City of San Leandro

Meeting Date: July 17, 2017

Staff Report

File Number: 17-410 **Agenda Section:** PRESENTATIONS

Agenda Number: 4.B.

TO: City Council

FROM: Chris Zapata
City Manager

BY: Debbie Pollart
Public Works Director

FINANCE REVIEW: Not Applicable

TITLE: Update on the San Leandro Greenhouse Gas Emissions Inventory 2015 and the San Leandro Climate Hazards Assessment

SUMMARY AND RECOMMENDATIONS

This report is for informational purposes only. No formal action is required.

BACKGROUND

Climate action planning in the Bay Area began in the late 2000s and resulted in a first round of carbon emission reduction plans that focused on energy efficiency and carbon reduction in the areas within the control of local governments, including: solid waste diversion, municipal operations, and building energy usage.

In 2006, StopWaste convened the Alameda County Climate Protection Project - a county-wide effort which included the cities of Alameda, Albany, Berkeley, Emeryville, Hayward, Newark, Oakland, Piedmont, Pleasanton, San Leandro, Union City and the County of Alameda - to join the International Council for Local Environmental Initiatives (ICLEI) Local Governments for Sustainability 5-Milestone process to:

1. Conduct an inventory of city-wide greenhouse gas emissions
2. Set a carbon emissions reduction target
3. Establish a Climate Action Plan
4. Implement a Climate Action Plan
5. Monitor and evaluate progress

In 2007, ICLEI conducted the 2005 inventory on behalf of the city (milestone #1) and subsequently the City Council set a target to reduce community-wide emissions by 25% below 2005 levels by year 2020 (milestone #2). San Leandro completed the third milestone by adopting the San Leandro Climate Action Plan at the end of 2009 with the theme, “Reduce,

then Produce" to first maximize energy efficiency and then look to generate electricity with renewable energy.

Since adoption of the 2009 Climate Action Plan, City staff has implemented the actions in the plan (milestone #4) by utilizing funds from federal stimulus programs, notably the Energy Efficiency and Conservation Block Grant (EECBG), to incorporate energy efficiency in government operations and promote green building and energy efficiency in community programs. Transit-Oriented Development has been promoted through the adoption of the San Leandro General Plan 2035 and approvals of transit-oriented development entitlements and zoning changes, as well as completion of various transportation improvement projects and bicycle/pedestrian planning.

Milestone #5, to monitor and evaluate emissions reductions, has been carried out on a five-year cycle since 2005. San Leandro's 2010 greenhouse gas emissions were inventoried in 2014 with assistance from StopWaste and PG&E. In 2016, through a grant from the East Bay Energy Watch and the Local Government Commission, the City obtained the services of an AmeriCorps/CivicSpark fellow, Ben Davenport, who completed the City's first in-house greenhouse gas emissions inventory for municipal and community-wide emissions for the year 2015. The results of this inventory are presented in detail in the attached 2015 Community and Municipal Emissions Inventory report.

Staff used the ICLEI methodology, which complies with the Global Protocol for Community-Scale Emissions (GPC) standards. This enabled the City to fulfill its obligations to the Global Covenant of Mayors via reporting these emissions to the Carbon Disclosure Project (CDP) in May 2017. A more detailed methodology for accounting and emissions factors is available in the Appendix.

Also included in this update is an in-depth assessment of climate hazards that are expected due to changing climate conditions already underway. In 2016, the services of a consultant, FourTwentySeven Climate Solutions, were sponsored by StopWaste to create Climate Hazard Assessments for the cities of Albany, Emeryville, Fremont, Hayward, Livermore, Piedmont and San Leandro to promote a consistent approach to incorporating adaptation and resilience into climate planning in Alameda County.

The resulting San Leandro Climate Hazard Assessment report will inform the City of San Leandro's future adaptation strategies and has already helped in the completion of its Local Hazard Mitigation Plan and reporting to the Global Covenant of Mayors. The Assessment will also assist San Leandro in obtaining funding for resiliency efforts and for federal funding from agencies such as the Federal Emergency Management Agency (FEMA.) The detailed report is attached and a summary analysis is presented in this staff report.

This summary report omits data tables and graphics. Please refer to the attached reports, San Leandro Community and Municipal Emissions Inventory for 2015 and the San Leandro Climate Hazard Assessment, for the full set of data tables, graphics, and citations for data presented in the narrative below.

Analysis

The City of San Leandro is committed to the measurement and reduction of greenhouse gas emissions within its management and control. The City has conducted inventories every five years since 2005 to continuously evaluate the scale and scope of emissions. Greenhouse gas inventories provide policymakers with information necessary to assess the existing state of carbon emissions within their jurisdictions and to make decisions on where to focus mitigation efforts. The community inventory represents all the energy used and waste produced within the City of San Leandro and its contribution to greenhouse gas emissions. The municipal inventory is a subset of the community inventory, and includes emissions derived from internal government operations.

Greenhouse gases are defined as carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulfur hexafluoride (SF6). Carbon dioxide equivalent (CO2e) is a unit of measure that normalizes the varying climate warming potential of the six greenhouse gas emissions. For example, one metric ton of methane is equivalent to 21 metric tons of CO2e. One metric ton of nitrous oxide is equivalent to 210 metric tons of CO2e. The global warming potential of these gases was determined in the International Panel on Climate Change (IPCC) 4th Assessment.

San Leandro Community Greenhouse Gas Emissions Inventory 2005 to 2015

Community Emissions, in metric tons (MTCO2e):

2005: 675,288
2010: 612,376
2015: 636,172

In 2015, San Leandro's community emissions were 636,172 metric tons (MT) CO2e, a reduction from the 2005 baseline of 675,288 MT CO2e by 39,116 MT CO2e. Municipal operations and facilities contributed 6,225 MT CO2e, about 1% of the total inventory. The largest sectors contributing to community emissions are transportation (60%), commercial and industrial energy use (23%), and residential energy use (13%). Solid waste and wastewater emissions contributed only about 4% of total emissions.

This mixed result can be attributed to a reduction in energy usage during the 2008-2010 Great Recession - a period of decreased economic activity with greater vacancies in San Leandro's building stock, a slowdown in building and goods shipments - and an uptick in development and population growth between 2010 and 2015. The surge in transportation, especially in the through-traffic of commercial trucks and passenger vehicles, are outside the direct control of the City of San Leandro.

The largest source of carbon emissions in San Leandro is transportation, accounting for 60% of all community emissions. Vehicle miles travelled (VMT) have increased over the past few years and overall transportation emissions, after declining slightly in 2010, went up significantly between 2010 and 2015. Analysis of the VMT data shows that much of this increase is due to heavy-truck traffic through San Leandro. As the economy has improved, goods movement up and down the I-880 corridor has increased transportation-related emissions occurring within city limits.

Commercial and Industrial emissions from building and process energy use, which accounts for 23% of citywide emissions, showed steep declines to approximately 29% less than 2005 levels. Residential building emissions also dropped 16% from 2005 levels. Variation in weather patterns can influence building energy usage, but efforts by residents, commercial/industrial building owners and businesses, and utilities (as part of the state-mandates and incentive programs under AB 32) have also played a role in improving the energy performance of San Leandro's building stock.

The types of power sources that make up a utility's electricity generation mix also have had a significant impact on a city's greenhouse gas emissions in the commercial, industrial and residential sectors. Over the past several years, PG&E's electric grid has reduced its reliance on carbon-intensive energy sources. PG&E's power mix in 2015 comprised of approximately 25% natural gas, 23% nuclear, 6% large hydro-electric and 30% renewable energy, with 17% remaining from "unspecified" sources. In 2015, PG&E's electricity created only one-third as many greenhouse gas emissions per kilowatt-hour compared to the industry average and produced over two times the amount of renewable energy than in 2005.

Waste diversion policies - mandatory recycling and composting though county-wide regulations - contributed to steep decreases in emissions from the Solid Waste sector. The 50% reduction in tons landfilled in 2015 compared to 2005 resulted in a decrease of 60% in emissions from solid waste. Wastewater treatment emissions remained flat between 2005 and 2015 even while San Leandro's Water Pollution Control Plan (WPCP) decreased its process emissions by 41%. The inclusion of emissions data from the Oro Loma Sanitary district in the 2015 emissions calculation offset the significant upgrades made at the WPCP.

San Leandro Municipal Emissions from 2005 to 2015

Municipal Emissions, in metric tons (MTCO2e):

2005: 5,146
2010: 7,413
2015: 6,225

Over the past ten years, San Leandro's municipal emissions have increased by 21% to approximately 6,225 MT of CO2e from the 2005 baseline of 5,150 MT CO2e. This increase may not reflect actual increase in emissions; improved methods of measurement and calculation as well as new sources counted in 2015 that were not included in the 2005 inventory. 2015 emissions are 16% lower than in 2010 and, while the target for 25% reductions by 2020 has not been met, ongoing energy efficiency and renewable energy projects for city facilities will enable municipal operations to make greater progress towards the 2020 goals.

City Buildings and Facilities emissions have decreased significantly since 2005, showing a decrease of 10%. This sector represents approximately 20% of municipal emissions. This decrease is due to the installation of more energy-efficient building equipment in 2010-2012, as well as the cleaner power mix coming from PG&E. Wastewater treatment emissions, which represent 27% of municipal emissions, have decreased by approximately 16% since first

accurately measured in 2010.

Substantive increases in city emissions have are only been noted in one sector: the city's vehicle fleet (representing 24% of emissions) increased by 20% since 2005. Staff is taking a closer look at the data associated with these percentages, as the number of fleet vehicles/mobile equipment has stayed flat between 2005-2015, and the State-mandated diesel retrofits have been installed prior to 2010.

Conversely, Streetlights and Traffic Signals show reductions of 18% since 2005, due to the partial conversion of some streetlights (14%) and all traffic signals to LEDs in 2012. The remaining 86% of streetlights are being retrofitted to smart controllers and LED light fixtures in 2017 through a guaranteed energy savings contract with Climatec, as are City buildings/parks interior/exterior lighting, which will result in greater reductions in emissions in the next inventory.

Climate Hazard Assessment

The climate hazard analysis covers the following likely scenarios that climate change may have on our community. San Leandro's climate is projected to grow hotter and experience fluctuations in precipitation. The analysis also finds that rising sea levels may inundate important city and community assets. The exposure to the hazards examined in the attached Climate Hazard Assessment include:

High exposure:

- *Inland Flooding*: Significant exposure during 100-year storm (1% annual chance) with increasing exposure and risk during 500-year storms (0.2% annual chance).
- *Wildfire*: Some assets are located in high fire hazard severity zones or are in close proximity to very high fire hazard severity zones.

Medium exposure:

- *Sea Level Rise*: Significant exposure likely by mid-century with a 5-year (20% chance) storm surge, a combination of permanent and temporary inundation equivalent to 36 inches of sea level rise.
- *Temperature Change*: Increase in the number of extreme heat days
- *Rainfall-induced Landslides*: important assets in a few landslide hazard zones.

Low exposure:

- *Precipitation*: Limited change in overall rainfall totals.

In summary, the Climate Hazards Assessment found that San Leandro will likely be affected by the combination of sea level rise, high tides and flooding along the shoreline and through the southwest portion of the city, which threaten to limit mobility and damage amenities and industry that are important to San Leandro and the regional economy. However, the most severe impacts will be seen in the long term, when projected temperature increases and the frequency of very hot days will impact a broader set of the city's assets and population,

resulting in greater occurrence of heat-related illness and increased energy usage for cooling.

Conclusions and Next Steps

Through its commitment to the Global Covenant of Mayors, the City has pledged to conduct continued tracking of greenhouse gas emissions. Municipal emissions inventories will be updated on a regular basis, while updates to citywide inventories (which rely on outside information more difficult to obtain) will continue to be conducted every three to five years. The City's transition to the ICLEI ClearPath platform will allow for more consistent tracking of greenhouse gas trends in future years. To translate the information contained in these inventories into action, the City and its partners continue to develop and execute policies intended to help mitigate greenhouse gas emissions.

Overall, the 2015 Greenhouse Gas Emissions Inventory and the Climate Hazards Assessment reveal a need to place emphasis on the City's efforts to reduce carbon emissions, especially in the transportation sector, and to plan for climate hazards already creating impacts in the medium term.

Transportation emissions within municipal operations can be addressed over the next few years by switching to renewable diesel for trucks and heavy equipment and electric vehicles (EVs) for certain city vehicles as fleet vehicles are replaced. To attain emissions reductions in the private use of vehicles and commercial trucks, the City can continue to promote the use of EVs but primarily must rely upon state- or utility-sponsored programs for fuel efficiency and fuel switching (converting from gasoline or regular diesel to electric, hydrogen, or renewable diesel fuels).

Certain energy efficiency projects (municipal LED streetlighting and efficient HVAC projects and community-wide residential energy upgrade incentive and DIY programs) outlined in the 2009 CAP were pursued with federal Energy Efficiency Community Block Grant (EECBG) funding in 2010-2012. However, after the Great Recession, overall coordination of climate action activities ceased and those federal programs were terminated when the EECBG funding ended in 2012. Mandatory measures that were proposed in the 2009 CAP to require residential or commercial energy conservation in local ordinances were not implemented. Again, state-wide regulations such as the CalGreen building code will be important elements in achieving energy efficiency in existing and new building projects.

In 2017, the City will complete a guaranteed energy savings project for streetlights, irrigation controls and building equipment as well as begin the design and installation of approximately 1 megawatt (MW) of solar photovoltaic at the Water Pollution Control Plant, a result of the award by the California Energy Commission of a $1.996M grant.

In the building and facilities sector, greener building codes will ensure that new construction is more energy efficient. The statewide energy benchmarking and disclosure program for large commercial buildings, mandated to begin in 2017 under AB 802, will help building owners, operators, and tenants better understand the opportunity to save energy and reduce carbon emissions in existing facilities. Finally, the overall electricity mix will become more weighted with renewables under the Community Choice Aggregation project, East Bay Community Energy. When combined with possible microgrid development, new renewable energy projects in San Leandro's private and public sector will contribute to decreased emissions in

building energy use.

These policies can have a significant impact on San Leandro's carbon footprint, but deeper reductions will be necessary to reach aggressive targets beyond 2020. San Leandro is currently working with StopWaste to develop a framework for reducing greenhouse gas emissions 50% from current baseline by 2030 and 80% by 2050, targets set by the California Air Resources Board (CARB). To reach these ambitious new goals for 2030 and 2050, deep cuts in carbon emissions are required. Cities must expand their focus to access hard-to-reach measures such as fuel switching, investment in renewable energy and materials re-use in an ambitious de-carbonization approach. The State of California and several cities nationally and worldwide have made such commitments. San Leandro hopes to partner with other small cities in Alameda County to create a CAP 2.0 that will enable smaller communities to achieve these deep carbon reduction targets.

Now that San Leandro has completed its 2015 emissions inventory, and the results reported to the CDP/Global Covenant of Mayors, staff will focus on engaging in public outreach efforts to create stakeholder momentum behind climate action. The work will also include policy research on best practices, coordination of community meetings to evaluate concerns and potential support for these actions, and assistance in preparing updates to City Council on progress.

With the results of the Hazard Assessment report, coordination with other city departments and functions such as Engineering & Transportation, Community Development, and Emergency Management will be conducted to plan for actions and investments needed to confront climate hazards in the medium- to long-term. Over the next year, the City will seek funding for a comprehensive Climate Action and Adaptation Plan to create strategies for deeper emissions reductions and preparedness for the climate changes already underway. Public engagement will be a cornerstone in these future efforts.

Current Agency Policies

- San Leandro Climate Action Plan (2009)
- San Leandro General Plan 2035 (2016)

ATTACHMENT(S)

- San Leandro Community and Municipal Greenhouse Gas Emissions for 2015
- San Leandro Climate Hazards Assessment

PREPARED BY: Sally Barros, Sustainability Manager and Ben Davenport, AmeriCorps/CivicSpark Fellow

San Leandro Community and Municipal Greenhouse Gas Emission Inventory for 2015

July 17, 2017

Credits and Acknowledgements

The 2015 greenhouse gas emissions inventory was completed by Benjamin Davenport, the 2016-2017 AmeriCorps Civic Spark Fellow, and Sally Barros, Sustainability Manager, for the City of San Leandro.

