SAFETY ELEMENT



Aerial view of Irvine

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Irvine City Hall

The City of Irvine is committed to safeguarding the community from natural and human-caused hazards to help ensure the security of public health and safety, minimize disruption to the economy, and the protection of people and businesses from injury, property damage, and other losses.

VISIONING THROUGH SAFETY



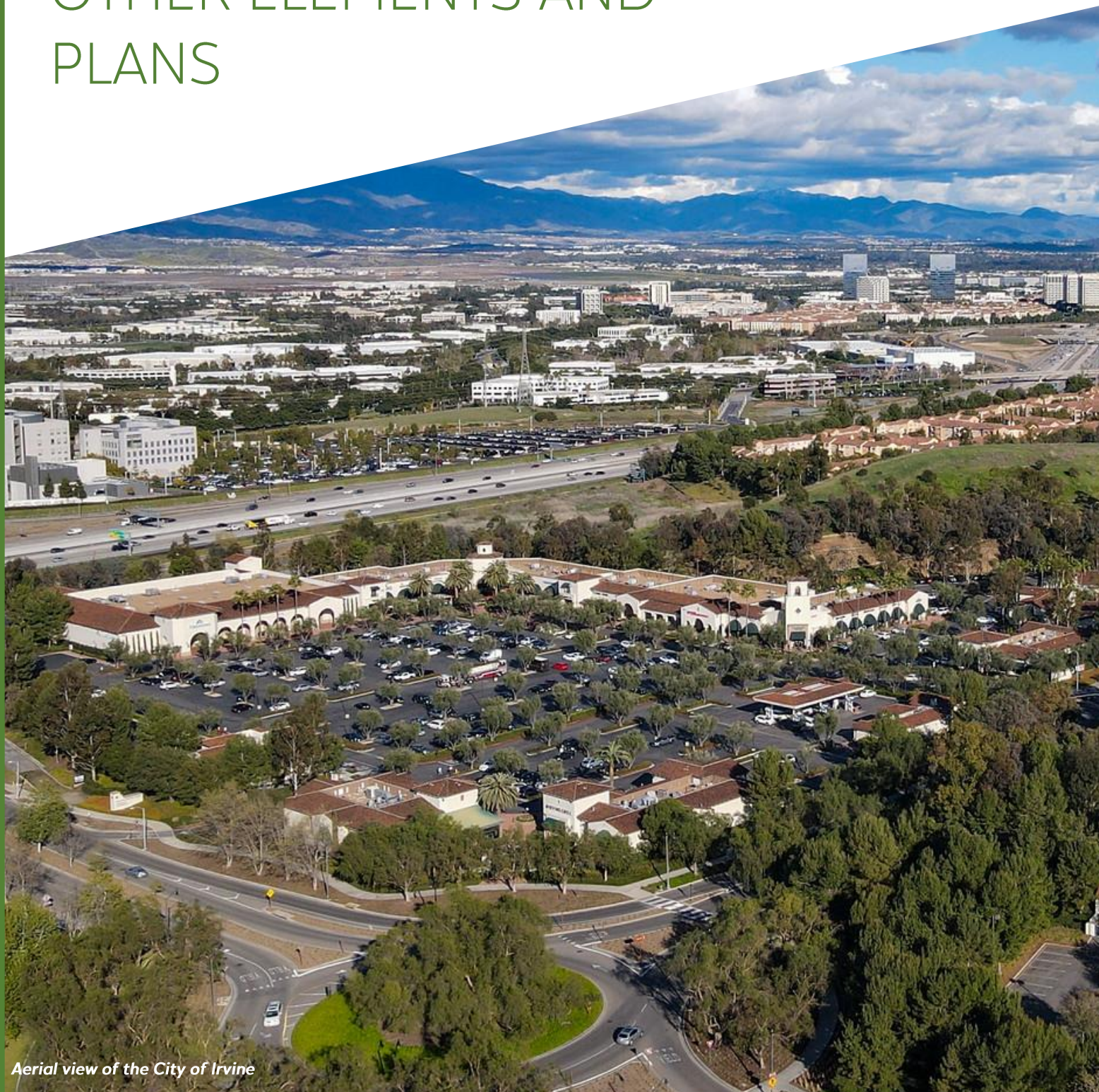


The Safety Element is a mandated component of the General Plan. The City of Irvine experiences various hazard conditions that could potentially impact overall community safety and sense of security. Community safety programs can reduce the potential for loss of life, injuries, and property damage associated with natural and human-caused hazards.

The most significant hazards the City faces include seismic hazards, wildfire, drought, and diseases and pests. The impact of climate change is also likely to intensify many of these risks. This Element provides policies, goals, objectives, and guidelines for avoiding and/or mitigating the harms and protecting the community from unreasonable risks associated with these hazards. The Safety Element focuses on determining the probability and severity of these risks and identifying goals, objectives, policies, and actions to address and prepare for them.


City of Irvine Wildland Management Event

RELATIONSHIP TO OTHER ELEMENTS AND PLANS



Aerial view of the City of Irvine

The Safety Element is in alignment with other Elements of the City's General Plan, as required by State law, including the (1) Housing, (2) Land Use, (3) Circulation, and (4) Conservation and Open Space, and (5) Environmental Protection and Climate Action Elements. Policies and plans in the Safety Element are designed to protect existing and planned land uses identified in the Land Use Element (and associated people and properties) from unreasonable risk from natural and human-caused hazards. Potential hazards are identified and associated actions are established to avoid or mitigate impacts to public safety.

- Land Use Element– The Land Use Element contains policies to ensure that environmental conditions, including hazards, are considered in all land use decisions. The distribution of residential and other sensitive land uses on the Land Use Policy Map is designed to avoid areas where hazardous conditions have been identified.
- Circulation Element – The Circulation Element provides the policy framework for a safe and efficient circulation system, which is critical during response to an emergency or in the event an evacuation is necessary.
- Conservation and Open Space Element – The Conservation and Open Space Element identifies the protection of open space areas that may contain hazardous conditions, such as increased risk of wildland fires and landslides.
- Housing Element – The Safety Element plays a crucial role in ensuring that housing developments adhere to safety standards and regulations to protect residents from hazards such as earthquakes, floods, and wildfires. It influences land use decisions in the Housing Element by guiding the selection of suitable locations for housing projects, taking into account factors like proximity to emergency services and vulnerability to natural disasters. Additionally, the Safety Element incorporates policies aimed at enhancing community safety and disaster preparedness.
- Environmental Protection and Climate Action (EPCA) Element – The partnership between the Safety and EPCA Elements ensures that safety planning considers environmental factors, including heightened hazard conditions linked to climate change. These elements collaborate to address safety issues while advocating for environmental responsibility, ultimately aiming to achieve a resilient and safe urban environment.



City of Irvine Police Chief in the community



Response efforts to Silverado Fire in Irvine

Irvine has also prepared a federally certified Local Hazard Mitigation Plan (LHMP) and an adopted Emergency Operations Plan (EOP), both of which allow the City to become eligible for federal grant funding to mitigate the natural hazards discussed therein.

The LHMP for the City of Irvine planning area was developed in accordance with Disaster Mitigation Act of 2000 (Assembly Bill [AB] 2140) and followed the Federal Emergency Management Agency's (FEMA's) Local Hazard Mitigation Plan guidance. The City's LHMP incorporates a process where hazards are identified and profiled, the people and facilities at risk are analyzed, and mitigation actions are developed to reduce or eliminate hazard risk. The implementation of these

mitigation actions, which include both short and long-term strategies, involve planning, policy changes, programs, projects, and other activities. The City's LHMP has been incorporated into the Safety Element: https://online.flippingbook.com/view/792205/.

Based on the City's LHMP, there are 11 hazard types, each with subcategories, that have the potential to impact Irvine. The top four hazards posing a threat to Irvine residents and businesses are seismic hazards, wildfires, drought, and diseases and pests. Other hazards listed by the probability of occurrence and level of impact on the City, ranked from highest to lowest, include severe weather, aircraft incidents, human-caused hazards (e.g., infrastructure failure, mass-casualty incident, cyber threats), geologic hazards, flooding, hazardous materials release, and dam failure.

General Plan Element objectives related to the Safety Element are as follows:

Circulation Element: C-2	EPCA Element: EPCA-2, EPCA-4, EPCA-5
Housing Element: HE-I, HE-L	Noise Element: N-1, N-4
Conservation and Open Space Element: COS-5	Land Use Element: LU-9



Aerial view of Irvine. Source: Irvine Standard

SCOPE AND CONTENT



CalFire response in the City of Irvine

The Safety Element is comprised of two sections:

1. Existing Conditions and Areas of Concentration
2. Objectives, Policies, and Implementation Actions

Government Code Section 65302(g) identifies the hazards and associated risks as they pertain to conditions in the City, that are required to be addressed in Safety Elements, which include:

- Seismic risks, including, but not limited to (per Government Code Section 65302[g][1]):
    - seismically induced surface rupture,
    - ground shaking,
    - ground failure,
    - tsunami,
    - seiche,
    - dam failure,
    - slope instability leading to mudslides and landslides, subsidence, liquefaction, and
    - other seismic hazards identified pursuant to Chapter 7.8 (commencing with Section 2690) of Division 2 of the Public Resources Code, and other geologic hazards known to the legislative body;
- Flooding (per Government Code Section 65302[g][2][A], AB 162, and Senate Bill [SB] 1035);
- Drought (per Government Code Section 65302[g][2]);
- Wildland and urban fires (per Government Code Section 65302[g][1] and 65302[g][3][A] and SB 1241);
- Climate change adaptation and resilience, including a vulnerability assessment (per Government Code Section 65302[g][4], SB 379, and SB 246);
- Evacuation routes and locations of identified fire and seismic hazards (per Government Code Section 65302[g][1] and 65302[g][5], SB 99, AB 747, and AB 1409);
- Other required topics, including military installations, peak load water supply requirements, and minimum road widths and clearances around structures (per Government Code Section 65302[g][1]); and
- Natural Infrastructure (per Government Code Section 65302[g][4][C][v] and AB 65).

State law allows communities to add additional safety issues to this list. The City has chosen to address the following safety issues within this Element:

- Diseases and Pests; and
- Airport Hazards.

All issue areas listed above are addressed in this Safety Element, in other General Plan Elements, or in the City's LHMP.



View of residential neighborhood in Irvine

HAZARDS NOT APPLICABLE

Given the City's distance to the ocean, the City has not experienced and is not expected to experience hazardous conditions related to tsunamis. Hazardous conditions related to a seiche within North Lake or South Lake in the Woodbridge community are unlikely given the small size of the lakes and the height of the banks surrounding the lakes. No other enclosed waterbodies where a seiche could occur exist within the City. Additionally, there are no active military installations within or adjacent to the City of Irvine. Therefore, tsunamis and seiches, and military installations do not apply and are not addressed further in this Safety Element.

