

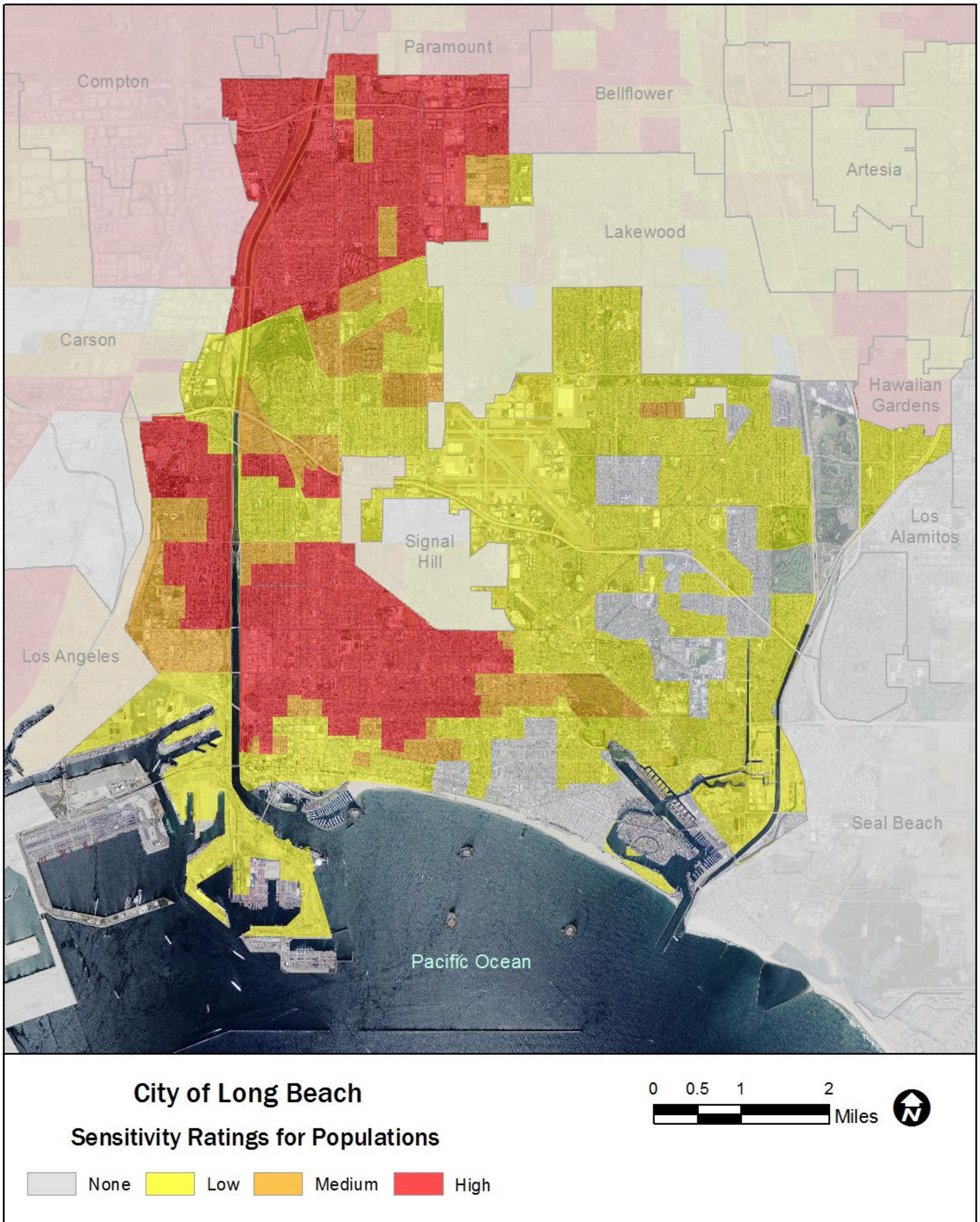
Low income communities face disproportionately higher rates of poor health outcomes and greater obstacles to achieving good health (LADCP 2015). Income varies across race and ethnic groups. Black or African American and Hispanic or Latino households had the lowest median incomes, about $10,000 less than the overall median income in Long Beach. Median income also varies by neighborhood, with higher incomes in the East and Southeast and lower incomes in the North, West Central, and Southwest. In addition, approximately 15.4 percent of all families in Long Beach live below the poverty line, which is 50 percent higher than the statewide poverty rate.

Social Vulnerability

The Climate-Smart Cities Los Angeles Project, with a Technical Advisory Team that included public health experts, local academic and research institutions, and community leaders developed a GIS decision support tool that includes social vulnerability index comprised of ten indicators. This index is based primarily on the Environmental Protection Agency's EJSCREEN[7] definition of demographic factors that indicate a community's potential susceptibility to environmental stressors, which include: people of color, low income, educational attainment less than a high school degree, linguistic isolation, population under 5, and population over 64. The index includes three additional characteristics, which were added based on recommendations from the Technical Advisory Team: unemployment, asthma, and low birth weight. Figure 16 shows the result of this index for Long Beach, demonstrating higher levels of indicators of social vulnerability in Central, West, and North Long Beach.

[7] EJSCREEN refers to Environmental Justice Screening and Mapping Tool. https://www.epa.gov/ejscreen

Figure 17: Indicators of Social Vulnerability



Disclaimer: The Sensitivity Ratings for Populations Map and the associated analyses are intended as planning level tools to illustrate populations that have high sensitivity to climate stressors.
Data source: Climate Smart Cities Los Angeles Results; AECOM, 2017

12.1 Sea Level Rise, Coastal Flooding, and Riverine Flooding

Storm surges and coastal flooding, often closely tied to extreme precipitation events and riverine flooding, have the potential to cause injury, loss of life, displacement and increased mental health burden (CDPH 2012). According to an analysis by the Aquarium of the Pacific, with 24 inches of SLR and a 100-year storm surge, over 22,000 residents are at risk of exposure to flooding (AOP 2015). In addition, the Southeastern portion of Long Beach, which is susceptible to coastal and riverine flooding, has a higher share of residents over the age of 65 than other parts of the City. Elderly people may be less able to evacuate and at higher risk of exacerbation of exiting health conditions as a result of a flooding. Sewage overflows could also result in water-borne illnesses following a flood event (CDPH 2012).

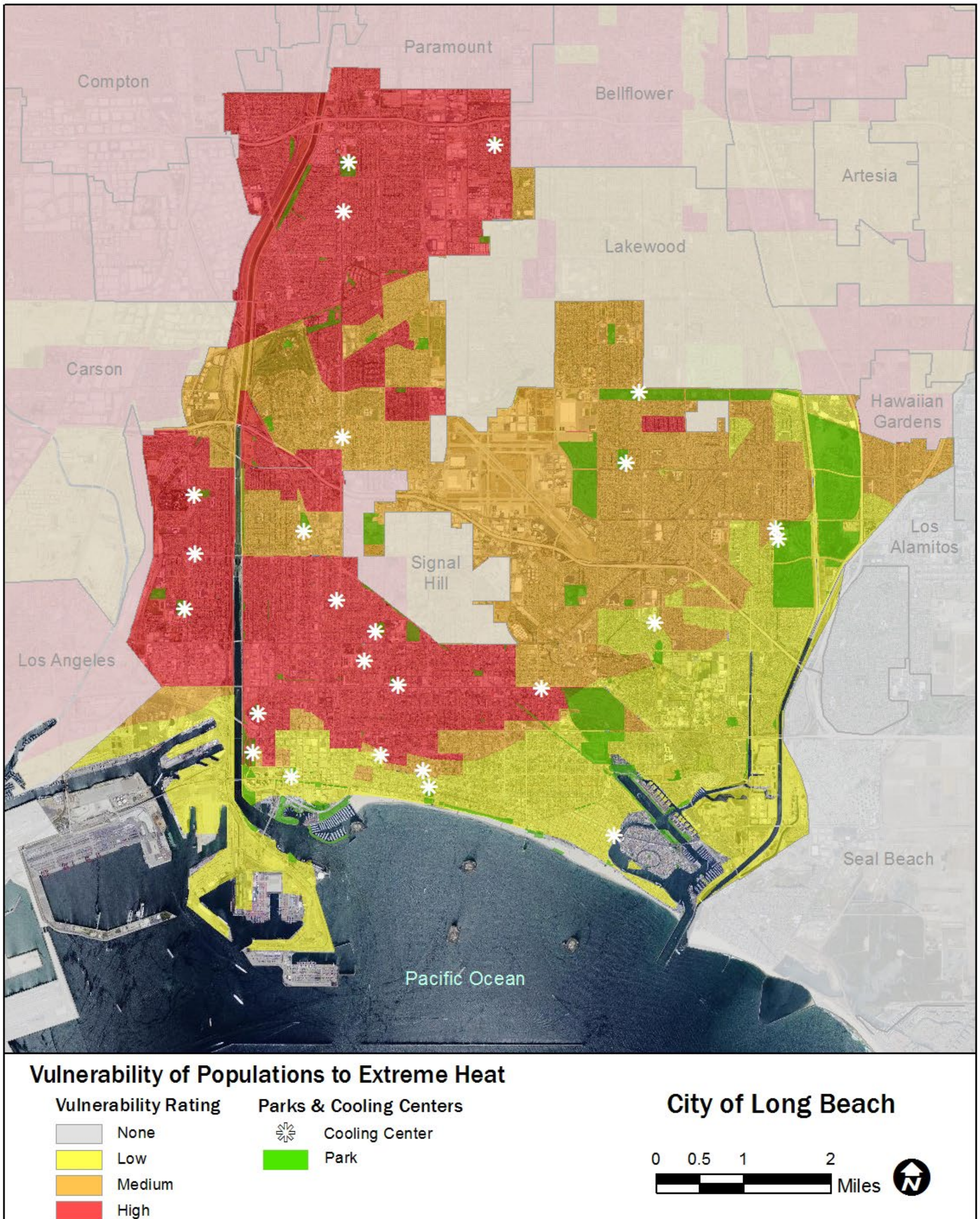
12.2 Extreme Heat

Extreme heat events can increase heat-related mortality, cardiovascular-related mortality, respiratory morality, and increase hospital admission and emergency department visits. A number of factors contribute the vulnerability of an individual to extreme heat. Particularly vulnerable populations include children, the elderly, people with respiratory disease, and those who work outdoors (CDPH 2012; CNRA 2014). Environmental factors also influence vulnerability including neighborhoods with high levels of impervious surfaces and limited green space, and housing units that lack air conditioning or household access to a vehicle. The amount of green space per 1,000 residents varies considerably across Long Beach with Central, West, and North Long Beach having a lowest amount (CLB DHHS 2013). Data from the Climate Smart Cities Los Angeles tool on modeling of the urban heat island effect[8] indicates that North and West Long Beach are more susceptible to high surface temperatures (Figure 17).

Analysis of census population data (from 2010) and the Climate Smart Cities Los Angeles heat vulnerability zone, indicate that approximately 275,000 residents of Long Beach live within the high vulnerability areas shown in Figure 17.

[8] Based on land surface temperatures, weighted 75% daytime, 25% nighttime temperatures.

Figure 18: Urban Heat Island Effect in Long Beach



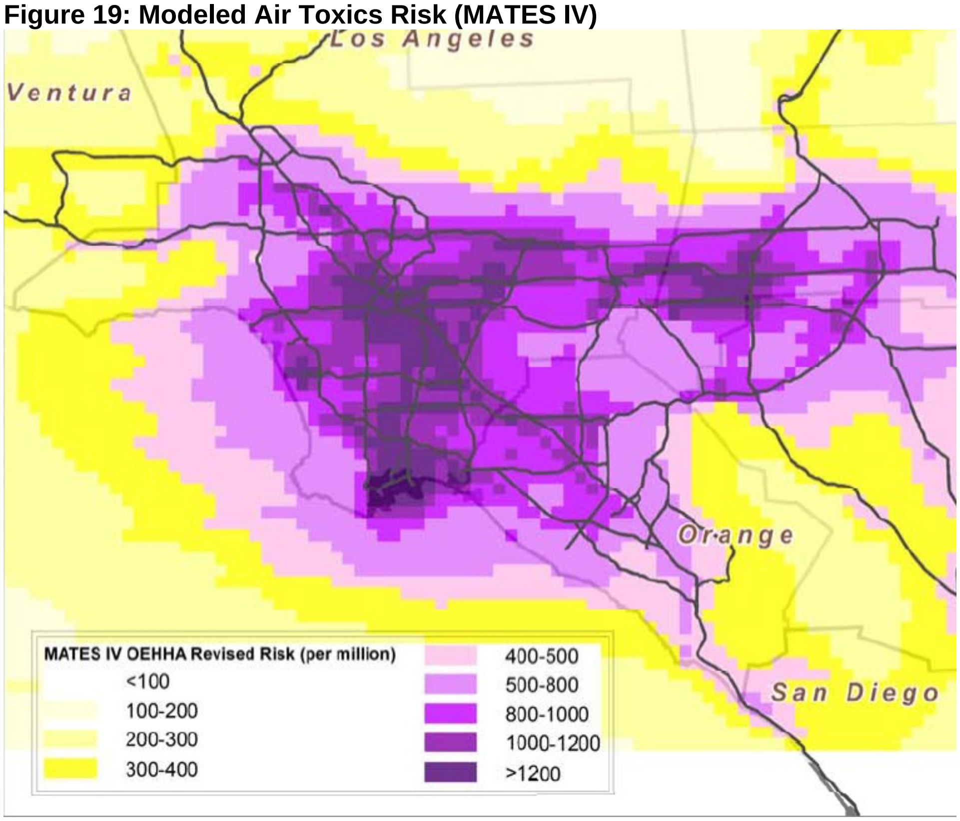
Disclaimer: The Vulnerability of Populations to Extreme Heat Map and associated analyses are intended as planning level tools to illustrate differing levels of vulnerability across the city.
Data source: Climate Smart Cities Los Angeles Results; AECOM, 2017

12.3 Air Quality

Air quality is especially relevant as a secondary climate stressor in Long Beach, as there are several sources that impact local air quality, including the 710 and 405 freeways, refineries, the Port of Long Beach, and major industrial sources (AOP 2015) and thousands of people whose health may be impacted by poor air quality. People who are especially sensitive to poor air quality include the young, elderly, those who have existing respiratory conditions, and those who work outside. Asthma and other cardiovascular and respiratory diseases may increase due to poor air quality (CNRA 2014; CDPH 2012). Asthma hospitalizations rates are highest in West and North Long Beach (CLB DHHS 2013).

Air toxics are pollutants that cause cancer or other serious health effects. Diesel particulate matter (PM) accounts for 68.2% of the carcinogenic risk from exposure to air toxics in the Southern California air basin (SCAQMD 2015). Diesel PM is emitted from diesel engines including trucks, buses, cars, ships, and locomotive engines and is concentrated near ports, rail yards, and freeways. Exposure to diesel PM has been shown to have numerous adverse health effects, including cardiovascular and pulmonary disease and lung cancer (EPA and 2016). As illustrated in Figure 18, the areas of the Los Angeles Basin that are exposed to the most risk to air toxics are those near the Ports of Los Angeles and Long Beach (SCAQMD 2015). According to the AOP (2015) study, 86 out of 116 census tracts in the City of Long Beach have diesel PM emissions in the top 10% of census tracts in California.

Figure 19: Modeled Air Toxics Risk (MATES IV)



Source: South Coast Air Quality Management District

12.4 Drought

Disrupted food and water supplies could result in hunger and malnutrition, particularly in low-income households, children, and the elderly (CDPH 2012).

12.5 Vulnerability Summary for Public Health

- Sea level rise, coastal flooding, and riverine flooding may result in injury, death, displacement, and mental health burden. The Southeastern neighborhoods, which are most susceptible to flooding, exhibit many demographic factors that make them less at risk to the health impacts of climate change (higher income, lower rates of respiratory disease, higher share of residents that identify as white), but also have a higher share of elderly residents, which are more vulnerable in extreme weather events.
- North, Central, and West Long Beach have the lowest amounts of greenspace and high urban heat island effect, which can further stress existing health conditions during extreme heat events.
- West and North Long Beach have poor air quality and high levels of hospitalizations for asthma.

C

APPENDIX C

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Appendix D
Climate Stressor Review

D

APPENDIX D

Climate Stressors Review

Long Beach Climate Action and Adaptation Plan

FINAL | August 27, 2018

Table of Contents

Section 1. Introduction

1.1 Background

The City of Long Beach is completing a climate vulnerability assessment to identify high level vulnerabilities, considering the City's unique geographical, social, and economic characteristics. The vulnerability assessment will inform the development of adaptation strategies that reduce vulnerability and enhance resilience. As a part of the vulnerability assessment process, this memo presents a review of the most relevant climate change stressors for the City of Long Beach based on the scientific literature. This memo is not intended to be an exhaustive literature review, but rather highlight the historic climate trends, climate projections, and potential impacts from the scientific literature that are most applicable to Long Beach in order to inform the exposure component of the vulnerability assessment.

The memo starts with a review of three primary climate change stressors (sea level rise, precipitation, and extreme heat) and two secondary climate change stressors (drought and decreased air quality.) Primary climate change stressors are first-order local conditions that are directly affected by changes in global atmospheric and oceanic temperatures. Secondary climate stressors are conditions affected by complex interactions between primary variables and other factors. The relevance of each stressor to Long Beach is described. Then, historic trends are provided so that future climate projections may be understood in comparison to past variability. Next, climate change projections are provided for mid-century and end-of-century. Lastly, the memo provides a high level overview of potential impacts these stressors could cause based on the literature. These impacts will be further assessed and specified during the vulnerability assessment process.

It should be noted that this memo represents a review of best available science at the time of writing (August 2018). As the science on climate change continues to evolve and new studies are available, this memo may require updating.

1.2 Information Sources

This memo draws on the best available data and climate science and the potential effects for Long Beach and/or the Los Angeles (L.A.) region. Where region-specific studies are not available, California and U.S. studies were reviewed. Regional and state level studies are available through the California Energy Commission's California Climate Change Center. To date, the California Climate Change Center has conducted three assessments, the latest released in July 2012, with a fourth assessment currently underway. The memo also draws on Cal-Adapt, a web-based climate data and information portal produced by the State of California's scientific and research community. The site contains historic data (1950-2013) and projections (2010-2100) from a variety of sources that have downscaled global climate models for more fine-scale resolution. National climate change studies are available through the National Climate Assessment.

1.3 Modeling Climate Change

General Circulation Models (GCM) are a tool used by climate researchers to better understand potential future changes in our global climate. GCMs incorporate the physical processes of the atmosphere, ocean, and land surface to simulate the response of the climate system to changing greenhouse gas (GHG) and sulfate aerosol emissions. These models are based on well-established physical principles and have been demonstrated to reproduce observed features of recent climate and past climate changes.

The science of climate change is continuously being revised as climate models are improved and updated with new data and observations. Such revisions improve our understanding of natural climate variability and the complexity of the global response to atmospheric greenhouse gases.

1.4 Greenhouse Gas Emission Scenarios as Climate Model Inputs

Because the level of future emissions is unknown and will be affected by population, economic development, environmental changes, technology, and policy decisions, the Intergovernmental Panel on Climate Change (IPCC), developed a range of possible future emissions that is used in climate models to provide scientific consistency in climate modeling efforts.

The IPCC's Fifth Assessment Report on Climate Change (AR5), released in 2014, adopted a new set of emissions scenarios referred to as Representative Concentration Pathways (RCP). Relative to previous GHG emission scenarios, RCPs offer an enhanced representation of climate processes, including updates in data and advances in model development. The RCPs represent the change between incoming and outgoing radiation to the atmosphere caused by differences in atmospheric composition. The four RCPs – RCP 2.6, RCP 4.5, RCP 6, and RCP 8.5 – are named after a possible range of radiative forcing in the year 2100 (+2.6, +4.5, +6.0, and +8.5 watts per square meter, respectively). Figure 1 describes each RCP scenario.

RCP8.5	RCP6	RCP4.5	RCP2.6
Describes a world characterized by rapid economic growth. CO_2-equivalent concentrations reach ~1,370 parts per million by the end of the century.	Represents a stabilization scenario. CO_2-equivalent concentrations reach ~850 ppm by the end of the century, followed by stabilization.	Represents a stabilization scenario where CO_2-equivalent concentrations reach ~650 ppm by the end of the century, followed by stabilization.	Signifies a peak and decline scenario where CO_2-equivalent concentrations peak at ~490 ppm by mid-century, followed by rapid GHG emission reduction.

Figure 1: Summary of RCP Scenarios

1.5 Downscaling of Global Circulation Models

GCMs provide estimates of climate change at a global level because the resolution—approximately 200 kilometers (km)—is typically too coarse to provide detailed regional climate projections. Therefore, model outputs are refined through additional analysis or modeling to provide finer regional detail through a process known as "downscaling." Downscaling is the term used to describe methods to generate locally relevant data from GCMs by connecting global-scale projections and regional dynamics (i.e., a 200 km GCM may be downscaled to a 25 km scale for a specific region). Downscaling GCM model output allows for more place-based projections of climate change at the state and local level; however, increased resolution does not necessarily equate to greater accuracy or reliability, as uncertainties remain in all climate projections.

Section 2. Climate Change Stressors

This section describes the relevance of each climate stressor to Long Beach, historical trends, and climate projections. The stressors analyzed include both primary climate stressors (sea level rise, temperature, and precipitation) as well as secondary climate stressors (drought and air quality). Table 1 summarizes the climate projections for Long Beach and/or the L.A. region. Where available, both mid-century and end-of-century projections are provided. More detailed discussion of each climate stressor is provided in the sections that follow.

Table 1: Summary of Climate Projections for Long Beach

	Climate Projections	
Sea Level Rise	Mid-Century • Projection 11.2 ± 3.5 inches • Range 5.0 to 23.9 inches (NRC 2012)[1]	End-of-Century • Projection 36.7 ± 9.8 inches • Range 17.4 to 65.6 inches (NRC 2012)[1]
	• Higher storm tides, more extensive inland flooding, and increased coastal erosion during storm events due to higher sea levels (CNRA 2009)	
Extreme Heat	Mid-Century • +7 to +12 extreme heat[2] days in Long Beach • Avg. temperature + 3 to +4°F in L.A. region (Sun et al. 2015)	End-of-Century • +7 to +33 extreme heat[2] days in Long Beach • Avg. temperature +3 to +8 °F in L.A. region • Avg. temperatures outside of historical (1981-2000) variability, particularly in late summer and early fall (Sun et al. 2015)
	• Heat waves will occur more frequently, be more intense, and longer-lasting (Cayan et al. 2009) More humid heat waves with less cooling at night (Gershunov and Guirguis 2012)	
Precipitation	Mid-Century • +6% to + 11% avg. annual precipitation in Long Beach (Cal-Adapt 2017)	End-of-Century • 1% to +25% avg. annual precipitation in Long Beach (Cal-Adapt 2017)
	• Near-zero change in avg. annual precipitation in L.A. region for both mid and end-of-century, but with large uncertainty. (Berg et al. 2015) • Increase in intensity of precipitation events (CEC 2012; Pagan et al. 2014) • High year-to-year variability in annual precipitation to continue under climate change (Berg et al. 2015; Pierce et al. 2011)	
Drought	• Overall regional drying trend with longer and more frequent droughts (CEC 2012; Pierce et al. 2011) • Higher temperatures leading to higher water demand (Pagan et al 2015) • Reduced snowpack and increased intensity of runoff events in watersheds that supply water to Long Beach (CEC 2012; Pagan et al 2015)	
Air Quality	• Higher temperatures will increase air pollution formation (CNRA 2014) • An increase in wildfire and energy consumption in the region could worsen air quality (CEC 2006) • Higher temperatures, precipitation change, and increasing CO_2 concentrations are expected to increase pollen and some airborne allergens (CNRA 2014; Fann et al. 2016) • Climate change may negatively impact indoor air quality through the growth and spread of pests, infectious agents, and disease vectors (Nazaroff 2013; Fann et al. 2016)	

1. NRC (2012) was considered best available sea level rise science at the initiation of this plan and is therefore referenced in the sea level rise section of this memo. Since this project was initiated, the California Ocean Protection Council (OPC) released new sea level rise guidance that is also considered and summarized in this memo.
2. Sun et al defines extreme heat at 95 ̊F and above.

2.1 Sea Level Rise, Coastal Flooding, and Shoreline Change

This section discusses sea level rise, which is a primary climate stressor, as well as coastal flooding and shoreline change, which are secondary climate stressors that are the result of complex interactions between sea level, wind, waves, and natural and human-altered landscapes.

The City of Long Beach is located within San Pedro Bay on the Pacific coast. The city shoreline is a combination of a 5.5 mile stretch of sandy beach along with a fortified shoreline within portions of the sheltered embayments and port. Portions of the city lie at a low elevation and have major industry along the water's edge, notably the Port of Long Beach – the second busiest seaport in the United States – as well as transportation, water, and power infrastructure, beaches, marinas, homes, and businesses. Sea level rise will elevate the mean sea level baseline, thereby elevating tides, waves, and storm surge. Even a small increase in sea levels will increase the frequency of coastal storm flooding events. The effects of tides, storm waves, and sea level rise are additive and together combine to cause increased coastal flooding, inundation, and erosion (AOP 2015). Sandy beaches, such as Junipero Beach, Belmont Shore Beach, and Peninsula Beach, will consequently become increasingly susceptible to coastal erosion as sea levels rise (NRC 2012).