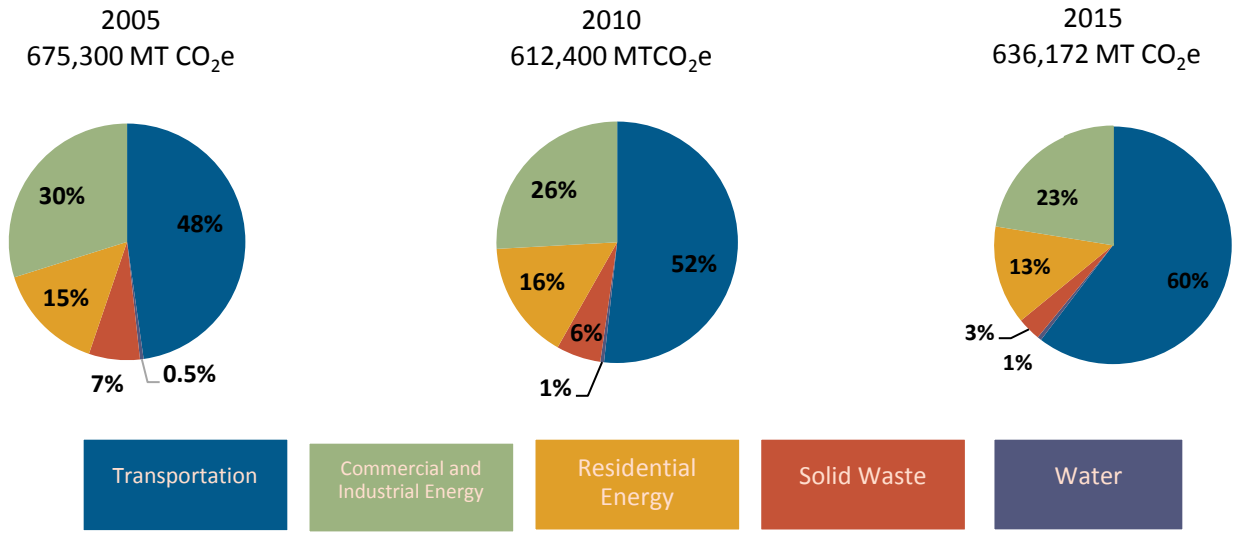
The City of San Leandro thanks the Local Government Commission, ICLEI, StopWaste, and East Bay Energy Watch for its support in underwriting a major portion of the cost to employ, train and manage the work of the Civic Spark Fellow. Without the support of the CivicSpark program, this first in-house inventory would not have been possible.

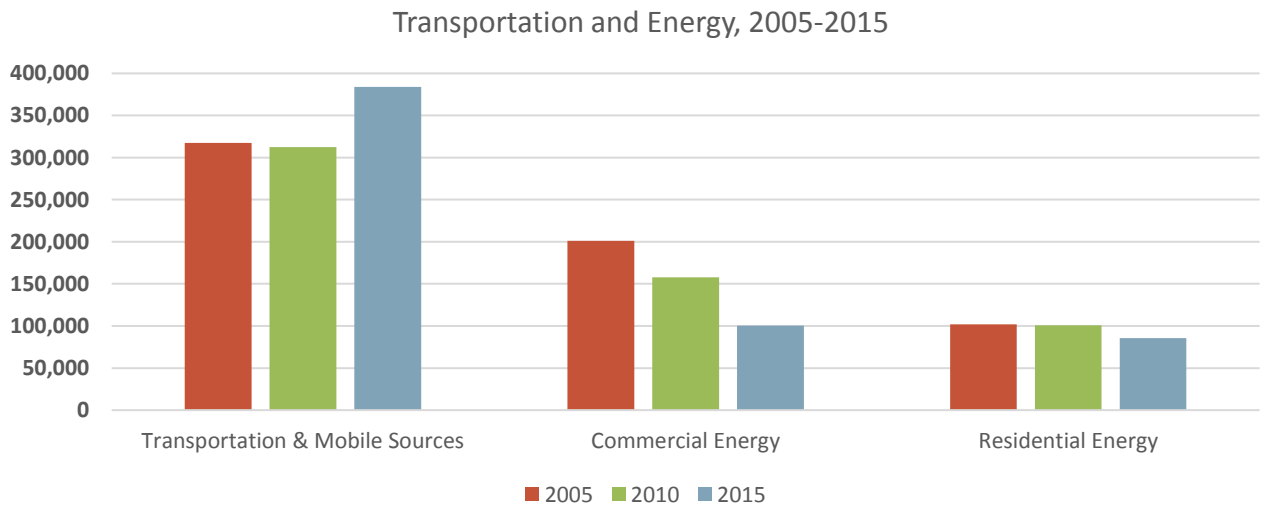
The Public Works Department is grateful to other City staff who provided data, as well as the numerous outside agencies such as the Metropolitan Transportation Commission (MTC), Pacific Gas and Electricity (PG&E), Bay Area Rapid Transit (BART), Oro Loma Sanitary District, East Bay Municipal Utility District (EBMUD), and Alameda-Contra Costa Transit (AC Transit) that provided data and guidance for the inventory.

Executive Summary

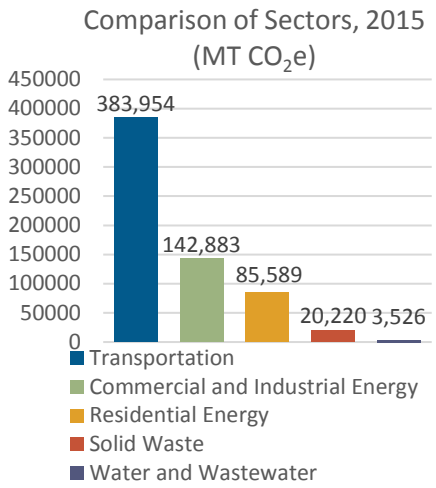
The City of San Leandro is committed to the measurement and reduction of greenhouse gas emissions within its management and control. The City has conducted inventories every five years since 2005 to continuously evaluate the scale and scope of emissions. Greenhouse gas inventories provide policymakers with information necessary to assess the existing state of carbon emissions within their jurisdictions and to make decisions on where to focus mitigation efforts. The community inventory represents all the energy used and waste produced within the City of San Leandro and its contribution to greenhouse gas emissions. The municipal inventory is a subset of the community inventory, and includes emissions derived from internal government operations.

In 2015, community emissions were 636,172 metric tons (MT) CO_2e, a reduction from the 2005 baseline of 675,288 MT CO_2e by 39,116 MT CO_2e. Municipal operations and facilities contributed 6,225 MT CO_2e, about 1% of the total inventory. The largest sectors contributing to are transportation (60%), commercial and industrial energy use (23%), and residential energy use (13%). Solid waste and wastewater emissions contributed only about 4% of total emissions.





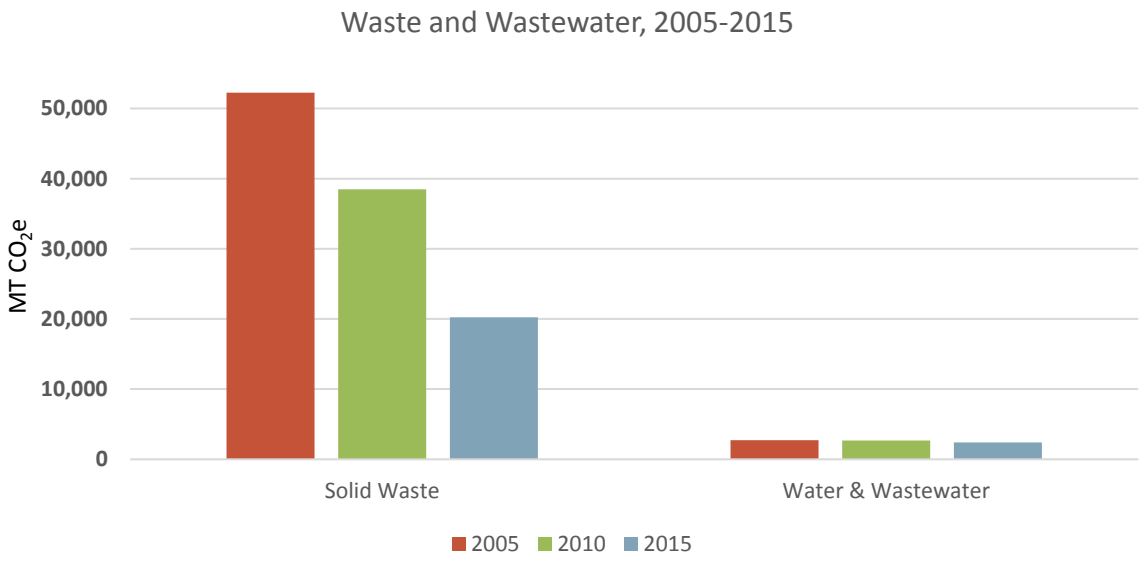
This mixed result can be attributed to a reduction in energy usage during the 2008-2010 Great Recession – a period of decreased economic activity with greater vacancies in San Leandro's building stock and associated slowdown in building and goods shipments – followed by an uptick in development and population growth between 2010 and 2015. The surge in transportation, especially in the through-traffic of commercial trucks and passenger vehicles, are outside the direct control of the City of San Leandro.



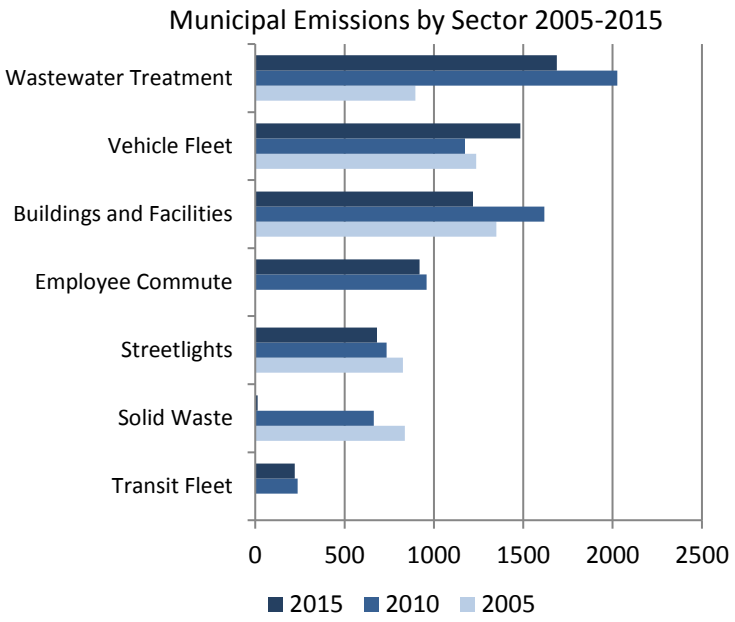
The largest source of carbon emissions in San Leandro is transportation, accounting for 60% of all community emissions. Vehicle miles travelled (VMT) have increased over the past few years and overall transportation emissions, after declining slightly in 2010, went up significantly between 2010 and 2015. Analysis of the VMT data shows that much of this increase is due to heavy-truck traffic through San Leandro. As the economy has improved, goods movement up and down the I-880 corridor has increased transportation-related emissions occurring within city limits.

Commercial and Industrial emissions from building and process energy use, which accounts for 23% of citywide emissions, showed steep declines to approximately 29% less than 2005 levels. Residential building emissions also dropped 16% from 2005 levels. Variation in weather patterns can influence building energy usage, but efforts by residents, commercial/industrial building owners and utilities (as part of the state-mandates and incentive programs under AB 32) have also played a role in improving the energy performance of San Leandro's building stock.

The types of power sources that make up a utility's electricity generation mix also have had a significant impact on a city's greenhouse gas emissions in the commercial, industrial and residential sectors. Over the past several years, PG&E's electric grid has reduced its reliance on carbon-intensive energy sources. PG&E's power mix in 2015 comprised of approximately 25% natural gas, 23% nuclear, 6% large hydro-electric and 30% renewable energy, with 17% remaining from "unspecified" sources. In 2015, PG&E's electricity created only one-third as many greenhouse gas emissions per kilowatt-hour compared to the industry average and produced over two times the amount of renewable energy than in 2005.



Waste diversion policies – mandatory recycling and composting though county-wide regulations – contributed to steep decreases in emissions from the Solid Waste sector. The 50% reduction in tons landfilled in 2015 compared to 2005 resulted in a decrease of 60% in emissions from solid waste. Wastewater treatment emissions remained flat between 2005 and 2015 even while San Leandro's Water Pollution Control Plan (WPCP) decreased its process emissions by 41%. The inclusion of emissions data from the Oro Loma Sanitary district in the 2015 emissions calculation offset the significant upgrades made at the WPCP.



Over the past ten years, San Leandro's municipal emissions have increased by 21% to approximately 6,225 MT of CO_2e from the 2005 baseline[1] of 5,150 MT CO_2e. This increase may not reflect actual increase in emissions; improved methods of measurement and calculation as well as new sources counted in 2015 that were not included in the 2005 inventory. 2015 emissions are 16% lower than in 2010 and, while the target for 25% reductions by 2020 has not been met, ongoing energy efficiency and renewable energy projects for city facilities will enable municipal operations to make greater progress towards the 2020 goals.

City Buildings and Facilities emissions have decreased significantly since 2005, showing a decrease of 10%. This sector represents approximately 20% of municipal emissions. This decrease is due to the installation of more energy-efficient building equipment in 2010-2012, as well as the cleaner power mix coming from PG&E. Wastewater treatment emissions, which represent 27% of municipal emissions, have decreased by approximately 16% since first accurately measured in 2010.

Substantive increases in city emissions have only been noted in one sector: the city's vehicle fleet (representing 24% of emissions) increased by 20% since 2005. Staff is taking a closer look at the data associated with these percentages, as the number of fleet vehicles/mobile equipment has stayed flat between 2005-2015, and with the State-mandated diesel retrofits having been installed prior to 2010.

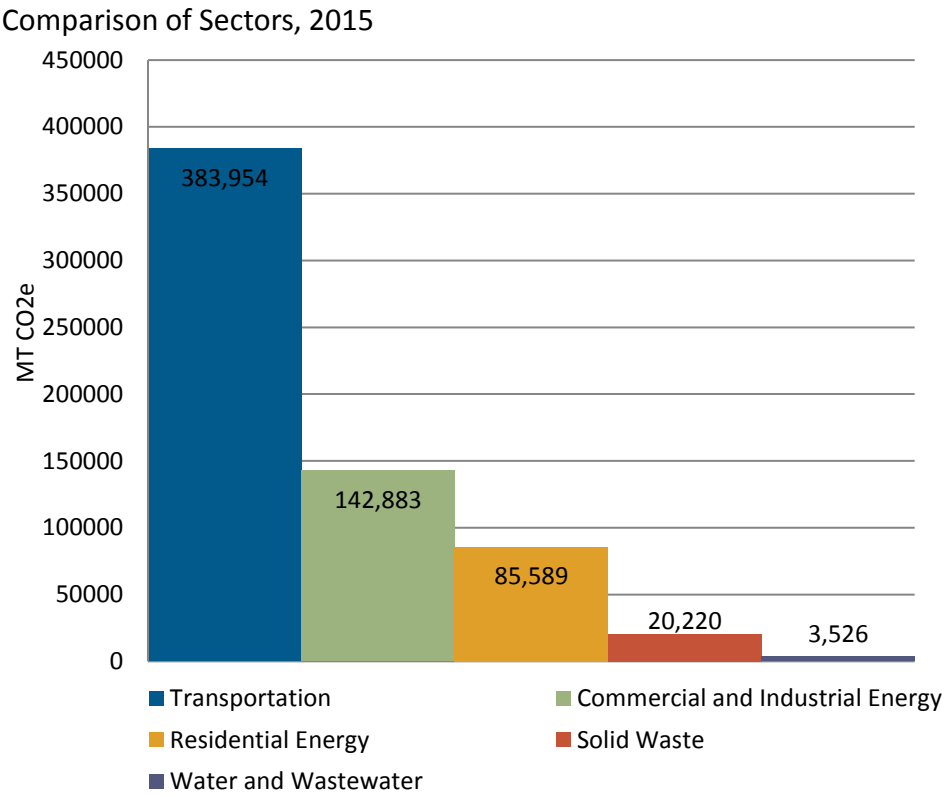
Conversely, Streetlights and Traffic Signals show reductions of 18% since 2005, due to the partial conversion of some streetlights (14%) and all traffic signals to LEDs in 2012. The remaining 86% of streetlights are being retrofitted to smart controllers and LED light fixtures in 2017 through a guaranteed energy savings contract with Climatec, as are City buildings/parks interior/exterior lighting, which will result in greater reductions in emissions in the next inventory.

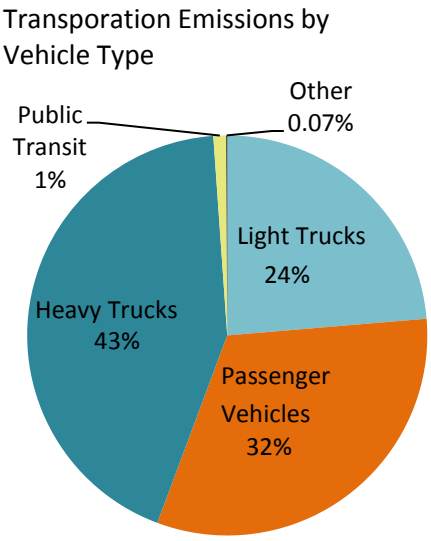
[1] Updated totals based on methodology updated in 2014 by StopWaste

Detailed 2015 Community Emissions

Methodology:

The City utilized Local Governments for Sustainability's (ICLEI) Clear Path software, which complies with the Global Protocol for Community-Scale Emissions (GPC) standards, to create the community inventory for 2015. This international standard was combined with global warming potential from the International Panel on Climate Change's (IPCC) 4th Assessment Report on Climate Change in order to determine the carbon dioxide equivalent (CO_2e of emissions).