SUPPORTING TECHNICAL STUDIES

A Climate Vulnerability Assessment (Appendix A) was prepared in compliance with SB 379, and Climate Change Adaptation and Resiliency Strategies were developed with extensive community input. These components have been incorporated into this Element, consistent with SB 379 and SB 246. An Emergency Evacuation Route Analysis (Appendix B) was prepared and incorporated into this Element. Additional policies were developed in response to the results of the analysis.

EXISTING CONDITIONS AND AREAS OF CONCENTRATION



City of Irvine Great park Patrol Police Truck

The following is a summary of existing and projected future conditions for the City's highest priority hazards as identified in the LHMP, as well as hazards required to be addressed in the Safety Element by State law and the California Governor's Office of Planning and Research (OPR). The discussion of Existing Conditions provides an overview of the current issues pertaining to hazardous conditions and safety issues within the City. The Areas of Concentration discussion describes threats to the City's physical assets (i.e., critical facilities and facilities of concern), people, and City services and systems (e.g., utilities, transportation infrastructure). The Areas of Concentration discussion also identifies the risk of future events for each hazard and how they may be exacerbated by climate change.

PUBLIC SAFETY AND EDUCATION



City of Irvine Police

Existing Conditions

Major emergencies occur periodically in all communities. Proper preparation for emergencies, including mitigation of risks and vulnerabilities specific to Irvine, are essential to minimize disruption, personal injury, and property damage associated with these events. Preventative measures and preparatory responses before an emergency occurs will reduce the time and cost of recovery from these emergencies.

The two primary civic agencies responding to safety hazards in Irvine are the Irvine Police Department and the Orange County Fire Authority. The Irvine Police Department is located at City Hall (1 Civic Center Plaza). The City also has a contract with the Orange County Fire Authority (OCFA) for fire prevention and response services within the City (Figure 1). OCFA stations are scattered throughout the County, with approximately 11 locations in the City of Irvine.

The City's 2023 Standard Plans and Design Manuals provide minimum recommended lane widths in the City to ensure that emergency vehicles can access residences and other development during emergency events. Specifically, the City of Irvine Standard Plans No. 101, 102, 103, and 103A provide

for the right-of-way and curb-to-curb design standards for constructing Major, Primary, Secondary highways, and Commuter Streets in the City of Irvine. Standard Plans No. 104, 104A, and Plan No.111 provide design standards that include lane widths for Local Streets, Local Collectors, and Private Ways. The recommended procedures present the ideal lane widths for typical street sections, both at mid-block and at the intersections. Additionally, Standard Plan No. 114 establishes minimum median widths for emergency vehicle median turn-arounds.

Minimum clearance requirements around structures in the City are consistent with the California Building Code, California Fire Code, and other State regulations. For example, AB 3074 establishes an ember-resistant zone within five feet of a structure as part of the defensible space requirements for structures located in specified high-fire hazard areas.

Areas of Concentration

The City's LHMP identifies natural and human-induced hazards that threaten the community, particularly the City's physical assets (i.e., critical facilities and facilities of concern), vulnerable populations, and City services and infrastructure (e.g., utilities, transportation infrastructure). The City's critical facilities and facilities of concern as mapped in the LHMP are shown in Figure 2.

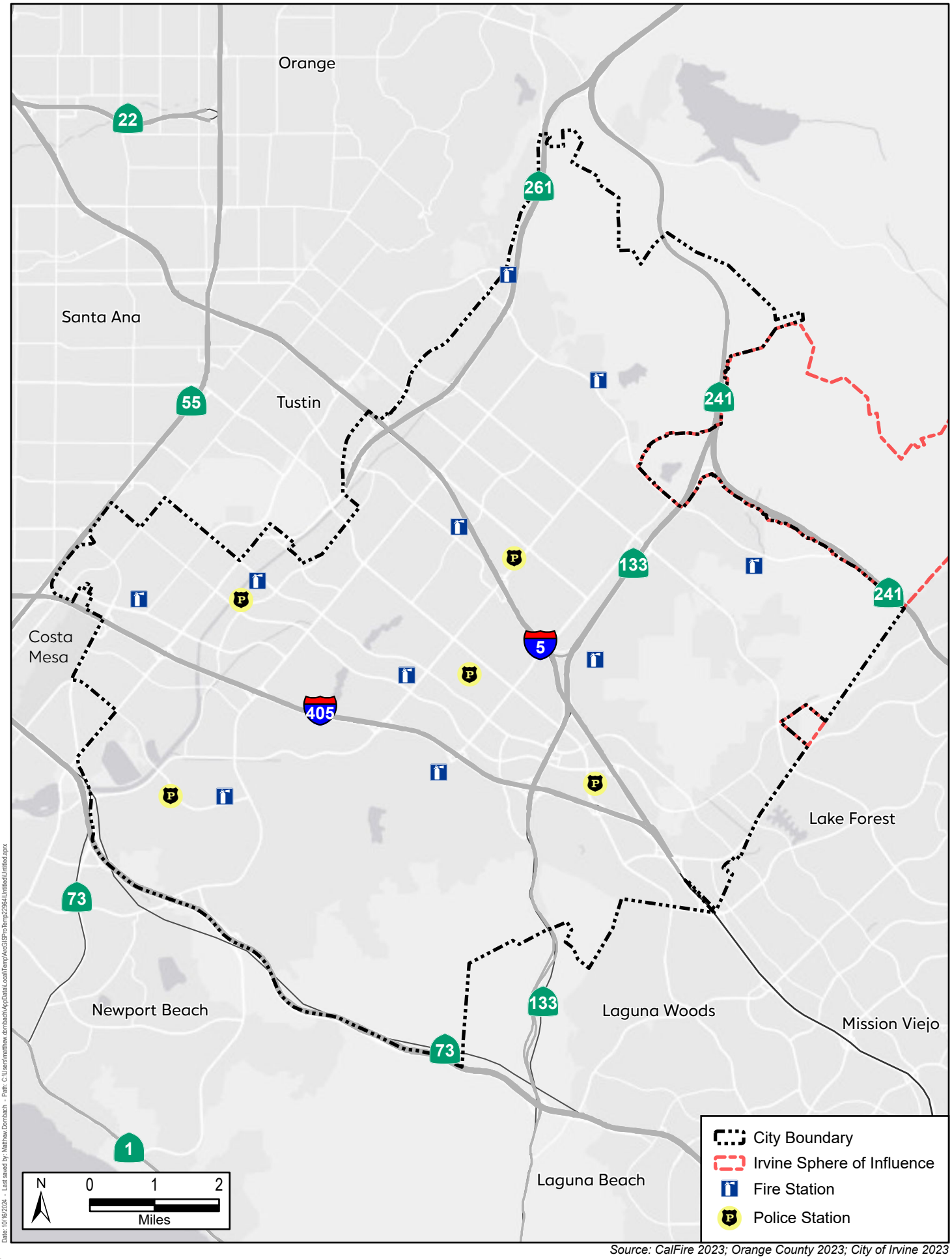
The LHMP provides resources, information, and strategies to reduce these threats. The LHMP also identifies hazard mitigation strategies, which include a comprehensive set of mitigation actions to respond to varying hazard situations and provide protection to residents, businesses, and community assets in Irvine. Several mitigation items focus on developing, enhancing, and implementing educational programs that aim to reduce the risk to citizens, public agencies, businesses, and schools.



Vehicles drive through the rain on the 101 freeway
Source: Mario Tama/Getty Images

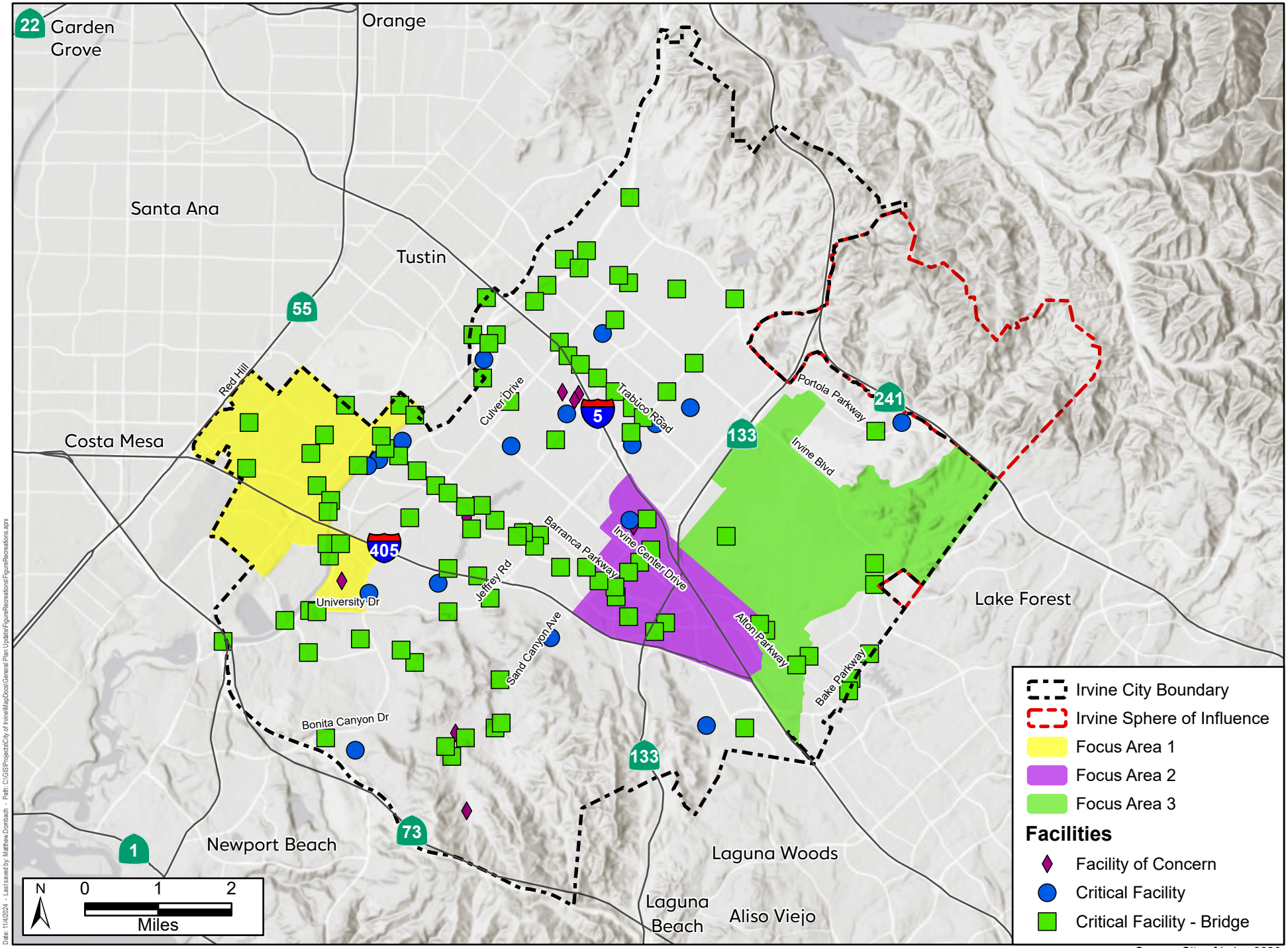
The LHMP also addresses the potential impacts of changing climate and weather patterns and contains information required pursuant to Gov. Code Section 65302(g)(4)(C). Although changing weather patterns are not a stand-alone hazard, they have the potential to change the characteristics, such as frequency and intensity, of other hazards (e.g., flooding, extreme temperatures) that affect the community.