2.1.1 Historical Events and Trends

Sea Level Rise

Sea levels have been rising globally since the end of the last Glacial Maximum around 18,000 years ago. Driven primarily by thermal expansion of ocean water and melting land ice, global seas have risen 400-450 feet in this time (Griggs et al 2017). Over the past century, a network of more than 1,750 tide gauges has been gathering data on ocean water levels. Several approaches have been used to analyze these data to calculate an average global sea level rise, yielding rates from about 1.2 mm/year to 1.7 mm/year (approximately 0.05 to 0.07 inches/year) for the 20th century. However, since 1990 this global rate has more than doubled and continues to increase (Griggs et al 2017). Satellite observations show accelerating rates of ice loss from both the Antarctic and Greenland ice sheets, which combined, contain enough water to raise sea levels around 200 feet (Griggs et al 2017).

These rates reflect global mean sea level rise values, but there is tremendous regional variability due to local and regional processes such as vertical land motion, ocean and atmospheric patterns, and other effects. Analysis of approximately 90 years of tide data from 1923 to 2016 at the Los Angeles tide station (#9410660) by NOAA indicates a long-term trend of historic mean sea-level rise of approximately 0.96 mm/yr (0.04 +/-0.01 inches/year) (NOAA 2017).

Coastal Flooding

Prior to the construction of the Port of Long Beach in 1911, the City of Long Beach shoreline was composed of extensive mudflats, barrier islands, estuaries, and sand spits (Griggs et al 2005; Hapke et al 2006). The region is part of the San Pedro Littoral Cell, which is bordered by Palos Verdes to the northwest and Newport Canyon to the southeast. Historically, the Los Angeles and San Gabriel Rivers supplied the shoreline with sand and longshore transport was generally to the southeast with sand transported offshore into Newport Canyon. Palos Verdes provided some protection from winter storm waves approaching from the northwest making the area suited to development and a port.

Extensive development of the area and shoreline has significantly altered coastal processes, which is important to consider when identifying existing and future climate risks. The last of three large breakwaters was constructed in 1942, such that the majority of the Port and Long Beach shoreline is sheltered from waves. The area is still vulnerable to storms and waves, particularly when they approach the coast from a more westerly or southerly direction (as opposed to the typical northwest winter storm waves).

Waves approaching from these directions can damage the breakwaters and propagate between gaps in the breakwaters that are used for navigation. These storms can be especially damaging during El Niño conditions, which can raise coastal sea levels 10 - 30 cm (0.33 - 0.95 ft) during the winter months (NRC 2012) and when the typical winter storm track shifts to the southwest. Multiple storms damaged the breakwaters and caused flooding and damage at the shoreline during the 1982-1983 El Niño winter. The breakwaters were again damaged when a southeaster struck the coast in January 1988. Historically, the most costly storm to impact the southern California coast is the 1939 southerly tropical storm, causing today's equivalent of $34.1 million of damage and the only tropical storm in California's history to make landfall (WRCC 2008; WRH 2010). The storm caused massive flooding in the low-lying areas of Long Beach (then unprotected by the breakwaters), damaging homes, and scattering large amounts of trash and debris along the beach (WRH 2010). Recently, Hurricane Marie produced waves of up to 20 feet causing extensive flooding in southeastern Long Beach in late August 2014, and causing an estimated $20 million in damages across southern California (Zelinsky & Pasch 2015). The waves significantly damaged a section of the Middle Breakwater leading to further damage within the Port of Long Beach from wave action (CLB Staff Survey 2017). While this storm did not make direct landfall in southern California, the size, period, and extreme southern angle of the waves made the event particularly damaging.

Figure 2: Port of Long Beach Damage from Hurricane Marie in 2014

Several inland locations within Alamitos Bay are protected from large storm waves but are flooded during high tides, particularly King Tides, which are the highest tides of the year. According to City staff, locations with recurrent King Tide flooding include Bay Shore Avenue, Colorado Lagoon, the Peninsula, and Alamitos Bay (Figure 3). According to a coastal flooding study by Strauss et al (2016), there were only 32 flood days between 1955-1984 compared to 133 flood days between 1985-2014 in La Jolla, California, the nearest location to Long Beach in the study. These additional flood days are largely attributed by the authors to anthropogenic climate change.

Figure 3: Examples of King Tide Flooding

Shoreline Change

Human development also significantly altered natural shoreline change patterns. This is important to consider as the wide sandy beaches along much of Long Beach can partially function as a buffer against future sea level rise. The channelization of the Los Angeles and San Gabriel Rivers significantly reduced the natural sediment supply to the Long Beach shoreline. Despite this, much of the sandy beach has accreted over the 20th century due to the breakwaters limiting wave-induced erosion, a system of sand retention structures including groins and jetties, and several ongoing beach nourishment and sand bypassing projects (Figure 4). Figure 2 shows historical shorelines derived from NOAA T-Sheets, historical photographs, and airborne topographic LiDAR data and illustrates the overall accretion trend. Long-term accretion rates range between +0.5 to 1.5 meters/year in much of the area resulting in a relatively wide, flat sandy beach (Hapke et al 2006). Although much of the sandy shoreline is currently accreting and will provide some protection against future sea level rise, historical shoreline trends may not be indicative of future shoreline change because the existing coastal processes, both natural and anthropogenic, may change and could be overwhelmed by more extreme future sea level rise.

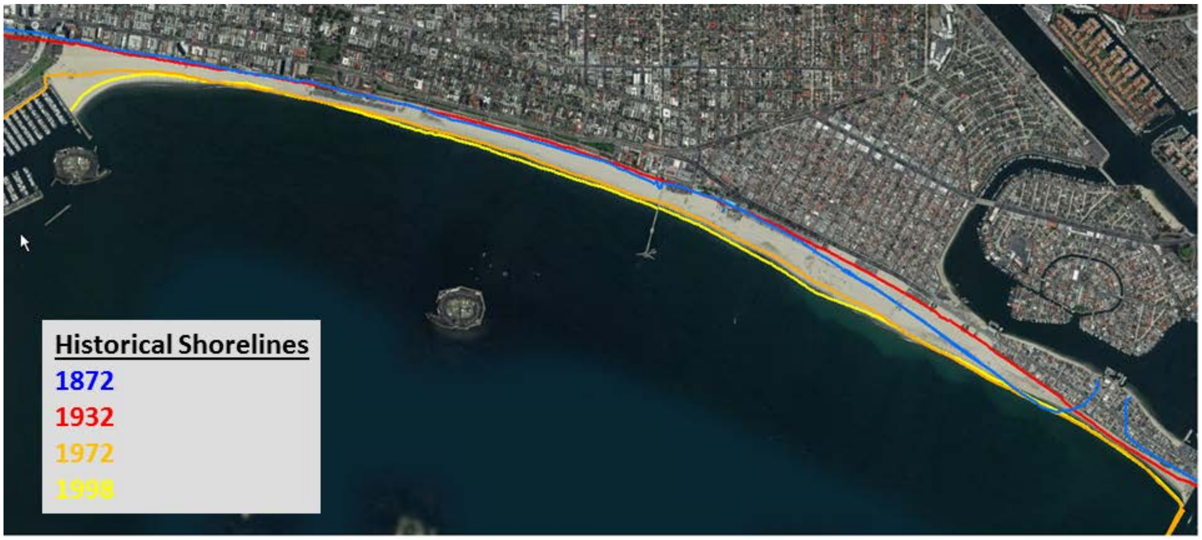

Figure 4: Historical Sandy Beach Shorelines in Long Beach
Notes: Historical high water line shorelines (1872, 1932, and 1972) are compared to a historical mean high water line (1998) and show historical accretion along the beach during the 20th century.
Source: Hapke et al (2006) – (https://pubs.usgs.gov/of/2006/1251/#data/)

The current breakwater and jetty configuration has left the southeastern tip of the Peninsula exposed to erosion, and several homes are threatened. This area is not adequately protected by the Long Beach Breakwater and waves attack the sandy beach from the south. The jetty at the San Gabriel river mouth inhibits northwest sand transport to naturally replenish this area. The City maintains a sandy beach here by bypassing sand from the accreting northwestern shoreline to the eroding southeastern shoreline (AOP 2015). In the winter and during large south swell events, an emergency sand berm is built to protect the homes from flooding.

Long Beach, once known as the "Sinking City," has a history of subsidence primarily from oil and gas extraction from the Wilmington Oil Field. A subsidence bowl, centered around the Port of Long Beach, reached a depth of 29 feet before measures were taken to arrest the subsidence. Over 20 square miles of land adjacent to the shoreline from the Port of Long Beach to Seal Beach are affected by subsidence. Constant monitoring and control is still required by Long Beach Energy Resources (the City's oil and gas department) to maintain stability and will continue to be so into the future (CLB 2017). The lowered land elevation from subsidence increases the City of Long Beach's vulnerability to storm flooding, sea level rise, and coastal erosion.

2.1.2 Future Projections

Sea Level Rise

Future sea level rise is expected to vary regionally due to differences in atmospheric and oceanographic process and vertical land motion. Various methods have been used to predict both future global sea level rise and regional sea level rise at numerous locations around the world. Up until 2018, the state of California utilized the National Research Council (NRC) 2012 sea level rise projections as best available science in state policy and guidance. In 2017, a new study was released by Griggs et al (2017) with updated modeled projections along the California coastline. This study informed the development of Ocean Protection Council's (OPC) new sea level rise guidance document that was adopted in March 2018. The OPC is currently reviewing the new guidance document with stakeholders and state agencies to develop an approach to administer the new guidance. Since the Long Beach Climate Action and Adaptation Plan was initiated prior to adoption of the OPC (2018) guidance, NRC (2012) projections were adopted to inform the vulnerability assessment; however, for completeness, both studies are summarized and compared in this section.

NRC (2012) used multiple global climate models with different global emissions scenarios to develop regional future sea level rise projections for the Los Angeles area and three other locations along the west coast. The study produced a projection, reflective of an average of the models, and a range of the model projections for three future years: 2030, 2050, and 2100. Generally, regional sea levels in the Los Angeles area are projected to increase at slightly higher rates than global sea levels. Table 2 summarizes the NRC projections for the Los Angeles area while also providing a comparison with mean global sea level rise projections. The NRC projections for the years 2030, 2050, and 2100 are 6, 11, and 37 inches respectively.

Table 2: Mean Regional vs Global Sea Level Rise Projections Relative to the Year 2000

Year	Southern California		Global	
	Projection	Range	Projection	Range
2030	5.8 ± 2.0 in	4.6 – 11.8 in	5.3 ± 0.7 in	3.3 – 9.1 in
2050	11.2 ± 3.5 in	5.0 – 23.9 in	11.0 ± 1.3 in	6.9 – 19.0 in
2100	36.7 ± 9.8 in	17.4 – 65.6 in	32.6 ± 4.2 in	19.8 – 55.2 in

Source: NRC (2012)

Note: The low value of the range for each year was computed by subtracting twice the standard deviation from the mean in the projection column, and adjusting to the difference between emission scenarios A1B and B1. The high value of the range was computed by adding twice the standard deviation to the mean, adjusting to the difference between emission scenarios A1FI and A1B, and adding the dynamical imbalance contribution (NRC 2012). Please refer to IPCC (2000) for more information on the emission scenarios.

Griggs et al (2017) completed an update to California's sea level rise science that informed the OPC's 2018 guidance document. Future sea level rise projections were developed at each tide station along the California coast. Table 3 presents sea level rise projections for Los Angeles, California. The study incorporated a range of global emissions scenarios ranging from aggressive emissions reductions (RCP 2.6) to no emissions reductions (RCP 8.5) through end of century. Multiple climate models for each global emissions scenario were evaluated to generate a range of future sea level rise predictions using a probabilistic approach. The advantage to this approach is it provides more detailed projections for asset managers to make risk-based decisions for sea level rise planning and design.

Table 3: Sea Level Rise Projections at Los Angeles, CA

Year (Emissions Scenario)	Inches Above 1991-2009 Mean Sea Level (in)			
	Median (50% probability of exceedance)	Likely Range (67% percent likely range)	1-In-20 Chance (5% probability of exceedance)	1-In-200 Chance (0.5% probability of exceedance)
2030	4	2 to 6	7	8
2050	8	6 to 12	14	22
2100 (RCP 2.6)	16	8 to 25	36	65
2100 (RCP 8.5)	26	16 to 38	49	80

Source: OPC (2018)

The NRC (2012) and OPC (2018) reports show similar regional sea level rise projections for comparable global emissions scenarios. The mid-range NRC (2012) projections for 2030, 2050, and 2100 are close to the OPC median projections. The high-range NRC projections for 2030 and 2050 are also comparable to the 0.5% exceedance OPC values; however, the OPC 0.5% exceedance projections for 2100 exceed the NRC high-range projection. The high-range OPC projection is 80 inches compared with 66 inches for NRC; however, the 66-inch value falls within the range of high-end projections for OPC (65 to 80 inches).

Coastal Flooding

In the next phase of the vulnerability assessment, SLR scenarios will be selected for further identification of asset-specific vulnerabilities. For illustrative purposes only, Figure 5 shows the areas in Long Beach that may be flooded during a 100-year tide event (i.e., the expected water level including astronomical tides, storm surge, and El Niño effects, but no wave effects) with one meter (39 inches) of sea level rise. This sea level rise projection is approximately equal to the mid-range NRC and OPC projections for 2100 and has a roughly 20% chance of being met or exceeded by 2100 under a high emissions scenario (RCP 8.5) according to OPC (2018). The figure illustrates a "bathtub" type analysis, where the floodwaters are simply projected inland to where ground elevations exceed the future 100-year flood level. The projected extent of inundation indicates the portions of Long Beach most susceptible to flooding impacts under a likely end-of-century sea level rise scenario.

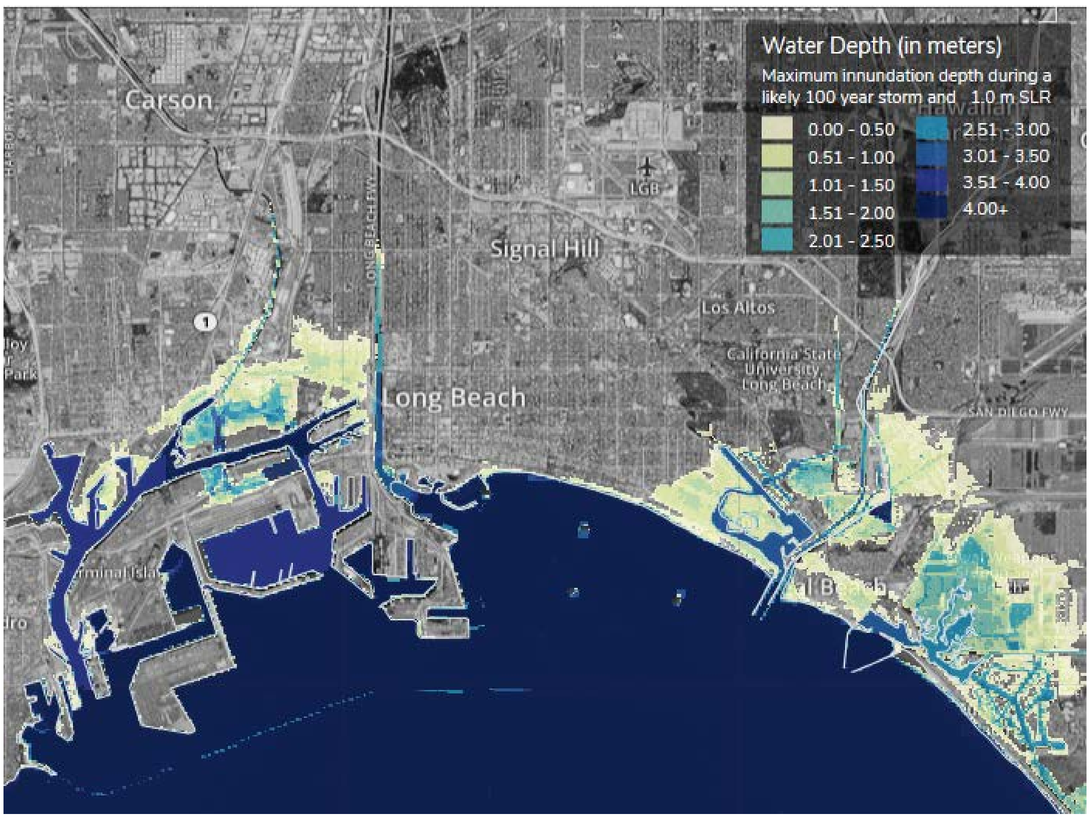

Figure 5: Projected Flooding During 100-year Tide Event with 1-meter Sea Level Rise

Source: NOAA

Rising seas and the associated increase in coastal flooding from waves, storm surge, and tides, potentially coupled with more intense coastal storms will increase the rate of coastal erosion and alter sediment transport patterns in the region (CNRA 2009). CoSMoS, a coastal storm modeling system created by the United States Geological Survey (USGS), is another source of future wave runup, sea level rise, and shoreline change modeling data. The USGS has conducted shoreline change modeling using CoSMoS for multiple future shoreline management scenarios, ranging from no beach nourishments and retreat from the shoreline to systematic beach nourishments and no retreat from the coast. As an example, Figure 6 displays the CoSMoS projected future shoreline change for multiple sea level rise scenarios assuming no future nourishments and a retreat from the shoreline. The figure illustrates that the entire beach will generally erode and that erosion will generally increase with higher amounts of sea level rise. In particular, the homes at the southeast tip of the peninsula and the facilities, parking lot, and park at Junipero Beach could be threatened under higher sea level rise scenarios.

Figure 6: Projected Shoreline Change due to Multiple Sea Level Rise Scenarios Assuming no Future Beach Nourishments
Source: USGS CoSMoS (https://www.sciencebase.gov/catalog/item/57f1d4f3e4b0bc0bebfee139)

Among scientists, there is general consensus that climate change will affect the intensity, frequency, and paths of coastal storms. However, there is yet to be a clear consensus on what the nature of these changes will be in the North Pacific Ocean (NRC 2012). “Storminess” is an overarching term used by the NRC to include physical processes such as frequency and intensity of storms, shifts in storm tracks, magnitude of storm surges, and changes in wind speed and wave height. Evidence of observed changes in storminess in the 20th century historical record as well as future modeled projections have been found by researchers, but the interpretation of these results is difficult due to natural climate variability. Further research is needed to determine the validity and relevance of these storminess projections, particularly for the southern California shoreline.

2.2 Extreme Heat

While trends in average annual temperature are an important indicator of climate change, extreme temperature events have greater impacts on communities. Although Long Beach’s climate is greatly influenced by its coastal geography, which leads to cooler temperatures compared to inland and valley locations, extreme heat is still a major threat to human health. In addition, due to normally mild temperatures, Long Beach residents may be less prepared for heat waves than other places. Furthermore, as a highly urbanized area with lots of impermeable surfaces (e.g., pavements, roofs), Long Beach is susceptible to the urban heat island effect, which makes air temperatures even hotter.

2.2.1 Historical Events and Trends

According to data from Cal Adapt, from 1950 to 2013, Long Beach experienced an average of 3.3 extreme heat days per year, but with considerable inter-annual variability, as depicted in Figure 7 (Livenh et al. 2015).

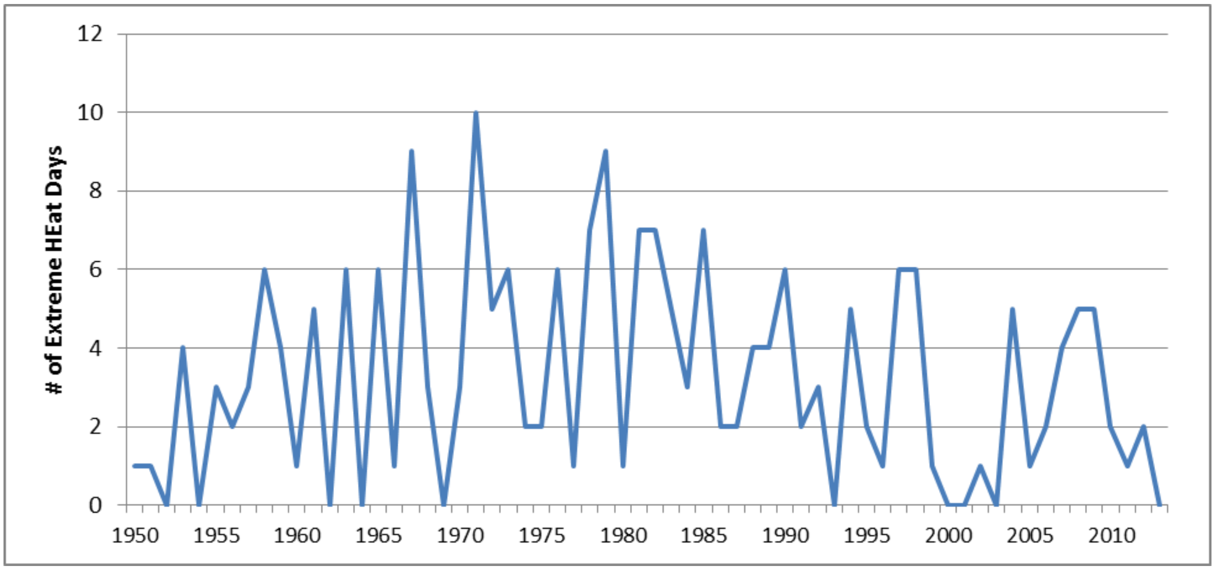

Figure 7: Number of Extreme Heat Days per Year, 1950-2013
Source: Livenh et al. 2015, via CalAdapt

Heatwaves are the tendency for multiple hot days in succession. In Long Beach, and California more broadly, heat waves have historically been dry (low humidity) and as a result, the temperature is high during the day, but cools off at night. However, since the 1980s, there has been an observed trend towards more humid, more intense, and longer lasting heat waves in California. Due to the increased humidity, heat waves have become more accentuated at night, meaning nighttime temperatures do not cool off (Gurshunov et al. 2009). Figure 8 below shows heat wave activity in California since 1950. The red line is based on maximum (daytime) temperature and the blue line is based on minimum (nighttime) temperatures. High nighttime temperatures limit the ability of people to cool down and recover, adding to the risk of illness and fatalities (CDPH 2012).

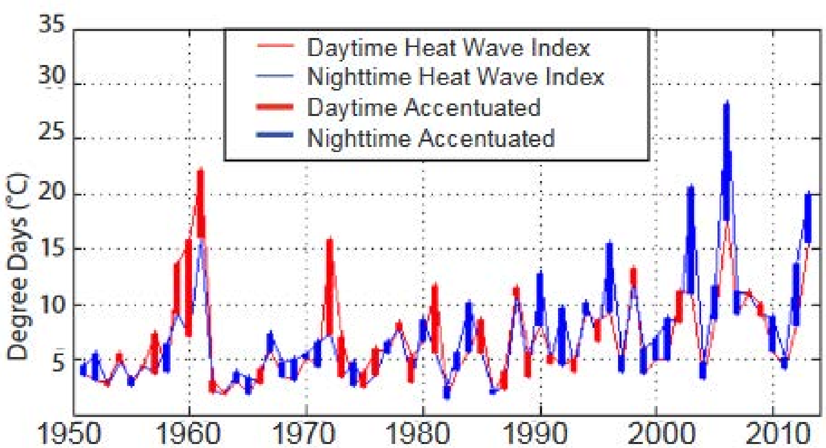

Figure 8: Daytime and Nighttime Accentuated Heat Waves
Source: California-Nevada Climate Application Program, 2015. “California Heat Waves”

In 2006, California experienced a heat wave that was particularly intense and long-lasting. Los Angeles County recorded its highest ever temperature at 119°F and high temperatures lasted for almost two weeks. Humidity levels in California were also unusually high during that event (Gurshunov et al. 2009). Approximately 163 deaths in Los Angeles County were attributed to the heat wave (Ostro et al. 2009). The increase in power demand also led to outages that affected more than 1 million households in Southern California (Barboza 2010b).

In July 2015, high temperatures may have been a factor in equipment failures that caused two powers outages in downtown Long Beach that left thousands of residents and businesses without power for days. The power outage stranded people without medical devices, refrigeration, air conditioning or elevator service during a period of high temperatures. This was particularly challenging for seniors living in high-rise apartments (KPCC 2015).

The urban heat island effect also contributes to extreme heat conditions in Long Beach. The urban heat island refers to the phenomenon that urban areas are often warmer than nearby rural areas due to the abundance of impervious and dark colored surfaces that absorb sunlight and release it back into the environment as heat. A study that modeled how urbanization in Los Angeles and San Diego Metropolitan areas contributes to warming found that averaged over the region during the month of July, urbanization increases the daytime (2pm) near-surface air temperature by 1.3˚C (2.3˚F) and nighttime air temperature by 3.1˚C (5.6˚F) (Vahmani et al. 2016). Urbanization results in even greater surface temperature warming at night with an increase of 6.1˚C (11.0˚F). The nighttime warming of air and surface temperatures are due to man-made materials, such as concrete, that absorb energy during the day and release it at night.