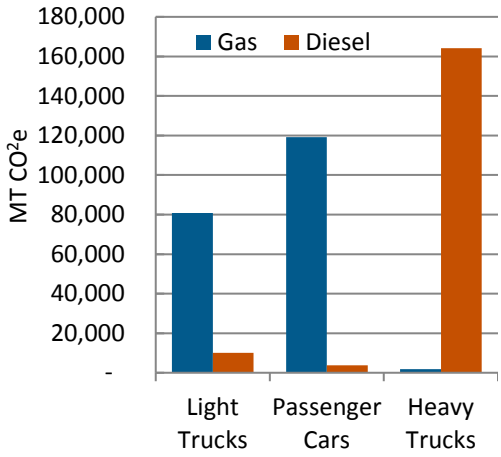
Transportation and Mobile Sources

Transportation emissions are the result of travel that begins or ends within city boundaries or is associated with resident activity. This includes both commercial and personal vehicle travel within San Leandro and includes BART, AC Transit, waterborne traffic, and Amtrak. In 2015, there were 383,954 MT CO_2e, accounting for 60% of all community emissions. The largest single contributor toward emissions was commercial diesel trucks (164,000 MT CO_2e) followed by gasoline passenger vehicles (200,000 MT CO_2e).

Due to the inherent difficulty of measuring vehicle miles traveled (VMT) or gasoline and diesel usage within city boundaries, the inventory relies on a VMT model provided by Metropolitan Transportation Commission (MTC). While VMT briefly declined at the 2010 Inventory, likely due to the recession, it has increased beyond the 2005 baseline by about 12%, and CO_2e emissions have increased by about 21%.

While VMT and emissions have gone up for the region, the population has increased over time. In San Leandro, VMT has only increased by 9% while population has increased by 11%. The California Air Resources Board (CARB) has

On-Road Emissions by Fuel Type, 2015

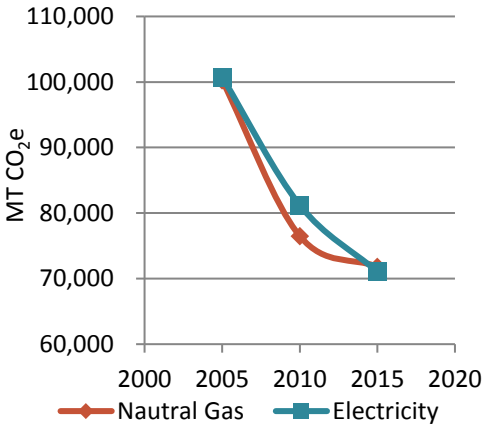


stringent fuel economy standards that require exhaust emissions for new vehicles to drop from 301 g CO_2e/mile in 2009 to 213 g CO_2e/mile in 2015 (and further to 205 g CO_2e/mile from 2016 onwards). These standards help keep our emissions lower even as our VMT increases. Beyond that, CARB has a rebate program that encourages purchases and leases of electric vehicles because they have the highest potential to reduce passenger vehicle emissions. San Leandro residents have purchased 368 such vehicles through CARB's rebate program to date.

Commercial and Industrial Energy

Commercial and Industrial energy emissions are caused by combustion of natural gas within city boundaries and procurement of electricity from PG&E for non-residential users. While the electricity data and commercial natural gas usage is available from PG&E, the industrial natural gas usage was not available for 2015 due to privacy restrictions[2]. Instead, industrial natural gas usage for 2015 was modeled using available industrial gas data from 2009-2013. Commercial and industrial energy usage accounts for 23% of community emissions. This share is smaller than in previous years, in part because of a decrease in emissions within this sector and partially due to a relative increase in emissions from the transportation sector.

Commercial and Industrial Emissions by Source, 2005-2015

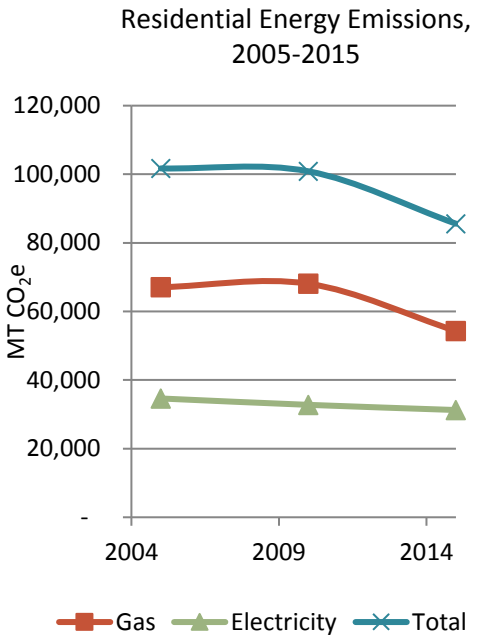


Emissions from commercial and industrial energy have dropped steadily since 2005 and continued to drop after the recession to 142,883 MT CO_2e in 2015. Emissions are now 29% lower than they were at baseline. This decrease is mostly attributable to a drop in usage, likely from energy efficiency measures installed by San Leandro's largest industrial companies. The 2015 inventory shows a 28% reduction in natural gas usage (and 28% reduction in CO_2e) and 19% reduction in electricity usage (29% reduction in CO_2e) since 2005. The remaining difference with CO_2e emissions is attributable to a PG&E's increased sourcing of renewable energy since 2005.

Residential Energy

Emissions from residential energy, like commercial and industrial energy, are a result of the use of electricity and natural gas. PG&E aggregates and provides all data.

[2] PG&E adheres to the 15/15 Rule adopted by the California Public Utilities Commission requiring aggregated information be made up of at least 15 customers and any single customer's load must be less than 15% of that category.

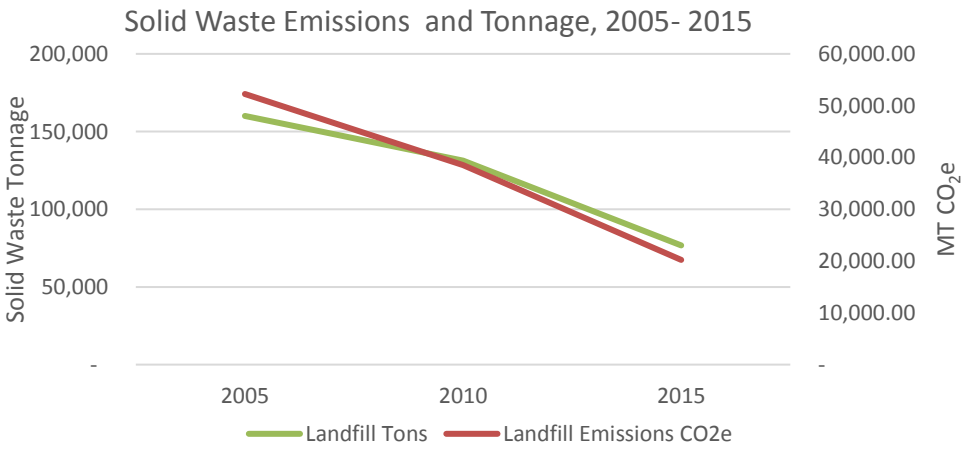


In 2015, Residential Energy usage emitted 85,589 MT CO_2e which accounted for 13% of community emissions. Overall, residential energy emissions are down by 16%. Electricity usage rose by 3% over the last 10 years, nearly a 9% increase per household. Even so, due to PG&E's cleaner energy portfolio, total CO_2e emissions from that electricity declined by 10%.

A large portion of the 16% CO_2e reductions in residential energy is attributable to a 19% decrease in natural gas usage over the last ten years. While electricity usage remains relatively unchanged by temperature, if there are fewer cold days there is a decrease in usage of gas-powered furnaces. The heating degree-day measurement estimates weather-related heating demand based on outside temperature. In 2015, there were 14% fewer heating degree-days in San Leandro than in 2010 and 25% fewer than in 2005. It is likely that the reduction in natural gas usage is in part due to warmer weather in 2015 than for the previous two inventories.

Solid Waste Disposal

When solid waste is landfilled, organic material decomposes in the anaerobic (absent oxygen) environment and releases methane. San Leandro sent 76,725 tons of solid waste to landfills in 2015, resulting in 20,200 metric tons of CO_2e. Nearly 30,000 tons of waste were diverted through recycling or composting, a 28% diversion rate. Overall, this is a significant 60% reduction in emissions and a 50% reduction in tons landfilled since 2005.



Water and Wastewater Treatment

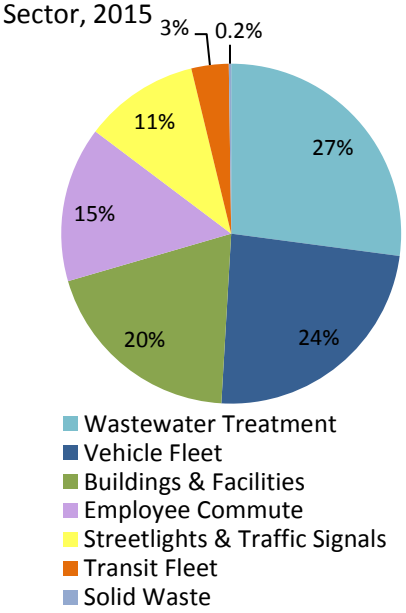
Wastewater treatment in San Leandro is shared between the San Leandro Water Pollution Control Plant and the Oro Loma Wastewater Plant. Greenhouse gases are emitted from the burning of natural gas, use of electricity, and nitrous

oxide (N_2O) released during the treatment process. The Plant is the largest consumer of electricity for municipal operations and accounts for a large portion of municipal emissions. In 2015, 2,710 metric tons of CO_2e were released from wastewater treatment, about the same as previous inventories (2005: 2,706 MT CO_2e; 2010 2,703 MT CO_2e).

Greenhouse gas emissions also result from the electricity used to clean and supply potable water to the City by EBMUD. The community used 3,092 million gallons resulting in 816 MT CO_2e. In total, water and wastewater account for 3,526 MT CO_2e, or about 0.55% of overall emissions.

The 2015 inventory is not exactly comparable to previous inventories, though, due to the recent inclusion of emissions from wastewater sent to Oro Loma and a new method of categorization. Despite that, it is clear that the largest sector of emissions for San Leandro's Water Pollution Control Plant, process-related emissions of N_2O, has decreased by about 41% over 10 years despite an increase in population in San Leandro. This decrease is almost exactly offset by the energy and process emissions from San Leandro's wastewater that is processed at Oro Loma's Wastewater Plant. Thus, overall wastewater treatment emissions appear to remain unchanged despite significant upgrades in energy and processing efficiency.

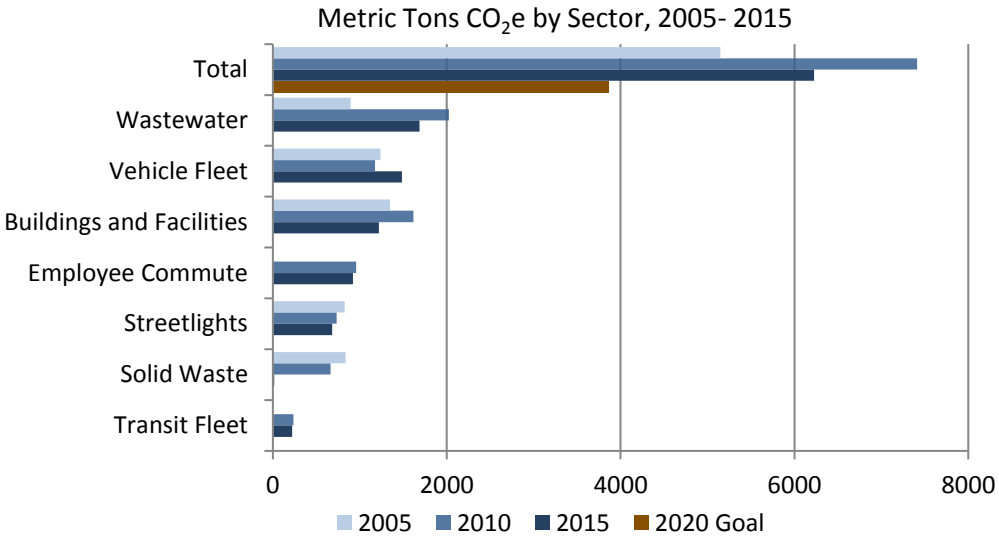
Municipal Inventory by Sector, 2015



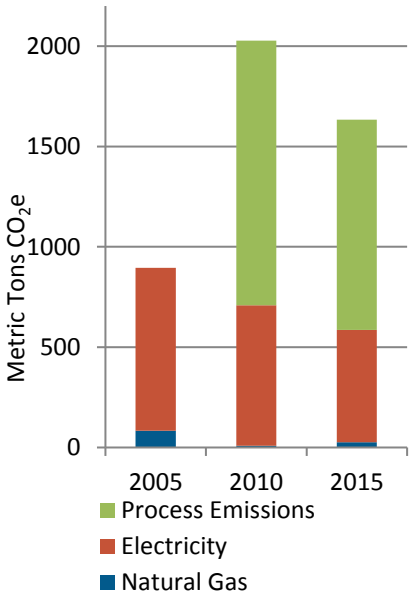
Detailed 2015 Municipal Emissions

The Buildings and Facilities sector has significantly decreased emissions by 10% since 2005. This is important because it represents about 20% of emissions. This is largely a factor of cleaner energy coming from PG&E. Wastewater treatment emissions, which represent about 27% of City emissions, have decreased by about 16% since first accurately measured in 2010.

Increase in city emissions has only been seen in one sector. Emissions from the City's vehicle fleet, representing about 24% of emissions, have increased about 20% since 2005. Conversely, due to converting traffic signals to LEDs around San Leandro, emissions in that sector have reduced by 18% since 2005.



Wastewater Treatment Plant Emissions, 2005-2015



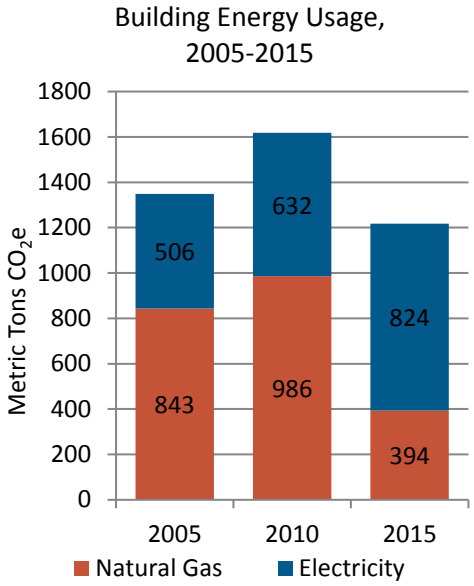
Wastewater

Wastewater is rich in carbon and nitrogen and must be collected, treated and discharged appropriately. This process creates and releases the greenhouse gases methane and nitrous oxide. San Leandro has operated the San Leandro Water Pollution Control Plant (WPCP) since 1939, and it serves approximately two thirds of the city's residential population as well as industrial users. The WPCP, beyond releasing greenhouse gases from the treatment process, also consumes a large amount of electricity and natural gas. Wastewater treatment is separated from the municipal Buildings and Facilities subsection because it uses significantly more natural gas and electricity than other city buildings.

At 1,687 MT CO_2e emissions from the WPCP and its processes, the water treatment plant represents 27% of the city's overall emissions. Of those emissions, nearly 60% come from N_2O emissions related to processing and

discharging effluent. Another 33% come from the plant's electricity load necessary for it to run 24/7.

Emissions from the WPCP, including its energy use, are about 16% lower than they were in 2010. Accurate numbers for comparison are not available from the original 2005 baseline inventory.

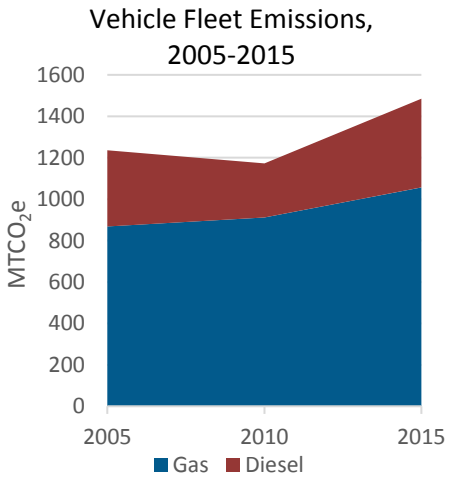


Buildings and Facilities

Facility operations contribute greenhouse gas emissions through consumption of electricity and natural gas. Emissions data for San Leandro's buildings and facilities was gathered from PG&E. Buildings and facilities represent 1,218 MT CO_2e, 20% of the City's total. Emissions from natural gas are down 53% from the 2005 baseline and 60% from 2010 due largely to HVAC retrofits at the Police Station and City Hall. Emissions from electricity have increased by 63% from the 2005 baseline and 30% from 2010, but the energy mix from PG&E now includes more renewables. This results in an overall 10% decrease in emissions for buildings and facilities since 2005 and a 25% decrease since 2010.

Streetlights, Traffic Signals, and Other Public Lighting

San Leandro operates public traffic signals, streetlights, median lights, park lights, etc. which created 682 MT CO_2e emissions through the consumption of electricity. PG&E supplied the data for municipal electricity consumption. The majority of energy use in this sector, 84%, is attributable to streetlights while traffic signals use about 12%. The remainder goes to irrigation of medians, and other sources. In total, streetlights and traffic signals are a smaller sector, making up about 11% of total City emissions.



Vehicle Fleet and Mobile Equipment

The vehicles and equipment used by San Leandro range from light-duty trucks, stationary equipment, heavy street sweepers, and sedans. They burn gasoline and diesel fuels that release greenhouse gas directly into the air. In 2015, San Leandro had 205 vehicles and emissions were estimated using the total gallons of diesel and gasoline used from the refueling pumps at Public Works Corporation Yard. Fleet emissions represent 24% of the overall inventory with 1,483 MT CO2e released. Emissions have increased by 20% since 2005 and 25% since 2010.