Figure 1. Police and Fire Stations in Irvine



Source: CalFire 2023; Orange County 2023; City of Irvine 2023

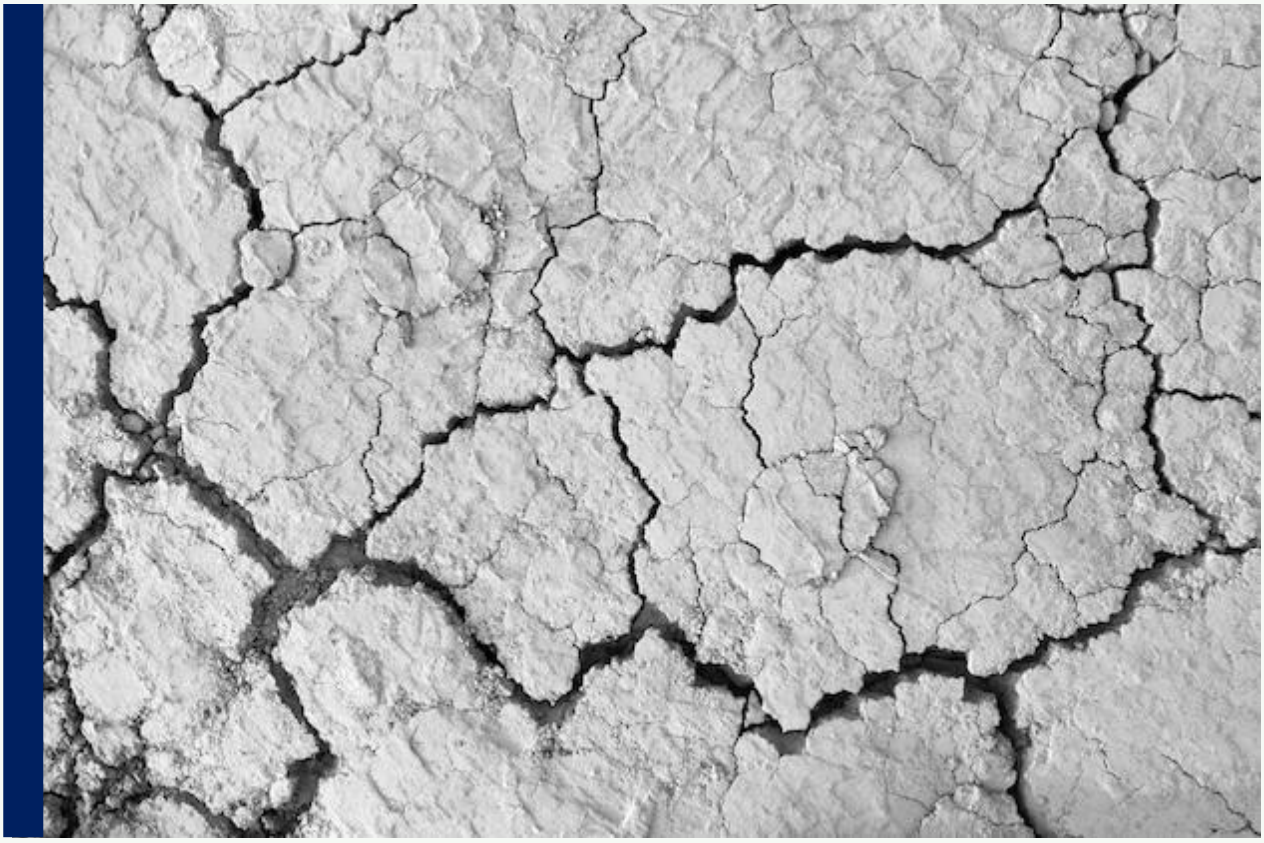
Figure 2. Critical Facilities and Facilities of Concern



Source: City of Irvine 2020.

SEISMIC HAZARDS

Seismic hazards of concern in Irvine include fault rupture, liquefaction, and seismic shaking, discussed further below.



Existing Conditions

FAULT RUPTURE

The shifting and movement of the Earth's tectonic plates are responsible for seismic events. The location at which two tectonic plates join is called a fault line. Any buildings or infrastructure situated around, on top of, or across a fault line are subject to severe seismic shaking and could potentially be severely damaged or destroyed.

The U.S. Geological Survey (USGS) and California Geological Survey are the primary agencies providing scientific information related to seismic hazards and geological resources in California. According to the USGS and California Geological Survey, there are several regional faults within Alquist-Priolo Special Study Zones near the City that could result in seismic hazards should an earthquake occur along one of them, including Newport-Inglewood-Rose Canyon fault zone (approximately 1.5 miles west of Irvine), Pelican Hill fault (approximately 1.5 miles west of Irvine), El Modena fault (approximately 5 miles north of Irvine) and Peralta Hills fault (approximately 5 miles north of Irvine). In addition, numerous faults have been identified within the City; however, they are not considered active (shown movement at the surface in the past 13,000 years) and therefore, do not require delineation within a special study zone. Regardless, these faults should be accounted for in future development decisions.

The San Joaquin Hills blind thrust fault is the only known fault that runs through Irvine and travels in an east-west/southeasterly direction through the City (Figure 3). The location of the fault is thought to run just north of the San Joaquin Hills, with the Irvine Civic Center sitting on top of the inferred location. If an earthquake were to occur on this blind thrust fault, the likelihood of surface rupture would be underground, thereby reducing potential risk to structures (see Seismic Shaking below).

LIQUEFACTION

Liquefaction occurs when seismic energy shakes an area with low-density, fine grain soil, like sand or silt, that is also saturated with water. During liquefaction events, the liquified soil can lose most of its stability, which can cause damage to buildings and infrastructure; in severe cases, some buildings may completely collapse. Parts of Irvine are in a potential liquefaction zone, according to the California Geological Survey (Figure 3). This is due to the types of soils in this area, the presence of shallow groundwater under the low-lying portions of the City, and proximity to active earthquake faults capable of generating large earthquakes. In this area of the City, the soils are predominantly sandy alluvial soils, and the depth to groundwater in some areas is as shallow as 10 feet beneath the ground surface.

SEISMIC SHAKING

Seismic shaking is the shaking felt on the Earth's surface caused by an earthquake. In most cases, earthquakes are not powerful enough for the shaking to be felt. However, particularly powerful earthquakes can generate significant shaking, causing widespread destruction, including property damage. Southern California, including Irvine, is a highly seismic area because of the major faults that run through the region and is subject to experiencing seismic shaking. The only known fault that runs through Irvine is the San Joaquin Hills blind thrust fault, which runs just north of the San Joaquin Hills.



Surface ruptures in the road due to an earthquake
Source: ShakeAlert

Areas of Concentration

FAULT RUPTURE

As shown on Figure 3, faults beneath the City are not considered active as defined by the California Geological Survey, therefore the risk associated with fault rupture is lower than other areas of Orange County and Southern California. In addition, most of the fault movement occurring in the region is associated with strike slip faulting along the San Andreas, San Jacinto, Whittier Elsinore, and Newport Inglewood fault zones. The faults within the City of Irvine are less likely to rupture in comparison to these faults, and if rupture were to occur it would most likely impact small areas. Additionally, there is no known direct connection between fault rupturing and climate change.



Surface rupture from 1992 Landers earthquake Source: California Earthquake Authority

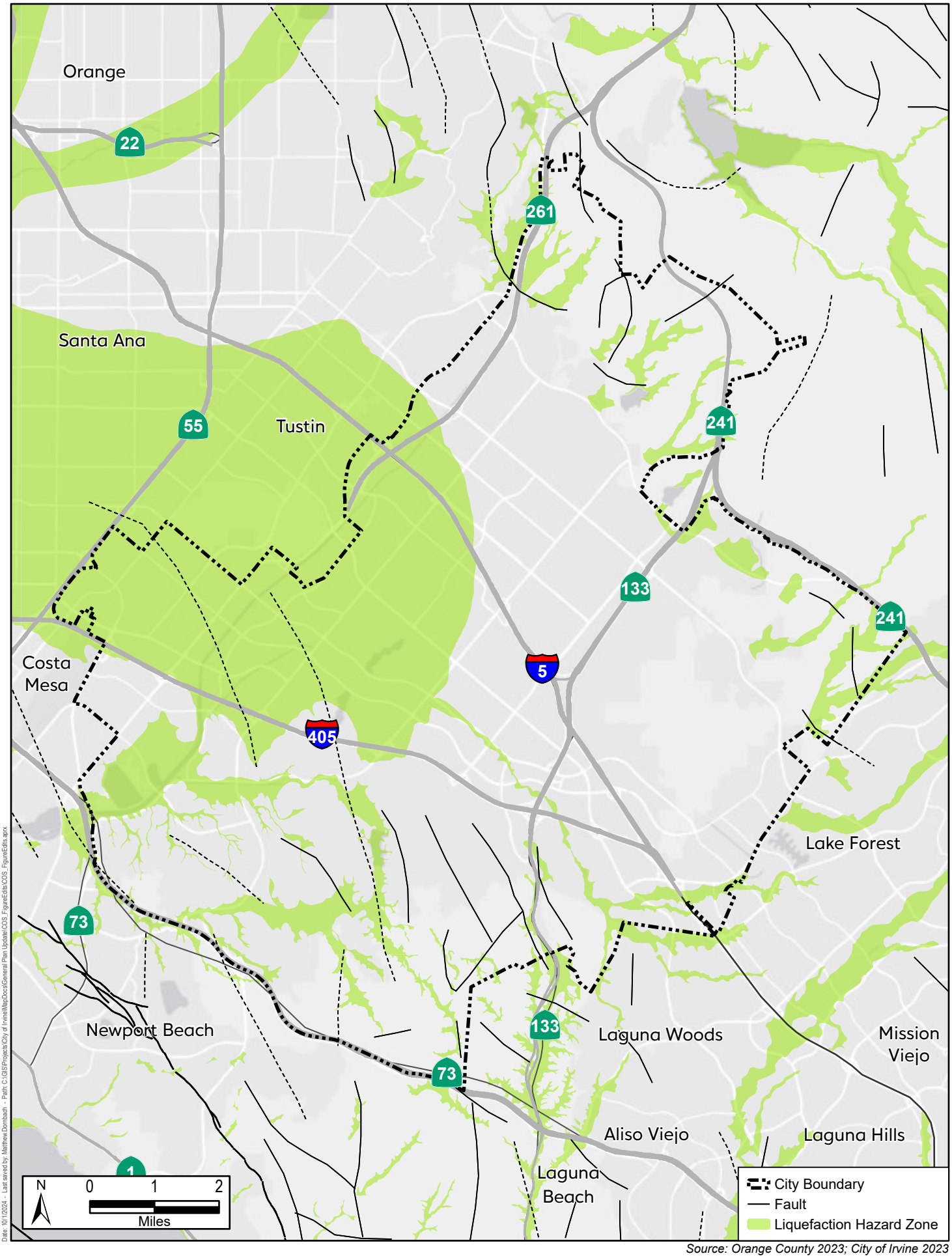
Potential losses associated with fault rupture could affect 4 critical facilities and 18 facilities of concern, including 3 community centers and 16 recreation support facilities (Figure 4). Surface fault rupture also tends to damage roads and structures in the areas of impact. Fault rupture could affect anyone within the City but may especially impact residents within 500 feet of a ruptured fault. The stronger the event, the greater distance that rupture can occur.