The most intense urban heat island effects are often seen in neighborhoods where dense land use and impervious, paved surfaces predominate and trees and vegetation are less common. Access to the cooling effects of urban greening and open space is often most limited for low-income urban communities (CDPH 2012). A Tree Canopy study conducted by Loyola Marymount University found a statistically significant relationship between high surface temperatures and minimal tree canopy in coastal Los Angeles County. As illustrated in Figure 7, higher surface temperatures tend to be found in Central, West, and North Long Beach, which are also areas with less tree canopy (LMU 2015). The amount of green space varies greatly across different parts of Long Beach. East and Southeast (coastal) Long Beach has significantly more green space per person while North and West parts of Long Beach have significantly less (CLB 2013). Green space not only influences temperatures, but also air quality, which is discussed in the next section.

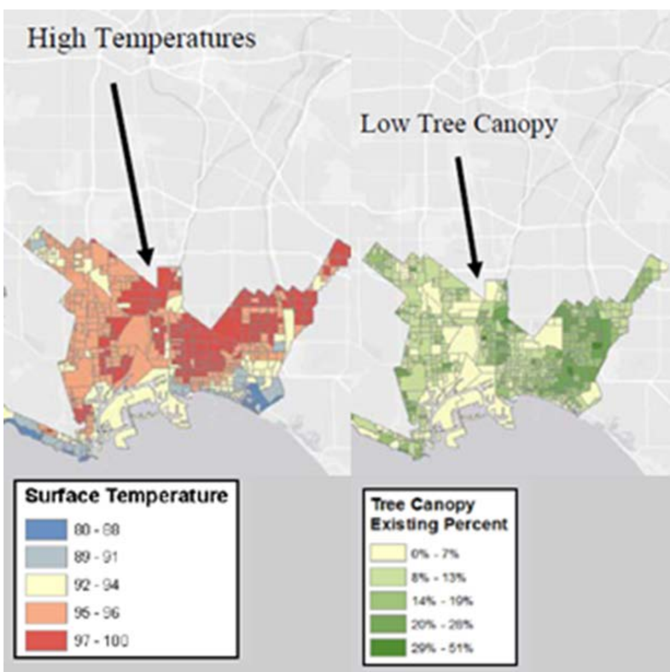

Figure 9: Surface Temperature and Tree Canopy in Coastal Los Angeles County
Source: Loyola Marymount University Tree Canopy Study

2.2.2 Future projections

The number of extreme heat days (over 95 ˚F) in Long Beach per year is projected to increase from an average of four in the baseline period (1980-2000) to 11-16 days by mid-century and 11-37 by end-of century, depending on the emissions scenario (Sun et al. 2015). Projections for extreme heat days (over 95.8 °F) from Cal Adapt, which draw from Pierce et al. 2015, are slightly lower: six-eight extreme heat days by mid-century; nine-20 extreme heat days by end-of-century in Long Beach, depending on the emissions scenario. As demonstrated in Figure 10, as a coastal city, Long Beach will not experience an increase in extreme heat days as severe as inland and valley locations in the region. Despite this, it is important to note that Long Beach might be more vulnerable to extreme heat than other coastal cities in the Los Angeles area. Coastal cities in this region are typically cooled by onshore winds, which blow from west to east. The Long Beach shoreline generally faces southward and Palos Verdes to the west can block some of the cooling onshore winds. Figure 10 illustrates that Long Beach is significantly warmer than Santa Monica, which is a coastal city with a more typical westward-facing shoreline.

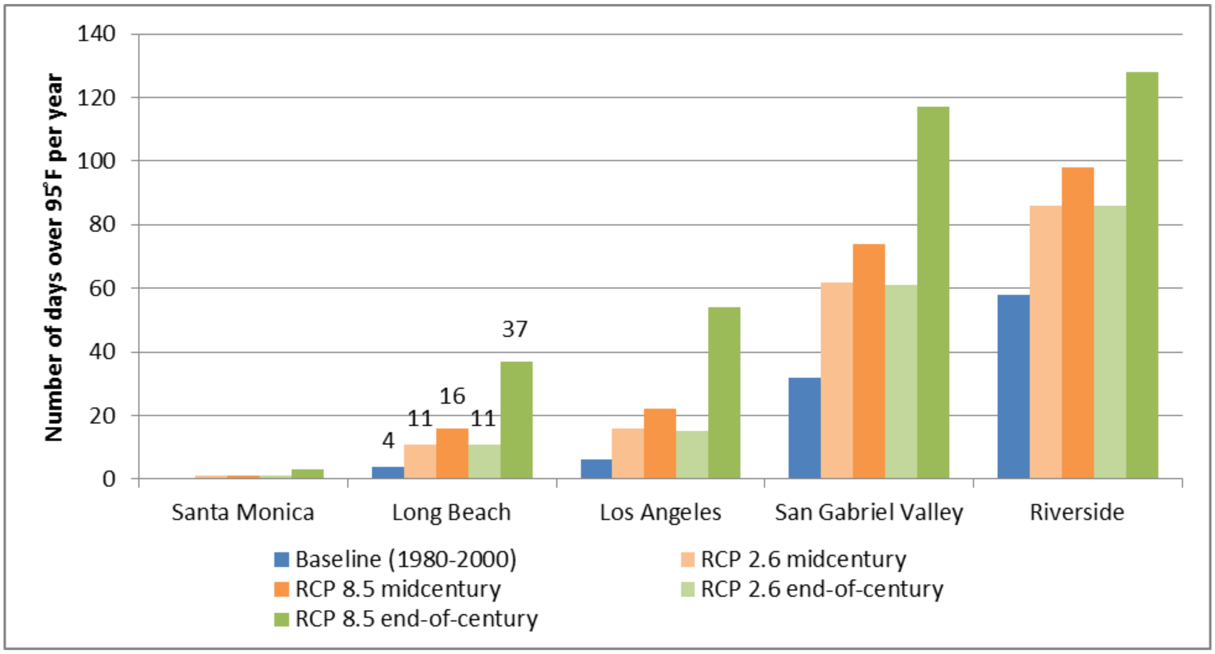

Figure 10: Average Number of Extreme Heat Days in Long Beach and around the LA Region
Source: Sun et al. 2015

Heat waves will not only occur more frequently, but will also be more intense and long-lasting due to climate change (Cayan et al. 2009). The occurrence of heat waves having durations of five days or longer will become more frequent (20 times more frequent in some simulations) by end-of century (Cayan et al. 2009). Relative to baseline local conditions, heat waves are expected to become more extreme along the coast relative to other parts of the state (Gershunov and Guirguis 2012). This has health implications as people living near the coast may be less prepared and acclimatized to extreme heat than others.

Towards end-of-century, extreme heat days will be particularly frequent and intense in late summer and into fall (Sun et al 2015; Pierce et al. 2015). The extended duration of when extreme heat events could occur has a variety of planning implications, including cooling energy demand and emergency response readiness.

2.3 Precipitation

Changing precipitation patterns in response to climate change is a primary climate stressor. Long Beach lies within a semi-arid region consistent with a Mediterranean climatic pattern of dry summers and wet winters (CEC 2012). Precipitation patterns, including quantity, frequency, and distribution, affect both water supply and flooding from runoff during storm events.

Precipitation can generate flooding in two distinct ways. *Riverine flooding* occurs during extreme, regional rainfall events as rivers, creeks, and channels discharge excess water from an entire watershed. The Los Angeles and San Gabriel rivers drain much of the Los Angeles Basin and discharge into San Pedro Bay. This type of flooding could impact the City of Long Beach if high flows overtop and/or comprise the levees bordering these rivers. Precipitation can also generate localized *urban flooding* during high rainfall events if the City's local stormwater collection system is overwhelmed and cannot drain the excess stormwater. This type of flooding tends to be localized near storm drains and other stormwater collection system components.

Sea level rise can exacerbate localized, precipitation based flooding in a number of ways. The stormwater system in Long Beach is designed to convey stormwater away from developed areas into adjacent water bodies such as Alamitos Bay and San Pedro Bay. The vulnerability of the system to sea level rise and storm events depends on the system's current storage and flow capacity, the elevation and location of the outfalls, and whether they are gravity drained or pumped. In general, stormwater pumping systems rely on uninterrupted power and many of the components are sensitive to water and salt exposure. The capacity to collect, convey, and discharge flows to the bay will be reduced by higher sea levels. Outfalls that are below future high tide or increased storm water levels may need to be elevated, have check valves installed to prevent backflow, or be pumped rather than gravity drained. Reduced discharge capacity and/or failures of pump stations could cause flooding of adjacent properties and disrupt access to homes, jobs, and recreation areas, leading to potentially significant consequences.

Without action, SLR poses the following threats to the stormwater system and adjacent areas:

- **Urban flooding.** The majority of the Long Beach stormwater system is gravity driven. Excess stormwater flows from higher elevations, including Belmont Heights, until reaching the bay. As low-lying stormwater outfalls become partially or completely inundated by rising water levels, drainage of stormwater can be impeded, resulting in inland urban flooding during storms. Difficulties draining stormwater can cause road closures, impede access to facilities, and damage private and public property.
- **Saltwater intrusion into the stormwater system.** During large tide and storm events, saltwater may enter the stormwater system through open outfalls, leaky tide gates, overflow weirs, and through catch basins located in areas where coastal waters have overtopped the shoreline. Backflow of high tides into the stormwater system may cause surface flooding in low-lying areas that sit at elevations below the hydraulic grade line, even if shoreline protection systems are high enough to prevent overland coastal flooding. Saltwater may also cause premature corrosion of pipes and equipment in the system.
- **Elevated groundwater levels.** As sea levels rise, so will groundwater levels. SLR causes saline water to intrude into underground reservoirs, raising the historical groundwater elevation ranges beyond what the Long Beach utilities were planned and built to accommodate.

2.3.1 Historical Events and Trends

Average annual precipitation recorded near Long Beach between 1950 and 2013 was 12.3 inches (Pierce et al. 2014). Seasonal averages ranged from 0.02 inches in July to 3.0 inches in February. Between 1970 and 2000, the Long Beach Airport experienced an average of 36 days per year with measurable precipitation (NCDC 2004). Increased variability in annual precipitation is already becoming apparent with both the driest and wettest years on record having occurred in the last decade in the Los Angeles region (DWR 2008).

Storm frequency and intensity in Southern California have increased, consistent with statewide and national trends. Between 1948 and 2011, the frequency of extreme downpours increased by 35 percent in California south of the San Francisco Bay (Madsen and Wilson 2012). Consequently, an intense storm that formerly occurred in the region only once per year now occurs every nine months on average. During the same period, Southern California experienced a seven-percent increase in the amount of precipitation per storm. Increases in extreme precipitation events are likely caused by warmer storms and atmospheric rivers over the Pacific carrying large amounts of moisture to the California coast through winter storms (CEC 2012).

Historic flood events include major storms in March 1938, February 1941, and January 1956, which resulted in flooding along the San Gabriel River (LHMP 2004). There has not been recent flooding along the San Gabriel

River due to channelization and flood control projects. In 1968, a high intensity rainfall coincided with high tide, causing flooding in Belmont Shore, Pacific Coast Highway near Pacific Avenue and the intersection of Orange and Wardlow Road (LHMP 2004).

A storm in January 2010, which was an El Niño year, overwhelmed the drainage system and caused flooding of residential neighborhoods and streets near Wilson High School, flooding of the 710 freeway, and the CSULB Student Union building (Barboza 2010). City staff report that flooding issues often relate to storm drain maintenance (for example, keeping storm drains clear of debris). According to a staff survey, the West Industrial Area suffered property losses due to flooding prior to installing a new storm drain system in 2012 (CLB Staff Survey 2017).

Most recently, the winter storms of 2017 caused street flooding, park flooding, beach closures, water quality issues, downed trees, and closure of the Main Library auditorium. Individuals experiencing homelessness were highly exposed to health hazards during this time (CLB Staff Survey 2017).

2.3.2 Future Projections

There is considerable uncertainty regarding the effects of climate change on precipitation and there is no general consensus among future precipitation models for Long Beach. Research conducted for California's Third Climate Change Assessment projects a considerably drier climate in southern California by the mid-to-late century (CEC 2012) as a result of decreased precipitation, earlier snowmelt, and increased temperatures. A study that examined downscaled outputs of 16 GCMs predict that the total amount of precipitation along the Southern California coast will decline by an average of nine percent by mid-century (2060-2069) compared to a 1985-1994 baseline (Pierce et al 2011). Berg et al (2015) reports a near-zero change in average annual precipitation in the L.A. area for both mid-century and end-of-century projections. Pagan et al (2015) reports a large variation in total annual precipitation projections depending on the model. Cal-Adapt, which provides an average of several climate model calculations, projects a six to 11 percent increase in precipitation by mid-century and a one to 25 percent increase in precipitation by end-of-century for Long Beach (Cal-Adapt 2017). This range spans low (RCP 4.5) to high (RCP 8.5) emissions scenarios.

Regardless of average annual precipitation estimates increasing or decreasing, precipitation events are projected to increase in intensity, decrease in frequency, and be concentrated during the winter months (Pagan et al 2015). The total number of days with rainfall per year is expected to decline by 13 percent on Southern California's coast by the 2060s (Pierce et al 2011), therefore concentrating the annual precipitation into fewer rainfall events leading to greater runoff and other such impacts.

2.4 Drought

Drought is a secondary climate stressor that is driven by both climate conditions and social and economic stressors. This discussion focuses on the climate-related stressors of precipitation and temperature patterns. Drought is particularly relevant as the City of Long Beach lies within a semi-arid climatic region that is already heavily dependent on imported water to meet local demand (Pagan et al 2015). As of 2015, 39 percent of the water supply is from imported sources, 54 percent from groundwater, which is also partially dependent on imported sources for recharge, and 7 percent is recycled (Pagan el al 2015). Regionally, the City of Long Beach is largely dependent on water imports from the Colorado River and Sierra Nevada watersheds for both reservoir storage and groundwater recharge; therefore, drought in the City of Long Beach is closely tied to drought and precipitation patterns in these watersheds (Pagan et al 2015).

2.4.1 Historical Data and Trends

A study of historic drought using tree ring data going back 1,200 years concluded that three-year droughts are not unusual in California and can occur with as little as a single year between events. Over the last 1,200 years, it was estimated that there were 37 occurrences of three-year droughts and 66 dry periods lasting between three and nine years (where a dry period is defined as being below the years' 800 – 2014 mean precipitation levels). Although periodic drought is normal for Southern California, 2014 was estimated to be the worst single drought year of the last 1,200 years in California (Griffin et al 2014). The recent 2011-2015 drought led the Metropolitan Water District of Southern California (MWDSC) to enter into shortage conditions and enact the Water Supply Allocation Plan, which more closely manages supply and demand (Pagan et al 2015).

2.4.2 Future Projections

Climate change, through its impacts on precipitation and temperature, is predicted to increase the severity and length of future droughts (CEC 2012). By the end of the century, all climatic models included in the California Climate Change Center's Third Assessment predict regional drying, primarily from decreased precipitation and compounded by warming (CEC 2012).

Both annual precipitation quantity and distribution affect aridity and drought. When total annual precipitation is concentrated into fewer events, reservoirs exceed their capacity and the ground becomes saturated, limiting groundwater recharge. Consequently, less water is retained within the watershed and more is lost to stormwater runoff than would be when annual precipitation is more evenly distributed throughout the year. Although average annual precipitation has for now remained relatively stable in the region, climate models project moderate annual precipitation increases as well as increased seasonal variability and intensity of precipitation events by the 2060s (Pierce et al 2011).

Temperature is the second significant driver of drought as higher temperatures increase snow melt, soil evaporation, and evapotranspiration, leading to drier soils and vegetation. Average annual temperatures in the Los Angeles region are projected to increase 3–4°F in the L.A. region by mid-century (Sun et al 2015).

As mentioned above, changes in climate in the Sierra Nevada and Colorado River Basin may have significant implications for water supply in Long Beach. One study predicts increased frequency of critically dry years in the Sierra Nevada watershed (CEC 2012). However, projections of climate change suggest that even if total precipitation does not change significantly, predicted warming will both reduce the amount of snowpack in these regions and increase the intensity and frequency of runoff and precipitation events (Pagan et al 2015). Intense precipitation events in these watersheds produce quantities of water in a short time frame that exceed the storage capacity of the reservoirs while reduced snowpack decreases the availability of the gradually released meltwaters throughout the drier summer months. In other words, the water from these critical supply areas is predicted to become less available to the City of Long Beach by mid-century (Pagan et al 2015). Even if precipitation does not decline overall in the region, the models still show drying based on the impacts of warming alone, including increased soil evaporation in the summer months and earlier snow melt in the Sierra Nevada, a major municipal water source (CEC 2012). Additionally, water rights allocations for the Colorado River Basin were based on a time period of unusually wet years. The State of California only holds surplus rights and the majority of this water goes to agriculture (MWDSC 2010). Reservoir levels along the Colorado River are expected to diminish up to 30% by 2050 (Barnett et al 2004) and as populations in Southern California expand, the municipalities will experience increased demand for a decreasing water supply.

2.5 Air Quality

Air quality is driven by emissions and climate factors. Emissions can come from vehicles, industries, power plants, and wildfires. Climatic factors that influence air quality include temperature, precipitation and wind. Other factors that contribute to poor air quality in Long Beach, and the region overall, include topography, intense traffic, and the urban heat island effect (AOP 2015). Air quality is especially relevant as a secondary climate stressor in Long Beach as there are several sources that impact local air quality, including the 710 and 405 freeways, refineries, the Port of Long Beach, and major industrial sources (AOP 2015) and thousands of people whose health may be impacted by poor air quality. People who are especially sensitive to poor air quality include the young, elderly, those who have existing respiratory conditions, and those who work outside.

2.5.1 Historical Events and Trends

Ozone and particulate matter (PM) are two air pollutants that pose a significant threat to human health. Ground level ozone, often called smog, forms when volatile organic compounds (VOCs) and nitrogen oxides (NOx) react in sunlight. These pollutants come from vehicles, industries, power plants, and products like paints and solvents. PM is a mixture of solids and liquid droplets floating in the air. They can be emitted directly from vehicles, power plants, industries, and wildfires, but most particles form in the atmosphere as a result of complex reaction of chemicals. Fine particles (PM 2.5) are particularly harmful to human health as they can penetrate deep into the lungs and even into the bloodstream.

Data reported in the AOP (2015) study show a recent downward trend in air pollution in the region. In the Los Angeles-Long Beach-Santa Ana region, there has been a downward trend in ozone pollution since early 2000s, but there were still 67 days when ozone levels were unhealthy for sensitive groups in 2014 (AOP 2015). The South Coast Basin is designated an extreme non-attainment zone for the federal ozone standard. The EPA recognizes that California has unique challenges in addressing ozone pollution because of its topography, wildfires, and transportation and freight movement. As a result, the South Coast Air Basin is not required to meet 2008 federal standards until 2032 (EPA 2015).

Days that violate air quality standards in Los Angeles County tend to occur in the summer months when temperatures are higher (CLB 2013). This is because heat can increase the formation of air pollution, such as ozone. In addition, high temperatures are also associated with weak winds and atmospheric stagnation which can cause air pollution to build up. Due to wind patterns and topography, Long Beach does not experience as much ozone pollution as other parts of the region, particularly compared to inland areas (AOP 2015). From 2014 to 2016, Long Beach had only 1 day in violation of the federal 2015 standard for 8 hour-concentration of ozone (CARB 2017).

There has also been a downward trend in PM pollution since 2000 in the Los Angeles-Long Beach-Santa Ana region, but there were still 16 days in 2014 when PM2.5 reached unhealthy levels for sensitive groups (AOP 2015). During the past decade, Central Long Beach experienced a 35% decrease in PM2.5; however, the annual average is still above the California clean air standard (Meijgaard 2012). Table 4 below shows the number of days above federal PM2.5 standards for three monitoring stations in Long Beach.

Table 4: Number of Days Where PM2.5 Exceeds Federal Standards

Monitoring Station	Site Number	Address	2014	2015	2016
North Long Beach	70072	3648 N. Long Beach Blvd	2	3	0
Long Beach-Route 710 Near Road	70032	5895 Long Beach Blvd	0	7	0
South Long Beach	70110	1305 E. Pacific Coast HWY	2	4	0

Source: California Air Resources Board, 2017

Air toxics are pollutants that cause cancer or other serious health effects. Diesel PM accounts for 68.2% of the carcinogenic risk from exposure to air toxics in the Southern California air basin (SCAQMD 2015). Diesel PM is emitted from diesel engines including trucks, buses, cars, ships, and locomotive engines and is concentrated near ports, rail yards, and freeways. Exposure to diesel PM has been shown to have numerous adverse health effects, including cardiovascular and pulmonary disease and lung cancer (EPA 2016). As illustrated in Figure 11, the areas of the Los Angeles Basin that are exposed to the most risk to air toxics are those near the Ports of Los Angeles and Long Beach (SCAQMD 2015). According to the AOP (2015) study, 86 out of 116 census tracts in the City of Long Beach have diesel PM emissions in the top 10% of census tracts in California.

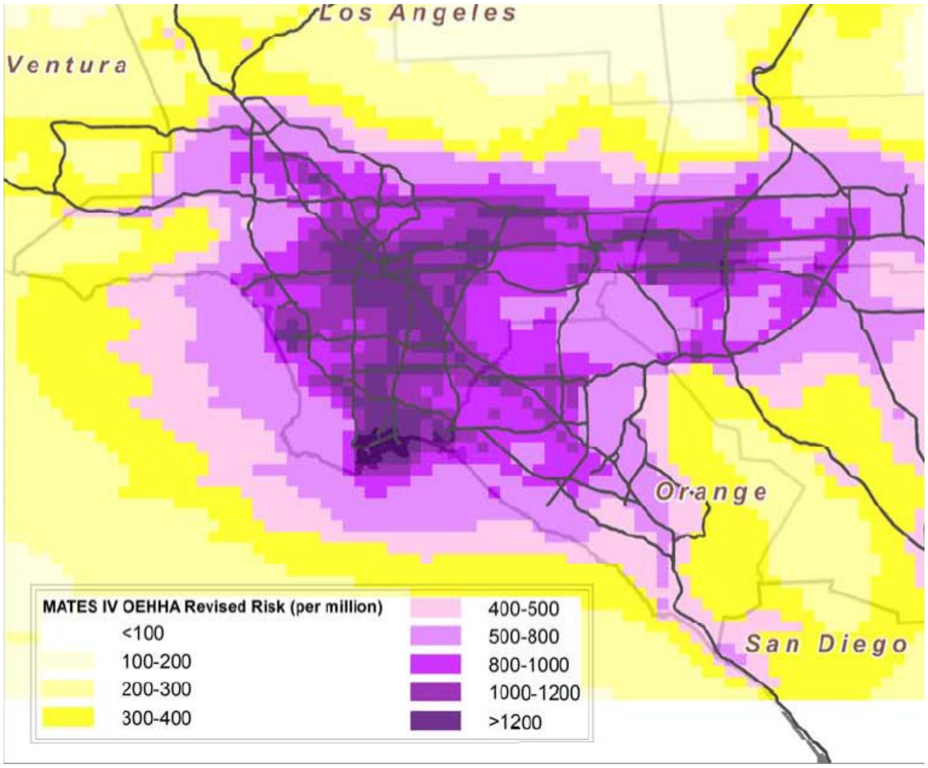

Figure9: Modeled Air Toxics Risk (MATES IV)
Source: South Coast Air Quality Management District

2.5.2 Future Projections

Higher temperatures are expected to increase the frequency, duration, and intensity of conditions conducive to air pollution formation (CNRA 2014). Specifically, studies have shown that ozone concentrations increase when maximum daytime temperatures increase (Kleeman et al. 2010). Since climate models project higher temperatures in the future for Long Beach, a "climate penalty" exists for ground level ozone, which means that greater emissions controls will be needed to meet a given air quality standard. If air pollution emissions levels remain at 1990-2004 levels, California could experience an additional 6-30 days per year with ozone concentrations above state air quality standards by 2050, due to the effects of a warmer climate (Kleeman et al. 2010). Aggressive emissions reductions have been mandated to bring the region into attainment of federal air quality standards and these policies will continue to reduce emissions, such that emissions will not remain at historic levels (SCAQMD 2016). However, higher temperatures could make meeting federal air quality standards more challenging. An increase in wildfire frequency or severity and energy consumption in the region could also contribute to the "climate penalty" for air quality (CEC 2006).

In addition to air pollution emissions, air quality can be affected by pollen, which contains allergens. Models indicate that pollen will likely increase in many parts of the U.S., there may be shifts in the timing of allergen production, and there may be increases in allergen content or potency (CNRA 2014). Allergens can cause or aggravate health problems, including asthma and other debilitating respiratory diseases (CNRA 2014).

Climate change may also negatively impact indoor air quality. Outdoor air quality may worsen and enter buildings, emissions from indoor sources may be exacerbated by heat, there may be more exposure to mold, bacteria, and other contaminants due to flood events, and increased air conditioning use can lead to poor indoor air quality if not well maintained (Nazaroff 2013; Fann et al. 2016).

Section 3. Summary of Potential Local Impacts by Sector

Climate impacts are the result of interactions between climate stressors and physical assets (such as roads) and populations (such as the elderly). Table 5 provides an overview of major categories of potential climate change impacts for Long Beach, based on existing studies and an understanding of the types of assets and populations that exist in Long Beach. Where Long Beach-specific studies are not available, regional or state-wide studies are referenced. These are not the results of the Long Beach CAAP vulnerability assessment, but rather the vulnerability assessment will seek to build upon this summary of existing research to identify key local impacts with greater specificity based on an inventory of critical assets, an assessment of exposure to climate stressors, and asset and population sensitivities.