Transit Fleet

The City of San Leandro partners with San Leandro Transportation Management Organization to run the LINKS and Kaiser shuttles. These shuttles are run on gasoline and compressed natural gas which directly emit greenhouse gases. Despite their emissions, these shuttles provide a lower-carbon alternative to trips in private cars. These shuttles represent about 221 MT CO_2e, or 4% of the City's total emissions.

Solid Waste

Solid waste generated by government operations (e.g. paper, boxes, plant debris, construction debris, food waste) can be recycled or composted though some still ends up in landfills. Once in landfills, organic materials decompose in anaerobic conditions releasing methane, a potent greenhouse gas. Due to consistent efforts, landfilled waste represents only 0.2% of city emissions releasing only 14 MT of CO_2e in 2015 compared to about 830 and 660 MT CO_2e in 2005 and 2010 respectively.

Employee Transportation Mode, 2015	
Drive Alone	89%
Carpool	5%
Bike and Walk	4%
Public Transit	2%

Employee Commute

Emissions from employee commuting results from the fuels used in private vehicles and the average miles traveled to work by employees reporting to city facilities. Results from an internal survey (with an impressive 38% response rate) allowed for effective modelling of employee commuting habits. Employee commuting to and from work represents nearly 15% of the city's emissions, releasing about 920 MT CO_2e in 2015. Results show a small but encouraging increase in hybrid and electric vehicles.

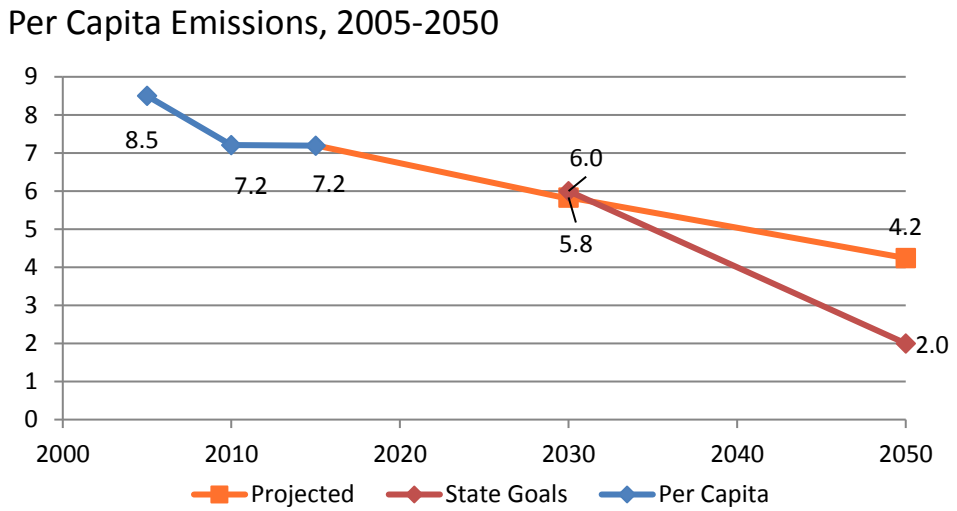
Employee Commute Vehicle Fuels		
	2010	2015
Gasoline	92%	90%
Diesel	3%	3%
Hybrids	5%	5%
Electric	0%	1.5%

Per Capita Emissions

Per capita measures of greenhouse gas emissions are useful for determining the efficiency, or intensity, of greenhouse gases emitted within a community. This allows for scalability of the metric across regions, counties, and cities as well as a method to compare smaller and larger communities.

The State of California committed to the *Under 2 MOU* in 2015, an agreement between subnational governments to limit emissions of greenhouse gases to fewer than two metric tons per capita by 2050. The current draft of the CARB's 2017 Scoping Plan focuses on per capita emissions reductions goals for 2030, 6 MT CO_2e per capita, and 2050, the aforementioned 2 MT CO_2e per capita.

Per capita emissions in San Leandro have decreased by 15% since 2005 to 7.2 MT CO_2e in 2015. If this 15% over ten years reduction were to continue, we would achieve the 2030 goal but would have to substantially decrease emissions by 33% every 10 years until 2050 to reach state targets. If, instead of ramping up after 2030, efforts started sooner, we would only need to reduce by about 24% every ten years to reach 2050 targets. The fact that per capita emissions have remained relatively stable between 2010 and 2015 indicates a need to increase efforts to reduce emissions across the community.

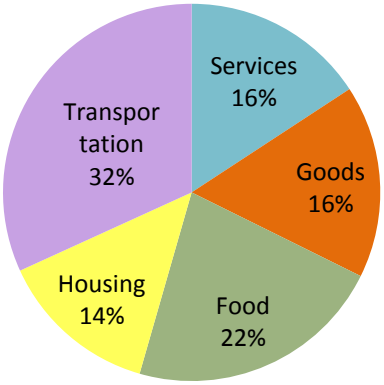


Consumption Based Inventory

A consumption based inventory (CBI) takes a different approach to calculating per capita and community emissions. The CBI takes into account greenhouse gas emissions from a full life-cycle analysis of goods and services consumed by local residents regardless of the location of the emissions. This method of inventorying recognizes the impacts of consumption of services in an integrated, global economy and encourages reduced emissions through green-buying practices.

The Cool Climate Network at UC Berkeley, in conjunction with Bay Area Air Quality Management District (BAAQMD), created a CBI for all of the cities in the Bay Area. The model relies heavily on consumption levels being correlated with income. The City of San Leandro has a footprint of 1.4 million tons of CO_2e, well below the Bay Area average of 115 million tons of CO_2e. Nearly a third of these emissions are a result of transportation emissions. Gasoline-related emissions alone represent about a quarter of the entire CBI for San Leandro.

Average San Leandro Household, Consumption Based Emissions



39.3 MT CO_2e / year

Future Inventories and Next Steps

The City is committed to continued tracking of greenhouse gas emissions. Municipal inventories will be updated on a regular basis, while updates to citywide inventories (which rely on outside information more difficult to obtain) will continue to be conducted every five years. The City's transition to the ICLEI ClearPath platform will allow for more consistent tracking of greenhouse gas trends in future years. To translate the information contained in these inventories into action, the City and its partners continue to develop and execute policies intended to help mitigate greenhouse gas emissions. Overall, the 2015 Greenhouse Gas Emissions Inventory reveal a need to place emphasis on the City's efforts to reduce carbon emissions, especially in the transportation sector.

Transportation emissions within municipal operations can be addressed over the next few years by switching to renewable diesel for trucks and heavy equipment and electric vehicles (EVs) for certain city vehicles as fleet vehicles are replaced. To attain emissions reductions in the private use of vehicles and commercial trucks, the City can continue to promote the use of EVs but primarily must rely upon state- or utility-sponsored programs for fuel efficiency and fuel switching (converting from gasoline or regular diesel to electric, hydrogen, or renewable diesel fuels).

Certain energy efficiency projects (municipal LED streetlighting and efficient HVAC projects and community-wide residential energy upgrade incentive and DIY programs) outlined in the 2009 CAP were pursued with federal Energy Efficiency Community Block Grant (EECBG) funding in 2010-2012. However, after the Great Recession, overall coordination of climate action activities ceased and those federal programs were terminated when the EECBG funding ended in 2012. Mandatory measures that were proposed in the 2009 CAP to require residential or commercial energy conservation in local ordinances were not implemented. Again, state-wide regulations such as the CalGreen building code will be important elements in achieving energy efficiency in existing and new building projects.

In 2017, the City will complete a guaranteed energy savings project for streetlights, irrigation controls and building equipment as well as begin the design and installation of approximately 1 megawatt (MW) of solar photovoltaic at the Water Pollution Control Plant, a result of the award by the California Energy Commission of a $1.996M grant.

In the building and facilities sector, greener building codes will ensure that new construction is more energy efficient. The statewide energy benchmarking and disclosure program for large commercial buildings, mandated to begin in 2017 under AB 802, will help building owners, operators, and tenants better understand the opportunity to save energy and reduce carbon emissions in existing facilities. Finally, the overall electricity mix will become more weighted with renewables under the Community Choice Aggregation project, East Bay Community Energy. When combined with microgrid development, new renewable energy projects in San Leandro's private and public sector will contribute to decreased emissions in building energy use.

Appendix 1: General Inventory Methodology Guidelines

Local Government Operations Protocol

A national standard called the Local Government Operations Protocol (LGO Protocol) has been adopted by the California Air Resources Board (ARB) in conjunction with ICLEI, the California Climate Action Registry, and The Climate Registry. This standard provides accounting principles, boundaries, quantification methods and procedures for reporting greenhouse gas emissions from local government operations. The LGO Protocol provides the basis of ICLEI's ClearPath software's government track. This software allows local governments to compile data and perform emissions calculations with standardized methods.

Greenhouse Gases and Carbon Dioxide Equivalent

In accordance with LGO Protocol, this inventory includes all six greenhouse gases regulated under the Kyoto Protocol (CO_2, CH_4, N_2O, HFCs, PFCs, and SF_6). Emissions from various greenhouse gases are converted into a carbon dioxide equivalent (CO_2e) because different greenhouse gases have different half-lives and stronger or weaker impacts on the greenhouse effect. This conversion is made based on the global warming potential of each gas as determined by the IPCC's 4th Assessment Report. All reported CO_2e is in metric tons ($MTCO_2e$).

Calculating Emissions

There are two methods by which emissions are calculated. Measurement-based methods are direct measurements of greenhouse gas emissions from a monitored system. This includes emissions from a power plant, wastewater treatment plant, landfill, or other industrial facilities. This is the most accurate method of measuring emissions but is only available for a few, stationary sources.

The other method of calculating emissions is using a calculation-based method. This method estimates emissions based on activity data and emissions factors. The activity data (e.g. kilowatt hours of electricity consumed, therms of natural gas consumed, gallons of gasoline, etc.) is multiplied by the emissions factor (e.g. CO_2 emitted / kWH, CO2 emitted/therm, etc.) which determines the estimated amount of emitted emissions.

The Scopes Framework

This inventory follows the LGO Protocol differentiation of emissions by sector and by three different "scopes".

Scope 1 is direct emissions from sources with a government's operations that it owns and controls with the exception of biogenic sources of CO_2. This includes stationary combustion for heat, electricity, or power, the mobile combustion of fuels (e.g. cars or equipment), process emissions from physical or chemical processing, and any fugitive emissions resulting from processing, transmission, and storage of fuels and refrigerants.

Scope 2 is indirect emissions associated with consumption of purchased electricity, steam, heating, or cooling.

Scope 3 is all other emissions sources relevant to the local government that can be measured and reported. This includes indirect emissions not covered in Scope 2 that occur within the operational boundary of the local government. This includes (but is not limited to) emissions from employee commuting, employee business travel, and emissions from government-generated solid waste.

Organizational Boundaries:

The organizational boundary for an inventory determines which operations are included and which are not. Under the LGO Protocol, there are two approaches for determining an organization's boundaries: operational control or financial control. A government has operational control over an operation if it has full authority over policies that impact the operation. A government has financial control if the operation is fully consolidated in financial accounts. LGO Protocol encourages local governments to utilize operational control for organizational boundaries for greenhouse gas inventories. This represents sources that the government can directly influence and runs in parallel to other environmental programs and reporting requirements. For these reasons, this inventory was conducted with an operational control framework.

Types of Emissions:

Per the LGO Protocol, there are multiple types of greenhouse gas emissions:

- Stationary or mobile combustion emissions are emissions from on-site combustion of fuels (e.g. natural gas, diesel or gasoline) to generate heat, electricity, or to power mobile vehicles and equipment.
- Purchased electricity emissions are produced by the purchase of power generated by utilities outside the municipal jurisdiction (e.g. PG&E)
- Fugitive emissions are greenhouse gases that are unintentionally released into the atmosphere (e.g. methane from waste decomposition, refrigerant leaking, etc.).
- Process emissions are greenhouse gas emissions from the physical or chemical processing of materials (e.g. wastewater treatment).

Understanding Totals:

The totals and sub-totals listed throughout this report represent complete totals for San Leandro's operations as measured. However, these totals only represent inventoried emissions available for estimation or direct measurement methods. Each sector may have additional emissions sources that are unaccounted for and could not be estimated.

Appendix 2: Climate Change background

Climate Change Background

Naturally occurring gases dispersed in the atmosphere determine the Earth's climate by trapping solar radiation. This phenomenon is the greenhouse effect. Overwhelming scientific evidence shows that human activities are increasing the concentration of greenhouse gases and changing the global climate. The most significant contributor is the burning of fossil fuels for transportation, electricity generation and other purposes, which introduces large amounts of carbon dioxide and other greenhouse gases into the atmosphere. Collectively, these gases intensify the natural greenhouse effect, causing global average surface and lower atmospheric temperatures to rise.

Climate scientists expect changing temperatures to result in more frequent and damaging storms accompanied by flooding and landslides, summer water shortages due to reduced snow pack, and the disruption of ecosystems, habitats, and agricultural activities. Sea level rise will particularly hurt Bay communities such as San Leandro, with sewage, water, and transit infrastructure along the coast.

Reducing fossil fuel use in the community can have co-benefits in addition to reducing greenhouse gas emissions. Increasing energy efficiency decreases utility and transportation costs for residents and businesses. Retrofitting homes and businesses to be more efficient creates local jobs. In addition, money not spent on energy is more likely to be spent at local businesses and add to the local economy. Reducing fossil fuel use further improves air quality, helping to decrease rates of asthma, heart attacks, and other health complications. At the same time, increasing opportunities for walking and bicycling improves residents' health by increasing activity, mobility, and resource accessibility.

San Leandro Climate Hazard Assessment

Four Twenty Seven
Climate Solutions

May 22, 2017

Contents

1. Introduction

Changing climate conditions such as higher temperatures, more intense periods of rainfall, and sea level rise are expected to exacerbate existing challenges that California's cities and counties face as well as present new opportunities to bolster hazard mitigation and climate action efforts. State legislation seeks to promote the integration of climate change adaptation and resilience into local planning processes. *Assembly Bill No. 2140 General plans: safety element (Hancock)* enables local jurisdictions to adopt a local hazard mitigation plan with their Safety Element, facilitating integration of hazard mitigation into General Plans. *Senate Bill No. 379 Land Use: general plan: safety element (Jackson)* (SB 379) calls on local governments to incorporate adaptation and resilience strategies into Safety Elements of their General Plans as well as their local hazard mitigation plans. To support local governments' implementation of SB 379, the Governor's Office of Planning and Research recently issued draft guidelines for integrating climate considerations into Safety Elements. The draft guidelines build on the State's *Adaptation Planning Guide* (2012), emphasize the need for communities to adopt a longer-term perspective in preparing for climate risks, and highlight the importance of identifying linkages and complementarity across different elements of the General Plan as well as other relevant plans.

This climate change chapter was developed as part of an effort by StopWaste, Alameda County's waste authority, to assist seven of the County's cities[1], including the City of San Leandro, respond to SB 379 requirements and promote a consistent approach to incorporating adaptation and resilience into relevant local plans in Alameda County. The chapter's purpose is to describe projected changes in key climate hazards of concern for San Leandro and the citywide assets that these hazards are likely to affect as well as to present adaptation actions that the city may incorporate into relevant plans to address these hazards.

The content is intended to inform the city's efforts to incorporate climate hazards and adaptation strategies into its local hazard mitigation plan, General Plan Safety Element, and other relevant plans such as its climate action plan. In doing so, the content can also assist San Leandro in meeting requirements to position it for federal funding (e.g., Federal Emergency Management Agency (FEMA)) and to meet voluntary commitments (e.g., Compact of Mayors). However, the information in this document should be situated in the context of the City's other planning efforts and stakeholder inputs obtained through these other planning processes.

In the remainder of this section, we provide an overview of San Leandro. Section 2 presents the climate hazard analysis, which helps San Leandro answer the questions "What climate change effects will a community experience?" (exposure) and "What aspects of a community (people, structures, and functions) will be affected?" (sensitivity) identified in Steps 1 and 2 of the State's *Adaptation Planning Guide*[2]. The climate hazard analysis covers inland flooding, sea level rise, changes in temperature (including extreme heat) and precipitation, rainfall induced landslides, and wildfires, which align with the climate hazards prioritized in the Draft City of San Leandro 2015 Local Hazard Mitigation Plan. The analysis includes the probability of occurrence, extent of exposure, and assets affected by key climate

[1] The six participating cities are Albany, Emeryville, Fremont, Hayward, Livermore, Piedmont and San Leandro.
[2] This assessment focuses on the exposure of important assets to climate hazards of concern. Understanding vulnerability also requires an examination of the sensitivity of communities and functions as well as of adaptive capacity, which was outside the scope of this project, and for which the *Adaptation Planning Guide* describes a process.