Given the presence of faults beneath and near the City, fault rupture could occur in the future. However, without further study of the fault segments within the City, it is difficult to estimate how often seismic events could occur along these segments (see *Seismic Shaking*).



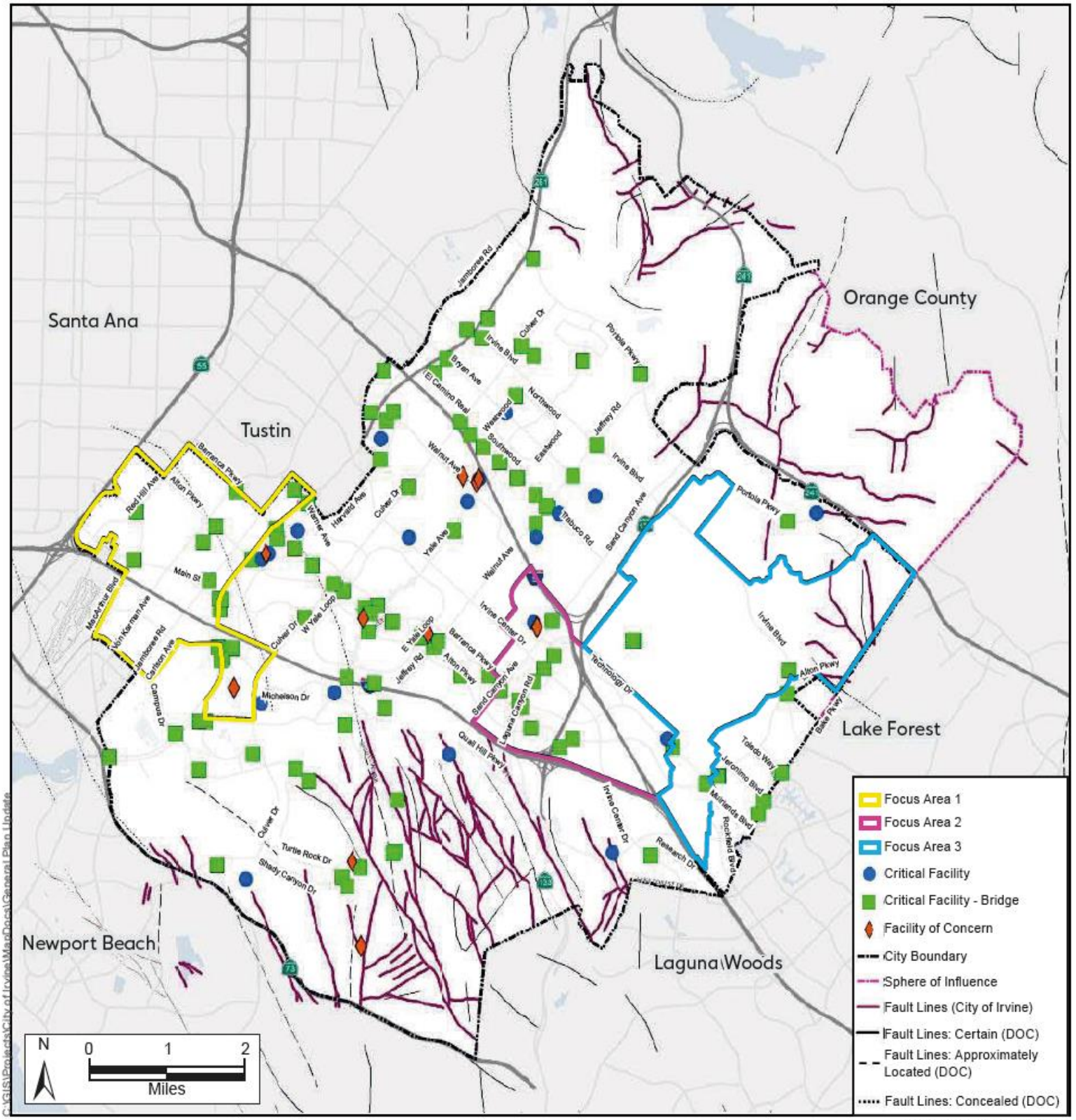
Surface rupture after an earthquake

Figure 3. Seismic Hazards in Irvine



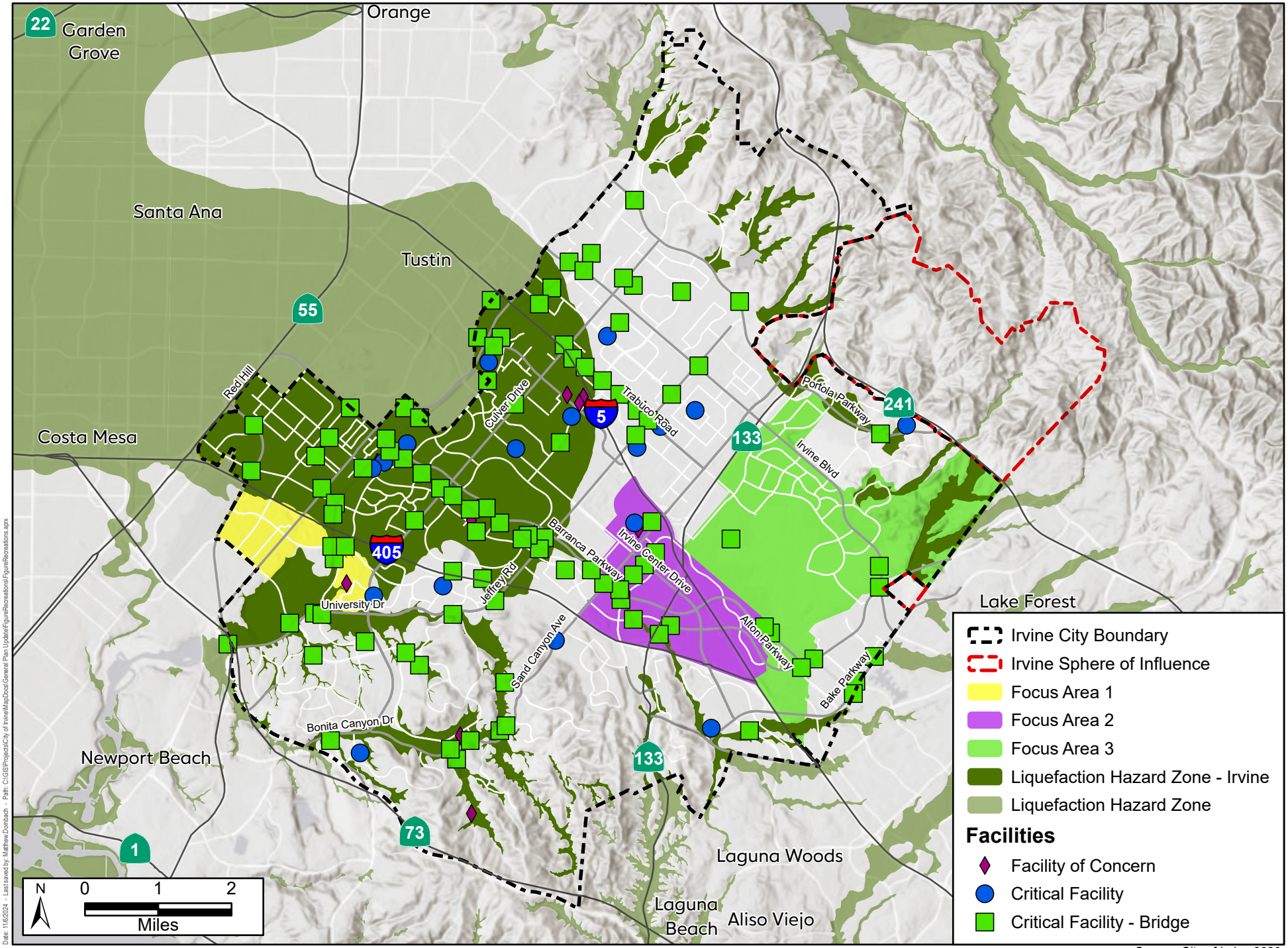
Source: Orange County 2023; City of Irvine 2023