Table 5: Potential Local Climate Change Impacts by Sector

Sector	Potential Local Climate Change Impacts
Public Health	• Increased risk of heat-related illnesses and death. Particularly vulnerable populations include: children, the elderly, people with respiratory diseases, those who work outdoors, and poor, urban residents (CDPH 2012; CNRA 2014) • Asthma and other cardiovascular and respiratory diseases may increase due to poor air quality and increased allergens (CNRA 2014; CDPH 2012) Asthma hospitalizations rates are highest in West and North Long Beach and lowest in East Long Beach (CLB DHHS 2013). • Communities in west-central and northern Long Beach are disproportionately more vulnerable to risk associated with pollution and climate change (AOP 2015; CalEPA 2017) • Flooding events may contribute to injury, death, displacement, mental health burden (CDPH 2012) • Sewage overflow could result in water and food-borne illness (CDPH 2012) • Disrupted food and water supply could cause hunger and malnutrition, particularly in low-income, children, and elderly population (CDPH 2012) • Changes in temperature and precipitation may lead to changes in the spread of vector-borne diseases and increase the number of disease carrying vectors (e.g. standing water and mosquitos) (CNRA 2014). The City is currently monitoring and treating approx.35 sites for insects (CLB DHHS 2013). • Damage to transportation infrastructure could inhibit or delay emergency response
Coastal Resources	• Deterioration of marine ecosystem health due to pollution from sewer discharges and increased stormwater runoff (CNRA 2014) • Beach inundation and erosion will increase from SLR and storm surge (AOP 2015; CNRA 2014) • Inundation and loss of access to marinas from SLR and storm surge (CDBW 2010) • Portions of breakwaters could be compromised and overtopped during storms with SLR, leading to transmission of waves into harbor and damage to infrastructure (AOP 2015; POLB 2016) • Damage to THUMS Oil Islands during coastal storms possible, especially with SLR (AOP 2015)

Sector	Potential Local Climate Change Impacts
	• Marine ecosystems and marine economic sectors may be disrupted by ocean acidification (CNRA 2014)
Transportation	• Damage to coastal roads, railways, bridges due to SLR, storm surge, and erosion (CDOT 2013; CNRA 2014) • Damage to Port infrastructure and disruption of operations due to SLR and storm surge (POLB 2016) • Airport runways may be damaged, operations disrupted due to flooding and extreme heat (CDOT 2013). • Damage to roads, highways, and rail from extreme heat (CDOT 2013; CNRA 2014)
Energy	• Increased peak electricity demand due to extreme heat (CNRA 2014) • Reduced electricity supply due to reduced hydropower output and reduced transmission line and power plant efficiency (CNRA 2014) • Damage to coastal energy infrastructure from SLR and storm surge (CEC 2012) • Increased risk of power outages due to increased extreme heat and wildfires (CNRA 2014)
Water Supply	• Reduced imported water supply due to reduced snowpack and drier conditions in the Sierra and Colorado watersheds (CNRA 2014; Pagan et al. 2015) • Increased risks to groundwater aquifers due to SLR and increased salinity intrusion (CNRA 2014) • Increased water demand due to higher temperatures (Pagan et al. 2015) • Increase in intense precipitation events may reduce groundwater recharge (Pagan et al. 2015) • Damage to potable water infrastructure possible in a flood event (CDPH 2012)
Stormwater/ Wastewater Infrastructure	• SLR + storm event may overwhelm stormwater infrastructure causing flooding (Heberger et al. 2009) • Damage to wastewater infrastructure and sewage backup and overflow in flooding event (CDPH 2012)
Housing & Neighborhoods	• Higher temperatures exacerbated by urban heat island in neighborhoods without greening (CDPH 2012), which include Central, West and North Long Beach (green space per 1,000 varies by zip code from 0.26 to 19.21) (CLB DHHS 2013) • Disruptions to the transportation system could impact neighborhood connectivity including access to jobs, goods, services, and healthcare. • Southeastern neighborhoods are vulnerable to flooding due to SLR and storm surge (AOP 2015) • Communities in west-central and northern Long Beach are disproportionately more vulnerable to risk associated with pollution and climate change (AOP 2015) • Increased risk of displacement and loss of home due to a flood event related to SLR, storm surge, or precipitation based flooding (CDPH 2012) • Permanent property loss possible due to SLR where inundation and erosion occurs (CNRA 2014) •
Biodiversity/ Habitat	• Increase in nonnative invasive species (CNRA 2014) • Increase in mismatches of timing of migration, breeding, pollination, and other ecological processes and interactions (Kadir et al. 2013) • Increases in tropical pathogens, parasites, and diseases due to higher temperatures (CNRA 2014) • Loss of wetland habitat due to SLR (CNRA 2014). The Los Cerritos wetlands are particularly vulnerable given surrounding urban development (Cope 2015).

Section 4. Conclusions and Next Steps

This review has summarized the most relevant literature on the historical climate events, trends, and future projections for primary and secondary climate stressors in Long Beach. This information is intended to inform decisions on the projections that the City uses in the exposure analysis in the next phase of the vulnerability assessment. Sea level rise, extreme heat, and precipitation are the primary climate stressors considered in this memo. Long Beach is projected to experience 11.2 ± 3.5 inches of sea level rise by mid-century and 36.7 ± 9.8 inches by end-of-century (NRC 2012). Higher sea level rise is possible: up to 24 inches by mid-century and up to 66 inches by end-of-century (NRC 2012).The City's risk tolerance, consistency with other studies, and critical asset lifespans should be taken into account in the selection of sea level rise projections for the exposure analysis. For extreme heat, projections show that the number of extreme heat days in Long Beach will increase from historical levels of approximately four days per year to 11-16 days by mid-century and 11-37 days by end-of century (Sun et al. 2015). There is less agreement in climate models on precipitation projections. Some studies show a drying trend in Southern California (Berg et al. 2015) while others show an increase in annual average precipitation for Long Beach (Pagan et al. 2015). Most models show that there will likely be fewer rainy days per year, but precipitation events will become more intense (CEC 2012; Pagan et al. 2015).

Drought and air quality are the secondary climate stressors considered in this review. Droughts are likely to be more frequent in the future (CEC 2012; Pierce et al. 2011). In addition, higher temperatures will lead to drier soils and vegetation and higher water demand (Pagan et al 2015). The mountains that supply water to Long Beach are projected to have reduced snowpack and increased intensity of runoff (CEC 2012; Pagan et al 2015). Air quality will be affected by a changing climate, particularly higher temperatures and increased wildfire which result in a "climate penalty," making it more challenging to meet air quality standards compared to current climate conditions.

The impacts summary table demonstrates the range of potential impacts for Long Beach based on existing studies. The vulnerability assessment will seek to provide more detail on these impacts, in particular for critical assets, which will be identified in the subsequent asset inventory phase.

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Appendix E
Community Engagement

CAAP COMMUNITY ENGAGEMENT

In 2017, City of Long Beach staff set out to create an inclusive, community-centered planning process that would engage the Long Beach community broadly, but give particular attention to those most affected by climate change. In partnership with other City departments, including Long Beach Parks, Recreation, and Marine and the Health and Human Services Department, staff developed the community engagement strategy based on an equity assessment.

The planning process sought to develop knowledge related to climate impacts and to collaboratively define priorities and solutions that would inform the Climate Action and Adaptation Plan (CAAP) and keep residents safe and healthy. The City's community engagement efforts have reached more than 10,000 community members at nearly 60 events, including open house events, community meetings, panel discussions, resource fairs, cultural fairs, and partnerships with local schools and universities.

The community engagement efforts are also a result of collaboration with every City department and Council District office.

Open House Workshops

Three CAAP open house workshops were held. At these educational, family-friendly, and interactive, events, community members were encouraged to share their feedback and generate solutions to local climate change impacts.

At each public workshop, City staff honored the community's time and expertise by offering a sustainability resource fair, refreshments, and free CAAP-branded giveaways. In addition, each workshop was hosted at community-friendly, trusted, and easily accessible locations. Interpreters and translated materials were available at each open house event.

Open House #1

On June 2, 2018, at Martin Luther King Jr. Park, the City hosted the first public workshop for the CAAP. At the event, staff shared detailed presentations on the results of the Long Beach greenhouse gas inventory and vulnerability assessment. More than 200 attendees were invited to weigh in on CAAP goals, priorities, and approaches. In addition, the workshop included:

- A sustainability resource fair attended by various City departments, public agencies, and community partners to share wide-ranging sustainability information and resources with attendees
- Augmented-reality mobile games
- Garden tours of the Long Beach Peace Garden
- Free health resources, including dental screenings and blood pressure readings

Open House #2

On January 26, 2019, at the Michelle Obama Neighborhood Library, the City hosted the second public workshop for the CAAP and convened more than 200 community stakeholders. This event focused on engaging the community on potential mitigation measures and adaptation strategies for consideration in the plan. As part of the event, a free sustainability resource fair was hosted in the Learning Garden at the library. The fair featured sustainability, health, and community resources from various City departments.

Open House #3 (LB ClimateFest)

On June 1, 2019, the City hosted LB ClimateFest, bringing together more than 500 community members, City departments and community partners and activating the Marine Stadium parking lot for the final CAAP workshop. The event included a student showcase of environmental science fair projects from participating Long Beach Unified School District

(LBUSD) students, St. Anthony's High School students, and participants in the Aquarium of the Pacific's youth program. The event featured the release of the draft plan, a sustainability resource fair that showcased local student projects, food, and music. The parking lot was transformed into a chalk art exhibit on the 2100 sea level rise prediction and attendees were encouraged to add to the artwork. The event opened with this native land acknowledgement:

We begin today by acknowledging that we are holding our gathering on the land of the Tongva/Gabrieleño and the Acjachemen /Juaneño Nations who have lived and continue to live here. We recognize the Tongva and Acjachemen Nations and their spiritual connection to the ocean and the land as the first stewards and the traditional caretakers of this area we now call Long Beach. As we begin, we thank them for their strength, perseverance, and resistance.

We also wish to acknowledge the other Indigenous Peoples who now call Long Beach their home for their shared struggle to maintain their cultures, languages, worldviews, and identities in our diverse city.

Stakeholder Working Groups

Scientific, business, and community working groups also helped to shape the CAAP and deliberately sought to incorporate environmental justice principles. See page E-6 for a list of individuals who participated in these working groups.

Scientific Working Group

The Scientific Working Group was convened to validate the project methodology and to provide feedback and input on local data as well as to review results and early actions. The Scientific Working Group included 13 independent experts from California State University, Long Beach; Long Beach City College (LBCC); University of California, Los Angeles; the Aquarium of the Pacific; the South Coast Air Quality Management District; and RAND Corporation.

Business Working Group

The Business Working Group was convened to obtain input on the climate-related concerns of business owners and companies that do business and operate in the City and to learn about the sustainability actions they can take currently and the future opportunities to reduce carbon emissions. Members were drawn from approximately 25 businesses representing the various disciplines of architecture, engineering, utilities, and sustainability. The group included firms large and small, global and local, and engaged in consultation with business association leaders and the Chamber of Commerce. In addition to the efforts of the Business Working Group, City staff also engaged the business community in partnership with business associations and through the Office of Sustainability's Green Business Program.

Community Working Group

The Community Working Group was convened to provide input on the public engagement approach and climate-related concerns and actions. The group included more than 20 representatives from local community-based organizations.

Panel Events

The City also hosted panel events on sea level rise and flooding, and extreme heat. Both events were recorded by the City's LBTV team and have been available for viewing on the City's YouTube channel:

Sea Level Rise Panel

On January 14, 2019, at Best Western Golden Sails, the City hosted a panel discussion titled "Sea Level Rise in Long Beach and What Residents Can Do to Prepare." The panel featured Jerry Schubel, CEO and President of the Aquarium of the Pacific, and Jeff Jeannette, Owner/ Architect of Jeannette Architects. More than 400 people attended the presentations and panel discussion, which covered sea level rise and the local projections for Long Beach, strategies for adapting homes to sea level rise and flooding, and the City's efforts to develop a CAAP.

Extreme Heat Panel

On March 30, 2019, at Silverado Park in West Long Beach, the City hosted a panel discussion — "Extreme Heat: Staying Safe and Solving Climate Change in Long Beach"— in collaboration with the Long Beach Health and Human Services Department, the Long Beach Fire Department, and the Long Beach Gray Panthers. The event featured information on how extreme heat from climate change causes power outages, heat stroke and heat exhaustion, and missed work/school. It also featured stories from older adults who were living in the city during the 2015 downtown power outages (likely a result from extreme heat), and talks on how residents can prepare for both extreme heat and extreme weather events.

Community Partnerships And Multilingual Outreach

Partnering with local neighborhood associations, faith-based groups, and community-based organizations, staff participated in more than 60 community meetings across the city.

There was a concerted effort to engage directly with Long Beach residents and community members at places where they already gather. For example, to "meet people where they are," staff coordinated presentations, small group discussions, and in-person interactions at:

- Community events (e.g., health and sustainability resource fairs)
- Council District meetings
- Cultural festivals (e.g., the Cambodian New Year Festival)
- Faith-based groups
- Local farmers' markets
- Neighborhood, civic, and parent associations
- Senior centers
- Youth programs

City staff considered the cultural appropriateness of all engagement activities and outreach materials and adapted them for a multilingual audience.

In June 2019, City staff were invited as featured speakers to the monthly meeting of Latinos in Action. As part of the meeting, City staff gave presentations on the CAAP and facilitated activities that would lead to developing solutions locally. The meeting was entirely in Spanish, with Spanish to English translators. City staff and the Latinos in Action team collaborated on the agenda, which included activities to solicit community feedback on the CAAP, a game of Lotería (similar to bingo), and an extended question and answer portion on the CAAP, the broader planning process, and how the CAAP connects to other city plans. Dinner, raffles, and free giveaways were also provided.

Early in the outreach process, City staff also met with staff from the United Cambodian Community to identify culturally appropriate activities to further strengthen relationships between the City and the local Cambodian community. These activities included participating in the annual Cambodian New Year Festival and health and resource fairs in Cambodia Town, and conducting presentations for the organization's members.

Youth And Emerging Leaders

Recognizing that climate change will impact young people most, now and into the future, the City partnered with local educational institutions and youth programs across Long Beach to engage youth and emerging leaders in developing the CAAP. Partnerships have included:

CSULB Climathon

The City participated in the Climathon Challenge at California State University, Long Beach (CSULB). In 2018, the Climathon Challenge focused on solutions to create sustainable housing, specifically solutions that will help meet the objectives set forth in the City's CAAP. As part of the challenge, City staff provided detailed presentations on the CAAP and a broad overview of sustainable housing across the city. In 2019, the Climathon Challenge focused on creating sustainable solutions to food insecurity, food waste, and food sourcing, and the City participated by sharing a broad overview of the CAAP.

Long Beach City College

On Earth Day 2019, City staff gave a presentation on the CAAP to the Long Beach City College – Environmental Movement Action Club. Long Beach City College has also been involved at resource booths at CAAP events, providing information on the numerous emerging water-saving and recycling efforts by the college's facilities and maintenance departments at both LBCC campuses in the city.

LBUSD Science and Engineering Fair

In May 2019, City staff participated in LBUSD's annual Science and Engineering Fair both as project reviewers for sustainability innovation projects and as event exhibitors sharing information on climate impacts to Long Beach. The sustainability innovation projects from the Science and Engineering Fair were featured as part of the student showcase at LB ClimateFest, which was held on June 1, 2019.

St. Anthony's High School – AP Environmental Science Class

Over the spring 2019 semester, City staff collaborated with the AP Environmental Science class at St. Anthony's High School on semester-long projects. Project prompts included:

- Create a video based on local science that shows how climate change has impacted your community (e.g., extreme heat, air quality, flooding, power outages, and green jobs).
- Develop, conduct, and present a campaign to engage the local community with solutions according to the vulnerability assessment and climate stressors.
- Develop, present, and lead a half-day summit for local middle school and high school students on topics related to the CAAP.
- Create a marketing campaign through social media, mass emails, and newsletters for citywide distribution.

Final projects were showcased at LB ClimateFest on June 1, 2019.

Public Health Week Career Paths

As part of National Public Health Week in April 2019, the City partnered with the Health and Human Services Department to engage high school students in public health career paths. As part of the event, 230 health and medical path students from Beach, McBride, Long Beach Polytechnic, and Jordan high schools and the Linked Learning Program were invited to the Health Department were invited to participate in interactive stations focusing on emergency management, environmental health, clinical health, and the CAAP.

Youth Leadership Long Beach

In 2019 and 2020, the City partnered with Leadership Long Beach's Youth Institute, an environmentally focused community leadership program for high school students to host a day-long field trip to City Hall with a focus on "Government, Public Service, and Sustaining our City." In both years, City staff participated in the career forum; shared information on career paths to working in the fields of sustainability, urban planning, and related fields; gave presentations on the CAAP, including interactive activities to provide feedback on CAAP mitigation and adaptation strategies; and took part in a mock City Council debate on micromobility options in the city (i.e., electric scooters).

Aquarium of the Pacific – Teen Science Café

In April 2019, City staff partnered with youth volunteers from the Aquarium of the Pacific to share more information about the CAAP and to host a community conversation on how youth leaders have experienced climate change in their community, what climate action in Long Beach looks like to them and what the City should do to address climate change impacts. Participants included youth and emerging leaders both in middle school and high school.

USC Capstone in Public Administration

In 2020, students in the University of Southern California's (USC's) Master's in Public Administration program completed their capstone project on the topic of cooling centers as an adaptation action of the CAAP. Students assessed the network of cooling centers in Long Beach and developed a survey that could be used to assess residents' familiarity and experience with and access to cooling centers.

ArtCenter College of Design Pasadena

In 2019, the City participated in an ArtCenter DesignStorm on Sea Level Rise in Long Beach coordinated by the Aquarium of the Pacific, The Nature Conservancy, and the U.S. Geological Survey. Over three days, student teams created adaptation design models for sea level rise in Long Beach, including design models for amphibious housing, living seawalls, a sea-based park, and aquaculture. In 2020, the City was a knowledge partner for an ArtCenter Image + Idea course, where students created posters, animations, comics, and other materials to communicate issues related to climate change in Long Beach.

Broader Citywide Engagement

Throughout the engagement process, City staff conducted presentations at City Council study sessions and various City commission meetings, including meetings of the Planning Commission, the Sustainable City Commission, the Environmental Committee of the City Council, and the Board of Water Commissioners. In February 2020, City staff also presented to the California Coastal Commission, a highlight of the extensive and inclusive outreach completed to date.

Marketing And Online Engagement

Print and digital engagement included:

- Project website: longbeach.gov/caaplb
- Social media hashtags: #CAAPLB and #ClimateActionLB
- 5x7 Counter cards (translated into Spanish, Khmer, and Tagalog)
- E-newsletters
- Animated CAAP videos
- Billboard and print/digital newspaper ads

- Brochures and infographics/fact sheets (translated into Spanish, Khmer, and Tagalog)
- Tchotchke/promotion items – tote bags, metal straws, and CAAP caps

Following is a list of individuals who participated in the various working groups:

Scientific Working Group

- Dr. George Ban-Weiss, Professor of Civil and Environmental Engineering, USC
- Dr. Suzanne Dallman, Professor of Geography, CSULB
- Katharine Davis-Reich, Associate
- Director, UCLA Institute of the Environment and Sustainability
- Dr. David Eisenman, Professor of Medicine and Public Health, UCLA; LA County Public Health Department
- Scott Epstein, Program Supervisor, SCAQMD
- Dr. Timu Gallien, Professor of Civil and Environmental Engineering, UCLA
- Kim Hatch, Professor of Geography and Environmental Science, LBCC
- Aaron Klemm, Chief of Energy, Sustainability and Transportation, CSU Chancellor's Office
- Dr. Lily House-Peters, Professor of Geography, CSULB
- Dr. Rob Lempert, Principal Researcher, RAND
- Dr. Jerry Schubel, President and CEO, Aquarium of the Pacific
- Dr. Dean Toji, Professor of Asian and Asian American Studies, CSULB
- Dr. Christine Witcraft, Professor of Biological Sciences, CSULB

Business Working Group

- Tom Bowman, Bowman Change
- Ann Carpenter, Braid Theory
- Alan Burks, Environ
- Norm Cauntay, Edward Jones
- Megan Christensen, Bryson Financial
- Tiffany Davy, Fourth Street Business
- Improvement District
- James Delmonaco, P2S Engineering
- April Economides, April Economides Consulting
- Julia Emerson, Sempra Utilities
- Michelle Engelman Berns, Long Beach Grocery Coop
- Ignacio M. Fernandez, Southern California Edison
- Mark Graham, Metropolitan Water District
- Gina Goodhill, Tesla
- Stephen Groner, SGA Marketing
- Sean Gunning, SLS Engineers
- Sara Hickman, Retail Design Collaborative and Studio 111
- Dean Hill, Boeing Facilities
- Agata Hinc, 3COTECH
- Shannon Heffernan, Studio 111
- Aaron Holloway, Moffatt + Nicholl
- Lily House-Peters, CSULB
- Tasha Hunter, Uptown Business Improvement District
- Kat Janowicz, 3COTECH
- John Lee, Southern California Edison
- Dr. Jennifer Lentz, Aquarium of the Pacific

- Jonathan Lo, Virgin Orbit
- Wade Martin, CSULB
- Willetta McCulloh, Environ Architecture
- Ruth Meghiddo, Farm Urbana
- Austin Metoyer, Downtown Long Beach Alliance
- Jan Miller, Long Beach Convention and Visitors Bureau
- Judy Nelson, Long Beach Chamber of Commerce
- Monorom Neth, Midtown Property and Business Owners Association
- Faviola Ochoa, Southern California Gas
- Jennifer Pezda, Southern California Gas Company
- Alan Pullman, Studio 111
- Greg Robinson, Virgin Orbit
- John Rouse, Aquarium of the Pacific
- Clay Sandidge, Muni-Fed Energy, INC
- Sinara Sagn, United Cambodian Community of Long Beach
- Ryan Serrano, Earth Steward Ecology
- Shruti Shankar, Studio 111
- Marcia Tolentino
- Joshua Torres, Southern California Edison
- Brian Ulaszewski, City Fabrick
- Stella Ursua, Green Education Inc.
- Morgan Wheeler, Long Beach Convention and Visitors Bureau
- Lisa West, Councilwoman Suzie Price
- Paul Wingco, CSULB
- Susan Wise, Susan Wise Law
- Jerard Wright, BizFed
- Adeline Yoong, Southern California Edison

Community Working Group

- Lauren Ahkiam, LAANE, Don’t Waste Long Beach
- Laurie Angel, Jane Addams Neighborhood Association
- Whitney Amaya, East Yard Communities for Environmental Justice
- Holland Brown, Alamitos Heights Improvement Association and Ground Education
- Anna Christensen, Long Beach Area Peace Network
- Patricia Chen, Unitarian Universalist Church of Long Beach
- Kirsten Cox, Long Beach Progressive Revolution
- Tiffany Davy, Long Beach Alliance for Clean Energy
- Karl Eggers, Walk Bike Long Beach
- Phil Geison, Long Beach Area Peace Network
- Joan Greenwood, Wrigley Area Neighborhood Alliance
- Elizabeth Lambe, Los Cerritos Wetlands Land Trust
- Dr. Robert Kalayjian, Citizens’ Climate Lobby
- Pedora Keo, California Nurses Association
- Nelson Kerr, Long Beach Health Department
- John Kindred, Long Beach Environmental Alliance/Long Beach Gray Panthers
- Christa Indriolo, California Nurses Association
- Robert Nothoff, Don’t Waste Long Beach
- Sokha Ny, Long Beach Environmental Alliance, LB 350, LB Gray Panthers
- Karen Reside, Long Beach Gray Panthers

- Joel Reynoza, City of Long Beach Department of Health and Human Services-Homeless Services
- Alejandro Sanchez-Lopez, City Of Long Beach
- Victor Sanchez, LAANE
- Kevin Shin, Walk Bike Long Beach
- Dave Shukla, Long Beach Alliance for Clean Energy
- Bill Sive, Long Beach Gray Panthers
- Alice Stevens, Long Beach 350
- Dinesa Thomas-Whitman, Habitat for Humanity of Greater Los Angeles
- Taylor Thomas, East Yard Communities for Environmental Justice
- Elsa Tung, Long Beach Forward

Appendix F
Additional Performance Metrics

This appendix details a range of potential performance metrics that may be considered in measuring the progress of CAAP mitigation and adaptation actions. The City is unlikely to track all of these metrics and, through the implementation process, will identify those metrics that best assist in measuring progress towards goals. Benefits associated with mitigation and adaptation actions typically can only be measured over the long term; the following metrics actions attempt to measure more near term, measurable effects. As it relates to mitigation, tracking of the core actions that will be quantified to achieve the City's GHG reduction target is detailed in Appendix A. Mitigation and adaptation metrics will be revised based on data availability, streamlining with data already collected by City departments, and their utility in assessing programs, co-benefits, GHG reductions, etc.