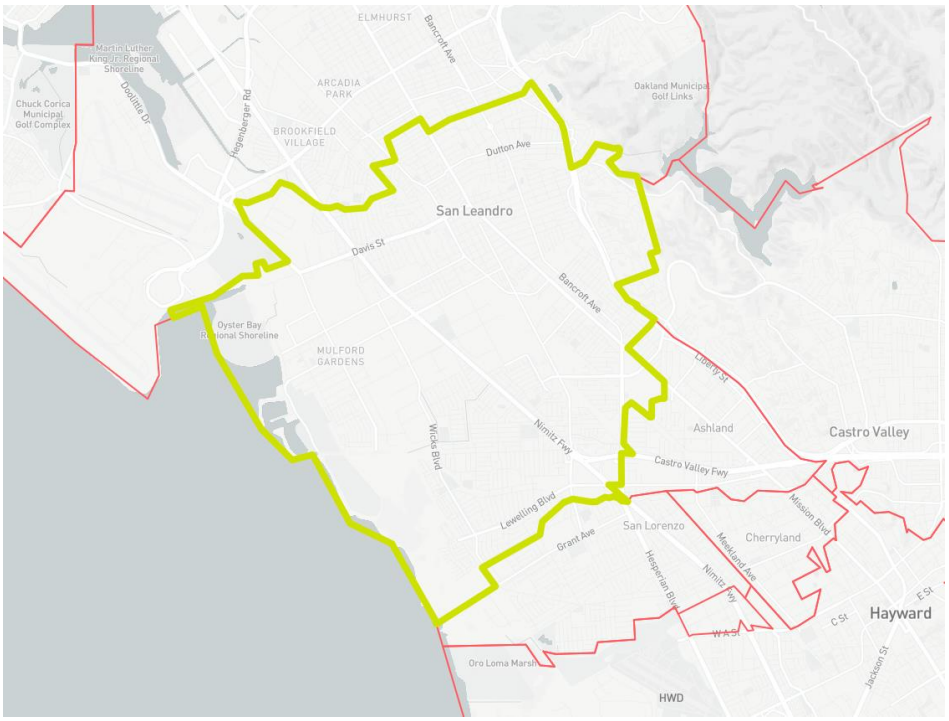
hazards in San Leandro. The methods used to assess the exposure of assets to the climate hazards as well as the data sources for each section are explained in Appendix A.

San Leandro, California will be affected by Climate Change

San Leandro is located on the shoreline of the San Francisco Bay and sits at an average elevation of 56 feet. Located between Oakland and Hayward with a population of about 88,000 people, it is highly urbanized, made up of residential properties with industrial and manufacturing uses in the west, mixed use areas in the southern portions of the city, and the downtown core to the northeast. Due to its geographic span from the Bay into the hills, San Leandro is susceptible to a variety of climate hazards. See Figure 1 for a map of San Leandro.

As a result, San Leandro will likely be most affected by the combination of sea level rise, high tides and flooding along the shoreline and throughout the southwest portion of the city, which threaten to limit mobility and damage amenities and industry that are important to San Leandro and the regional economy. However, the most severe impacts will be seen in the long-term, when projected temperature increases and the frequency of very hot days will impact a broader set of the city's assets and population, resulting in greater occurrence of heat related illness.

Figure 1. Map of San Leandro



2. Climate Hazards Analysis

According to the analysis conducted for this report, San Leandro's climate is projected to grow hotter and experience fluctuations in precipitation patterns throughout the remainder of the 21st century. The

climate hazards analysis also finds that rising sea levels threaten to inundate some of the city's critical sewer system and power line assets, facilities that use or contain hazardous materials, and shoreline neighborhoods by mid-century. Fortunately, San Leandro's core emergency response assets are located outside of the areas found to be exposed to projected rising sea levels. However, wildfire poses a substantial threat to the city, since a very high fire hazard severity zone is located just to the east of the city and increasingly dry, hot conditions may exacerbate wildfire risk. Figure 2 summarizes exposure to each of the hazards examined in this assessment.

Figure 2. Climate Hazards and Exposure

Climate Hazard	Exposure	Summary
Inland Flooding	High	Significant exposure during 100-year storm (1 percent annual chance) with increasing exposure and risk during 500-year storm (0.2 percent annual chance)
Wildfire	High	Some emergency assets located in high fire hazard severity zones or in close proximity to very high fire hazard severity zones
Sea Level Rise	Medium	Significant exposure likely by mid-century with a 5-year, or 20 percent annual chance, storm surge (a combination of permanent and temporary inundation equivalent to 36 inches of sea level rise)
Temperature Change	Medium	Increase in the number of extreme heat days
Rainfall-Induced Landslides	Medium	Important assets located in the few landslide hazard zones
Precipitation Change	Low	Limited change in overall rainfall

Inland Flooding

Climate change may increase flood risks in San Leandro

Many of San Leandro's citywide assets are vulnerable to flooding, including most notably Fire Station 13, Bayfair Center, the Bay Fair BART station, the Marina and parks along the shoreline, and the neighborhoods in southern San Leandro. This includes some essential emergency response, national shelter system and education assets. With more extreme precipitation events, the potential for more high intensity rainfall events may cause more frequent flooding of these and other assets. Flood events expected to have a 0.2 percent chance of occurring in a given year, or a 500-year recurrence interval,

based on historical information may occur more often under changing climate conditions.[3] These changing conditions would translate to a shift in the FEMA maps of the 100- and 500-year floodplains, and have considerable economic consequences for the city in the event of a flood. Flooding already poses significant financial challenges to cities by incurring structural repair, transportation delay and utility service interruption costs.[4]

San Leandro will potentially face more frequent, severe floods

Flood Insurance Rate Maps created by FEMA[5] were analyzed to identify exposed assets in the 100-year and 500-year floodplains. The 100-year floodplain includes land that has a one percent chance of flooding in a given year and therefore is expected to flood once every 100 years. The 500-year floodplain includes land that has a 0.2 percent chance of flooding in a given year. The flood maps are based on historical data and updated about every 10 years. Although they do not currently incorporate climate projections into the floodplain delineations, they provide an indication of where floodwaters are likely to concentrate, even if the probability of flooding changes with the climate.

Many citywide assets are exposed to flood risks

According to 2009 FEMA flood maps, San Leandro has many assets located in areas that have a one percent (Figures 3 and 4) and 0.2 percent (Figures 5 and 6) chance of flooding in a given year. Note that the citywide assets addressed in this report are limited to those available through open data sources and identified as important facilities by City staff. Important direct effects of inland flooding exist for other vital community assets such as business corridors, places of community assembly, and housing, but these are not necessarily all considered here.

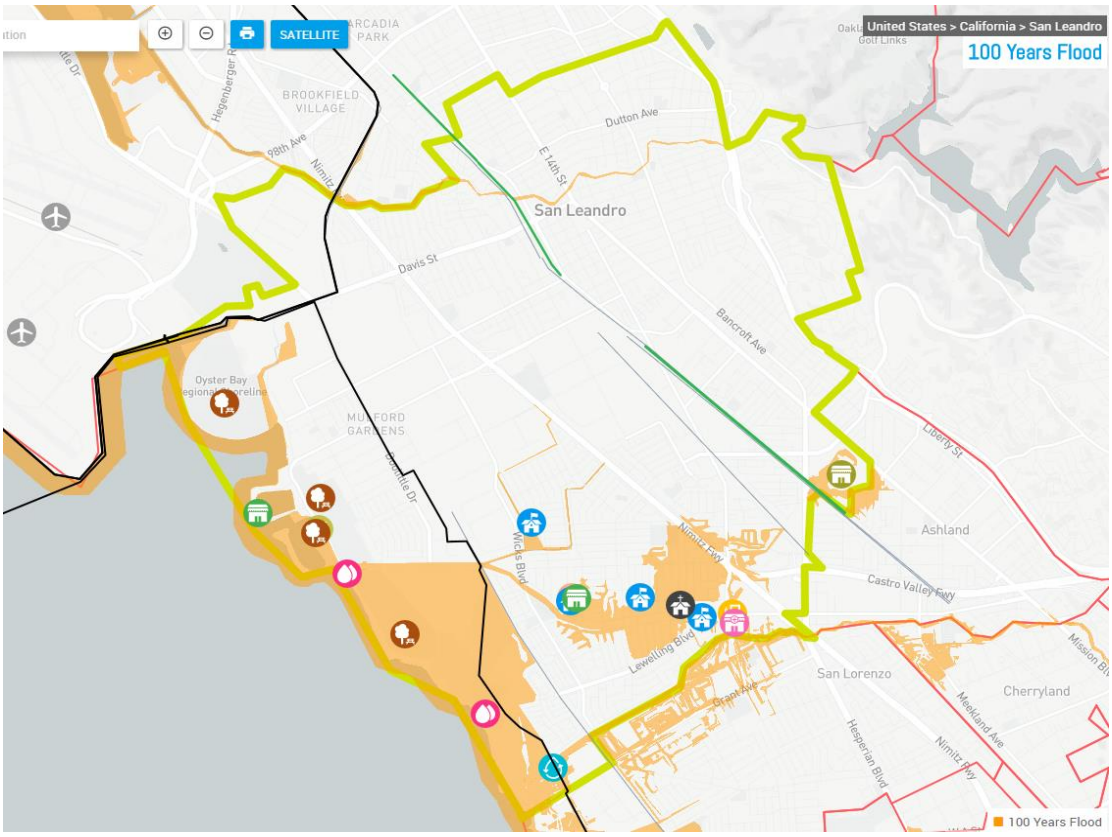
Areas that have a one percent chance of flooding in a given year include the shoreline and southern edge of the city up to Bayfair Center. Most critically, sewer and transportation assets are exposed. The Livermore-Amador Valley Water Management Agency (LAVWMA) Valve Box, Roberts Landing Stormwater Pump Station, and the Marina Dechlorination Facility are all in the floodplain. In addition, the area between the Bay Fair BART station and Hesperian Boulevard is flooded under these conditions, including the BART parking lot, nearby retail locations and portions of the Caltrans East Bay Region Maintenance Station. The railways running through the center of the city and along the shoreline all cross the floodplain, as does a Pacific Gas and Electric Company (PG&E) powerline that runs through the marshlands.

A number of community assets[6] in the southwest part of San Leandro also have a one percent chance of flooding in a given year, including Dayton Elementary School which serves as a National Shelter System facility, James Madison School, the southeast corner of Saint Felicitas School, Washington Manor Middle School, and Woodroe Woods School. The Chinese Christian Church and Burbank Preschool are also close to the floodplain, and the Christ Presbyterian Church and New Life Church are in the floodplain.

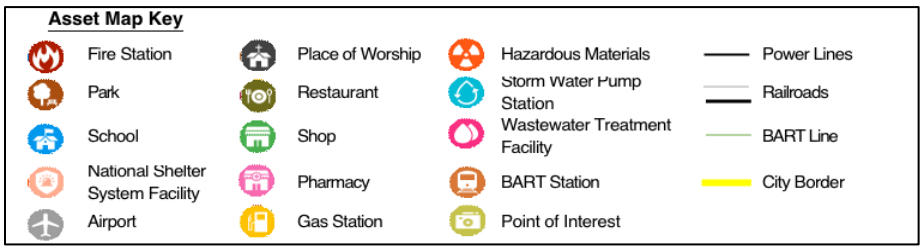
[3] Read, L. K., and R. M. Vogel. (2015). Reliability, Return Periods, and Risk under Nonstationarity. *Water Resources Research*, 51. doi:10.1002/2015WR017089.
[4] The Bay Area Council. (2015). *Surviving the Storm*. Accessed at: http://documents.bayareacouncil.org/survivingthestorm.pdf
[5] FEMA Flood Insurance Rate Map. (2009). 100 and 500-Year Floodplain. Alameda County. Effective August 3, 2009.
[6] Community assets include business corridors, places of community assembly, schools and neighborhoods that have value to the community but are not emergency assets or part of core infrastructure.

Other community assets with a one percent chance of flood exposure include the neighborhoods north of Lewelling Boulevard. Retail assets in this area include the pharmacy in the Walgreens on Washington Avenue and Lewelling Boulevard, the retail area between Washington Avenue and the I-880 freeway, and portions of the Bayfair Center Mall parking lot and north buildings. Parks in areas that have a one percent chance of flooding in a given year include the Tony Lema Golf Course and Marina Park. Flooding also affects Marina Golf Course and the Oyster Bay Regional Shoreline by inundating the area around the parks and possibly blocking access. See Figure 3 for a map of areas that have a one percent chance of flooding in a given year, and Figure 4 for a list of the key assets in areas with a one percent chance of flooding in a given year

Figure 3. San Leandro assets in areas that have a one percent chance of flooding in a given year



Notes: The area shaded in orange is the 100-year floodplain and has a one percent chance of flooding in a given year based on historical data. Source: Local asset data provided by San Leandro City staff, OpenStreet Map, Open Data and FEMA [7] as represented on Vizonomy.



[7] FEMA. Flood Insurance Rate Map. (2009). 100 Year Floodplain. Alameda County. Effective August 3, 2009.

Figure 4. List of Assets in areas that have a one percent chance of flooding in a given year

Asset Type	Impact	Number of Assets
National Shelter System Facilities	H	1
BART Line	H	1
Railroads	H	7
Waste Water Facilities	H	2
Stormwater Pump Stations	H	1
Airports	M	1
Marina	M	1
Power Lines	M	3
Schools	M	5
Places of Worship	M	1
Pharmacies	L	1
Shops	L	4
Parks	L	4
Non-Residential Buildings	L	9
Roads	L	265

Notes: Exposed asset types and estimated level of impact. The "impact" ranking is based on a high, medium, low scale. High - Critical resources during a disaster or assets that could lead to immediate secondary hazards if damaged. Medium – Important assets or those that could lead to secondary hazards if damaged. Low – Assets that will not compound hazard effects or that do not house critical resources during an emergency. This distinction is based upon reasonable judgement and should be scrutinized by local officials for accuracy. Source of asset count: Local Asset Data provided by San Leandro City staff, OpenStreet Maps, Open Data, FEMA[8] *as represented on Vizonomy.*

Exposed core assets in areas that have a 0.2 percent chance of flooding in a given year include Alameda County Fire Department Station 13 and the Bay Fair BART station. Increased flooding at Bayfair Center inundates the bus stations there, the ARCO gas station and the rail assets in the area. The Caltrans East Bay Region Maintenance Station is also affected, as are sewer assets Line D-1 and Line F. Three industrial sites that store hazardous materials, owned by the Coca Cola Bottling Company of California, XLC Corp and Foamex Innovations Operating Company are in the floodplain as well.

Exposed community assets include James Madison Elementary School - a National Shelter System facility - the Walgreens Pharmacy and Safeway on Washington Avenue, the International Christian School and the Hilton Garden Inn. On the waterfront, these assets include the Marina Golf Course, Marina Park, Marina Inn and Horatio's Restaurant. Figure 5 illustrates the core assets in areas with a 0.2 percent chance of flooding, and Figure 6 lists the key assets in areas with a one and 0.2 percent chance of flooding in a given year.

In addition to the assets in the FEMA flood maps, increased or higher intensity flooding due to climate change and/or high intensity storms could place strain on dams at the Lake Chabot or Upper San Leandro Reservoirs. Although unlikely, dam failure in either location would flood most of San Leandro

[8] FEMA Flood Insurance Rate Map. (2009). 100 and 500-Year Floodplain. Alameda County. Effective August 3, 2009.

and cause catastrophic damage.[9] Dam failure inundation maps pursuant to California Code Section 8589.5 are available from the Office of Emergency Services[10]. Although the dams are being seismically strengthened and are outside the FEMA designated floodplain, it may be pertinent for San Leandro to maintain a catastrophic emergency response plan for these conditions.

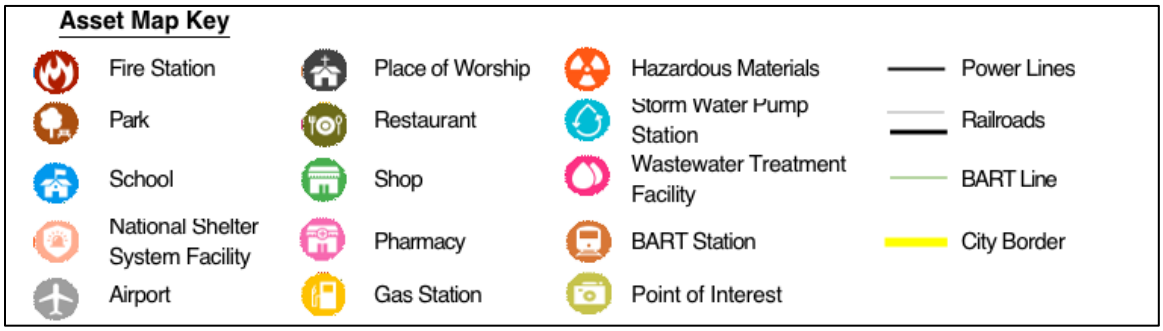
Even in a less catastrophic scenario, the considerable number of assets in areas with a one and 0.2 percent chance of flooding in San Leandro make flooding a noteworthy threat to the city. Economically, floods are costly. In addition to structural and contents damages caused by flood waters, the cost of transportation delays, utility service outages and lost economic activity can be significant.[11] City-wide preparedness can help minimize these impacts and even benefit public health, as flooding and the presence of standing water not only limit mobility by obstructing roads and disrupting utility service, but also increase the chance of public exposure to water-borne pathogens, toxic algae or chemicals that enter the water from spills.[12]

As sea level rise encroaches on the marshlands that help protect the city from coastal floods, it will become increasingly essential to minimize the contribution of land use change, site design and impervious cover to water runoff, which may cause flooding to affect a wider area and occur more frequently than historical records indicate. Exposed emergency and transportation assets such as Fire Station 13 and the Bay Fair BART Station will be critical to account for in future planning.