Figure 4. Fault Rupture Physical Threat in Irvine



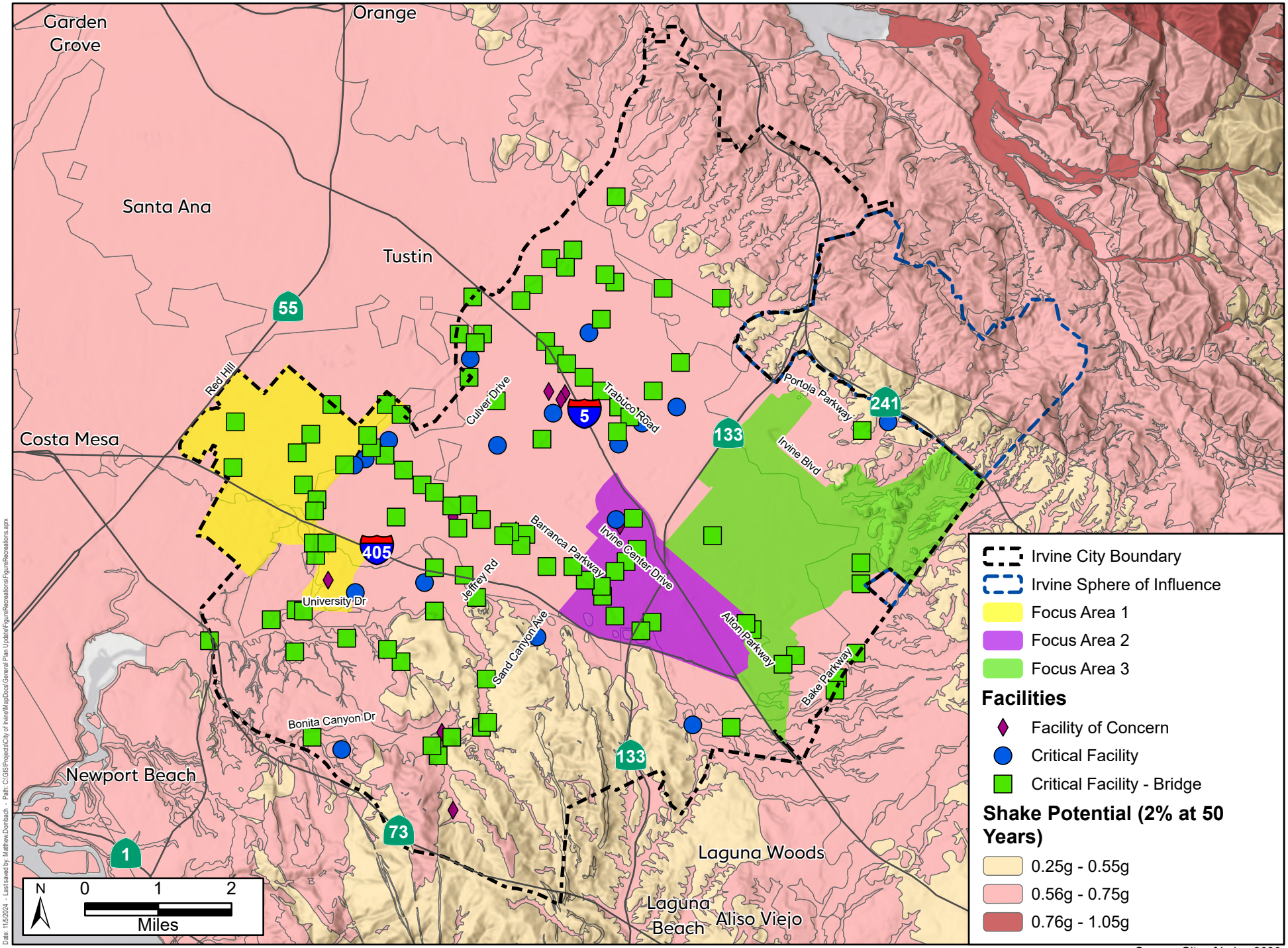
Source: City of Irvine 2020.

Figure 5. Liquefaction Physical Threat in Irvine



Source: City of Irvine 2020.

Figure 6. Seismic Shaking Physical Threat in Irvine



Source: City of Irvine 2020.

Liquefaction

Liquefaction potential is predominantly located within the northwestern portion of the City, as well as along stream courses in the Santa Ana foothills and San Joaquin Hills. Figure 5 identifies the areas susceptible to liquefaction and location of critical facilities and facilities of concern. Given the extent of the liquefaction zone and density of City facilities, this hazard poses the greatest potential loss. City assets composed of 78 critical facilities and 30 facilities of concern are located within these areas, including 70 bridges and 20 schools.



Soil liquefaction due to earthquakes Source: California Earthquake Authority

A large proportion of the City's population (over 37%) face the threat of impact due to liquefaction. This hazard zone covers the largest population and number of households when compared to other hazard areas. Fortunately, newer construction in these areas have taken liquefaction into consideration. These areas are anticipated to contain moderate- and high-income tenants that would have greater amounts of disposable income to use during recovery after an incident. However, lower income residents and residents located in areas of older construction may be impacted greater due to the lack of financial resources needed to make repairs and/or the cost associated with retrofitting older buildings.

Services and mobility may be disrupted during and following a liquefaction event. Sidewalks, roadways, and pipelines may become fractured and disjointed because of the liquefying soils. Roads and sidewalks may be usable in some form, but a severe liquefaction event may render them impassible until they are repaired. Broken gas and water pipelines would result in utilities outages in Irvine homes and businesses. Since these are underground, the duration of the outage could likely be extended until the pipelines are excavated and replaced by utility operators. Damage to power lines is unlikely since the power lines themselves are not rigid structures and can move if any of the transmission towers experience slight leaning. Homes may be damaged and mid-rise office buildings would likely be rendered unsafe for occupancy if they experience any leaning or structural damage resulting from the liquefaction, which would curtail the City's and region's economic activity.

Due to the types of soil in Irvine and the surrounding area, the City will be perpetually at risk of a liquefaction event if the water table remains as high as it is. An earthquake could occur along the numerous local faults running through Orange County that may lead to a liquefaction event. However, the likelihood of one of these local faults experiencing an earthquake powerful enough to trigger a liquefaction event within the next 25 years is exceptionally low. Regional faults, like the San Andreas or San Jacinto faults, are more likely to experience a significant earthquake within the next 25 years but may be

too distant from Irvine to generate significant shaking intensity to trigger a liquefaction event. As a result, although liquefaction could occur in the City, it cannot be determined with certainty when or where a future liquefaction event may occur in Irvine.

Climate change is anticipated to change the usual precipitation patterns in Southern California. Periods of both rain and drought are anticipated to become more intense and frequent. This means that more precipitation will likely occur during rainy periods and drought is expected to last even longer. As a result, the groundwater aquifer beneath Irvine, and Orange County as a whole, could rise during intense periods of precipitation. Alternatively, longer-lasting drought may lead to more groundwater withdrawal and could lower groundwater elevations. Therefore, climate change could either increase or decrease the future risk of liquefaction in Irvine depending on the circumstances.

Seismic Shaking

The only known fault that runs through Irvine is the San Joaquin Hills blind thrust fault, which runs just north of the San Joaquin Hills, with the Irvine Civic Center sitting on top of the inferred location. If an earthquake were to occur on this blind thrust fault, the rupture would most likely occur underground, reducing the risk to surface structures. However, there would still be a danger of damage to buildings or infrastructure posed by any seismic shaking. Many physical assets in the City are estimated to experience the same seismic shaking intensity, ranging from "55 to 75% g" (meaning the shaking intensity in relation to earth's gravity). Therefore, all facilities could potentially be damaged during a significant seismic event, which would likely be extremely costly for the City. Underground physical assets, like pipelines or utilities, could be damaged if nearby faults were to rupture below the surface. In such a scenario, natural gas and water delivery service to Irvine homes and businesses would be out of commission until repairs are completed. Figure 6 identifies critical facilities and facilities of concern in Irvine that are threatened by seismic shaking.



View of San Joaquin Hills looking west from Aliso Viejo
Source: Los Angeles Times

Seniors, pregnant women, and persons with disabilities are more threatened by seismic shaking since they may have limited mobility and may be unable to reach shelter in time. Even if these groups reach shelter in time, they may find themselves trapped if furniture or building components have fallen around them. Renters and low-income persons are also more threatened by seismic shaking since these groups may live in homes that are not properly retrofitted to survive the stresses of a seismic event. These groups may not be able to absorb the costs associated with repairing their homes or looking for new housing should their existing housing be too damaged for occupancy. In terms of geography, seismic shaking effects are anticipated to reduce in areas of higher elevation, which tend to have lower population densities and higher household incomes.

A significant earthquake would likely put utilities out of commission and halt any employment activity in the City for a few hours or several days. Therefore, all services will be non-operational during the seismic shaking and remain inactive until authorities are confident that it is safe to reactivate utilities and to return employees to their workplaces. The length of this time would vary depending on the magnitude of the event. The City and the region would lose economic activity that would normally occur during the period of the outage. Structures, like telephone poles or power transmission towers, which are felled by the shaking could potentially block roadways and prevent emergency response teams from reaching victims or evacuees who need assistance.

It is almost inevitable that an earthquake will occur along one of the adjacent or regional fault lines and cause a major seismic event. The Third Uniform California Earthquake Rupture Forecast (UCERF3) was released in 2015 and is the most recent assessment of the probability of a major earthquake on various faults between 2015 to 2044. The U.S. Geological Survey also forecasts the severity of seismic shaking in different locations for various plausible earthquake scenarios. The U.S. Geological Survey scenarios show that lower magnitude earthquake scenarios may overall be more destructive in Irvine than higher magnitude earthquake scenarios that are more distant. The likelihood of a powerful earthquake occurring along these faults within the next 25 years is exceptionally low.

In addition, there is no direct link between climate change and seismic activity that could impact Irvine. As such, climate change is not expected to cause any changes to the frequency or intensity of seismic shaking.

GEOLOGIC HAZARDS

Geologic hazards of concern in Irvine include landslides and subsidence.

Existing Conditions

LANDSLIDE



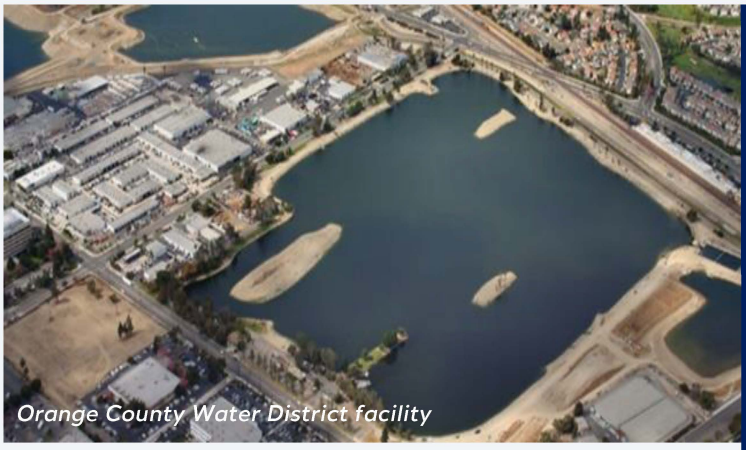
View of a landslide
Source: California Department of Conservation

Landslides occur when earth on slopes become destabilized, typically after heavy rains, when precipitation saturates the soil and makes it less stable, or when significant erosion from rainfall destabilizes the ground. Slopes that have recently burned, as well as areas that have experienced earthquakes, may be more susceptible to landslides. There is the potential for landslides in the steeper portions of the foothills of the Santa Ana Mountains to the northeast of the City and the San Joaquin Hills to the southwest of the City. These areas are characterized by steep topography and geologic units that can become unstable. Figure 7 identifies the areas of the City that are considered vulnerable to seismic-induced landslides. However, even these areas are designated as having a moderately low risk of landslides due to seismic conditions and a low likelihood of a landslide under other conditions. Figure 8 identifies the deep-seated landslide susceptibility for Irvine. As shown on Figure 8, areas in the foothills of the Santa Ana Mountains and San Joaquin Hills are the most susceptible to landslides.