ADAPTATION ACTIONS - POTENTIAL PERFORMANCE METRICS

CLIMATE STRESSOR	KEY PERFORMANCE METRICS
Extreme Heat	Number of hospitalizations for heat-related sickness during extreme heat events
Air Quality	Measure of local air pollutants
Drought	Number of gallons of water used per person per day
	Usage of recycled water and greywater
Flooding	Critical infrastructure retrofitted or relocated to protect from flooding

ACTION	POTENTIAL PERFORMANCE METRICS
EXTREME HEAT	
EH-01: Increase presence of cool roofs and cool walls	Regulatory change to require cool roofs and cool walls Updated City standards plant to use reflective materials for streets and surfaces
EH-02: Increase presence of reflective streets, surfaces, and shade canopies	# lane miles of pavement treated with "cool pavement" by the City
EH-03: Enhance and expand urban forest cover	# of trees existing and planted
	% tree canopy coverage
	# of trees existing/planted and% tree canopy cover age in neighborhoods vulnerable to extreme heat and lowest tree canopy coverage
EH-04: Install additional water fountains and other actions to increase public access to water	Number of drinking fountains and water refill stations existing and installed total and in extreme heat vulnerability zones
EH-05: Identify future vulnerability potential for power outages related to extreme heat and develop plans to prevent such outages	Assessment of grid vulnerabilities
	Actions developed to prevent future power outages related to extreme heat

EH-06: Enhance and expand accessibility of cooling centers	# of publicly accessible cooling centers in the City and within extreme heat vulnerability zones
	Accessibility measures including hours of operation and proximity to transit
	Visitor count to cooling centers during extreme heat events
EH-07: Provide bus shelter amenities	% of bus stops with shade structures
	% of bus stops with seating
	% of bus stops with real-time arrival information
EH-08: Improve beach and coastal transit access during extreme heat events	Number of newtransit options (routes, services, passes, etc.) created to improve beach and coastal transit access during extreme heat events
	# riders or enrollees in new transit options
AIR QUALITY	
AQ-01: Incentivize installation of photocatalytic tiles	# pilot photo catalytic roofsprojects and associated reduction in NOx and ozone
AQ-02: Encourage urban agriculture practices that reduce air quality	# measures adopted that encourage urban agriculture practices
	Electricity, natural gas, and water use
AQ-03: Support the development of the Long Beach Airport Sustainability Plan	% electric vehicles and ground support equipment electrified
	% diversion of waste from disposal
AQ-04: Electrify local, small emitters such as lawn and garden equipment, outdoor power equipment, and others	# of incentives utilized from SCAQMD Commercial Electric Lawn and Garden Incentive and Exchange Program
	City-owned small emitter equipment transitioned to electric
AQ-05: Work with LBUSD to support school bus electrification	# ofdiesel buses switched to electricpower and associated reduction in air pollutants
AQ-06: Implement the San Pedro Bay Ports Clean Air Action Plan	# of zero emissions heavy-duty drayage trucks
	% of ships utilizing shore power
	% of zero or reduced emission cargo equipment
	% of ships participating in Vessel Speed Reduction Program
	Participation by ships that qualify for Green Ship Incentives
AQ-07: Increase monitoring and regulation of oil extraction and refining process	# air quality monitors installed

DROUGHT	
DRT-01: Continue development and implementation of water use efficiency programs and implement additional water conservation programs	Measure of water consumption against State water efficiency targets
	Participation in Certified Blue Restaurant program
DRT-02: Enhance outreach and education related to water conservation	Participation in Green Business program
	# of individuals and businesses reached
	# of education and outreach events
DRT-03: Expand usage of green infrastructure and green streets	Requirements and incentives developed for new development to expand the use of green infrastructure
	# City green infrastructure and streets projects
DRT-04: Expand usage of recycled water and grey water for non-potable use	Requirements and incentives developed for new development to expand the use of recycled water
	% use of recycled water and grey water in City facilities
DRT-05: Incorporate increased rainfall capture to offset imported water	Requirements and incentives developed for new development to integrate rainfall capture and harvest
	# of rainfall capture/storage installations

FLOODING	
FLD-01: Update the floodplain ordinance	Established ordinance
FLD-02: Incorporate sea level rise language into citywide plans, policies, and regulations	Strategies, policies, and regulations updated or developed to incorporate sea level rise language
FLD-03: Establish a flood impacts monitoring program	Established flood impacts monitoring program
	# of annual crowdsourced documentations
FLD-04: Incorporate adaptation into City lease negotiations	Updated leasing guidelines to incorporate adaptation
FLD-05: Update the City's existing Stormwater Management Plan	Updates to Stormwater Management Plan
FLD-06: Conduct citywide beach stabilization study	Completed study
FLD-07: Review and conduct studies of combined riverine/coastal flooding and increased precipitation impacts on watershed flooding	Completed studies

FLD-08: Enhance dunes	# of Dunes enhanced
FLD-09: Inventory and flood-proof vulnerable sewer pump stations	Inventory of sewer pumpstations prioritized by highest vulnerability
	# of retrofitted sewer pump stations
FLD-10: Relocate/Elevate critical infrastructure	# of Facilities/infrastructure identified for retrofit/relocation
	# of Facilities/infrastructure retrofitted/ relocated
	# of Facilities with continuity plan to maintain operations
FLD-11: Elevate riverine levees	Prioritized levees and adaptation strategies

MITIGATION ACTIONS - POTENTIAL PERFORMANCE METRICS

ACTION	POTENTIAL PERFORMANCE METRICS
BUILDING + ENERGY	
BE-1: Provide access to renewably generated electricity	% of residential customers that purchase 100% renewable electricity
	% of non-residential customers that purchase 100% renewable electricity
BE-2: Increase use of solar power	Regulatory change to increase the use of solar power
BE-3: Promote community solar and microgrids	# of identified local opportunity sites
	kWh per year generated by community solar facilities located within Long Beach
	# of critical facilities connected to islandable microgrid power (that can stand alone from the grid)
BE-4: Develop a residential and commercial energy assessment and benchmarking program	# housing units that received an energy audit
	# certified HERS raters in the community
BE-5: Provide access to energy efficiency financing, rebates, and incentives for building owners	Established energy resource center
	# of residents and businesses engaged by the City through the energy resource center
	Use of financial incentives, rebates, and other programs and associated financial/energy savings
BE-6: Perform municipal energy and water audits	# municipal building/facility audits completed
	Electricity and natural gas use
BE-7: Update building codes to incentivize electric new residential	Updated building code to incentivize electric new residential and commercial buildings
BE-8: Implement near-term measures to reduce emissions related to oil and gas extraction	# measures implemented to reduce oil and gas emissions
TRANSPORTATION	
T-1: Increase frequency, speed, connectivity, and safety of transit options	Increase in ridership on Long Beach Transit, Metro Blue Line, and regional transit routes
	Increase in operating hours
	# increase of rapid bus and regional connector routes
	Increase in safety perception from transit riders
	Decrease in crime on transit
	Free/reduced price transit passes for CSULB and LBCC students

T-2: Expand and improve pedestrian infrastructure citywide	% change in travel mode for short trips (e.g., less than 2 miles) made by walking or personal mobility device
	% change in vehicle-pedestrian accidents
	# of improved crosswalks (e.g., signalized, non-signalized, scrambles)
	# of installed traffic calming measures (e.g., medians, roundabouts, bulb-outs, curb extensions)
T-3: Increase bikeway infrastructure	% of city population that can walk to bikeshare stations within 5 minutes
	% change in usage of Long Beach Bike Share (# of rides and miles)
	% change in e-scooter ridership (# of rides and miles)
	# of new miles of bikeways delivered by class
T-4: Implement the San Pedro Bay Ports Clean Trucks Program	% of zero emissions heavy-duty drayage trucks
T-5: Develop an Electric Vehicle Infrastructure Master Plan	Number of publicly accessible EV charging stations
	Number of publicly accessible EV charging stations installed in disadvantaged communities (CalEnviroScreen)
	Number of building permits issued for private property EV charging stations
T-6: Increase employment and residential development along primary transit corridors	Quantification of additional capacity for development in TOD areas
	# of city permits issued for TOD development
	# of housing units permitted in transit areas
	# of affordable housing units permitted in transit areas
	Increase in population and employment density in transit station areas and along transit corridors
T-7: Update the Transportation Demand Management Ordinance	# of employees participating in the TDM program
	% or # of employers that participate in TDM programs
	# of TDM requirements leveraged through new development permits
T-8: Increase density and mixing of land uses	% increase in population and employment density within ½ mile of high-frequency transit routes
	Quantification of additional capacity for development in TOD areas
	% change in travel mode for short trips (e.g., less than 2 miles) made by walking, biking, transit, or personal mobility device
T-9: Integrate SB 743 planning with CAAP process	VMT reduction

WASTE	
W-1: Ensure compliance with state law requirements for multi-family residential and commercial property recycling programs	Waste reduction and recycling outreach materials developed and distributed
	% compliance of multi-family and commercial properties
W-2: Develop a residential organic waste collection program for City-serviced accounts	Organic waste outreach materials developed and distributed
	% of organic waste diverted from landfills and SERRF
W-3: Partner with private waste haulers to expand organic waste collection community wide	% compliance of multi-family and commercial properties
	Tons of organic waste collected from multi-family and commercial properties
	Organic waste outreach materials developed and distributed
W-4: Identify organic waste management options	Tons of organic waste sent to different facility types
	Identified process for organic waste disposal

F

APPENDIX F

CITY OF LONG BEACH

Appendix G
Oil and Gas
Technical Memo

AECOM
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San Francisco, CA 94104
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415.796.8100 tel
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Long Beach Oil and Gas Technical Memorandum

AECOM prepared this Memorandum (memo) to help the City of Long Beach understand lifecycle emissions associated with oil and gas extraction operations occurring within the city boundary. This analysis can provide a more holistic view of the City's contribution to global greenhouse gas (GHG) emissions, and complements the previous analysis of the city's GHG emissions provided through the more traditional production- and consumption-based inventories.

The memo is organized into 6 sections that address the following goals:

1. To understand the GHG footprint of gas and oil operations in Long Beach,
2. To understand how the carbon intensity of these operations in Long Beach compares with oil extraction elsewhere in California and internationally,
3. To give an overview of what happens to the oil and gas that is extracted in Long Beach,
4. To describe how oil and gas operations in Long Beach are regulated by the State,
5. To provide descriptions of best practices in technological interventions to minimize lifecycle emissions from gas and oil operations, and
6. To give a high-level overview of recommendations to transition away from gas and oil activity over time.

This memo is a focused, high level analysis of lifecycle oil intensity that used the Oil Climate Index (OCI) methodology for assessing the lifecycle impacts of global oils. The memo does not include a cost or cost effectiveness analysis, quantification of the potential lifecycle GHG reductions, or an assessment of the recommendations' impact on the city's oil and gas economy (e.g., revenue, employment). This evaluation also does not include considerations about specific economic benefits to the City from its oil production activities, local public health impacts, domestic energy security, human rights records of oil producing countries, or other socio-political factors.

This memo was amended with information provided by the City of Long Beach Energy Resources Department.

Executive Summary

In 2015, 13.3 million barrels of crude oil and 5.1 million Mcf of natural gas were extracted in Long Beach. The lifecycle emissions resulting from this energy production total 8.3 million metric tons of carbon dioxide equivalent (MT CO_2e), which is 2.7 times greater than the city's 2015 production-based GHG emissions inventory.[1] The city's oil and gas lifecycle emissions were estimated based on an upstream emissions factor from the California Air Resources Board (CARB) specific to the Long Beach oil field, and midstream and downstream emissions factors from the Oil Climate Index (OCI) for a proxy oil field (California Wilmington) in lieu of a Long Beach-specific analysis, which has not been analyzed in the OCI. Based on the resulting lifecycle emissions factor, the total carbon intensity of oil extracted in Long Beach is the 14th highest out of 75 global oils surveyed in the OCI.

Approximately 96 percent of the city's oil and gas lifecycle emissions are attributed to oil, with the remaining 4 percent resulting from natural gas. It is estimated that 100 percent of natural gas extracted

[1] The City's production-based inventory, sometimes referred to as a scope-based inventory, was developed to be consistent with the Basic level requirements for a community inventory as outlined in the Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GPC)

First Released: 5/31/19; Revised: 7/24/20 and 11/23/20

in Long Beach is consumed in the community, and that 100 percent of the oil extracted in Long Beach is consumed within California. Of the total oil and gas lifecycle emissions, 76 percent occur downstream (i.e., transport to consumers and end use of fuel), 14 percent occur midstream (i.e., oil refining), and 5 percent occur upstream (i.e., extraction); the remaining 4 percent are lifecycle natural gas emissions. Based on the OCI information for the Wilmington oil field, this analysis also assumes that the refining of Long Beach oil results in the creation of petcoke as a byproduct, which is likely exported for combustion outside of the United States because it has limited permitted uses within the United States. This byproduct contributes importantly to downstream emissions from Long Beach oil.

Understanding the lifecycle emissions sources help to define the City's opportunities for meaningful intervention. Upstream emissions occur at the oil fields within the city boundary. The City issues well permits for petroleum operations, and has relatively more direct control over these emissions. Opportunities to reduce upstream emissions primarily include energy efficiency improvements in the extraction process and increased leak monitoring and detection. Oil refining occurs outside the City's jurisdiction, where opportunities to reduce midstream emissions are limited to advocacy efforts for more stringent requirements from CARB, the Southern California Air Quality Management District, or other relevant permitting entities. Oil extracted in Long Beach is refined into various end products, which are consumed inside and outside the city boundary. Through its Climate Action and Adaptation Plan (CAAP), the City is pursuing actions that would reduce local consumption of fossil fuels from building energy efficiency improvements, reduced vehicular travel, and expansion of electric vehicle technology. As with the midstream emissions, the City's ability to influence use of Long Beach oil products outside of the city is primarily limited to advocacy for greater local action in those jurisdictions to limit fossil fuel use or for more stringent regulation (e.g., state, federal) of fossil fuel consuming uses (e.g., vehicle efficiency standards).

The City's long-term strategy to address oil and gas lifecycle emissions should be multi-pronged and include a goal to replace fossil fuel consumption in Long Beach with clean electricity and other renewable energy sources, support efforts to minimize global demand for oil and gas resources, phase-out local oil and gas extraction, and invest in carbon capture technology.

1. Summary of Oil and Gas Footprint

AECOM estimated the lifecycle footprint of oil and gas produced in Long Beach. Based on guidance from staff at CARB, this analysis combined information from OCI and the Low Carbon Fuel Standard (LCFS) Regulation to develop a lifecycle emissions factor for crude oil that approximates emissions for the Long Beach oil fields. Additional information was collected to estimate emissions from the production and use of natural gas occurring as a byproduct of oil production. The following sections describe these various inputs before presenting the lifecycle emissions estimates.

Emissions Factors

OIL-CLIMATE INDEX

OCI is an analytic tool that estimates the total lifecycle GHG emissions of individual oils and compares them among a global sample pool of 75 different oil fields. The lifecycle emissions include upstream extraction, midstream refining, and downstream end use. The database "was developed to alert public and private stakeholders to the full array of oils' climate impacts from various perspectives",[2] and can support a more holistic understanding of what public policies can address oil-related emissions.

OCI uses three different models to develop its emissions factors:

1. Oil Production Greenhouse Gas Emissions Estimator (OPGEE) for upstream production data

[2] Oil-Climate Index. Available: <https://oci.carnegieendowment.org/#about>

2. Petroleum Refinery Life-Cycle Inventory Model (PRELIM) for midstream refining data
3. Oil Products Emission Module (OPEM) for calculating GHG emissions associated with transporting petroleum products from the refinery outlet to the end-use destination, including end-use combustion

Each of the global oils included in the database has an individual emissions footprint, based on their unique chemical composition, extraction and refining technologies, and other factors. These differences add up to high variability in lifecycle emissions from oil produced at different oil fields, and a better understanding of these differences can inform policy making designed to achieve climate goals and protect local air quality. According to Deborah Gordon, the former director of the Carnegie Endowment for International Peace Energy and Climate Program (an OCI funding partner):

"California today stands at two ends of a spectrum: the nation's climate policy leader is also the country's third largest oil-producing state and the state with the third largest oil-refining capacity in the nation. Despite ambitious goals to reduce carbon emissions, some California oils are as high-emitting as Canadian oil sands and other difficult-to-extract heavy oils. This poses critical global climate risks and calls for immediate policy attention."[3]

Crude Oil Emissions Factors

OCI provides emissions factors specific to each of the lifecycle phases (i.e., upstream, midstream, downstream) expressed as kilograms of carbon dioxide equivalent (kg CO_2e) per barrel of crude oil.[4] OCI does not have emissions factors specific to the Long Beach oil fields; the Wilmington oil field is the closest option geographically. AECOM consulted with CARB staff about using Wilmington as a proxy for the Long Beach fields, and were informed that the LCFS Regulation does include upstream emissions factors specific to the Long Beach fields, which could be combined with midstream and downstream factors from OCI to develop a more nuanced and locally-specific emissions factor. CARB staff suggested that OCI's midstream and downstream emissions factors for Wilmington might be a good proxy for Long Beach in lieu of more specific analysis. AECOM staff contacted a co-developer of the OCI database to discuss this question further and understand if Long Beach oil field-specific factors are available, but did not receive a response prior to developing this memo. Therefore, the lifecycle emissions factor for oil production used in this analysis is based on the best available data and consists of the components shown in Table 1.

Table 1 – Crude Oil Lifecycle Emissions Factors

Sector	kg CO_2e/barrel of crude	Source
Upstream Emissions[1]	32.6	CARB
Midstream Emissions[2]	90.0	OCI - Wilmington
Heat	27.0	
Electricity	5.0	
Steam	6.0	
Hydrogen (via steam methane reformer)	47.0	
Catalyst Regeneration (fluid catalytic fracking)	5.0	
Downstream Emissions[2]	478.0	OCI - Wilmington
Transport to Consumers	12.0	
Gasoline	213.0	

[3] Gordon, Deborah and Samuel Wojcicki. Need to Know: The Case for Oil Transparency in California. Carnegie Endowment for International Peace. March 15, 2017. Available: <https://carnegieendowment.org/2017/03/15/need-to-know-case-for-oil-transparency-in-california-pub-68166>

[4] The emissions factors from OCI do not account for natural gas extraction, distribution, or use, so additional lifecycle emissions estimates were developed to analyze this emissions source from production in Long Beach.

Sector	kg CO_2e/barrel of crude	Source
Jet Fuel	43.0	
Diesel	137.0	
Petroleum Coke	40.0	
Residual Fuels	17.0	
LPG	16.0	
Total	600.6	Calculated value

[1] California Air Resources Board Low Carbon Fuel Standard Regulation, Unofficial Electronic Version provided to AECOM via email April 2019. Table 9 - Carbon Intensity Lookup Table for Crude Oil Production and Transport. Conversion from g CO_2e/MJ to kg CO_2e/barrel of crude provided to AECOM via email by CARB staff.
[2] Oil-Climate Index, "U.S. California Wilmington" Created 2015. Accessed 4/12/2019. Available: <https://oci.carnegieendowment.org/?toggle-carbon=on&carbon-tax=20&ratio-select=perBarrel&step-select=ghgTotal&sort-select=true#oil/u.s.-california-wilmington>

The total lifecycle emissions factor developed for this analysis is approximately 601 kg CO_2e per barrel of oil. Of this total, 5 percent of emissions occur upstream (e.g., extraction), 15 percent occur midstream (e.g., refining), and 80 percent of the emissions occur downstream from transport to consumers and final product use (e.g., gasoline, diesel, jet fuel).

NATURAL GAS EMISSIONS FACTORS

The OCI emissions factors do not include emissions occurring from natural gas that is produced as a byproduct of the oil extraction process. To account for these emissions in Long Beach, the total natural gas production volume in the city was estimated and then organized according to its final end use to determine the applicable emissions factors. Of the natural gas produced in Long Beach, approximately 99 percent is combusted, either for auxiliary energy use at oil facilities or in building appliances and systems, like hot water heaters and stoves. The remaining 1 percent is fugitive emissions, lost to the atmosphere through leakage in the natural gas supply chain.

EPA emissions factors for stationary combustion of natural gas were applied to the volume of combusted natural gas. Table 2 summarizes these natural gas emissions factors.

Table 2 – Natural Gas Combustion Emissions Factor

Value	Unit	Source
0.05444	kg CO_2 per scf	U.S. EPA emissions factors[1]
0.00103	g CH_4 per scf	
0.0001	g N_2O per scf	
0.054	Total kg CO_2e per scf	Calculated value[2]

[1] U.S. EPA. Last modified 9 March, 2018. Available: <https://www.epa.gov/sites/production/files/2018-03/documents/emission-factors_mar_2018_0.pdf>
[2] Global warming potential factors for CH_4 and N_2O were used to convert to carbon dioxide equivalent; the UN IPCC Fourth Assessment Report values were used for consistency with the city's production-based GHG inventory. Available: <https://www.ipcc.ch/site/assets/uploads/2018/02/ar4-wg1-chapter2-1.pdf>

Fugitive emissions were estimated based on the amount of methane in the volume of lost natural gas, combined with its relative global warming potential (GWP) factor from the International Panel on Climate

Change Fourth Assessment Report (IPCC 4AR).[5] Use of these GWP values provides consistency with the city's production-based inventory, which also uses 4AR 100-year GWP factors.

Total Emissions

The emissions factors presented above were combined with oil and natural gas production information from the City Energy Resources Department. Oil production data was provided in barrels per quarter from 2001-2017; 2015 values were used in this analysis for consistency with the city's production-based inventory. The City does not directly track natural gas production, and instead provided a factor to estimate total natural gas produced as a result of total oil produced. However, the Thums oil facility does report oil and natural gas production volumes to the EPA. This data was combined with the natural gas production factor provided by the City to estimate total natural gas production in Long Beach. Oil and gas production volumes for 2015 are shown in Table 3.

Table 3 – 2015 Oil and Natural Gas Production

2015 Production	Volume	Unit	Source
Crude Oil			
Total Oil Production	13,321,018	barrels	City of Long Beach Energy Resources Department
Natural Gas			
Thums Gas Production	3,450,425	Mcf	EPA GHG Reporting Protocol
Thums Oil Production	8,936,765	barrels	EPA GHG Reporting Protocol
Remaining Oil Production in Long Beach	4,384,253	Barrels	Calculated as (Total oil production) – (Thums oil production)
Gas Production Factor	0.38	Mcf/barrel	Provided by staff from Long Beach Energy Resources Department
Remaining Gas Production	1,666,016	Mcf	Calculated as (Gas production factor) * (Remaining oil production)
Total Natural Gas Production	5,116,441	Mcf	Calculated as (Thums gas production) + (Remaining gas production)

Based on the emissions factors and production volumes presented above, AECOM calculated total lifecycle emissions from the oil and gas produced in the city in 2015. As shown in Table 4, 96 percent of the emissions are attributed to oil and the remaining 4 percent are from natural gas. For comparison, the table also shows the city's 2015 production-based inventory emissions that are addressed in the City's draft CAAP. The lifecycle emissions from oil and gas produced in Long Beach are 2.7 times greater than the production-based inventory emissions generated as a result of activity in the community (e.g., residential energy use, on-road transportation, waste disposal).

It should be noted that the production-based inventory methodology used to calculate the communitywide emissions does not use a lifecycle emissions approach. Therefore, the comparison of these two emissions values shown in Table 4 is for informational purposes only, and the two values should not be summed to represent a total emissions inventory for Long Beach. Further, the lifecycle oil and gas emissions are approximately 1.2 times greater than the city's' consumption-based inventory as

[5] International Panel on Climate Change, 2007. Changes in Atmospheric Constituents and in Radiative Forcing. In: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Available: <https://www.ipcc.ch/site/assets/uploads/2018/02/ar4-wg1-chapter2-1.pdf>

well, but these two emissions sources are not directly comparable beyond demonstrating the relative volume of emissions resulting from different types of activities in Long Beach.

Table 4 – 2015 Emissions Summary from Long Beach Oil and Gas Production

2015 Emissions	MT CO_2e
Oil and Gas Lifecycle Emissions	8,329,292
Oil Production	8,000,604
Natural Gas Production	328,689
Community Inventory Emissions (production-based inventory)	3,100,468

2. Long Beach Carbon Intensity Compared to Other Areas

The carbon intensity of a barrel of crude oil is not homogenous across all oil fields. Various factors influence oil's carbon intensity, including differences in physical characteristics, as well as in how the oil is extracted, processed, and ultimately used. Certain physical properties are used to characterize oil. For example, "sweetness" is defined by the sulfur content of the crude - the lower the content, the sweeter the oil. "Heavy" oils are those which have a lower API gravity (equivalent to specific gravity expressed as weight per volume) and conversely, light oils are those with higher API gravity.

OCI Lifecycle Emissions

The physical properties for a sample of six global oils from the OCI are shown in Table 5, including the Wilmington oil field that was used to estimate the midstream and downstream emission factors for Long Beach as referenced in Table 1. The selected oils also include the most carbon intensive in the OCI (Canada Athabasca DC SCO), the least carbon intensive (U.S. Texas Eagle Ford Volatile Oil Zone), the largest producer by volume (Saudi Arabia Ghawar), and the two other California oils surveyed in the OCI.