[9] Draft City of San Leandro 2015 Local Hazard Mitigation Plan.
[10] These maps have not been updated since the 1970s.
[11] The Bay Area Council. (2015). *Surviving the Storm*. Accessed at: http://documents.bayareacouncil.org/survivingthestorm.pdf
[12] U.S. Global Change Research Program (USGCRP). (2016). *Impacts of Climate Change on Human Health in the United States: A Scientific Assessment*. dx.doi.org/10.7930/J0R49NQX

Figure 5. San Leandro Assets in areas that have a 0.2 percent chance of flooding in a given year

Notes: The area shaded in orange is the 100-year floodplain and has a one percent chance of flooding in a given year based on historical data. The area shaded in red is the 500-year floodplain and has a 0.2 percent chance of flooding in a given year based on historical data. Source: Local asset data provided by San Leandro City staff, OpenStreet Map, Open Data and FEMA [13] as represented on Vizonomy.



[13] FEMA. Flood Insurance Rate Map. (2009). 100 Year Floodplain. Alameda County. Effective August 3, 2009.

Figure 6. List of Assets in areas that have a 0.2 percent chance of flooding in a given year

Asset Type	Impact	Number of Assets
Fire Station	H	1
Bayfair BART Station	H	1
BART Line	H	1
Railroads	H	8
Stormwater Pump Stations	H	2
Airports	M	1
Marina	M	1
Hazardous Materials Sites	M	4
Power Lines	M	2
Schools	M	2
Gas Stations	L	1
Pharmacies	L	1
Restaurants	L	1
Shops	L	2
Parks	L	3
Non-Residential Buildings	L	16
Roads	L	222

Notes: See Figure 4 for an explanation of the asset impact ranking. The asset count for areas that have a 0.2 percent chance of flooding in a given year does not include the assets areas that have a one percent chance of flooding in a given year. Source of asset count: Local asset data provided by San Leandro City staff, OpenStreet Maps, Open Data and FEMA[14] as represented on Vizonomy.

Sea Level Rise

San Leandro will experience sea level rise due to climate change

Sea levels are rising as a result of higher atmospheric and oceanic temperatures across the globe. The rate of sea level rise is expected to accelerate throughout the century, threatening coastal resources, but projections are complicated by the potential for a substantial acceleration of glacial ice melt, which is not currently accounted for in many global scenarios and may result in rapid sea level rise.[15]

The Bay Area is especially exposed to the impacts of sea level rise because of the large number of assets located on the coast that are significant to the local economy and communities. In San Leandro, the assets most at risk from sea level rise include transportation assets, powerlines and cultural amenities along the shoreline as well as the neighborhoods, parks and schools in the southwest portion of the city. While the downtown core and area surrounding the San Leandro BART station remain outside of the projected boundaries of sea level rise, the compounding effects of sea level rise could impede access to the city via I-880 and significantly impact San Leandro residents that live west of this freeway.

[14] FEMA. Flood Insurance Rate Map. (2009). 100 and 500-Year Floodplain. Alameda County. Effective August 3, 2009.
[15] M. K. Buchanan, R. E. Kopp, M. Oppenheimer, and C. Tebaldi. (2016). Allowances for evolving coastal flood risk under uncertain local sea-level rise. *Climatic Change* 137, 347-362. doi:10.1007/s10584-016-1664-7.

Sea level rise is a certainty

Sea level rise is occurring and is expected to accelerate throughout the 21st century. However, it is uncertain how much and how quickly sea levels will rise in the Bay Area. Considered the best available science, the National Research Council (NRC) identified likely sea level rise estimates for the west coast of the United States.[16] These values are accompanied by ranges of possible sea levels based on low and high emissions scenarios and ice melt scenarios. Figure 7 summarizes these projections: six inches of sea level rise by 2030 (range: 2-12 in), 11 inches by 2050 (range: 5-24 in), and 36 inches by 2100 (range: 17-66 in) relative to the year 2000.

Figure 7. Sea Level Rise Estimates Relative to the Year 2000

Year	Projections	Ranges
2030	6 ± 2 in	2 to 12 in
2050	11 ± 4 in*	5 to 24 in
2100	36 ± 10 in	17 to 66 in

Source: NRC, 2012. [17]

These projections characterize the estimated timeline for permanent increases in water levels. However, the conditions may occur sooner on a temporary basis under a number of different circumstances given the combination of permanent sea level rise and temporary extreme tides resulting from the additive impact of high tides and storm surge. For example, water levels could reach the equivalent of 48 inches of inundation by 2050 in the event of a 50-year storm, or a storm that has a two percent chance of occurring in a given year, even though that level of sea level rise is not projected to occur by the end of the century (See Appendix A, Figure A2).

In the 2035 General Plan, the City of San Leandro adopted a sea level rise scenario of 55 inches by 2100[18] according to conservative estimates in the San Francisco Bay Conservation and Development Commission (BCDC) report *Living with a Rising Bay*.[19] City planning and projects in San Leandro will work to account for the threats posed by this estimate of sea level rise over the remainder of the century. In order to provide a wider lens to evaluate near and long term sea level rise relative to the established planning horizon of 55 inches, this climate hazard assessment explores the exposure of assets to sea level rise of 12 to 96 inches as presented in the *Adapting to Rising Tides: Alameda County Shoreline Vulnerability Assessment,* which was conducted as part of a related effort by BCDC and provides more localized sea level rise projections.[20] See Appendix A for further information on the data used in this analysis.

[16] National Research Council. (2012). *Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present, and Future*. Report. DOI: 10.17226/13389
[17] National Research Council. (2012).
[18] City of San Leandro. (2016). San Leandro 2035 General Plan. Adopted September 19, 2016.
[19] San Francisco Bay Conservation and Development Commission (BCDC). (2011). *Living with a Rising Bay: Vulnerability and Adaptation in San Francisco Bay and on its Shoreline*.
[20] Alameda County Flood Control and Water Conservation District and the San Francisco Bay Conservation and Development Commission (BCDC). (2015). *Adapting to Rising Tides: Alameda County Shoreline Vulnerability Assessment Final Report*.

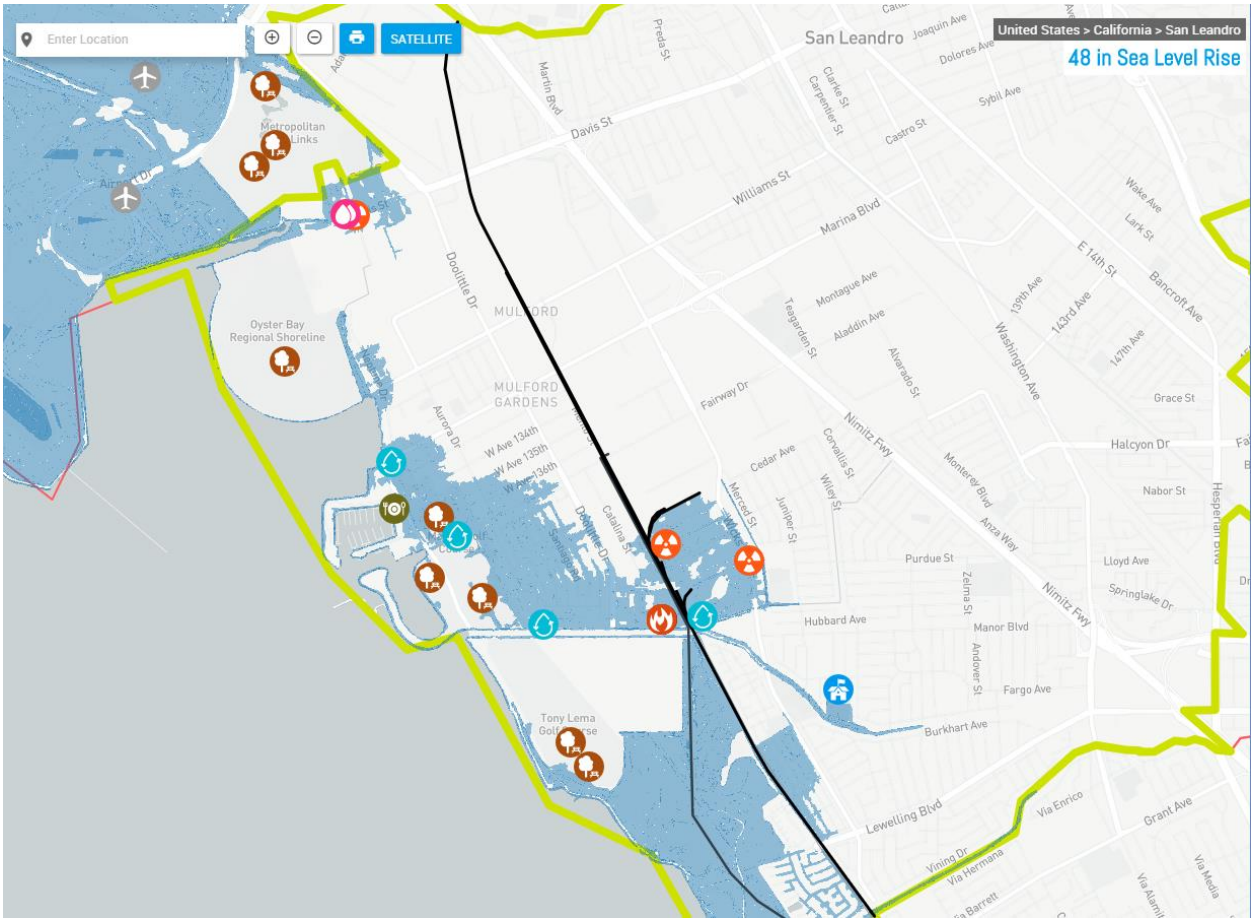
Sea level rise will mean floods affect more assets over time

Sea level rise associated flooding will first affect marshlands and eventually threaten property and assets in southwest San Leandro, reaching the neighborhoods east of Wicks Boulevard in some areas. By mid-century, about 12 inches of sea level rise is projected to permanently inundate the marshlands, eroding the southern portion of the city's defense to storm surge and high tides. Assets flooded under these conditions include a powerline that runs through marshlands and the coastal boundaries of the city's shoreline parks. As water levels reach 24 inches, which is possible as soon as 2030 with a two-year extreme tide, the Union Pacific Railroad along the coast may experience flooding. At this level, water begins to encroach on the Oyster Bay Regional Shoreline, and creep up the Estudillo Channel and the edges of Marina Park, Marina Golf Course, and Tony Lema Golf Course.

At 36 inches of sea level rise, water begins to flood into the neighborhoods between Wicks Boulevard and the railroad, and affects the Wicks Boulevard bridge where it crosses the Estudillo Channel. At this height, water levels reach the San Leandro Water Pollution Control Plant. These assets could be temporarily inundated by a five-year recurrence interval storm by mid-century and will potentially be permanently inundated by the end of the century. Although the Port of Oakland plans to raise levees in the area, which will increase protections along the southern border of the Water Pollution Control Plant and decrease projected flooding, some of the plant will remain exposed to rising sea levels.

The consequences of sea level rise escalate quickly once water levels reach 48 inches, likely by the end of the century when combined with average yearly storm surge. At this level of inundation, Alameda County Fire Department Station 11 is exposed, as is more of the San Leandro Water Pollution Control Plant. Other sewer assets are exposed as well, namely, Line D-1, Belvedere, Line F, Line H, and the San Leandro Effluent Pump Station on Davis Street. These assets support sewer function and their proper functioning is critical to protect public health throughout San Leandro. Dayton Elementary School, which serves as a national shelter system facility, and three industrial facilities with hazardous materials onsite, owned by Davis Street Smart, US Printing Ink Corporation, and the Coca Cola Bottling Plant of California respectively are also at risk. There is also an increase in exposed power line and rail assets that could negatively affect commerce and the availability of resources and electricity in the city. See Figure 8 (on following page) for a map of areas inundated by 48 inches of sea level rise.

Figure 8. San Leandro Assets Exposed to 48 Inches of Sea Level Rise



Notes: The area shaded in blue indicates the area inundated by 48inches of sea level rise. Source: Local asset data *provided by San Leandro City staff, OpenStreet Maps, Open Data, and Alameda County Flood Control and Water Conservation District and BCDC [21] as represented on Vizonomy.*

In the worst-case scenario, with predicted end-of-century sea level rise compounded by glacial melting and/or seasonal King tides and storm surge, there is the possibility that the Bay Area may experience sea

[21] Alameda County Flood Control and Water Conservation District and BCDC. (2015). *Adapting to Rising Tides: Alameda County Shoreline Vulnerability Assessment Final Report*.

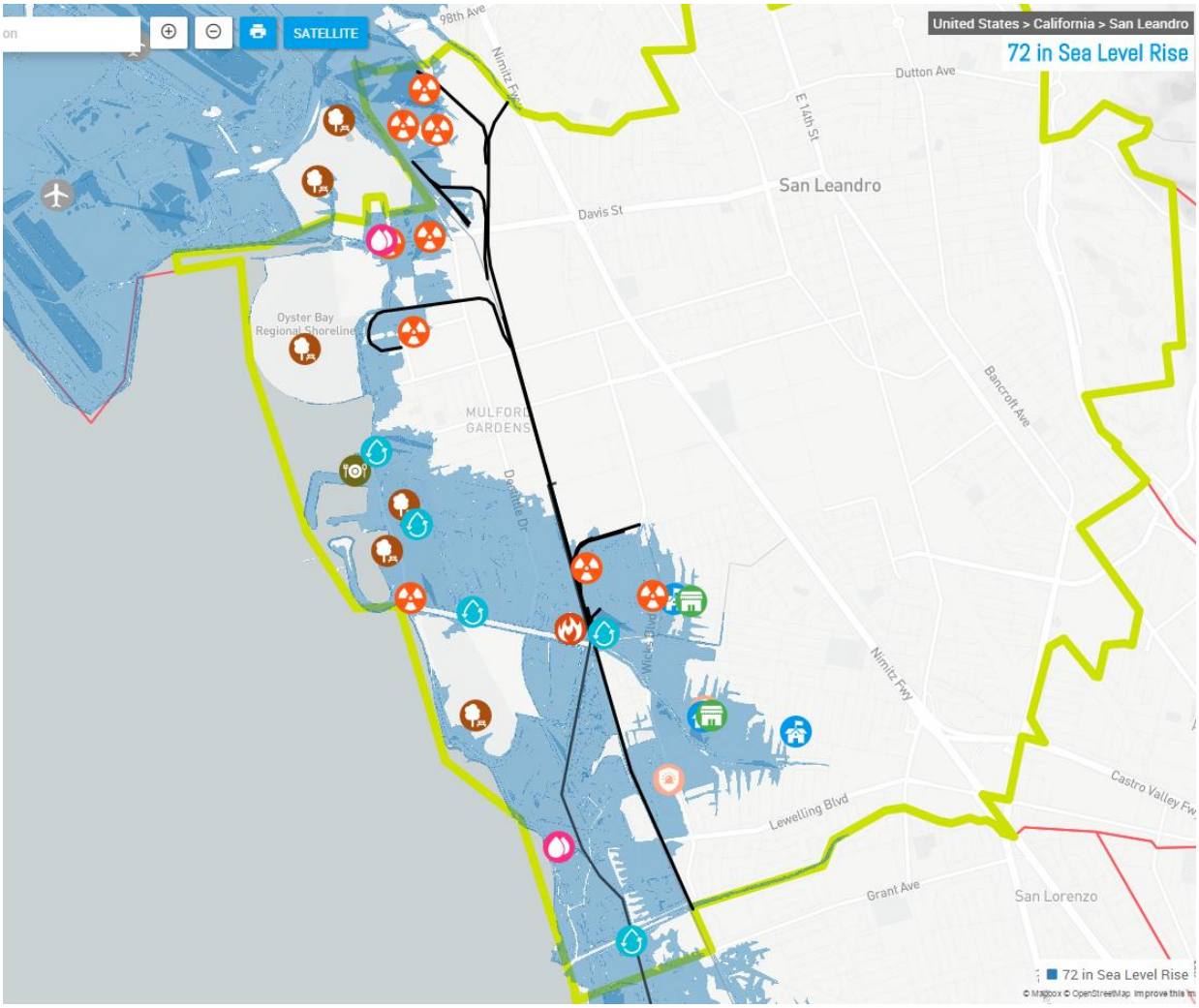
level rise related flooding of up to 72 inches or more. See Figure 9 for a map of areas inundated by 72 inches of sea level rise, and Figure 10 for a list of key exposed assets under different levels of sea level rise. At 72 inches, the Marina and neighborhoods east of it are completely inundated. This includes Mulford Gardens and Marina Faire neighborhoods, as projected flooding reaches most of the area west of the railroad and extends out into the neighborhoods east of the railroad and south of Fairway Drive. Exposed assets include two non-emergency ambulance facilities located on Wicks Boulevard, Washington Manor Middle School, James Madison Elementary School, St. Felicitas School, and the Marina Community Center, which also serves as a National Shelter Service facility.

To the north, additional flooding occurs behind the Oyster Bay Regional Shoreline. Ten facilities that use or contain hazardous materials onsite are inundated at this magnitude of sea level rise throughout the city, with five facilities clustered inland of the Oyster Bay Regional Shoreline and the Oakland Metropolitan Golf Links. These include the Davis Street Smart, Copper Harbor Company, Foamex Innovations Operating Company, Safeway Milk Plant, Benkiser Electric, Cast Aluminum and Brass Corporation, and the Wyman Gordon Company properties. To the south, the East Bay Dischargers Authority Joint Outfall and facilities owned by the US Printing Ink Corporation, Coca Cola Bottling Company of California are also exposed.