SUBSIDENCE

Subsidence occurs when the level of the ground decreases, as if the surface is sinking. Subsidence can either be sudden or can happen gradually over time and can be caused by mining, groundwater pumping, fossil fuel extraction, erosion, natural cave collapses, or seismic activity.

The most likely locations for subsidence in Irvine are the low-lying areas that sit on top of the Orange County Water District (OCWD) groundwater basin. Although other sections of the City may be subject to subsidence in the event of a major earthquake (magnitude 5.0 or greater), Irvine does not have a history of seismically induced subsidence.



Orange County Water District facility

It is also important to note that there is evidence of subsidence in most of Orange County due to excessive groundwater pumping in the first half of the 20th century. In addition, it is estimated that the greater Los Angeles Basin (including Orange County) experiences approximately 20 millimeters of net subsidence seasonally due to groundwater pumping and artificial recharge.

Areas of Concentration

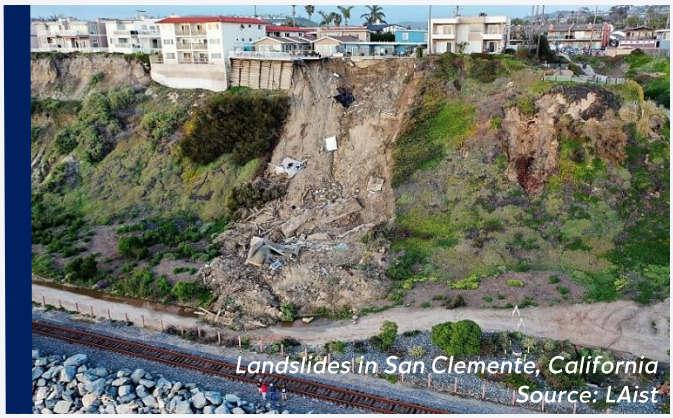
LANDSLIDE

The City mapped the critical facilities and facilities of concern with the California Geological Survey's Earthquake Induced Landslide zones (Figure 9). In addition, Figure 10 identifies the facilities located within the Deep-Seated Landslide hazard zone, which identifies a larger landslide hazard footprint. Most of these landslide hazard zones are in the foothills of the Santa Ana Mountains and San Joaquin Hills. These areas are characterized with steep slopes, which can trigger a landslide during long periods of rainfall. Deep seated landslides could impact the 30 critical facilities and 7 facilities of concern located in this zone.



Landslide in San Clemente, California
Source: California Department of

There are 2,200 people and 683 households living within a deep-seated landslide hazard zone, which is only a small percentage of the City's population. This population has a significantly higher median household income than the City overall. Additionally, households living under the poverty limit and households with one member aged 65+ within the deep-seated landslide hazard zone are lower than the City overall. These indicators suggest that populations within the landslide hazard zones have higher disposable incomes and lower proportions of residents that are retired or living on limited incomes.



Landslides in San Clemente, California
Source: LAist

Landslides may block roadways causing long-term disruptions to mobility and City capabilities. Utility lines, such as power lines or water pipes, may be broken or damaged by a landslide, interrupting important services. Homes and businesses can be damaged or destroyed by landslides. In addition to potentially causing significant injuries or fatalities, this can cause economic harm and create a need for long-term emergency sheltering and temporary housing until these buildings can be reconstructed. Landslides could also affect sensitive ecological areas around the community, causing localized harm to the region's ecosystem.

Given the topography and geologic units within the foothills of the Santa Ana Mountains and San Joaquin Hills, it is anticipated that landslide risk will remain high in those areas. However, the City requires mitigation of these types of conditions to reduce landslide potential in the developed areas of the City, including entire landslide removal and/or landslide stabilization in accordance with approved site-specific geotechnical analyses and recommendations.

Areas near the foothills of the Santa Ana Mountains and San Joaquin Hills also have the potential to fail during an earthquake (Figure 9) or during intense rainstorms when the water adds extra weight that the soil cannot bear. These conditions can be further exacerbated after a wildfire, when rainstorms pass through as the water liquefies unstable, dry soil and burned vegetation. Overall, the probability of future landslides within Irvine is considered occasional.

Due to the variety of factors that lead to landslides, it is possible that climate change could indirectly affect the conditions for landslides. For example, more frequent and intense rain events could subsequently result in moisture-induced landslides. Additionally, warmer temperatures and frequent drought conditions may also lead to more fires, which could destabilize soils and increase the probability of future landslide events.

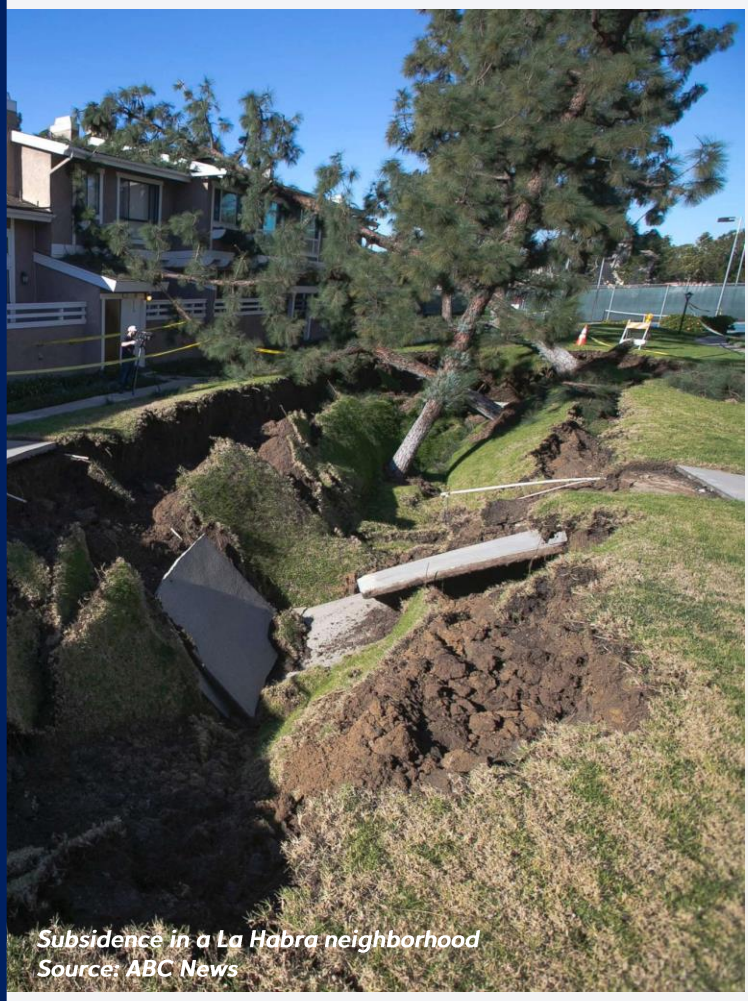
SUBSIDENCE

If subsidence were to occur in Irvine, it could have a significant effect on large-scale systems such as utility infrastructure, transportation infrastructure, buildings, and aquifers. For example, subsidence could irreversibly decrease an aquifer's capacity to store water. Sinking of the ground could also reduce the distance to the groundwater table, which could increase risk of contamination from hazardous materials. Because water lines are gravity driven, a change in elevation because of subsidence could make the system more inefficient. Although accurate subsidence mapping data is not available, many important critical facilities could be gradually affected by subsidence in Irvine and may require further study to examine their function and safety.



Source: California Department of Water Resources

Buildings could gradually sink because of subsidence, causing minor issues such as cracks or misalignments of doors and windows, or more costly problems such as sinkholes. These issues could impact residents living in older homes, which may not have been built with foundations reinforced with steel. Because insurance companies may not cover damages caused by subsidence or other geologic hazards, lower-income households may find it financially difficult to cope with subsidence.



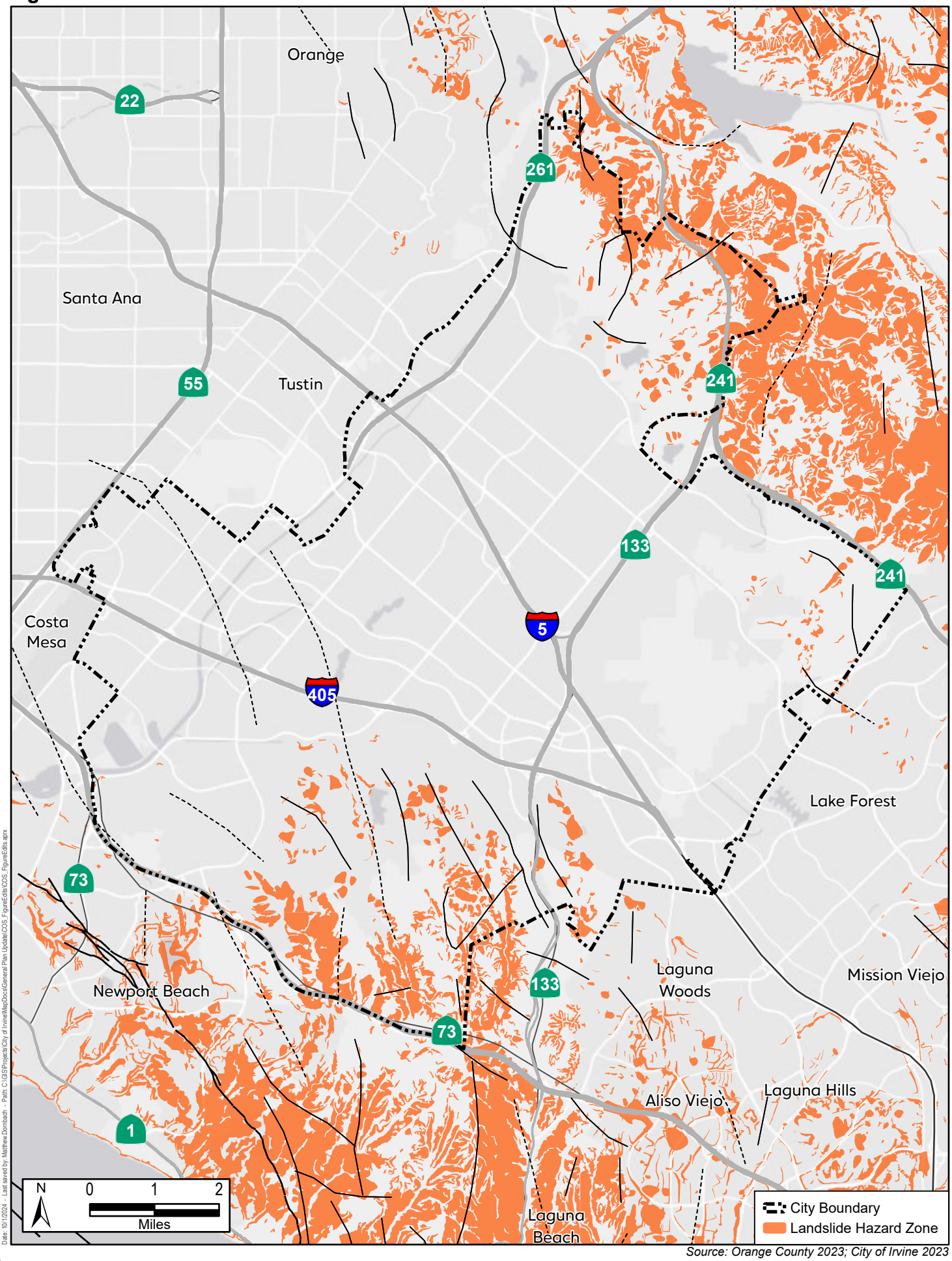
Subsidence in a La Habra neighborhood
Source: ABC News