Table 5 – Physical Properties of Various Crude Oils

Oil Name	Oil Type	Classification	API	Sweet or Sour	Sulfur Content
U.S. Texas Eagle Ford Volatile Oil Zone	Condensate	Ultra-light	50	Sweet	0.13%
Saudi Arabia Ghawar	Light	Light	33	Sour	1.63%
U.S. California Wilmington Oil	Depleted	Heavy	19	Sour	1.56%
U.S. California Midway Sunset	Depleted	Medium to extra-heavy	23	Sour	1.19%
U.S. California South Belridge	Depleted	Heavy to extra-heavy	15	Sweet	0.25%
Canada Athabasca DC SCO	Extra-heavy	Extra-heavy	33	Sweet	0.16%

Source: Oil-Climate Index; adapted by AECOM 2019

Wilmington oil is characterized as heavy and sour. The use of pumps to extract a watery, depleted crude from the Wilmington reservoir generate most of its upstream GHG emissions. As noted above, this analysis uses an upstream emissions factor specific to the Long Beach crudes. Per input from CARB staff, Long Beach crudes inject less water than in Wilmington to produce the same amount of oil. Long Beach crudes also have a higher API than Wilmington crudes. These two factors result in lower upstream emissions from Long Beach crudes than Wilmington. This analysis uses Wilmington emissions factors for the midstream and downstream lifecycle phases. When Wilmington crude is refined, petcoke (or petroleum coke) is produced. This product has a high carbon and low hydrogen content that, when exported and combusted, contributes significantly to Wilmington's downstream GHG emissions.[6]

Heavy oils like Wilmington's or extra heavy oils like Canada Athabasca DC SCO (Athabasca) or the other U.S. California oils require more energy resources to extract and to separate out the usable fractions. Wilmington has higher midstream emissions than many other OCI oils because of the amount of hydrogen and heat used to transport and store the oil. Crudes like those found at Texas Eagle Ford Volatile Oil Zone (Texas Eagle) are considered ultra-light, sweet and relatively easy to extract from their source material. However, oil production in Eagle Ford uses hydraulic fracturing which is more energy and water intensive. The City does not use this well stimulation method. Sour oils such as Wilmington also have higher sulfur content (1.56 percent sulfur) than sweet oils and therefore require greater desulfurization at the midstream refining level.

Table 6 shows the emissions by lifecycle phase (e.g., upstream) for the same six global oils presented in Table 5, along with the approximated Long Beach oil emissions factor, ranked from lowest lifecycle emissions to highest. Texas Eagle has the lowest overall carbon intensity of all 75 oils surveyed in the OCI, and Athabasca has the highest. Lifecycle emissions from Long Beach and Athabasca oils are 1.3 and 1.6 times greater than those extracted from Texas Eagle, respectively.

Table 6 – Oil Emissions by Field[7]

Oil-Climate Index Model	kg CO_2e/barrel of oil			
Oil Name	Upstream	Midstream	Downstream	Total
U.S. Texas Eagle Ford Volatile Oil Zone	33	23	403	458
Saudi Arabia Ghawar	34	28	430	491
Long Beach Oil[1]	33	90	478	601
U.S. California Wilmington Oil	56	90	478	625
U.S. California South Belridge	103	98	489	690
U.S. California Midway Sunset	180	81	464	725
Canada Athabasca DC SCO	163	13	560	736

[1] Rounded to nearest whole number; see Table 1 for emissions inputs for Long Beach Oil; Total values for OCI survey oils may not sum to total shown

As represented in the OCI, Wilmington oil has a standard emissions factor of 625 kg CO_2e per barrel, ranking it as tenth most carbon intensive of all 75 global oil types surveyed in the OCI. The approximated Long Beach oil emissions factor presented in Section 1 is 601 kg CO_2e/barrel oil, and would rank as the 14th most carbon intensive global oil in the OCI. Of the 75 global oils surveyed in the OCI, the median lifecycle emissions are 514 kg CO_2e per barrel; all three of the California oils in the OCI exceed the median value.

As shown in Table 6, Athabasca oils have the highest carbon footprint in the OCI at 736 kg CO_2e/barrel oil. Its high carbon footprint is largely attributable to the unconventional nature of the tar from which the oil must be separated in order to have a usable product; 22 percent of the total emissions occur from upstream processes alone for Athabasca. That compares to Texas Eagle (with the lowest total emissions in the OCI) at 458 kg CO_2e/barrel where 7 percent of emissions come from upstream operations. Upstream emissions from Long Beach oil (33 kg CO_2e/barrel oil), as informed by CARB's LCFS research,

[6] Carnegie Endowment, Oil-Climate Index. Available <https://oci.carnegieendowment.org/?toggle-carbon=on&carbon-tax=20&ratio-select=perBarrel&step-select=ghgTotal&sort-select=true#oil/u.s.-california-wilmington>
[7] Carnegie Endowment, Oil-Climate Index. Available: <https://oci.carnegieendowment.org>

ranks among the lowest of those surveyed in the OCI; the lowest upstream emissions in the OCI are from U.S Wyoming WC at 21 kg CO_2e/barrel oil. The majority of Long Beach emissions come from downstream processes, comprising 80 percent of the total emissions profile, based on the assumption that Wilmington oils are a suitable proxy for Long Beach for midstream and downstream emissions.

CARB Crude Oil Upstream Carbon Intensity

The California Air Resources Board estimates the upstream and transport-related emissions for more than 100 California crude oil sources in its role of implementing the state's low carbon fuel standard (LCFS). The objective of the LCFS is to reduce the fuel-cycle carbon intensity of transportation fuels used in California. For this analysis, CARB staff provided a link to the Unofficial Electronic Version of the 2019 LCFS Regulation for reference, and recommended that the Long Beach-specific upstream carbon intensity factor included therein could be used to replace the Wilmington upstream emissions factor from the OCI.

The information provided by CARB includes carbon intensity values for 157 California oil fields, expressed as gCO_2e/MJ. The lowest carbon intensity factor is from the Olive oil field (1.82 gCO_2e/MJ), the highest carbon intensity is from the Chico-Martinez oil field (48.13 gCO_2e/MJ), and the median carbon intensity is 4.94 gCO_2e/MJ. The Long Beach oil field carbon intensity is 5.48 gCO_2e/MJ; 94th out of 157 when ranked lowest to highest. For comparison, the Wilmington oil field carbon intensity listed in the LCFS is 8.31 gCO_2e/MJ, or 118th out of 157. This suggests that even among other California oil fields, the majority have a lower carbon intensity value than Long Beach and Wilmington oil.[8]

3. What Happens to Oil and Gas Extracted in Long Beach

This section briefly outlines the assumed final destination of oil and gas produced in Long Beach. The primary takeaway is that there is imperfect tracking of the oil and gas produced in Long Beach and elsewhere in the state, so inferences have been made based on various sources of information to estimate where the city's oil and gas production might go.

Oil

It is assumed that all oil produced in Long Beach is eventually consumed within the state. In 2018, 31.1 percent of the crude oil supply for California refineries was produced in-state, 11.4 percent was imported from Alaska, and 57.5 percent was imported from abroad. Foreign sources of crude oil imports came from more than 10 countries in 2018, with the largest imports from Saudi Arabia (37 percent), Ecuador (14 percent), and Colombia (13 percent).[9] According to the EIA, "California is the second largest consumer of petroleum products in the nation and the largest consumer of motor gasoline and jet fuel."[10] On a statewide average, 66 percent of crude oil product from California refineries is motor gasolines, 13 percent is distillate fuel, 12 percent is aviation fuel, and 9 percent is residual fuel.[11] This information suggests that California consumes all of its domestic oil production, including that from Long Beach, and needs additional imports to satisfy in-state demand.

As a caveat to this assumption, it is possible that petcoke is produced as a byproduct of refining Long Beach oil; petcoke combustion is a contributor to downstream emissions from Wilmington oils in the

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8 This considers emissions resulting from fuel transport, however it is important to note that this assessment does not include risk of spills from overseas transport.
9 California Energy Commission. Oil Supply Sources to California Refineries. Available: <https://www.energy.ca.gov/almanac/petroleum_data/statistics/crude_oil_receipts.html>
10 EIA. California State Profile and Energy Estimates. Last updated November 15, 2018. Available: <https://www.eia.gov/state/analysis.php?sid=CA>
11 California Energy Commission. California's Oil Refineries. Available: <https://www.energy.ca.gov/almanac/petroleum_data/refineries.html>

OCI, and the same emissions factors were used as a proxy for Long Beach oil given the oils' similar characteristics. Strict state and federal regulations make combustion of petcoke difficult in the U.S., which limits the domestic market. According to a 2013 CBS report, "California exports 128,000 barrels of petroleum coke a day. Most of it goes to China, where it's burned to generate electricity, and where it emits five to 10 percent more carbon dioxide than coal."[12] The Port of Long Beach website also lists petroleum coke as a top export item.

Natural Gas

The City of Long Beach operates one of the largest municipally owned natural gas utilities in the U.S., and is one of only three such operations in California. According to the *2016 California Gas* Report prepared by the California Gas and Electric Utilities:

"Long Beach receives a small amount of its gas supply directly into its pipeline system from local production fields that are located within Long Beach's service territory, as well as offshore. Currently, Long Beach receives approximately 5 percent of its gas supply from local production. The majority of Long Beach supplies are purchased at the California border, primarily from the Southwestern United States. Long Beach, as a wholesale customer, receives intrastate transmission service for this gas from SoCalGas."[13]

As presented in Table 3, this analysis estimated that Long Beach produced 5.1 million Mcf of natural gas in 2015. It is further assumed that 100 percent of the natural gas produced in Long Beach is consumed within the city as well. Of the total gas production volume, approximately 1.4 million Mcf is assumed to be distributed as natural gas for local consumption, while the remainder is primarily combusted on-site during oil production or to generate auxiliary energy at the oil fields; a fraction (1.44 percent) is also assumed for total leak loss from the natural gas supply chain. Based on the city's total natural gas production estimate, approximately 3.1 percent of natural gas consumed in the city (as represented in the production-based inventory) is produced locally.

Implications of Oil and Gas Use from Long Beach

As was described in the previous sections, oil emissions account for 96 percent of total lifecycle emissions from oil and gas extracted in Long Beach. Further, while the upstream emissions of local oil extraction are relatively low when compared to global oils in the OCI, the total lifecycle emissions from Long Beach oil are relatively much higher than other sources. This suggests that as the city and other global actors (e.g., cities, countries) strive to reduce fossil fuel use over the long-term, there are lower carbon-intensive oil options available that could be used in the interim as economies shift away from fossil fuels.

4. State Regulations of Gas and Oil Operations

This section gives a generalized overview of the state regulatory framework applicable to the oil and gas industry.

California Air Resources Board

In March 2017, CARB adopted its "Methane Regulations", which impose emission controls for on- and offshore oil production and processing facilities, as well as natural gas distribution facilities. The intent of the regulations is to help the state to achieve its GHG reduction targets codified in Assembly Bill 32 and

[12] CBS SF Bay Area. Dirty Substance from California's Oil Refineries Burned Overseas. October 1, 2013. Available: <https://sanfrancisco.cbslocal.com/2013/10/01/dirty-substance-from-californias-oil-refineries-burned-overseas/>
[13] 2016 California Gas Report. Page 101. Available: <file:///C:/Users/lathanj1/Downloads/TN212364_20160720T111050_2016_California_Gas_Report.pdf>

Senate Bill 32 through the oil and gas industry. The regulation is designed to reduce methane emissions from oil and gas operations, which account for approximately 4 percent of methane emissions in the state.[14] The regulations include stringent best management practices for vapor collection and flow rate measurements from well casing vents, among other things. The regulations also include plans to implement advanced Leak Detection and Reporting programs (LDAR) that exceed the current industry practice.[15] The anticipated impact of the regulations includes average methane reductions of 1.4 million MT CO_2e/year (based on a 20-year GWP value), reductions of over 3,600 MT/year in volatile organic compounds (VOCs) statewide, and reductions of more than 100 MT/year in toxic air contaminants.[16]

CALIFORNIA CAP-AND-TRADE PROGRAM

In 2006, California took steps to develop a long-term response to the challenges of climate change through adoption of Assembly Bill 32, which includes California's Cap-and-Trade regulation as one of 70 separate measures used to reduce GHG emissions in the state.[17] The Cap-and-Trade program established a declining cap on carbon emissions and a framework in which companies can trade emission allowances to achieve statewide GHG reduction objectives. Organizations registered in the program account for 80 percent of California's overall GHG emissions.

The Cap-and-Trade program mandates that companies account for GHG emissions by acquiring credits (allowances) and retiring them with the state. Companies are also permitted to purchase a limited number of offsets to achieve compliance. According to CARB, emissions from oil and gas production decreased slightly (by 0.9 percent) from 2016 to 2017 partially as a result of the Cap-and-Trade program.[18] The City's oil operations fund approximately $3.5 million per year to the State's Cap-and-Trade program which helps reduce the State's GHG emissions.

The California Resources Corporation (CRC), which operates the THUMS Long Beach Company and the Tidelines Oil Production Company (both within the city boundary), is subject to California's Cap-and-Trade program requirements. From 2013-2017, CRC has spent $148 million to purchase GHG allowances at auction and purchase sustainable forestry offsets.[19]

South Coast Air Quality Management District

The South Coast Air Quality Management District (SCAQMD) is the air pollution control agency for a southern California region that includes Long Beach and nearly half of the state's population. SCAQMD's primary role is to control stationary emissions sources, such as oil refineries, power plants, and gas stations, as well as consumer products like paint and solvents. Other relevant emissions sources regulated by SCAQMD include oil and gas storage vessels, equipment leaks at gas processing plants, and fugitive emissions at wells. SCAQMD has an Air Quality Management Plan that outlines how the agency will comply with federal and state clean air standards through adoption of rules and regulations that manage stationary emitters. The agency has permitting authority, which helps to implement and monitor its air quality rules. SCAQMD also continuously monitors air quality to track overall progress toward the agency's goals and notify the public of unhealthy conditions. Various

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[14] California Air Resources Board. Oil and Natural Gas Production, Processing, and Storage. Available: <https://ww2.arb.ca.gov/our-work/programs/oil-and-natural-gas-production-processing-and-storage/about>

[15] Stoel Rives, LLP. California Environmental Law: ARB Adopts GHG Emission Standards for Oil and Gas Facilities; Operators Wary of Costs. Available: <https://www.californiaenvironmentallawblog.com/oil-and-gas/arb-adopts-ghg-emission-standards-for-oil-and-gas-facilities-operators-wary-of-costs/>

[16] California Air Resources Board. Oil and Gas Methane Regulation, Standards and Implementation. Available: <https://ww2.arb.ca.gov/resources/fact-sheets/oil-and-gas-methane-regulation>

[17] Environmental Defense Fund. AB 32 Cap-and-Trade Rule Fact Sheet. Available: <https://www.edf.org/sites/default/files/EDF-CA-CT-Fact-Sheet-August-2011.pdf>

[18] California Air Resources Board. 100 Percent of Companies in Cap-and-Trade Program Meet 2015-2017 Compliance Requirements. Available: <https://ww2.arb.ca.gov/news/100-percent-companies-cap-and-trade-program-meet-2015-2017-compliance-requirements>

[19] California Resources Corporation. Greenhouse Gases. Available: <http://www.crc.com/sustainability/energy-conservation-efficiency/greenhouse-gases>

SCAQMD rules may apply to oil and gas operations, depending on the specific type of operation. For example, Regulation XI – Source Specific Standards includes several rules for oil and gas well operators with the purpose to reduce emissions from VOCs, toxic air contaminants (TACs), and total organic compounds (TOCs).

Division of Oil Gas and Geothermal Resources

The Division of Oil Gas and Geothermal Resources (DOGGR) oversees drilling, operation, maintenance, and plugging/decommissioning of abandoned oil, natural gas, or geothermal wells. All statutes and regulations are codified in the California Department of Conservation, Oil, Gas and Geothermal Resources document titled "Statues & Regulations – April 2019".[20] DOGGR maintains records on retired, existing, and active wells in the state. An important aspect of DOGGR's work is oversight of well abandonment to ensure that idle wells (i.e., inactive for two or more years) are properly plugged to avoid oil and gas leaks into water supplies or to the surface. DOGGR also regulates infrastructure within oil fields from the wellheads to the sales meter. This oversight includes infrastructure like storage tanks, pumps and valves, compressors, and oil and gas production pipelines.

Case Study: Synergy Oil Wetlands Restoration and Oil Consolidation Project

As part of this analysis, staff from Synergy Oil were interviewed to better understand specific reporting requirements to various agencies and to learn about their wetland restoration and operational efficiency improvement efforts. Synergy Oil has implemented a comprehensive wetlands restoration project, restoring a privately-owned oil field in Long Beach using a wetlands mitigation bank in order to reduce the overall GHG emissions impact. Synergy Oil restored a total of 150 acres of wetlands. An additional 33 acres owned by the City of Long Beach will be restored in the near future as well. Per the project's environmental impact report (EIR), all of Synergy Oil's operations will be concentrated and consolidated from the Synergy Oil Field and Long Beach-owned property to two off-site properties (i.e., Los Cerritos Wetland Authority and Pumpkin Patch Site).[21]

According to the Los Cerritos Wetlands Restoration and Oil Consolidation Draft EIR, the specific project objectives are to:

1. Restore the historic tidal connection to a greater portion of the degraded Los Cerritos Wetlands through establishing a wetlands mitigation bank that will result in restoration and creation of a self-sustaining 78-acre restored coastal wetlands habitat, including habitat for special-status plant and animal species.
2. Restore tidal salt marsh habitat and associated subtidal, intertidal, transitional, and upland habitats, taking into consideration potential sea level rise due to climate change.
3. Improve the efficiency of oil production operations through the eventual phase out of early-20th-century oil production equipment and replacement with more-efficient and modern equipment and operations that will utilize the latest technology and operational advancements related to safety, energy, and production efficiency and concentrate production on a smaller footprint.
4. Protect coastal-dependent energy development by optimizing oil and gas production from the oil reserves within the City's jurisdiction that will help fund the costs of wetlands restoration, and continue to provide a source of revenue to the City of Long Beach, as well as short-term and long-term employment opportunities.
5. Help achieve statewide goals of sustainability by reducing reliance on foreign oil and inter-state natural gas pipelines by developing locally-sourced and consumed resources using energy-efficient technology.

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[20] California Department of Conservation - Oil, Gas, & Geothermal Resources. Statutes and Regulations, April 2019. Available: <https://www.conservation.ca.gov/index/Documents/DOGGR-SR-1%20Web%20Copy.pdf>
[21] City of Long Beach Planning Department. Environmental Reports. Available: <http://www.lbds.info/planning/environmental_planning/environmental_reports.asp>

6. Reduce energy use environmental impacts, efficiently use project-sourced natural gas, and increase project reliability/safety with a microgrid that integrates multiple on-site energy sources with high-efficiency controls on energy-using equipment.[22]

Overall, the City has made a number of investments in its oil operations to reduce GHG and air pollutant emissions and address the environmental impacts of extraction activities. These investments include: reducing the City's flare hours and NOx emissions by over 60 percent through an investment in connecting its Tidelands processing plants to the THUMS power plant in 2014; investing $2 million into the power plant to reduce its NOx emissions by 50 percent in the year 2024; using electric drilling rigs on the THUMS islands; and converting idle wells into energy storage devices.

5. Near-term Recommendations – Technological Interventions to Minimize Lifecycle Emissions

This section provides short-term strategy recommendations for reducing GHG emissions through emission control technology and mitigation actions. This list includes a set of recommendations that focus primarily on minimizing process and fugitive emissions associated with upstream petroleum and natural gas production as this is the primary process in the City's control. Brief recommendations for midstream and downstream actions are summarized, as applicable.

The recommendations were developed to correspond closely to the sources of lifecycle emissions identified in the previous sections of this memo. The recommendations presented are high-level opportunities, and are not site-specific or based on an analysis of existing operations at the various oil production facilities in Long Beach. The recommendations are intended to represent opportunities to exceed the minimum compliance levels of current regulations. Several advocacy recommendations are also included for emissions sources or regulatory opportunities over which the City does not have direct control.

Upstream Emissions Reductions

1. Expand current emission control requirements to further capture greenhouse gas emissions.

The U.S. EPA has a voluntary GHG reduction program for oil and gas operations called Natural Gas STAR that provides guidance on methane control technologies.[23] Participants in the program have contributed to the development of a library of tools and technical resources that other oil and gas operators can incorporate into day-to-day operations to evaluate and implement emissions reduction actions. Based on Natural Gas STAR program recommendations, the following opportunity for emissions control technology could potentially be implemented at Long Beach oil facilities:

- **Install vapor control technology that is adequately sized for the maximum amount of vapor on tanks**. Under CARB, emission controls are only required for tanks with emissions greater than 10 metric tons of methane per year. Based on the "lessons learned" studies from the Natural Gas STAR program, vapor recovery unit systems should be sized to handle the maximum volume of vapors expected from storage tanks. As additional guidance, Noble Energy has developed a modeling guideline that can be used to determine the potential peak instantaneous vapor flow rate.[24]

2. Implement energy efficiency improvements at oil facilities to reduce the amount of energy required to produce each barrel of oil.

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[22] ESA. Los Cerritos Wetlands Oil Consolidation and Restoration Project Draft Environmental Impact Report. Executive Summary. July 2017. Available: <http://www.lbds.info/civica/filebank/blobdload.asp?BlobID=6663>
[23] U.S. EPA (2015a). EPA's Natural Gas STAR Program. Available: < https://www.epa.gov/natural-gas-star-program/natural-gas-star-program>
[24] Noble Energy, Inc. (2015, May 21). Noble Modeling Guideline, Well Site Tank System. Semi-Annual Report, Appendix B.

CARB released the *Energy Efficiency and Co-Benefits Assessment of Large Industrial Sources Refinery Sector Public Report* (Oil Refinery Sector Report) on June 6, 2013.[25] The report included an assessment of energy efficiency opportunities at California's oil refineries, including opportunities for boiler equipment. While boilers used at refineries tend to be substantially larger units than those used in oil production fields, boilers are likely a significant source of emissions at Long Beach oil facilities regulated under the Cap-and-Trade program. Therefore, boiler efficiency opportunities could reduce the upstream carbon intensity values of oil produced, while also minimizing the amount of carbon allowance purchases needed to maintain compliance with the Cap-and-Trade program. The findings in the report may be useful in lieu of an oil production sector-specific report.

3. **Require oil producers to report natural gas production volumes and final destination of gas to the City.**

The estimates of natural gas production and end of life use (e.g., combustion on-site, flaring, sales) in this analysis were developed from various sources with differing levels of quality. While lifecycle natural gas emissions only represent 4 percent of the total oil and gas emissions, the various assumptions required to develop that estimate provide room for inaccuracy. Better natural gas accounting would improve this segment of the lifecycle analysis and could help identify more impactful intervention opportunities. The City should collect information on the volumes of natural gas from Long Beach oil fields that are flared, combusted during oil production, combusted on-site for auxiliary energy use, and sold for distribution in the natural gas transmission system.

Upstream Emissions Detection

Under the CARB methane regulations, quarterly leak detection and repair (LDAR) inspections using Method 21 (M21) and daily audio visual inspections are required at upstream oil and gas facilities, including well sites and natural gas gathering plants at a threshold of 1,000 parts per million (ppm). According to the EPA's Control Techniques Guidelines for the Oil and Natural Gas Industry, M21 inspections conducted on a quarterly basis reduce fugitive emissions by an estimated 80 percent.[26] The flame ionization detector used in M21 provides a concentration of VOCs and methane at the sampling point, but does not provide a visual of the leak source. This method has been used for over 20 years in downstream oil and gas operations. For upstream oil and gas operations, technological advances have been made that can better identify leaks. The recommendations below represent an advocacy approach where the City can demonstrate support for more stringent leak detection or the required use of newer technologies. The City may also be able to directly pursue these strategies through use of its oil facility permitting authority.

4. **Advocate for development of a process to approve and incorporate alternative technologies for use in CARB compliance.**

The largest emissions are often episodic;[27] requiring continuous emission monitoring would support quicker corrective action and better emission source characterization. Recently, there have been major advancements in continuous monitoring technologies.[28] However, there is currently no path to request approval to use these technologies as an alternative inspection method from CARB or SCAQMD. The

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[25] California Air Resources Board, Stationary Source Division. Energy Efficiency and Co-benefits Assessment of Large Industrial Sources, Refinery Sector Public Report. June 6, 2013. <https://www.arb.ca.gov/cc/energyaudits/eeareports/refinery.pdf>

[26] U.S. EPA (2016). Control Techniques Guidelines for the Oil and Natural Gas Industry. Page 9-20 and 9-21. Available: <https://www.epa.gov/sites/production/files/2016-10/documents/2016-ctg-oil-and-gas.pdf>

[27] Alvarez, Ramón & Zavala-Araiza, Daniel & R. Lyon, David & T. Allen, David & R. Barkley, Zachary & Brandt, Adam & Davis, Kenneth & C. Herndon, Scott & J. Jacob, Daniel & Karion, Anna & A. Kort, Eric & Lamb, Brian & Lauvaux, Thomas & D. Maasakkers, Joannes & J. Marchese, Anthony & Omara, Mark & W. Pacala, Stephen & Peischl, Jeff & L. Robinson, Allen & Hamburg, Steven. (2018). Assessment of methane emissions from the U.S. oil and gas supply chain. Science. 361. eaar7204. 10.1126/science.aar7204.

[28] https://arpa-e.energy.gov/?q=program-projects/MONITOR

City can advocate for a process that allows companies to have new leak detection technologies approved for use in regulation compliance.