By 96 inches, flooding creeps further into the neighborhood south of Cedar Avenue and west of the I-880 by another two or three blocks. While few additional critical assets are immediately impacted as water levels rise above 72 inches, the number of people affected will continue to increase significantly.

Overall, the potential impacts to the sewer system and the number of schools threatened by sea level rise flooding will increase threats to public health from sewer overflows and backups, mold and rust, limit the number of community resources available to use as shelters, and threaten vulnerable neighborhoods in the southwest regions of the city. In addition, as water levels encroach on shoreline amenities along the Bay and into the industrial and manufacturing areas slightly inland, many of the resources that the city depends on to thrive economically may be challenged and forced to close or relocate outside the city. Appropriate planning and adaptive measures focused on mitigating these impacts will be essential for the City of San Leandro.

Figure 9. San Leandro Assets Exposed to 72 Inches of Sea Level Rise



Notes: The area shaded in blue indicates the area inundated by 72 inches of sea level rise. Source: Local asset data provided by San Leandro City staff, OpenStreet Maps, Open Data, and Alameda County Flood Control and Water Conservation District and BCDC [22] as represented on Vizonomy.

[22] Alameda County Flood Control and Water Conservation District and BCDC. (2015). *Adapting to Rising Tides: Alameda County Shoreline Vulnerability Assessment Final Report*.

Figure 10. List of Assets Exposed to Sea Level Rise

Asset Type	Impact	12in	24in	36 in	48 in	72 in	96 in
Fire Station	H				1	1	1
National Shelter System Facilities	H					2	3
Water Pollution Control Plant	H			1	1	1	1
Waste Water Facilities	H			1	1	2	3
Stormwater Pump Stations	H				4	5	5
Ambulence Services	H					2	2
Railroads	H	2	4	4	1	19	25
Airports	M	1	1	1	1	1	1
Marina	M	1	1	1	1	1	1
Hazardous Materials Sites	M			1	3	10	10
Power Lines	M	1	1	1	1	2	2
Schools	M				1	4	5
Places of Worship	M						1
Libraries	L				1	1	1
Gas Stations	L					1	2
Restaurants	L				1	2	3
Parks	L	2	3	3	4	5	5
Non-Residential Buildings	L	1	1	1	3	6	9
Roads	L	19	25	46	179	357	490

Notes: See Figure 4 for an explanation of the asset impact ranking. The asset counts for increasing levels of sea level rise are cumulative. Source of asset count: Local asset data provided by San Leandro City staff, OpenStreet Maps, Open Data, FEMA,[23] and Alameda County Flood Control and Water Conservation District and BCDC [24] as represented on Vizonomy.

Temperature Changes and Precipitation Events

Climate Change may increase temperatures in San Leandro, but impacts on rainfall are unclear

As greenhouse gas emissions increase, temperatures are expected to warm globally. San Leandro's climate is no exception and temperatures are projected to increase throughout the city with the number of days over 90 ˚F increasing from a model history baseline average[25] of less than once a year to 11 days per year by the end of century[26]. The impact of climate change on precipitation is more ambiguous, and

[23] FEMA Flood Insurance Rate Map. 2009. 100 and 500-Year Floodplain. Alameda County.
[24] Alameda County Flood Control and Water Conservation District and BCDC. (2015). *Adapting to Rising Tides: Alameda County Shoreline Vulnerability Assessment Final Report*.
[25] The climate model history is intended to capture climate conditions experienced from 1970-2000, but not to predict the weather conditions on any given day, month, or year. For this baseline period, the climate models were run with an emissions scenario representative of the observed history from those past years but with the same physics and configurations as in future-year runs. This enables comparison of like historical and future model data to better establish the magnitude of likely future changes. This climate modeled history is referred to here as the historical baseline.
[26] Reclamation. (2013). 'Downscaled CMIP3 and CMIP5 Climate and Hydrology Projections: Release of Downscaled CMIP5 Climate Projections, Comparison with preceding Information, and Summary of User Needs', prepared by the U.S. Department of the Interior, Bureau of Reclamation, Technical Services Center, Denver, Colorado.

although precipitation patterns are expected to become more variable, projections of annual totals show no clear signal of significant directional change.

San Leandro may experience higher average daily temperatures and more extreme heat days

Temperature and precipitation projections were provided by Four Twenty Seven using scenarios from the Intergovernmental Panel on Climate Change (IPCC). The Representative Concentration Pathway (RCP) 8.5 is characterized by a minimal greenhouse gas mitigation effort and high emissions scenario, resulting in the largest increase in radiative forcing and warming, while RCP 4.5 is considered a moderate mitigation scenario where climate action limits the amount of global emissions.[27] Future temperature rise scenarios vary based on which government policies and commercial and human actions are actually implemented in the coming years and how well these climate change mitigation efforts work cumulatively. While, temperatures in San Leandro are projected to increase under both scenarios, daily average temperatures are projected to increase by about twice as much under the RCP 8.5 (high emissions) scenario than under the RCP 4.5 (lower emissions) scenario by the end of the century. (RCP 8.5 leads to a 6.9 to 8.8 ˚F increase in daily average temperature, compared to 3.2 to 4.9 ˚F increase under RCP 4.5.)

Temperatures in San Leandro may be two to four degrees higher

According to the model baseline (1970-2000), San Leandro's climate has been characterized by a daily average temperature of about 58.6 ˚F, an average maximum temperature of 67 ˚F, and an average minimum temperature of 50.2 ˚F.[28] Temperature projections exhibit a clear trend toward warmer average temperatures and more frequent occurrence of high or even extreme temperature events. Under RCP 8.5 (a high emissions scenario), daily average temperatures are projected to increase from the model baseline by as much as 2.5 ˚F to 3.5 ˚F, daily minimum temperatures by about 2.5 ˚F to 3.5 ˚F, and daily maximum temperatures by about 2.5 ˚F to 4 ˚F between now and mid-century. Even under RCP 4.5 (a lower emissions scenario), temperature increases are anticipated, and projections range between an average daily increase of as much as 2.5 ˚F and 3.5 ˚F by mid-century. By the end of the century, temperature changes are estimated to be substantial, for daily average, minimum, and maximum temperatures with the high-end of the range of RCP 8.5 temperature increase projections suggesting increases from about 7 ˚F to 9 ˚F.[29] This means that San Leandro's average maximum temperature would be comparable to current levels in San Luis Obispo, California. These projections do not indicate seasonal fluctuations, but yearly averages.

The greatest potential impact of temperature increases lies in the relative increase in the severity of extreme heat and the frequency of hot days. According to the modelled historical baseline of San Leandro's climate, the occurrence of temperatures exceeding 90 ˚F is rare.[30] The average number of days over 90 ˚F is projected to rise significantly after mid-century. Under RCP 4.5, 90 ˚F days in San Leandro are projected to double by mid-century, with a threefold increase under RCP 8.5 over the same period.

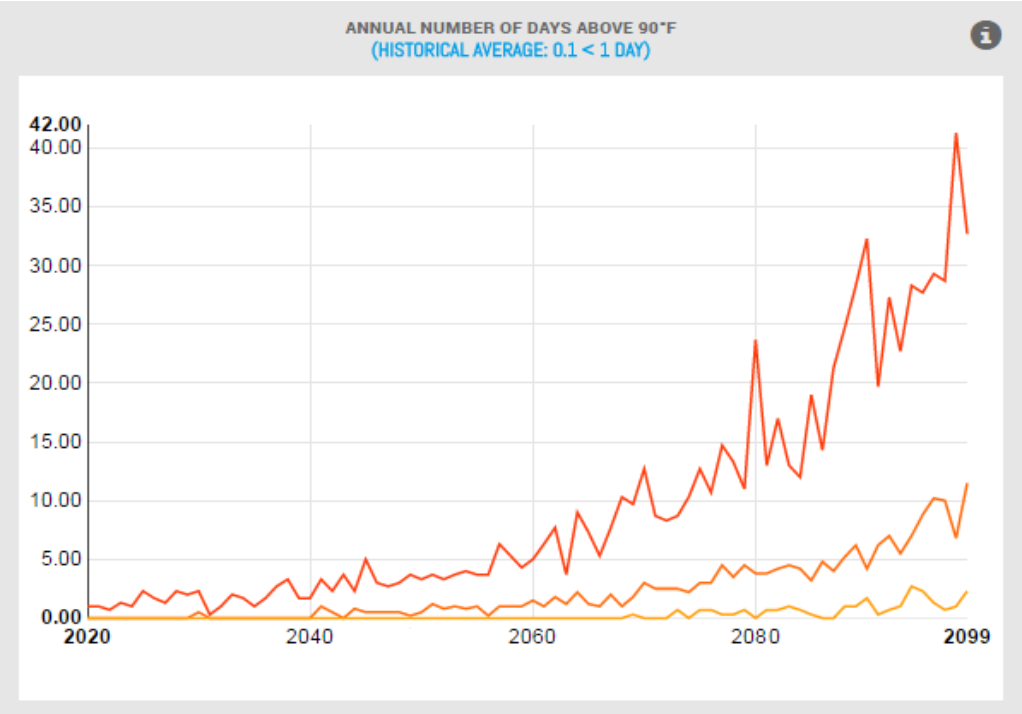
---

[27] IPCC. (2014). Scenario Process for AR5. Accessed at: http://sedac.ipcc-data.org/ddc/ar5_scenario_process/RCPs.html
[28] Reclamation. (2013).
[29] Reclamation. (2013).
[30] Reclamation. (2013). 'Downscaled CMIP3 and CMIP5 Climate and Hydrology Projections: Release of Downscaled CMIP5 Climate Projections, Comparison with preceding Information, and Summary of User Needs', prepared by the U.S. Department of the Interior, Bureau of Reclamation, Technical Services Center, Denver, Colorado.

By century's end, the increase in the number of days per year above the 90 °F mark could reach fivefold under RCP 4.5, but be as much as 41 times higher in a business-as-usual scenario. However, mid-range RCP 8.5 projections indicate the number of days may be closer to 11 times higher (see Figure 11).[31]

Higher temperatures will likely increase the magnitude of heat hazards in the city, for instance, heat stroke or exhaustion among local residents, workers and visitors, or raised demand for power during peak periods which could affect the frequency of outages. Since San Leandro residents are unlikely to have air conditioning units in their homes,[32] residents, especially the elderly, disabled or socially isolated, will be more vulnerable to extreme heat events.[33] These high temperatures and the associated hazards may be exaggerated by local conditions, such as the urban heat island effect, where buildings and pavement absorb heat during the day and then radiate that heat at night, limiting nighttime cooling and amplifying daytime high temperatures.[34]

Figure 11. Projected Extreme Heat Days in San Leandro



Notes: RCP 8.5 projected annual number of days above 90 °F throughout the 21st century. Lines represent low-end (light orange), mid-range (dark orange) and high-end (red) model results. Source: Reclamation[35] as represented on Vizonomy.

[31] Reclamation. (2013).
[32] Pacific Institute. (2012). Social Vulnerability Index. Percent of Households without Air Conditioning. Accessed at: http://pacinst.org/publication/study-maps-social-vulnerability-to-climate-change-in-california-and-identifies-need-for-adaptation-planning/
[33] USGCRP. (2016). *Impacts of Climate Change on Human Health in the United States: A Scientific Assessment*. dx.doi.org/10.7930/J0R49NQX
[34] USGCRP. (2016).
[35] Reclamation. (2013). 'Downscaled CMIP3 and CMIP5 Climate and Hydrology Projections: Release of Downscaled CMIP5 Climate Projections, Comparison with preceding Information, and Summary of User Needs', prepared by the U.S. Department of the Interior, Bureau of Reclamation, Technical Services Center, Denver, Colorado.

According to the historical baseline (1970-2000), San Leandro's climate trends suggest that temperatures drop below freezing on average two days per year. Based on climate scenarios, the number of very cold days is expected to decrease and minimum temperatures gradually to rise. Under RCP 8.5, mid-range projections show no days below freezing after 2035 and even the high-range scenario drops to zero days per year by 2095. Even under RCP 4.5, it would be unlikely for San Leandro to experience a day below 32 °F after 2064.[36]

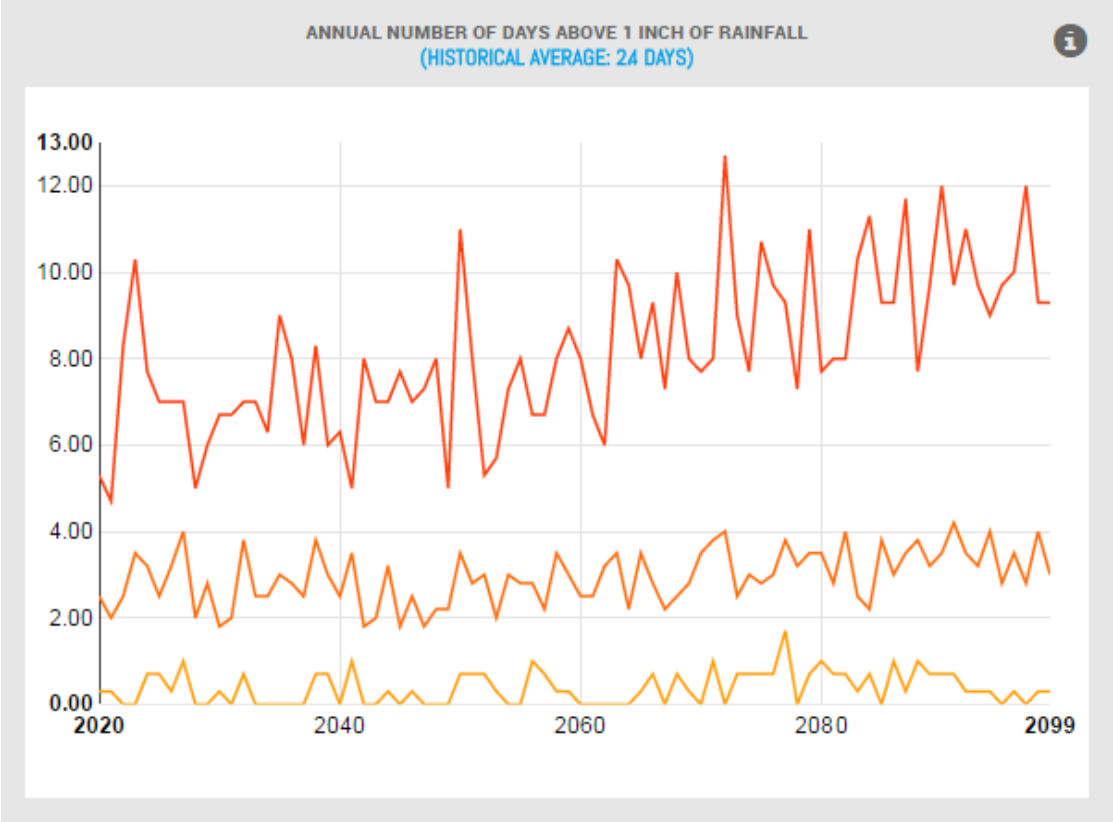
The impacts of climate change on rainfall are ambiguous

During the model baseline period of 1970-2000, San Leandro's typical climate conditions resulted in approximately 18 inches of rainfall per year. By mid-century, under RCP 8.5 (a high emissions scenario), the percent change in total precipitation varies widely between a decrease of 19.6 percent and an increase of 35.8 percent, indicating that no clear directional change in cumulative precipitation volumes is expected by the end of the century. Under both RCP 8.5 and 4.5, mid-range projections of maximum five-day precipitation totals estimate an increase in rainfall of only 15 percent by the end of the century.[37] Thus, annual precipitation totals may remain analogous to present conditions in all but the high-end model projections. Figure 12 depicts the projected occurrence of heavy rainfall events in San Leandro between 2020 and 2099.

These extreme rainfall event projections may not account for rare, but increasingly intense events such as atmospheric rivers (i.e., Pineapple Express). [38] Studies using computational models suggest that climate change will cause the most intense atmospheric river storms hitting California to become more frequent and last longer by the end of the century.[39]

[36] Reclamation. (2013).
[37] Reclamation. (2013). 'Downscaled CMIP3 and CMIP5 Climate and Hydrology Projections: Release of Downscaled CMIP5 Climate Projections, Comparison with preceding Information, and Summary of User Needs', prepared by the U.S. Department of the Interior, Bureau of Reclamation, Technical Services Center, Denver, Colorado.
[38] Shields, C. A., and J. T. Kiehl. (2016). Simulating the Pineapple Express in the half degree Community Climate System Model, CCSM4, *Geophysical Research*. Letters, 43, 7767–7773, doi: 10.1002/2016GL069476
[39] Shields, C. A., and J. T. Kiehl. (2016).

Figure 12. Projected Occurrence of Heavy Rainfall Events in San Leandro



Notes: RCP 8.5 projected percent changes in heavy precipitation throughout the 21st century. Lines represent low-end (light orange), mid-range (dark orange) and high-end (red) model results. Source: Reclamation[40] as represented on Vizonomy.

Rainfall Induced Landslides

Areas where landslides have already occurred are at greatest risk

Landslides are considered to be most likely to occur in and around the places where they have previously taken place. Wildfire and high-intensity rainfall events, both anticipated to occur with greater frequency due to climate change, increase the risk of inland flooding.[41] Secondary impacts associated with flooding include landslides, subsidence, slippage, creep or sinkholes. Cities with hilly terrain can experience increased risk of these events. Due to San Leandro's location and topography, there is a medium risk of experiencing landslides in the hills to the east.