Subsidence could damage roads and rail lines as well as underground pipes such as water, wastewater, and natural gas. This could create more congestion on Irvine's transportation networks and interrupt key utility services.

Since Irvine has not experienced acute subsidence events, it seems unlikely that subsidence will occur in the City's future. The most likely cause of a future event would be linked to an extreme drought in the future that leads to intensified groundwater withdrawals from the groundwater aquifer. In addition, the City's proximity to seismically active faults suggest the potential for a significant earthquake exists, which could lead to seismically induced subsidence in the future.

It is possible that climate change could indirectly influence subsidence in Irvine. While more intense rainstorms could potentially recharge underground aquifers, adequate infrastructure would need to be available to accommodate this water, allowing for greater recharge and reducing the risk of subsidence. On the other hand, more severe and prolonged periods of drought may encourage more groundwater withdrawals and increase the risk of subsidence.

Figure 7. Landslide Hazards in Irvine



Source: Orange County 2023; City of Irvine 2023

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Figure 8. Deep-Seated Landslide Susceptibility in Irvine

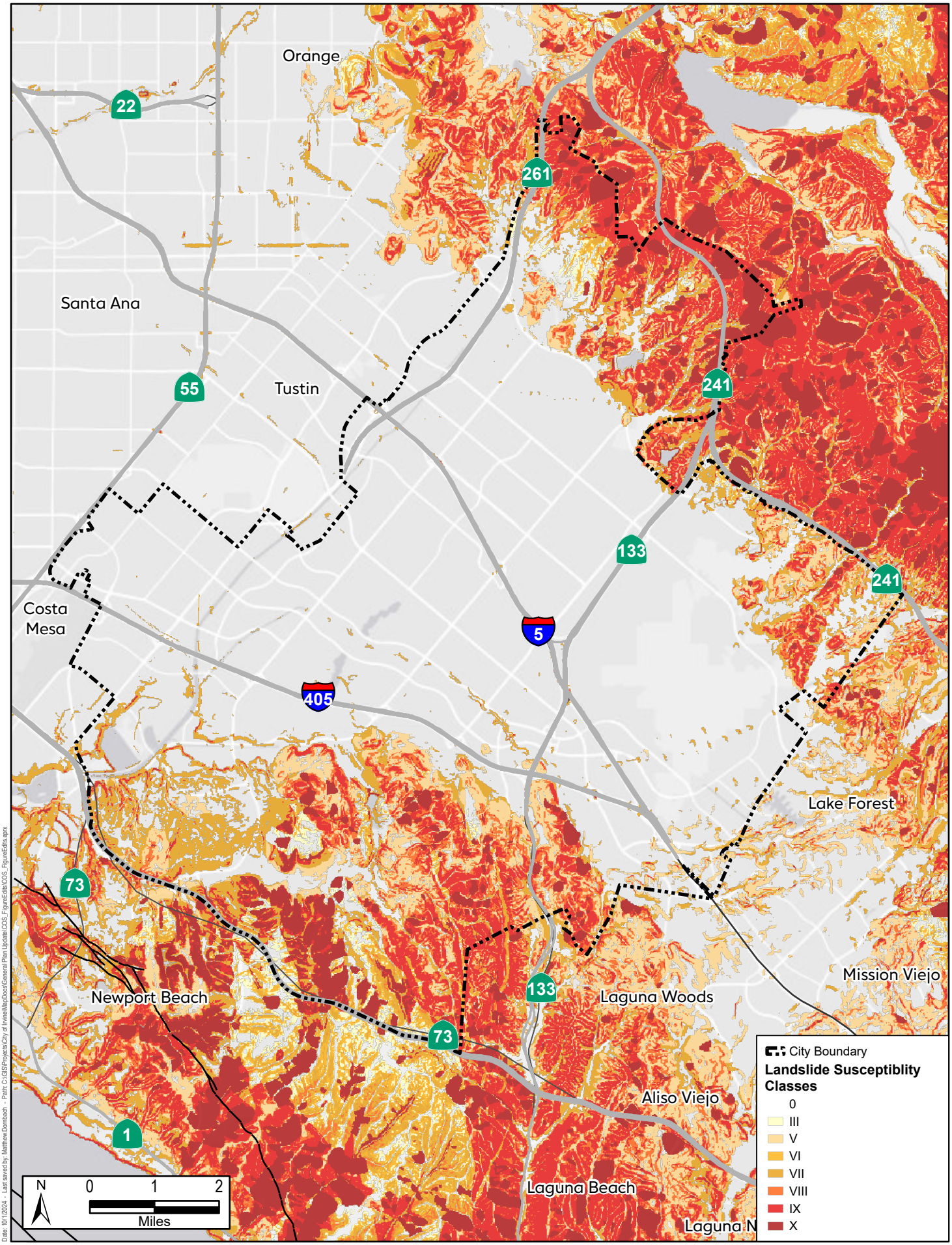
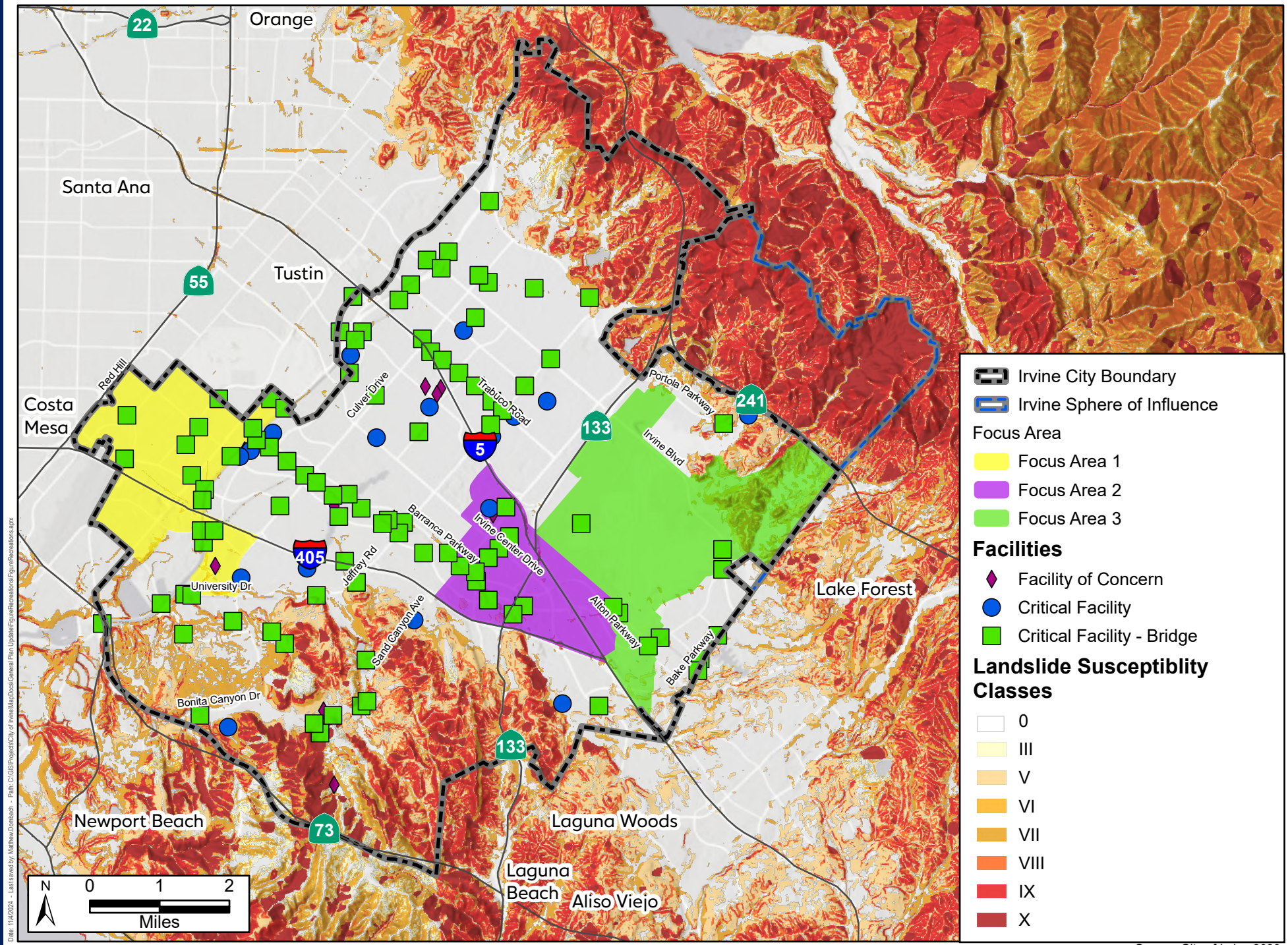
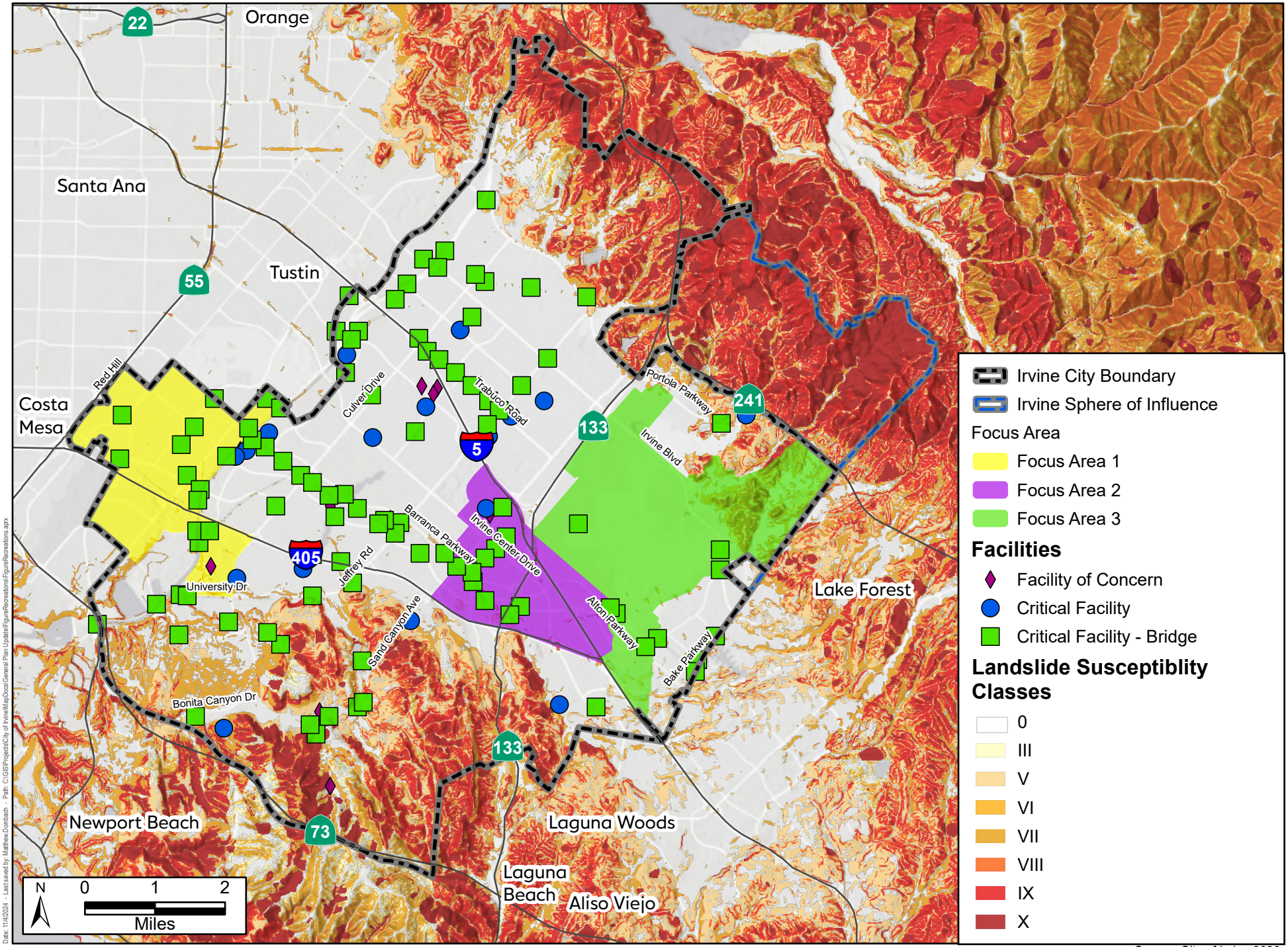