5. Advocate for CARB to implement a quarterly pneumatic LDAR protocol.

Current CARB regulations require annual measurement of low-bleed and intermittent pneumatic devices, with no specific guidance on the measurement method. A recent study on gathering station emissions found that 42 percent of measured pneumatic devices had abnormal emission patterns,[29] and abnormal emissions from intermittent controllers were found to be over five times higher than those operating normally. Under the current M21 requirement for LDAR, it is difficult to assess if a device was operating properly in a quarterly leak inspection because of the nature of a concentration-only device used during inspections. Allowing for optical gas imaging as an alternative approach for LDAR survey would support accurate identification of the leak source and a visualization of the emission pattern of the device. Implementing an LDAR protocol specific for pneumatics on a quarterly basis would further reduce lifecycle emissions. Guidance documents on including pneumatics in an LDAR protocol are expected to be available in the near future from the American Petroleum Institute (API) and the Colorado Air Pollution Division.

Midstream and Downstream Emissions Reduction

6. Increase utility sector leak detection.

Studies have found that current assumptions may be underestimating distribution and end-of-use emissions in the natural gas supply chain.[30] The EPA National Emission Inventory natural gas distribution emissions were used, in part, to derive the city's natural gas lifecycle emissions in this analysis. This approach estimated that 0.2 percent of natural gas production is lost in the lifecycle of this sector. However, regional studies have estimated that this value could be as much as 3.5 percent of production.[31] A study that analyzed downstream emissions in Boston, showed that as much as 2.7 percent of natural gas in the end user utility sector was lost due to leaks.[32,33] Although downstream and end user emissions are estimated to be a minor source of lifecycle GHG emissions in Long Beach, there is potentially an opportunity to reduce these emissions by locating end-user leaks through additional detection around meters and at pumps and compressors.

7. Dis-incentivize petcoke production and use.

Refining heavy crude oils, like those produced in Long Beach, can result in petcoke generation when a coking unit is used at the refinery. In general, extra-heavy oils generate 22 percent petcoke by volume, heavy oils generate 7 percent petcoke, and light or extra-light oils generate no petcoke.[34] Petcoke is a relatively inexpensive fuel source that can be used as a substitute for coal, but it has higher GHG emissions than coal or natural gas and can contribute to poor air quality due to its high sulfur content.

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[29] Multiday Measurements of Pneumatic Controller Emissions Reveal the Frequency of Abnormal Emissions Behavior at Natural Gas Gathering Stations Luck et al Environmental Science & Technology Letters Article ASAP DOI: 10.1021/acs.estlett.9b00158
[30] Alvarez, Ramón & Zavala-Araiza, Daniel & R. Lyon, David & T. Allen, David & R. Barkley, Zachary & Brandt, Adam & Davis, Kenneth & C. Herndon, Scott & J. Jacob, Daniel & Karion, Anna & A. Kort, Eric & Lamb, Brian & Lauvaux, Thomas & D. Maasakkers, Joannes & J. Marchese, Anthony & Omara, Mark & W. Pacala, Stephen & Peischl, Jeff & L. Robinson, Allen & Hamburg, Steven. (2018). *Assessment of Methane Emissions from the U.S. Oil and Gas Supply Chain*. Science. 361. eaar7204. 10.1126/science.aar7204.
[31] Brandt, Adam & Heath, Garvin & A Kort, E & O'Sullivan, F & Petron, Gabrielle & Jordaan, Sarah & Tans, P & Wilcox, Jennifer & M Gopstein, A & Arent, Doug & Wofsy, Steven & J Brown, N & Bradley, R & D Stucky, G & Eardley, D & Harriss, Robert. (2014). *Methane Leaks from North American Natural Gas Systems*. Science (New York, N.Y.). 343. 733-5. 10.1126/science.1247045.
[32] ibid
[33] Kathryn McKain, Adrian Down, Steve M. Raciti, John Budney, Lucy R. Hutyra, Cody Floerchinger, Scott C. Herndon, Thomas Nehrkorn, Mark S. Zahniser, Robert B. Jackson, Nathan Phillips, Steven C. Wofsy. *Methane Emissions from Natural Gas Infrastructure and Use in the Urban Region of Boston, Massachusetts.* Proceedings of the National Academy of Sciences Feb 2015, 112 (7) 1941-1946; DOI: 10.1073/pnas.1416261112
[34] Tao, Wang. *Managing China's Petcoke Problem*. Carnegie-Tsinghua Center for Global Policy. May 2015. Available: <https://carnegieendowment.org/files/petcoke.pdf>

Petcoke can also be used in certain industrial processes, such as cement production and manufacturing aluminum or other metals. As refineries in the U.S. continue to process heavy oils from Canada, Venezuela, and elsewhere, stockpiles of petcoke have grown substantially. According to a Carnegie-Tsinghua Center for Global Policy report, "faced with a substance that is produced in large volumes and costly to store, U.S. oil firms have become eager to sell petcoke to energy-hungry developing countries…"[35] As with many other recommendations in this memo, direct control of the petcoke challenge is outside the City's control (with the exception of implementing a moratorium on oil extraction). The City could potentially advocate for long-term storage solutions for petcoke produced at U.S. refineries to dis-incentivize exports of the material. It could also advocate for investments in or greater regulation of U.S. refineries that process heavy crude oils to require installation of systems that support residue fuel hydrogenation to reduce the amount of petcoke produced.

6. Long-term Recommendations – Transition from Oil and Gas Activity

This section provides high-level, longer-term strategy recommendations to reduce lifecycle emissions from oil and gas production in Long Beach. It is important to note that based on the definition of lifecycle emissions used in this analysis, which includes emissions from extraction, refining and processing, and final consumption by end users, there are very few actions that could reduce these emissions entirely. Most of these actions would only result in reducing upstream and midstream emissions and shifting where the downstream emissions occur.

Upstream extraction emissions can be reduced through efficiency improvements that reduce the amount of energy required to produce each barrel of oil and through minimization of methane leaks, as described in Section 5. Similarly, midstream refining and processing emissions can be reduced through efficiency improvements as well. However, more than 75 percent of the City's oil and gas lifecycle emissions are assumed to occur downstream where efficiency improvements do not help to avoid these emissions. For example, national vehicle efficiency requirements could significantly improve car fuel economy. The result would be that oil produced in Long Beach and refined into vehicle gasoline would be consumed with greater efficiency by vehicles, but would ultimately be combusted for power at which point the downstream emissions would still occur. Even if the City prohibited use of fossil fuels within its boundary, the oil and gas produced at City wells would be sold on the global energy market and consumed somewhere else to produce the downstream emissions component of the lifecycle emissions.

The City's long-term approach to manage oil and gas lifecycle emissions should be multi-pronged to include the:

1. gradual phase-out of fossil fuel consumption in the city,
2. advocacy and support for other jurisdictions to take the same bold action (domestically and abroad) resulting in decreased global demand for oil and gas produced in Long Beach,
3. gradual reduction in local oil and gas production, and
4. investment in carbon capture technology to offset lifecycle emissions from remaining local oil extraction activity.

Decrease Local Oil and Gas Consumption

The following recommendations primarily reduce the emissions accounted in the city's production-based inventory. If local oil and gas consumption is reduced, the energy resources produced in Long Beach would likely still be exported for use elsewhere, at which point the downstream emissions would occur.

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[35] ibid

1. Increase renewable natural gas supply with an organic waste-to-anaerobic digestion program. (Draft CAAP action)

As previously described, it is assumed that 100 percent of the natural gas produced in Long Beach is consumed in the city and natural gas imports are used to meet the remaining local demand. If the City's Energy Resources Department can procure renewable natural gas (RNG) for local use, this would help to further reduce the City's energy sector emissions in the production-based inventory. The draft CAAP includes actions to develop a robust organic waste collection program and identify opportunities for beneficial reuse of the waste stream, including anaerobic digestion at a regional facility that could potentially produce RNG. This action would help to decrease landfill emissions that occur from the anaerobic decomposition of organic waste materials and could also reduce building energy natural gas emissions.

2. Electrify public and passenger vehicle transportation. (Draft CAAP action)

Electric vehicles (EVs) have become more popular in recent years, in public transit fleets and for private passenger vehicles. The City can facilitate an increase in local use of EVs to reduce its reliance on vehicle fossil fuels. The draft CAAP includes actions to expand EV charging infrastructure communitywide in new construction and retrofits to existing buildings and properties, and to promote available financial incentives or rebate programs for EVs and associated charging equipment. The draft CAAP also includes a set of actions designed to increase non-vehicular trips in the community from walking, biking, or shared mobility options (e.g., electric scooters), and to minimize single occupancy trips through a transportation demand management program. These actions would also serve to reduce the community's vehicle fuel consumption.

3. Reduce building energy use through energy efficiency upgrades and electrification of end-use appliances. (Draft CAAP action)

Natural gas is consumed in homes and businesses in Long Beach for space and water heating, cooking, and producing on-site energy. Building energy efficiency improvements, like commercial retro-commissioning or hot water heater insulation, can reduce the amount of natural gas consumed in the community's buildings and facilities, which will reduce energy sector emissions in the production-based inventory. The draft CAAP includes several actions to increase building energy efficiency through a home energy audit program, improved access to technical assistance and financial resources or other incentives, and a public building energy audit and improvement program. Incentivizing building energy fuel switch opportunities, like converting from a gas boiler to an air source heat pump, will also support long-term GHG reduction goals in the community and is further enhanced as the share of renewables in the electricity grid increases.

4. Advocate for regional, state, and national oil and gas consumption reductions.

The above actions indicate what the City can do locally to reduce emissions from oil and gas consumption. However, if the energy resources produced locally are not consumed locally, they will find new users through the global energy market. Further, it is possible that all or most of the oil produced in Long Beach is consumed outside the city boundary, where the City has no jurisdictional control over the final end users. Long Beach can join other interested cities and organizations to advocate at the state and national level for action that results in further reductions in fossil fuel use. For example, more stringent vehicle fuel economy standards, improved regional and national public transit networks, enhanced EV incentive programs, stricter building energy codes, and improved access to financial resources for energy efficiency improvements. These actions would enable the City to indirectly support fossil fuel reductions on a larger scale through expanded implementation in other communities.

Decrease Local Oil and Gas Extraction

5. Phase-out local oil and gas extraction.

One of the most direct ways to reduce the city's oil and gas lifecycle emissions is to halt or severely curtail local fossil fuel extraction in the first place. Oil extracted in Long Beach oil fields has relatively higher carbon intensity per barrel than other global oils based on the oils surveyed in the OCI (i.e., 14th most carbon intensive overall). As noted elsewhere, this is due in part to the production of petcoke as a byproduct of the oil refining process, which contributes to downstream emissions when combusted to generate energy. Lower carbon-intensive oil sources are available to replace the supply produced in Long Beach, which would result in lower global oil emissions in general. For example, if Long Beach were to cease oil extraction operations altogether, it would be less carbon intensive to import oil from lower intensity areas like the Texas Ford Eagle field.

This strategy should be combined with actions to reduce fossil fuel use locally (see long-term recommendations 1-3 above), and advocacy efforts to reduce fossil fuel demand outside of Long Beach as well (see long-term recommendation 4 above). This recommendation is based solely on the relative emissions intensity of global oil sources, and does not consider the revenues generated to the City and other benefits of local oil production. Further, this recommendation does not consider local public health impacts or other potentially important factors like domestic energy security, wealth transfers to oil producing countries with poor human rights records, or other socio-political factors.

Support Carbon Capture Technology

6. Invest in direct air capture technology or other leading-edge technologies to reduce the global emissions impact from continued fossil fuel combustion.

The City may determine that economic, social, and environmental factors make local oil and gas extraction a preferable strategy over the long-term. Carbon capture technologies are being developed and implemented today, and the market for similar interventions will likely mature over time to become an important pathway to achieving the climate goals outlined in the 2016 Paris Agreement. Systems like direct air capture plants are envisioned as location-independent strategies that can be deployed to remove carbon from the atmosphere at an industrial scale. The goal is that these plants could also produce ultra-low carbon intensity transportation fuels from the captured CO_2. The plants could also be located at oil fields for use in enhanced oil recovery, which uses CO_2 to extract additional oil, and can then permanently store the CO_2 within the oil field reservoir. In the future, the City could dedicate a portion of its oil and gas revenue to help fund development of carbon capture facilities or to implement other carbon capture technology.

Increase Access to Information

7. Require oil field operators to report oil assays to CARB.

The City could advocate for CARB to require oil assays from operators within the state, and make the information publicly available to provide better understanding of the relative midstream and downstream emissions from California's oil fields. Per the Carnegie Endowment for International Peace, "California's oil ranks among some of the highest- and lowest-emitting worldwide."[36] Without accurate information on each oil field's oil composition, it is difficult to accurately estimate midstream refining emissions; "…this

[36] Gordon, Deborah and Samuel Wojcicki. Need to Know: The Case for Oil Transparency in California. Carnegie Endowment for International Peace. March 15, 2017. Available: <https://carnegieendowment.org/2017/03/15/need-to-know-case-for-oil-transparency-in-california-pub-68166>

likely introduces error to estimated refining emissions on the order of plus or minus 50 percent."[37] Alternatively, the City could consider requiring assays as a permitting requirement for new and/or continued oil field operation. This oil field-specific information would help to better inform the City's opportunities to reduce its oil lifecycle emissions.

8. Consider including oil and gas lifecycle emissions in future Long Beach GHG target-setting and analysis.

To further support a more holistic understanding of the community's GHG emissions sources and reduction opportunities, the City can incorporate this type of oil and gas lifecycle emissions analysis in future CAAP updates. At that time, additional Long Beach-specific information may be available to further refine the initial analysis provided in this memo, including midstream and downstream emissions factors specific to the Long Beach oil field, verified natural gas production volumes, and greater detail on the final destination of oil and gas extracted in the city.

[37] ibid

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ATTACHMENT C: This is the 2030 GHG Reduction Pathway, excerpted from the larger Appendix A which can be found in plan appendices (Attachment B).

PART II – 2030 REDUCTION TARGET PATHWAY

The CAAP evaluated a 2030 GHG target that was established to demonstrate consistency with the state's adopted 2030 GHG target (i.e., 40% below 1990 levels by 2030), and CAAP actions were defined to demonstrate a feasibly reduction pathway toward target achievement. While the CAAP does also include a 2045 carbon neutrality goal and high-level estimates of the City's potential progress toward that the goal, this appendix focuses on describing the assumptions and calculation methodology used to demonstrate 2030 target achievement in the CAAP.

Table 18 summarizes the GHG reductions by action that provide the City's pathway to 2030 target achievement. The remainder of this section provides quantification details for each action listed below to document assumptions related to action implementation and sources of information to support future CAAP monitoring and updates. GHG reductions have been rounded to the nearest tens value and the green highlighted values within each action section correspond to the GHG reductions shown in the table below. The CAAP reflects the sector-level reductions total shown here.

Table 18 – Quantified CAAP Actions

CAAP Action	2030 GHG Reductions (MT CO_2e/yr)
BUILDING + ENERGY ACTIONS	**247,700**
BE-1 Provide access to renewably generated electricity	188,960
BE-2 Increase use of solar power	3,880
BE-6 Perform municipal energy and water audits	13,120
BE-8 Implement short-term measures to reduce emissions related to oil and gas extraction	41,740
TRANSPORTATION ACTIONS	**30,480**
T-1 Increase the frequency, speed, connectivity and safety of transit options	5,230
T-4 Implement the Port of Long Beach Clean Trucks Program	25,250
WASTE ACTIONS	**116,680**
W-1 Ensure compliance with state law requirements for multifamily and commercial property recycling programs	45,340
W-3 Partner with private waste haulers to expand organic waste collection community-wide	39,730
W-4 Identify organic waste management options	31,610
TOTAL CAAP REDUCTIONS	**394,860**

Some action quantification methodologies refer to the demographic forecasts used to estimate the city's BAU emissions scenario. The relevant demographic information is documented in Table 19.

Table 19 – City of Long Beach Demographic Forecasts

	2012	2015	2016	2020	2030	2035
Population	466,255	468,911	469,796	478,346	480,424	481,463
Employment	153,154	155,402	156,900[1]	165,800	172,297	175,546
Service Population	619,409	624,312	626,696	644,146	652,721	657,009

Notes:
Service population = population + employment
Values for 2012, 2016, 2020, and 2035 provided to AECOM by City of Long Beach, Table LU-8: Population, Household and Employment Growth
Values for 2015 and 2030 interpolated
[1] Employment data is for 2017

Clean Electricity Grid Options

The general quantification approach used to evaluate emissions reductions from actions that would reduce electricity use or offset it with carbon-free energy sources is presented in the section below.

Overarching Methodology

The CAAP evaluated the GHG reduction potential that would result from implementation of SCE's commitment to provide 80% carbon-free energy by 2030, as well as the additional net emissions reductions that would occur from voluntary participation in SCE's Green Rate program.

Potential emissions reductions were estimated according to the following equation:

Emissions Reduction = (Business-as-Usual Emissions) – (Mitigated Scenario Emissions)

The primary inputs supporting calculations for the above equation include activity data (e.g., MWh of electricity use) and emissions factors (e.g., MT CO_2e/MWh). Each component of the equation is described below.

Business-as-Usual (BAU) Emissions Scenario

Activity Data

BAU emissions were calculated based on the 2030 electricity activity data forecasts that underpin the CAAP's GHG emissions forecasts. These were developed for three subsectors: residential, commercial, and industrial electricity accounts. 2030 forecasts were calculated using growth indicators to estimate how the 2015 base year inventory might change by the CAAP's 2030 target year. Residential activity data was projected using city population forecasts and the commercial and industrial activity data was projected using city employment forecasts. Population and employment forecast information was collected form the SCAG 2016 Regional Transportation Plan/Sustainable Community Strategy and provided to AECOM by the City of Long Beach in August 2018 (see Table 19). CAAP action BE-6 separately estimates the GHG reduction potential from a City commitment to purchase renewable electricity for all municipal accounts by 2030. The community inventory did not separately evaluate municipal GHG emissions, however the City did prepare a 2015 municipal operations inventory from which municipal electricity activity data was collected for purposes of evaluating GHG reduction potential. This activity data was subtracted from the communitywide electricity data for commercial accounts provided by SCE in order to avoid double counting emissions reduction potential. Table 20 presents the city's 2015 and 2030 electricity activity data.

Table 20 – Electricity Activity Data

Energy Sub-sector	2015 (MWh)	2030 (MWh)
Residential	813,346	833,316
Commercial	678,407	872,200
Municipal	108,264	108,264
Industrial	1,409,718	1,562,987

Note: Values are rounded; for purposes of community emissions planning, no activity data growth was assumed for municipal electricity accounts from 2015-2030.

Emissions Factor

In the CAAP forecasts, BAU emissions were calculated using an estimated SCE 2030 electricity emissions factor that assumes compliance with the state's Renewables Portfolio Standard (RPS). The RPS requires SCE to procure 60% RPS-eligible sources by 2030. In the CAAP 2015 base year, SCE's electricity came from the energy source mix shown in Table 21. The project team estimated a 2030 mix that assumes compliance with the RPS requirements (i.e., 60% eligible renewable sources), with the remainder of energy provided by unspecified sources of power. This scenario represents a conservative estimate based on the 2015 energy mix by allocating the full 40% of non-RPS energy to the potentially highest emissions option in use in the 2015 base year. It is a conservative approach in that it results in an estimated emissions factor that is greater (i.e., more carbon intensive) than other scenarios could provide. For example, if SCE maintains its large hydroelectric and nuclear power sources through 2030 and provides 60% RPS-eligible energy sources, then only 32% of energy would need to come from unspecified sources.

Table 21 – SCE Electricity Mix

Energy Source	2015 SCE Power Mix (Actual)[1]	2030 SCE Power Mix (Estimated)[2]
Eligible Renewable	25%	60%
Coal	-	-
Large Hydroelectric	2%	-
Natural Gas	26%	-
Nuclear	6%	-
Other	-	-
Unspecified Sources of Power	41%	40%
Total	**100%**	**100%**

Source:
[1] California Energy Commission. 2015 SCE Power Content Label.
[2] Estimated by AECOM.

At the time of emissions forecast analysis, an unspecified energy source emissions factor of 0.428 MT CO_2e/MWh was collected from the California Air Resources Board[42] to evaluate the estimated 2030 SCE emissions factor. When applied to the estimated energy mix shown above, the resulting weighted emissions factor for SCE's estimated 2030 electricity portfolio is 0.1712 MT CO_2e/MWh, as shown in Table 22.

[42] CARB Unofficial Electronic Version of the Regulation for the Mandatory Reporting of Greenhouse Gas Emissions. Available online: https://ww3.arb.ca.gov/cc/reporting/ghg-rep/regulation/mrr-2018-unofficial-2019-4-3.pdf?_ga=2.85289563.330032031.1594773045-55257910.1560365597

Table 22 – 2030 Estimated Electricity Emissions Factor

Energy Sources	2030 Energy Mix	Emissions Factor ($MT\ CO_2e/MWh$)	$MT\ CO_2e/MWh$
Eligible Renewable	60%	0	0
Unspecified Sources of Power	40%	0.428	0.1712
Total	**100%**	**-**	**0.1712**

The estimated 2030 emissions factor was combined with the estimated 2030 activity data to calculate the BAU electricity emissions scenario (see Table 23).

Table 23 – 2030 BAU Electricity Emissions Scenario

Energy Sub-sector	2030 (MWh)	2030 Emissions Factor ($MT\ CO_2e/MWh$)	2030 BAU Emissions ($MT\ CO_2e$)
Residential	833,316	0.1712	142,664
Commercial	763,936	0.1712	130,786
Municipal	108,264	0.1712	18,535
Industrial	1,562,987	0.1712	267,583
Subtotal	**3,268,504**		**559,568**

MITIGATED EMISSIONS SCENARIO

The mitigated scenario was developed with participation estimates and/or goals for the different electricity focused CAAP actions to calculate what amount of future electricity demand would be achieved in a manner that differs from the BAU scenario. The calculations and assumptions are presented below.

BE-1 PROVIDE ACCESS TO RENEWABLY GENERATED ELECTRICITY

SCE-Provided 2030 Electricity Emissions Factor

In September 2020, SCE provided City staff with its estimated 2030 electricity emissions factor that aligns with the utility company's long-term carbon free energy source commitments. The 2030 factor provided by SCE has a lower emissions intensity (i.e., $MT\ CO_2e/MWh$) than the 2030 emissions factor used in the BAU emissions forecast analysis presented in the previous section. The result is that if SCE does achieve its proposed 2030 electricity factor, the City will experience even greater electricity emissions reductions than currently estimated in the BAU scenario. The net additional reductions from use of this new 2030 emissions factor were calculated based on the difference between the 2030 BAU forecast scenario and one in which SCE does achieve its proposed 2030 emissions factor.

PARTICIPATION ASSUMPTIONS

Because this scenario was analyzed as an alternative to the current BAU emissions forecast scenario, this action was quantified to assume that all Long Beach SCE customers would receive electricity with the provided 2030 emissions factor, unless they participate in the SCE Green Rate program or a solar PV installation program. Therefore, participation in this action is assumed to be 100%.

Emissions Factors

SCE provided City staff with a proposed replacement 2030 electricity emissions factor of 0.1192 MT CO_2e/MWh, which is referenced throughout the remainder of this section.

SCE Green Rate Program

For purposes of the CAAP analysis, a scenario was evaluated in which the City of Long Beach encourages voluntary participation in the existing SCE 100% Green Rate program through which residential and commercial electricity customers fund solar energy development with 100% of their energy use. Participation in this program would provide a net GHG reduction beyond implementation of SCE's 80% carbon-free commitment described above.

Participation Assumptions

A review of the Sacramento Municipal Utility District's (SMUD) 2017 Annual Report[43] shows that 74,000 customers participated in the Greenergy program that provides 100% renewable electricity (comparable to SCE's 100% Green Rate program). The report notes that SMUD had 628,952 customer contracts in 2017 and 1,500,000 total customers. The report is unclear if the Greenergy participation reference to 74,000 customers uses that term in the same way as the total customer metric is reported, or if it more closely reflects the number of customer accounts. The different interpretations result in a Greenergy participation rate in 2017 that ranges from 4.9% to 11.8%.

For purposes of the CAAP, voluntary participation in the SCE Green Rate program was assumed to reach 10% by 2030 for residential and commercial customers (industrial customers were not included in this assumption). This could either be viewed as an approximate doubling of participation in SMUD's comparable program from 2017 (which would provide a decade of CAAP implementation to achieve that participation rate) or achieving slightly less participation than SMUD experienced in its comparable program in 2017.

Based on the stated participation assumptions above, Table 24 shows the resulting 2030 electricity demand by sub-sector and SCE rate program option.

Table 24 – Energy Demand Estimate by SCE Rate Option

Energy Sub-sector	2030 (MWh)	SCE Green Rate Participation	SCE Green Rate Energy Demand (MWh)	SCE Non-Green Rate Energy Demand (MWh)
Residential	833,316	10%	83,332	749,985
Commercial	763,936	10%	76,394	687,543
Municipal	108,264	0%	-	108,264
Industrial	1,562,987	0%	-	1,562,987

Emissions Factors

As described above, the assumption is that participation would be in the 100% Green Rate program, which has an emissions factor of 0.0 MT CO_2e/MWh. The portion of electricity demand that is not covered by the 100% Green Rate program (as shown in Table 24) would be provided by SCE at its committed 2030 electricity rate of 0.1192 MT CO_2e/MWh.

[43] SMUD, *2017 SMUD Annual Report*. Available online: https://www.smud.org/-/media/About-Us/Reports-and-Statements/2017-Annual-Report/2017-Annual-Report.ashx

Mitigated Scenario Emissions

The combination of activity data shown in Table 24 with the emissions factors described above result in the mitigated scenario emissions shown in Table 25.