[40] Reclamation. (2013).
[41] USGS. (2005). "Southern California – Wildfires and Debris Flows" Fact Sheet 2005–3106.

San Leandro is at a medium risk for landslides

As defined by the United States Geological Survey (USGS),[42] most of the city of San Leandro is in a zone that experiences "very few landslides." However, Bay-O-Vista, a neighborhood located east of I-580, has experienced recent landslides, and Lake Chabot Road and the area near Kindred Hospital are also vulnerable to instability. While these assets are located in a USGS zone designated as experiencing "few landslides" the consequences of a potential landslide affecting the hospital and surrounding neighborhoods makes this area a concern for hazard mitigation and response as climate conditions and flood risks change.

Wildfires

Climate change may increase wildfire risk

Extreme temperatures and increased variability in rainfall will likely cause dry conditions in California, exacerbating the risk of wildfire throughout the state. Large areas east of the I-580 freeway and throughout the hills adjacent to San Leandro are at risk of high to very high hazard severity in the event of a wildfire. This includes areas with increased exposure along the eastern edge of the city where San Leandro borders Lake Chabot Regional Park, which is designated as a very high hazard severity zone. While these zones do not affect the city's key emergency response or transportation assets, a couple of regional hospital facilities are exposed which may challenge the city's contracted fire agency's, the Alameda County Fire Department, capacity to respond to wildfire impacts.

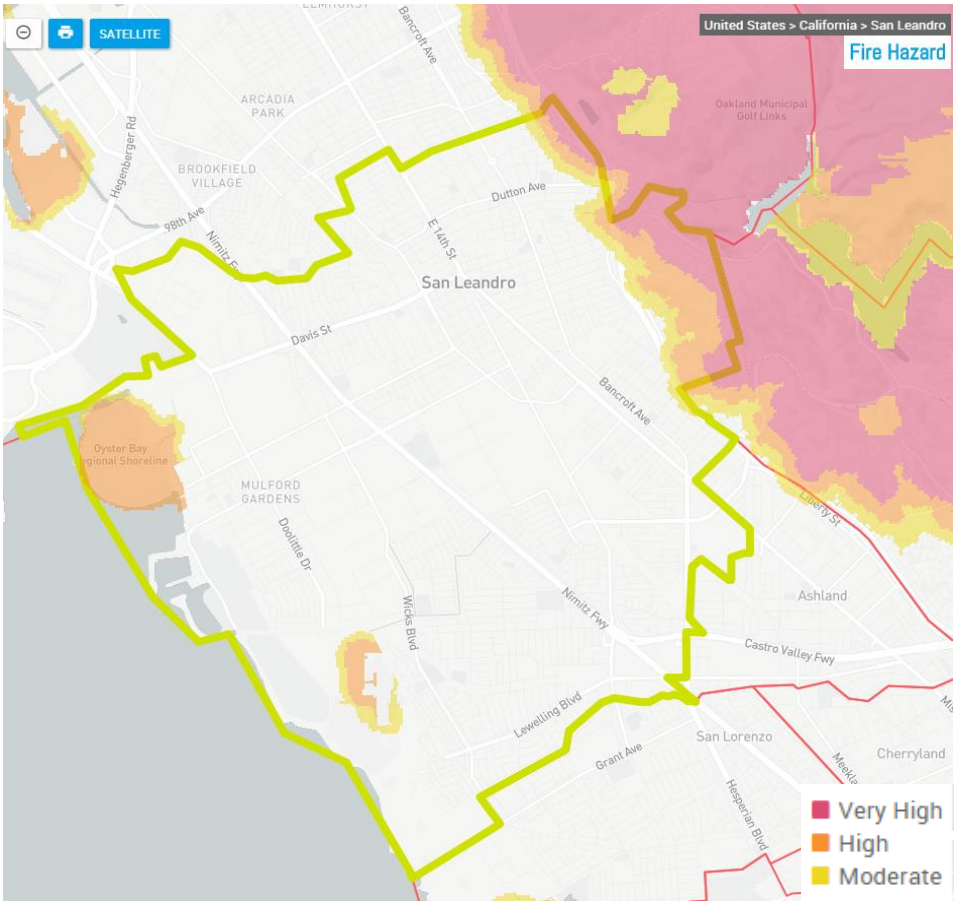
Wildfires may become more common or severe

According to the California Department of Forestry and Fire Protection (CAL FIRE) Fire Hazard Severity Zone maps,[43] San Leandro has moderate to very high wildfire severity zones in many areas of the city, primarily east of the MacArthur Freeway, but with some high severity areas in the Oyster Bay Regional Shoreline and the inland areas of the marshlands near the shoreline. Fire hazard severity is a metric of the potential exposure of wildland and urban properties to wildfire based on vegetation, topography, and dangerous fire characteristics. The extent of these zones will therefore depend on land use change, but the occurrence of fire within these zones may increase due to climate change impacts such as more frequent droughts. Figure 13 depicts the geographic distribution of fire hazard severity risk throughout San Leandro.

[42] Pike, R.J. (1997). San Francisco Bay Region Landslide Folio Part D. USGS. Accessed at: http://pubs.usgs.gov/of/1997/of97-745/of97-745d.html

[43] CalFIRE. Wildland Hazard and Building Codes: Fire Hazard Severity Zone Development. Accessed at: http://www.fire.ca.gov/fire_prevention/fire_prevention_wildland_zones_development

Figure 13. Fire Hazard Severity Zones within and near San Leandro



Source: Open Data, OpenStreet Map and USGS [44] as represented on Vizonomy.

Many assets are already exposed to wildfire risks

Fire risk in San Leandro is low throughout most of the city, however, the city borders a very high fire severity zone to the east and is therefore exposed to potentially higher severity fires in the event of a wildfire. San Leandro assets in the designated high hazard severity zone include Kindred Hospital, Fair Haven Bible Chapel, Creekside Community Church, and the San Leandro Church of Christ on MacArthur, and the assets in the moderate zone include Grand Gas Station and Rite Aid pharmacy on Grand and MacArthur. Two power lines also run right through the very high hazard severity zone in Anthony Chabot Regional Park and could affect power service in the city if damaged. Along the coast, the Oyster Bay Regional Shoreline is at a moderate level of fire risk.

Community assets in the city located near fire hazard severity zones include Roosevelt Elementary School, which serves as a National Shelter System facility, and St. James Lutheran Church. Relevant assets located outside the city border but in very high hazard severity zones include the Chabot Dam,

[44] CalFIRE. Wildland Hazard and Building Codes: Fire Hazard Severity Zone Development. Accessed at: http://www.fire.ca.gov/fire_prevention/fire_prevention_wildland_zones_development

Fairmont Hospital, including John George Psychiatric Hospital and George Mark Children's House, and Sheffield Village Clubhouse and Pre-School.

Since the area exposed to wildfire risk overlaps with areas that are at a medium risk for landslides, especially those surrounding Kindred Hospital, an emergency asset, special attention should be paid to preventing wildfire in San Leandro. Wildfire damages soil and can diminish its water-absorbing capacity, leading to increased runoff, debris flows and exacerbated landslide risk post-fire.[45]

[45] USGS. (2005). "Southern California – Wildfires and Debris Flows" Fact Sheet 2005–3106.

Appendix A: Methods & Data Sources

Methods

The San Leandro climate hazards analysis was conducted using a digital mapping tool called the Vizonomy Climate Risk Platform (Vizonomy). This platform overlays geographical representations of sea level rise and rainfall-induced inland flooding with the location of citywide assets throughout San Leandro, creating a visual representation of the spatial extent and the number of specific assets that could be affected by each hazard throughout the city. The asset data was collected from open data sources available through various federal agencies, OpenStreet Map and local data provided by the City of San Leandro and Alameda County. Hazard projections and data were collected from the data sources explained in the next section of this appendix. In addition, statistical analysis of downscaled climate models and graphical representations of projected temperature and precipitation changes throughout the 21st century were provided by Four Twenty Seven.

The spatial evaluation of hazards and assets limited this analysis to the consideration of asset exposure. In order to assess vulnerability to climate change hazards, more information is needed on the sensitivity and adaptive capacity of affected communities and assets. This analysis provides a thorough examination of the city's potential spatial exposure to a variety of climate hazards and is meant to complement further analysis of overall vulnerability and the appropriate adaptive responses.

Data Sources

Rainfall Induced Inland Flooding

FEMA creates Flood Insurance Rate Maps as part of the National Flood Insurance Program to determine flood insurance requirements and inform local hazard mitigation actions that address flood risks. These flood maps incorporate statistical information on river flow, storm surge, hydrology and topography in order to delineate 100-year and 500-year floodplains, or areas that will experience floods with a one percent or 0.2 percent chance respectively of being exceeded in a given year. The statistical information and associated maps are based on historical data and do not incorporate climate projections into floodplain delineations, yet do provide an accurate depiction of where floodwaters are likely to concentrate, even if recurrence intervals change.

Sea Level Rise

The 2012 NRC Report *Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present, and Future* identified likely sea level rise estimates throughout the 21st century for the west coast of the United States based on moderate greenhouse gas emissions and continued acceleration of glacial melt patterns. These values are accompanied by ranges of possible sea levels based on low and high emissions scenarios and ice melt scenarios. Figure A1 presents these projections: six inches of sea level rise by 2030 (range: 2-12 in), 11 inches by 2050 (range: 5-24 in), and 36 inches by 2100 (range: 17-66 in) relative to the year 2000.

Figure A1. Sea Level Rise Estimates Relative to the Year 2000

Year	Projections	Ranges
2030	6 ± 2 in	2 to 12 in
2050	11 ± 4 in*	5 to 24 in
2100	36 ± 10 in	17 to 66 in

Source: NRC. 2012. [46]

In the report *Adapting to Rising Tides: Alameda County Shoreline Vulnerability Assessment*, these projections inform a sea level rise analysis for Alameda County. Four inundation maps were created which incorporate remote sensing data using light detection and ranging (LiDAR) methods to depict the elevation on natural and hard structures and determine the level of "overtopping" at five-meter resolution. Each map represents a range of scenarios that are possible given different combinations of sea level rise and extreme tides. Extreme tides are caused by the additive impact of unusually high tides, or King tides, which happen twice per year, and storm surge, which results from the high winds and low atmospheric pressure associated with storm conditions.

The analysis includes maps of water levels increasing by 12 inches, 24 inches, 36 inches and 48 inches over the Mean Higher High Water (MHHW), or the average height of the higher high tide of each day. (Refer to Figure A2.) Based on the likely sea level rise projections within climate scenarios, the areas flooded in the map depicting 36 inches of sea level rise are likely to be permanently inundated by 2100. However, this same water level could occur temporarily on an annual basis by mid-century with high tides and storm surge.

Two additional maps of water level increases at 72 and 96 inches illustrate flooding that can potentially take place under the circumstances that sea level rise is combined with higher than projected glacial melt and extreme tides. For example, a 72-inch scale flood is possible with 36 inches of sea level rise and a 50-year extreme tide. A 95-inch scale flood, which would inundate half the city, is possible with 54 inches of sea level rise and a 100-year storm event.

[46] National Research Council. (2012). *Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present, and Future*. Report. DOI: 10.17226/13389

Figure A2. Sea Level Rise and Extreme Tide Matrix (Hydrodynamic Zone 3)

Sea Level Rise Scenario	Daily Tide *Permanent Inundation*	Extreme Tide (Storm Surge) *Temporary Flooding*						
	+SLR	1-yr	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr
	Water Level above MHHW (in)							
Existing Conditions	0	15	20	24	27	32	36	41
MHHW + 6 inch	6	21	26	30	33	38	42	47
MHHW +12 inch	12	27	32	36	39	44	48	53
MHHW +18 inch	18	33	38	42	45	50	54	59
MHHW +24 inch	24	39	44	48	51	56	60	65
MHHW +30 inch	30	45	50	54	57	62	66	71
MHHW +36 inch	36	51	56	60	63	68	72	77
MHHW +42 inch	42	57	62	66	69	74	78	83
MHHW +48 inch	48	63	68	72	75	80	84	89
MHHW +54 inch	54	69	74	78	81	86	90	95
MHHW +60 inch	60	75	80	84	87	92	96	101
HYDRODYNAMIC ZONE 3								

Source: Alameda County Flood Control and Water Conservation District and BCDC, 2015. [47]

Temperature and Precipitation

Temperature and precipitation projections were derived from a statistically downscaled Bias Corrected Constructed Analog (BCCA) dataset,[48] from which Four Twenty Seven extrapolated temperature and precipitation indices. Statistically downscaled data was used to better represent local conditions, and an ensemble of 19 global circulation models was used to reduce individual model uncertainties. Probabilistic estimates were generated for extreme indicators using Gaussian distribution, with the most likely value falling between the 25th and 75th percentiles. For indicators showing changes to average precipitation and temperature, an envelope-based approach was used by bounding the range of models based on their departure from the historical mean. Temperature and precipitation indicators have been parametrized to show future trends in terms of averages and extremes at the city-level (approximately 12 x 12 km). All future values (2020-2060) were amended with probabilistic estimates and compared to a historical baseline (1970-2000).

The historical baseline is a climate model history intended to capture climate conditions experienced from 1970-2000, but not to predict the weather conditions on any given day, month, or year. For this baseline period, the climate models were run with an emissions scenario representative of the observed history from those past years but with the same physics and configurations as in future-year runs. This

[47] Alameda County Flood Control and Water Conservation District and BCDC. (2015). *Adapting to Rising Tides: Alameda County Shoreline Vulnerability Assessment Final Report.*

[48] Reclamation. (2013). 'Downscaled CMIP3 and CMIP5 Climate and Hydrology Projections: Release of Downscaled CMIP5 Climate Projections, Comparison with preceding Information, and Summary of User Needs', prepared by the U.S. Department of the Interior, Bureau of Reclamation, Technical Services Center, Denver, Colorado.

enables comparison of like historical and future model data to better establish the magnitude of likely future changes.

The models used scenarios from the IPCC. The RCP 8.5 represents the most minimal greenhouse gas mitigation effort and high emissions, resulting in the largest increase in radiative forcing and warming, while RCP 4.5 is considered a moderate greenhouse gas mitigation scenario where climate action limits the amount of global emissions.[49]

Rainfall Induced Landslides

The USGS conducted a survey of landslide risk in the San Francisco Bay Area leading up to the 1997-1998 El Niño event. Today, these maps are used to predict future landslides since these events are generally believed likely to occur within and around the places where they have previously taken place.[50] Geographic locations are assigned risk based on a five-point scale from surficial deposits (low risk) to mostly landslide (high risk). Areas which have experienced few landslides have a mid-level risk for landslide events.

Wildfires

CAL FIRE produces Fire Hazard Severity Zone maps to determine the potential exposure of wildland and urban properties to wildfire based on vegetation, topography, and dangerous fire characteristics such as crown fire potential and ember production and movement. Fire hazard is a metric for determining physical fire behavior in order to predict the amount of damage a fire in a certain location is likely to cause and is classified as Very High, High or Moderate. The Fire Hazard Severity Zones are based on the evaluation of the likelihood that an area will burn and how, without consideration of the risk for property damage.[51]

[49] IPCC. (2014). Scenario Process for AR5. Accessed at: http://sedac.ipcc-data.org/ddc/ar5_scenario_process/RCPs.html
[50] Pike, R.J. (1997). San Francisco Bay Region Landslide Folio Part D. USGS. Accessed at: http://pubs.usgs.gov/of/1997/of97-745/of97-745d.html
[51] CalFIRE. Wildland Hazard and Building Codes: Fire Hazard Severity Zone Development. Accessed at: http://www.fire.ca.gov/fire_prevention/fire_prevention_wildland_zones_development

Appendix B: Calculated Priority Risk Index

The Calculated Priority Risk Index in Figure B1 is informed by FEMA's guidelines for comparing hazards, as described in the *Local Mitigation Planning Handbook* (2013). The focus here, based on available data, is on the types of assets exposed to a given hazard and the magnitude of the impact. The rankings for types of assets exposed to a given hazard are: low – only assets that will not compound hazard effects or that are replaceable are subject to the hazard, medium – important assets or those that could lead to secondary hazards if damaged are subject to the hazard, and high – critical assets that could lead to immediate secondary hazards if damaged are subject to the hazard. For magnitude, the rankings are: low – no critical assets are affected, medium – some critical assets and/or a large number of important assets are affected, and high – several critical assets are affected.

FEMA defines critical facilities as "all public and private facilities deemed by a community to be essential for the delivery of vital services, protection of special populations, and the provision of other services of importance for that community."[52] This includes emergency response facilities, healthcare facilities, transportation infrastructure, schools, emergency shelters, utilities, communications facilities and other assets important to maintaining the health and safety of city residents.

Figure B1. Calculated Priority Risk Index[53]

Hazard	Types of Assets Exposed to Hazard	Magnitude	Rank
Inland flooding	H	M	H
Wildfires	M	H	H
Sea level rise	M	M	M
Temperature change	M	M	M
Rainfall-Induced Landslides	H	L	M
Precipitation Change	L	L	L

[52] FEMA. (2007). *Design Guide for Improving Critical Facility Safety from Flooding and High Winds: Providing Protection to People and Buildings,* FEMA 543. Accessed at: https://www.fema.gov/media-library/assets/documents/8811

[53] FEMA. (2013). Local Mitigation Planning Handbook.