Table 25 – Mitigated Scenario Electricity Emissions

Energy Sub-sector	SCE Green Rate Energy Demand (MWh)	SCE 100% Green Rate Emissions Factor (MT CO_2e/yr)	SCE Non-Green Rate Energy Demand (MWh)	SCE Non-Green Rate Emissions Factor (MT CO_2e/yr)	Total Emissions (MT CO_2e/yr)
Residential	83,332	0.0	749,985	0.1192	89,408
Commercial	76,394	0.0	687,543	0.1192	81,964
Municipal	-	0.0	108,264	0.1192	12,906
Industrial	-	0.0	1,562,987	0.1192	186,328
Subtotal	**159,725**	**-**	**3,108,779**	**-**	**370,605**

The estimated reduction resulting from implementation of this action is calculated based on the difference between the BAU and mitigated scenarios and total approximately 188,960 MT CO_2e/yr (see Table 26).

Table 26 – Emissions Reduction

Energy Sub-sector	BAU Scenario Emissions (MT CO_2e/yr)	Mitigated Scenario Emissions (MT CO_2e/yr)	Emissions Reductions (MT CO_2e/yr)
Residential	142,664	89,408	53,256
Commercial	130,786	81,964	48,822
Municipal	18,535	12,906	5,628
Industrial	267,583	186,328	81,256
Total	**559,568**	**370,605**	**188,960**

Note: Total reduction value has been rounded for use in the CAAP.

BE-2 Increase Use of Solar Power

Participation Assumptions

Based on a review of Google's Project Sunroof dashboard, the City of Long Beach currently has 1,469 roofs with solar PV installations and a maximum coverage potential of 91,992 roofs (see Table 27). Therefore, approximately 2% of candidate roofs currently have solar. Project Sunroof also estimates that the average system size in Long Beach is 6.8 kW DC with 476 square feet of coverage, producing 10,400 kWh AC per year.

Table 27 – Long Beach Solar PV Data

	Value	Unit
Maximum Coverage Potential	91,992	Roofs
Existing Coverage	1,469	Roofs
% Current Coverage	2%	% of candidate roofs
Per Roof Estimates	6.8	kW DC
Average System Size	476	sq ft
Average Electricity Generation	10,400	kWh AC per year

Source: Google Project Sunroof for City of Long Beach, accessed February 2020

This action assumes that 5% of Long Beach's candidate roofs will have solar installations by 2030; or approximately double the current coverage. This means that more than 3,100 new solar systems would be installed, generating approximately 32,500 MWh of carbon-free electricity (see Table 28). To avoid double counting emissions reductions, this value of carbon-free electricity can be compared to the amount of electricity demand estimated in 2030 that will not be provided through the SCE Green Rate program (see Table 25). The net additional carbon-free energy provided through action BE-2 is approximately 1% of that total remaining energy demand.

Table 28 – Solar Action Implementation Assumptions

	Value	Unit
Roof Coverage by 2030	5%	%
New Installations	3,131	New Roofs
Generation per roof	10,400	kWh AC per year
Total Generation per year	32,562,400	kWh AC per year
Total Generation per year	32,562.40	MWh
BAU Scenario Electricity EF	0.1192[1]	MT CO_2e/MWh
Mitigated Electricity EF	0	MT CO_2e/MWh

[1] This emissions factor corresponds to the SCE 2030 commitment to provide 80% carbon-free electricity; see Action BE-1 description for further information.

EMISSIONS FACTORS

The electricity generated from solar PV systems is a carbon-free energy source for community CAAP planning purposes. The energy provided by these systems would offset purchases of SCE electricity. As shown above, Action BE-1 already estimates the GHG reductions associated with implementation of SCE's 80% carbon-free commitment by 2030. Therefore, this action is calculated to show the net marginal GHG reductions that result from avoiding using of SCE's 2030 electricity.

MITIGATED SCENARIO EMISSIONS

This action would provide net GHG reductions totaling 3,880 MT CO_2e/yr, as shown in Table 29.

Table 29 – Emissions Reduction

Action Electricity Generation (MWh)	BAU Scenario Emissions (MT CO_2e/yr)	Mitigated Scenario Emissions (MT CO_2e/yr)	Emissions Reductions (MT CO_2e/yr)
32,562	3,880	-	**3,880**

BE-6 Perform municipal energy and water audits

PARTICIPATION ASSUMPTIONS

Energy Efficiency
The City regularly takes action to implement energy efficiency improvements as part of standard business operations. The Public Works Department provided information on the primary electricity savings from efficiency improvement programs implemented since 2015, which were quantified for inclusion in the CAAP GHG reduction estimates:

- Street and park light retrofits – 1,538,927 kWh/yr
- Houghton Community Center window upgrades – 295 kWh/yr

The Public Works Department also committed to a reduction in natural gas use within City buildings and facilities of 5% below 2015 base year levels by 2030.

Renewable Energy Development
Public Works staff also provided information on the City's solar PV development programs, including use of power purchase agreements to implement additional solar installations. Table 30 shows the solar installation capacities evaluated in this CAAP action; this table also includes a 1 MW commercial solar program planned for installation by the Energy Department at Pier A West.

Table 30 – Municipal Solar Development Projects

Solar Location	kW Size
ECOC	238.5
Main Health Dept. Building	656
Public Works Yard	668
East Division Police Sub-Station	176
LBGO Headquarters	851
Airport Parking Garage (Lot B)	736
City Place Lot A	216
City Place Lot B	280
City Place Lot C	150
Pike Parking Structure	539
Aquarium Parking Structure	524
Convention Center	2,800
Pier A West	1,000
Total	**8,834.5**

The project team used the PV Watts calculator estimate the approximate electricity generation potential of the City's solar projects shown above. The calculation was performed using the default assumptions within the calculator based on the Long Beach Airport Garage location. Based on these assumptions, the City's 8,834.5 MW of solar development could generate 14,50,584 kWh/yr.

In addition to the solar development projects listed above, the Public Works Department is implementing two battery storage projects totaling 1,685 MWh of storage, and the Energy Department is evaluating and piloting gravity well potential energy storage systems at wellbore sites within the City's oil fields. Neither of these additional actions were included within this action evaluation but could demonstrate additional GHG reduction potential in future CAAP updates.

100% Carbon-Free Electricity

In CAAP action BE-1, the City has committed to purchasing 100% renewable electricity for all municipal accounts by 2030. The GHG quantification shown here assumes that all remaining municipal electricity demand following energy efficiency programs and solar development projects will be offset through participation in the SCE Green Rate program. Note that the action BE-1 quantification inputs above do not include municipal participation in the Green Rate program. GHG reductions related to 100% renewable municipal electricity are included here to illustrate all municipal energy reductions together.

Table 31 summarizes the BAU and mitigated scenario inputs for this action. The municipal energy demand is based on the City's 2015 municipal operations GHG inventory and assumes for CAAP action planning purposes that municipal energy demand does not increase in the future; municipal emissions are represented in inventory sector I.2, as described in Part I of this appendix, and therefore their potential emissions growth was included within the commercial sector energy growth forecasts.

Table 31 – BAU and Mitigated Scenario Inputs

BAU Scenario Energy Demand					
	Value	**Units**	**Emissions Factor**	**Unit**	**MT CO_2e**
Electricity	108,264	MWh	0.1192	MT CO_2e/MWh	12,906
Natural Gas	787,878	therms	0.00532	MT CO_2e/therm	4,190
Subtotal	-	-	-	-	17,097
Mitigated Scenario - Energy Savings					
	Value	**Units**	**Emissions Factor**		**MT CO_2e**
			BAU	**Mitigated**	
Solar Development	14,508	MWh/yr	0.1192	-	1,729
Energy Efficiency - electricity	1,539	MWh/yr	0.1192	-	183
Energy Efficiency - natural gas	39,394	therms	0.0053	-	210
Renewable Electricity Purchase	92,217	MWh/yr	0.1192	-	10,993
Subtotal					**13,116**

Emissions Factors

To avoid double counting with GHG reductions estimated in action BE-1, the electricity savings and solar development potential were multiplied by the SCE 2030 emissions factor that corresponds to its 80% carbon-free energy commitment. The natural gas emissions factor was derived from the 2015 municipal operations GHG inventory, dividing natural gas emissions by reported therms consumption.

Mitigated Scenario Emissions

Table 32 shows the mitigated scenario emissions and allocates the GHG reductions to energy efficiency, solar energy development, and carbon-free electricity purchases.

Table 32 – Mitigated Scenario Emissions by Source

Reductions Source	MT CO_2e
Energy Efficiency	393
Solar PV Development	1,729
Carbon-free Electricity Purchase	10,993
Subtotal	**13,116**

BE-8 Implement short-term measures to reduce emissions related to oil and gas extraction

Participation Assumptions

The Long Beach Energy Department committed to decrease oil production 20% below 2018 production volumes by 2030. In 2018, 11,158,706 barrels of oil (bbl) were produced in the city. This commitment would result in a 2030 production volume of 8,926,965 bbl. The CAAP emissions forecasts had assumed that 2018 production levels would remain constant based on year-over-year production declines. This was a conservative approach in that production has already been decreasing, but the forecasts did not assume continued declines beyond the last year for which empirical data was available at the time of analysis (i.e., 2018).

Emissions Factors

To estimate GHG reductions associated with decreased oil production, the project team calculated a per barrel emissions factor based on the 2015 GHG inventory oil industry emissions divided by the 2015 production volume. The emissions sub-sectors included in this analysis include I.4.1 and I.8.1 (see Part I of this appendix for further information).

Mitigated Scenario Emissions

Table 33 shows the inputs used to quantify this action.

Table 33 – Oil and Gas Emissions per Barrell

	Value	Unit
2015 Oil Production	13,321,018	bbl
2015 Oil-related Emissions	249,139	MT CO_2e/yr
2015 Emissions per Barrel	0.019	MT CO_2e/bbl
2030 Oil Production – BAU	11,158,706	bbl
2030 Oil Production – Mitigated	8,926,965	bbl
2030 Oil Production Reduction	2,231,741	bbl
2030 GHG Reductions	**41,740**	**MT CO_2e/yr**

T-1 Increase the frequency, speed, connectivity and safety of transit options

Participation Assumptions

This action assumes that implementation of transit system and ridership improvements will result in a 1% VMT reduction below 2030 BAU levels for light duty vehicles (gas and diesel).

EMISSIONS FACTORS

Reductions from this action were calculated using the same methodology used to estimate GHG emissions for sub-sector II.1 On-Road Transportation. The project team re-ran the emissions forecast calculations based on VMT values that included a 1% reduction in gas and diesel VMT for light duty vehicles. Refer to Part I of this appendix for further detail on the on-road emissions quantification methodology.

MITIGATED SCENARIO EMISSIONS

As with the electricity actions described above, GHG reductions from this action were calculated as:

Emissions Reduction = (Business-as-Usual Emissions) – (Mitigated Scenario Emissions)

See Table 34 for outputs from this on-road emissions model analysis. This action is estimated to result in reductions of approximately 5,230 MT CO_2e/yr.

Table 34 – Action Quantification Inputs

	Value	Unit
VMT Reduction – LDV – gas and diesel	1	1%
2030 BAU – LDV Gasoline	2,390,410,729	VMT/yr
2030 BAU – LDV Diesel	25,468,434	VMT/yr
2030 BAU – LDV Gasoline and Diesel	522,835	MT CO_2e/yr
2030 Mitigated – LDV Gasoline	2,366,506,622	VMT/yr
2030 Mitigated – LDV Diesel	25,213,750	VMT/yr
2030 Mitigated – LDV Gasoline and Diesel	517,607	MT CO_2e/yr
Reduction	**5,228**	**MT CO_2e/yr**

T-4 Implement the Port of Long Beach Clean Trucks Program

PARTICIPATION ASSUMPTIONS

This action is based on implementation results for the Port of Long Beach Clean Trucks Program. The Clean Air Action Plan estimates GHG reductions from this action could range from 10-46% in 2031. The project team conservatively estimated the low-end of this range for use in quantifying GHG reductions.

The 2015 CAAP inventory did not have granular enough information from the on-road travel model to isolate VMT associated with Port truck activity. The project team used the diesel heavy-duty vehicle (HDV) on-road category as a proxy for Port trucking activity. The ratio of HDV VMT from the Port's 2015 Air Emissions Inventory was compared to the CAAP on-road VMT data to help scale the emissions reduction estimates. As shown in Table 35, the comparison of HDV VMT in these two inventories shows the Port value is approximately 8.2% lower than that assumed based on the community-wide on-road inventory. Since this action is quantified as a reduction in future GHG emissions, the community-wide diesel HDV emission were extracted from the on-road emissions inventory and normalized by multiplying by -8.2%. A 10% reduction in the 2030 diesel HDV emissions was then calculated to estimate the reduction potential of this action.

EMISSIONS FACTORS
The calculations were based on the emissions from the CAAP GHG inventory and forecasts. See Part I of this appendix for further information on how on-road emissions were calculated.

Table 35 – Action Quantification Inputs

	VMT	MT CO_2e/yr	
		2015	2030
Port Inventory - Diesel HDV on-road emissions	151,857,117	256,283	-
Community Inventory - Diesel HDV on-road emissions	164,234,998	230,181	274,876
Ratio (Port/Community Inventory)	-8.2%	-	-8.2%
Scaled Diesel Emissions (Estimate of Port's diesel HDV emissions in community inventory)	-	-	252,471
Clean Trucks Program – GHG Reduction Potential	-	-	10%
GHG Reductions	-	-	**25,250**

ADDITIONAL PORT EMISSIONS CONSIDERATIONS
In addition to the Clean Trucks Program quantified above, the Port of Long Beach has committed to achieve 100% emissions-free cargo handling equipment (CHE) by the year 2030. The city's 2015 GHG inventory estimated off-road vehicle and equipment emissions based on ARB's OFFROAD model (the most up to date program at the time), which did not include emissions associated with CHE. ARB's current offroad emissions model, Orion, does include CHE emissions, so future GHG inventories can accurately reflect this emissions source. The Port's 2015 Air Emissions Inventory estimated that CHE emissions totaled nearly 127,000 MT CO_2e/yr. The Port's ongoing GHG reduction actions will serve to fully reduce this emissions source by the 2030 CAAP target year.

The Port will also implement ARB's Ocean-Going Vessels At-Berth Regulation that will result in reduced fuel use by certain vessel types when at-berth in the Port of Long Beach. ARB has estimated that implementation of this regulation will result in emissions reduction totaling approximately 100,500 MT CO_2e/yr at the Port of Long Beach

Neither of these GHG reduction values is included in the CAAP's target achievement pathway because they both represent emissions sources that are not included in the city's jurisdictional production inventory. However, both actions demonstrate the ongoing commitment of the Port of Long Beach to identify and implement programs and actions that will reduce GHG emissions and improve local air quality.

T-5 Develop an Electric Vehicle Infrastructure Master Plan

Long Beach Airport is implementing programs to increase use of electric ground service equipment (GSE) to reduce emissions from gasoline- and diesel-powered equipment. Sufficient data was unavailable during CAAP development to estimate potential future reductions from these efforts. However, the Airport's 2031 BAU Emissions Inventory report estimates emissions from GSE will total approximately 2,559 MT CO_2e/yr. Future CAAP updates will monitor implementation of vehicle and equipment electrification programs citywide to understand if additional GHG reductions are occurring beyond those currently estimated within this appendix.

SOLID WASTE CALCULATIONS

The solid waste actions are calculated based on the methane commitment methodology equations described in the Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GPC), and replicated in Part I of this appendix. Specifically, the calculations follow Equation 8.3, and use the same default factors as described in Part I. The methodological descriptions of the actions included below describe the process for calculating other inputs needed in the GPC equation. Please refer to Part I of this appendix for a full description of the methane commitment method and its corresponding equations and default assumptions.

The solid waste disposal data from 2015 was used to estimate landfill disposal amounts by facility in 2030 (see Table 36). AECOM used the 2015 disposal data shown in Table 14 and converted from short tons to metric tons for use in the preceding equations. The rate of disposal, expressed as metric tons per service population (MT/SP), where service population is residents plus employees, was calculated based on 2015 values, and held constant to estimate future disposal values in the emissions forecasts.

Table 36 – Landfill Waste Disposal Forecasts

Year	Short Tons (ST)	Metric Tons (MT)	Service Population (SP) [3]	MT/SP [4]
2015	409,258 [1]	371,273 [2]	624,312	0.595
2030	-	388,167 [5]	652,721	0.595

Source: AECOM 2018

Notes: Service population (SP) = population and jobs

[1] See Table 13, landfill plus ADC volume

[2] 1.0 short ton = 0.9072 metric tons

[3] See Table 19 for demographic data sources

[4] Calculated for 2015 as MT/SP, and held constant for 2030

[5] Calculated as SP * (MT/SP)

For CAAP action planning purposes, the volume of waste disposal was further disaggregated into single-family residential, multi-family residential, commercial, and ADC. Table 37 shows the breakdown by land use type and treatment destination. The project team used the CalRecycle Waste Characterization Web Tool – Residential Waste Stream Data Export tool to evaluate the contribution of single-family and multi-family waste in Long Beach (values shown in Table 37). Single-family residential waste collected in the city is sent to SERRF for incineration; multi-family residential waste is sent to regional landfills as shown in Table 13. The project team then derived the commercial portion of the waste stream by subtracting the multi-family residential value from the total volume sent to landfills in 2015.

Table 37 – Landfill Waste by Type and Destination

CalRecycle Land Use Splits	Tons (ST)	Tons (MT)	Destination	Landfill Waste Ratio
Single-family Residential	71,963	65,284	SERRF	-
Multi-family Residential	49,413	44,827	landfill	12%
Commercial	228,292	207,103	landfill	56%
ADC	131,553	119,343	landfill - ADC	32%
Total (non SFR city hauled)	409,258	371,273	-	100%

The corresponding landfill waste ratio was applied to the total 2030 disposal forecast (see Table 36). Table 38 shows the modeled 2030 disposal tonnage by land use and type for use in the CAAP action quantification.

Table 38 – 2030 Landfill Waste Estimates

Land Use Splits	Disposal Value (landfill or ADC)	Units
Multi-family Residential	46,867	tons (MT)
Commercial	216,527	tons (MT)
ADC	124,773	tons (MT)
Total	388,167	tons (MT)

W-1 Ensure compliance with state law requirements for multifamily and commercial property recycling programs

PARTICIPATION ASSUMPTIONS

This action would increase paper and cardboard recycling in the multi-family residential and commercial waste streams to reduce waste in these categories 75% below the 2030 estimated levels.

EMISSIONS FACTORS

To model emissions reductions, separate multi-family residential and commercial hypothetical landfill profiles were developed. This allowed each CAAP action to be applied differently based on land use type. The same methane commitment calculation inputs were used as described in Part I of this appendix. A weighted landfill methane collection factor was calculated based on the estimated 2030 waste disposal volume by landfill facility and the methane collection rates shown in Table 14. The resulting weighted methane collection rate was 77.61% for landfills that received Long Beach waste in 2015.

MITIGATED SCENARIO EMISSIONS

Tables 39 and 40 show the modeled 2030 multi-family and commercial landfill emissions by waste type based on the methane commitment methodology calculations described in Part I. The total landfill waste weight by composition correspond to the values shown in Table 38. This action would divert 75% of the paper/cardboard waste tonnage away from landfills, and therefore avoid 75% of these estimated future emissions. Reductions would total 7,461 MT CO_2e/yr from the multi-family sector, and 37,873 MT CO_2e/yr from the commercial sector; total reductions from this action are estimated to be approximately 45,340 MT CO_2e/yr.

Table 39 – 2030 Multi-family Residential Landfill Emissions

Waste Type	Landfill Waste Composition (Weight)	DOC Content in Waste	GHG Emission (Methane)	GHG Emission (MT CO_2e)
Paper/Carboard	11,019	40.0%	355	9,949
Textiles	3,785	24.0%	73	2,050
Food	11,609	15.0%	140	3,931
Garden and Park	5,268	20.0%	85	2,378
Wood	2,228	43.0%	77	2,163
Rubber and Leather	0	39.0%	0	0
Plastics	5,162	0.0%	0	0
Metal	1,657	0.0%	0	0
Glass	1,402	0.0%	0	0
Other	4,736	0.0%	0	0
Total	**46,867**		**731**	**20,470**
W-1 Paper/Cardboard Reduction				
75%				**7,461**
W-3 Food / Garden and Park / Wood Reduction				
75%				**6,354**

Table 40 – 2030 Commercial Landfill Emissions

Waste Type	Landfill Waste Composition (Weight)	DOC Content in Waste	GHG Emission (Methane)	GHG Emission (MT CO_2e)
Paper/Carboard	55,930	40.0%	1,803	50,498
Textiles	9,751	24.0%	189	5,282
Food	53,648	15.0%	649	18,164
Garden and Park	25,225	20.0%	407	11,388
Wood	15,409	43.0%	534	14,956
Rubber and Leather	48	39.0%	2	42
Plastics	26,210	0.0%	0	0
Metal	7,662	0.0%	0	0
Glass	4,910	0.0%	0	0
Other	17,732	0.0%	0	0
Total	**216,527**		**3,583**	**100,330**
W-1 Paper/Cardboard Reduction				
75%				**37,873**
W-3 Food / Garden and Park / Wood Reduction				
75%				**33,381**

W-3 Partner with private waste haulers to expand organic waste collection community-wide

PARTICIPATION ASSUMPTIONS

This action would increase organic waste diversion in the multi-family residential and commercial waste streams to reduce waste in these categories 75% below the 2030 estimated levels.

Note that a similar action is included in the CAAP for single-family residential waste (action W-2). However, single-family waste is processed at SERRF and its corresponding GHG emissions are excluded from the CAAP for GHG target achievement purposes (see Part I of this appendix for further information on this). Therefore, GHG reductions are not estimated for W-2 since the corresponding emissions are not included in the jurisdictional production inventory.

EMISSIONS FACTORS

The same approach to action quantification as described in W-1 was taken for this action.

MITIGATED SCENARIO EMISSIONS

Tables 39 and 40 included above with action W-1 also highlight the reductions associated with this action. Each table shows a GHG reduction value from diverting 75% of the food, garden and park, and wood waste tonnages away from landfills, therefore avoiding 75% of these estimated future emissions. Reductions would total 6,354 MT CO_2e/yr from the multi-family sector, and 33,381 MT CO_2e/yr from the commercial sector; total reductions from this action are estimated to be approximately 39,730 MT CO_2e/yr.

W-4 Identify organic waste management options

PARTICIPATION ASSUMPTIONS

This action would ensure that 50% of ADC disposal volume by 2030 consists of non-green waste materials to avoid landfill emissions generation from organic material. It assumes the remainder of ADC waste would be composed of inert materials that would not generate landfill emissions.

EMISSIONS FACTORS

To model emissions reductions, a separate hypothetical ADC landfill profile was developed, as with action W-1 and W-3 described above. The same methane commitment calculation inputs were used as described in Part I of this appendix. A weighted landfill methane collection factor was calculated based on the estimated 2030 waste disposal volume by landfill facility and the methane collection rates shown in Table 14 for those facilities that received ADC waste in 2015. The resulting weighted methane collection rate was 74.87% for landfills that received Long Beach ADC waste in 2015.

As described in Part I of this appendix, the project team conservatively assumed that 100% of ADC waste disposed by the city was green waste and therefore allocated the tonnage to the garden and park material category and corresponding DOC factor. It is likely that some or all of the ADC waste was inert materials that would not decompose to generate landfill emissions, and therefore the city's solid waste emissions could be lower than estimated in the inventory and forecasts. New ADC tracking data provided by CalRecycle that was unavailable during inventory preparation shows that a relatively minor portion of Long Beach's ADC consists of green waste. Based on the *2018 CalRecycle Disposal Reporting System Green Material Alternative Daily Cover Tonnages by Jurisdiction* report, only 13.37 tons of Long Beach ADC volume was identified as green waste. This represents 0.01% of the reported 2015 ADC volume from the city. Therefore, this action's assumption that 50% of ADC waste would be non-green waste materials by 2030 is highly plausible and still a reflects a conservative estimation of the corresponding GHG reductions from this action (i.e., since nearly 100% ADC emissions reductions might be supported given the very low current use of green waste as an ADC material by the city).

MITIGATED SCENARIO EMISSIONS

Table 41 shows the modeled 2030 ADC landfill emissions by waste type based on the methane commitment methodology calculations described in Part I. The total landfill waste weight by composition correspond to the values shown in Table 38. This action would divert 50% of the garden and park waste tonnage away from landfills, and therefore avoid 50% of these estimated future emissions. Reductions would total approximately 31,610 MT CO_2e/yr.

Table 41 – 2030 ADC Landfill Emissions

Waste Type	Landfill Waste Composition (Weight)	DOC Content in Waste	GHG Emission (Methane)	GHG Emission (MT CO_2e)
Paper/Carboard		40.0%	0	0
Textiles		24.0%	0	0
Food		15.0%	0	0
Garden and Park	124,773	20.0%	2,258	63,217
Wood		43.0%	0	0
Rubber and Leather		39.0%	0	0
Plastics		0.0%	0	0
Metal		0.0%	0	0
Glass		0.0%	0	0
Other		0.0%	0	0
Total	124,773		2,258	**63,217**
W-4 Garden and Park Waste Reduction – ADC Green Waste				
50%				**31,609**