Figure 9. Earthquake Induced Landslide Physical Threat in Irvine



Source: City of Irvine 2020.

Figure 10. Deep-Seated Landslide Physical Threat in Irvine



Source: City of Irvine 2020.

FLOODING



Flooding hazards of concern in Irvine include inland flooding, dam inundation, and coastal inundation related to sea level rise.

Existing Conditions

INLAND FLOODING

A flood occurs when land that does not normally have bodies of water becomes suddenly inundated with water. Flooding can occur after periods of heavy rainfall, whether it occurs as a single extreme episode or as a series of storms. Drainages and stream courses may flood their banks and shores if their capacity is exceeded by rainwater. When heavy rainfall hits an area where the ground is already saturated, the risk of flooding is high. In developed areas, the presence of pavement and other impervious surfaces means that the ground is less able to absorb water. As a result, rainwater must be carried away in storm channels or waterways. Floods pose several threats to communities and public safety and can cause property damage, destroy homes, and carry away vehicles or other large debris.

Electronic or mechanical equipment on the ground could become waterlogged and nonfunctional. Flooding could also temporarily stop any type of transportation in the City. Debris carried by floodwaters can block roadways, hinder access for vehicles, and potentially affect emergency response services. Rushing water only one foot deep is enough to carry small vehicles. Key underpasses beneath major freeways and rail lines in the City may become flooded and impact transportation mobility throughout the City.



Inland flooding in the City of Irvine
Source: UC Irvine News

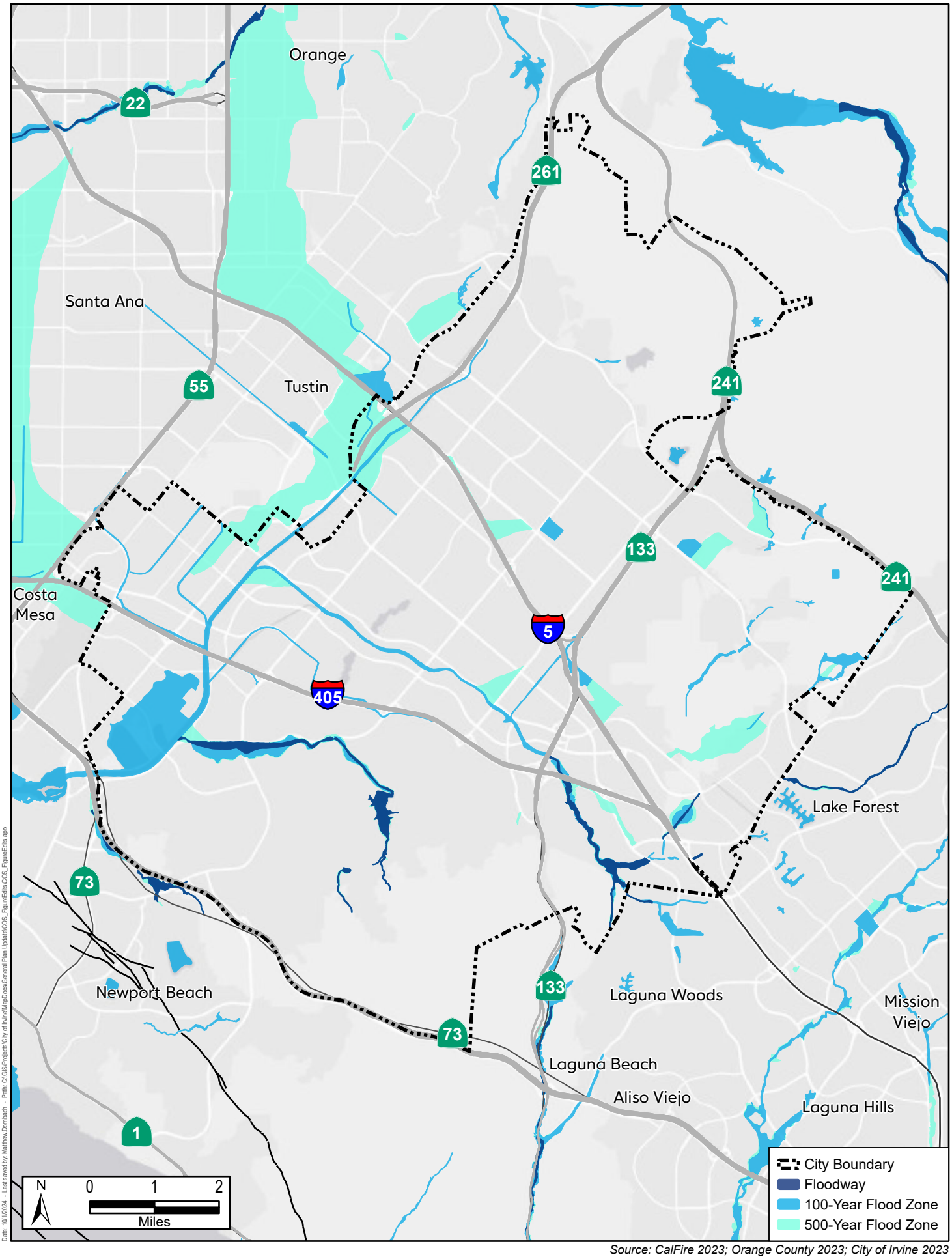
In addition, flooding in watersheds could impact water quality by bringing more nutrients and total dissolved solids into the water supply. Flood water may have high levels of raw sewage or other hazardous substances. During a flood, underground storage tank systems may become displaced or damaged and release their contents into the environment, causing soil, surface water, and groundwater contamination. Flooding events can generate tons of debris, including building rubble, soil and sediments, green waste (e.g., trees and shrubs), personal property, ash, and charred wood.

The City has limited vulnerability to precipitation-driven flooding and is prepared to adapt to future effects of climate change related to flooding. For example, the City has adopted floodplain management regulations with the purpose of "promoting the public health, safety, and general welfare, and to minimize public and private losses due to flood conditions in specific areas." The City applies a Floodplain District designation to all areas identified as flood channels and floodplains on maps published by FEMA, the Federal Insurance Administration, and flood insurance rate maps designating the floodplain areas. Any development within this zone is required to incorporate a series of improvements or modifications to ensure the ability of structures to withstand periodic flooding. Figure 11 shows the 100-year (1-percent annual chance of flooding) and 500-year flood hazard zones (0.2-percent annual chance of flooding) as identified by FEMA.



Flood Protection Infrastructure
Source: Orange County Public Works

Figure 11. FEMA Flood Hazard Zones in Irvine



Source: CalFire 2023; Orange County 2023; City of Irvine 2023

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DAM INUNDATION

Dam failure can result from several causes such as earthquakes, rapidly rising floodwaters, and structural design flaws. These hazards can occur instantaneously or gradually depending on the source of the failure. Inundation associated with these events has the potential to cause loss of life, damage property, and other ensuing hazards, as well as the displacement of persons residing in the inundation path.

There are seven dams that have the potential to inundate areas of the City if failure were to occur. Of these dams, three of them are located within Irvine and four are located outside of the City limits.



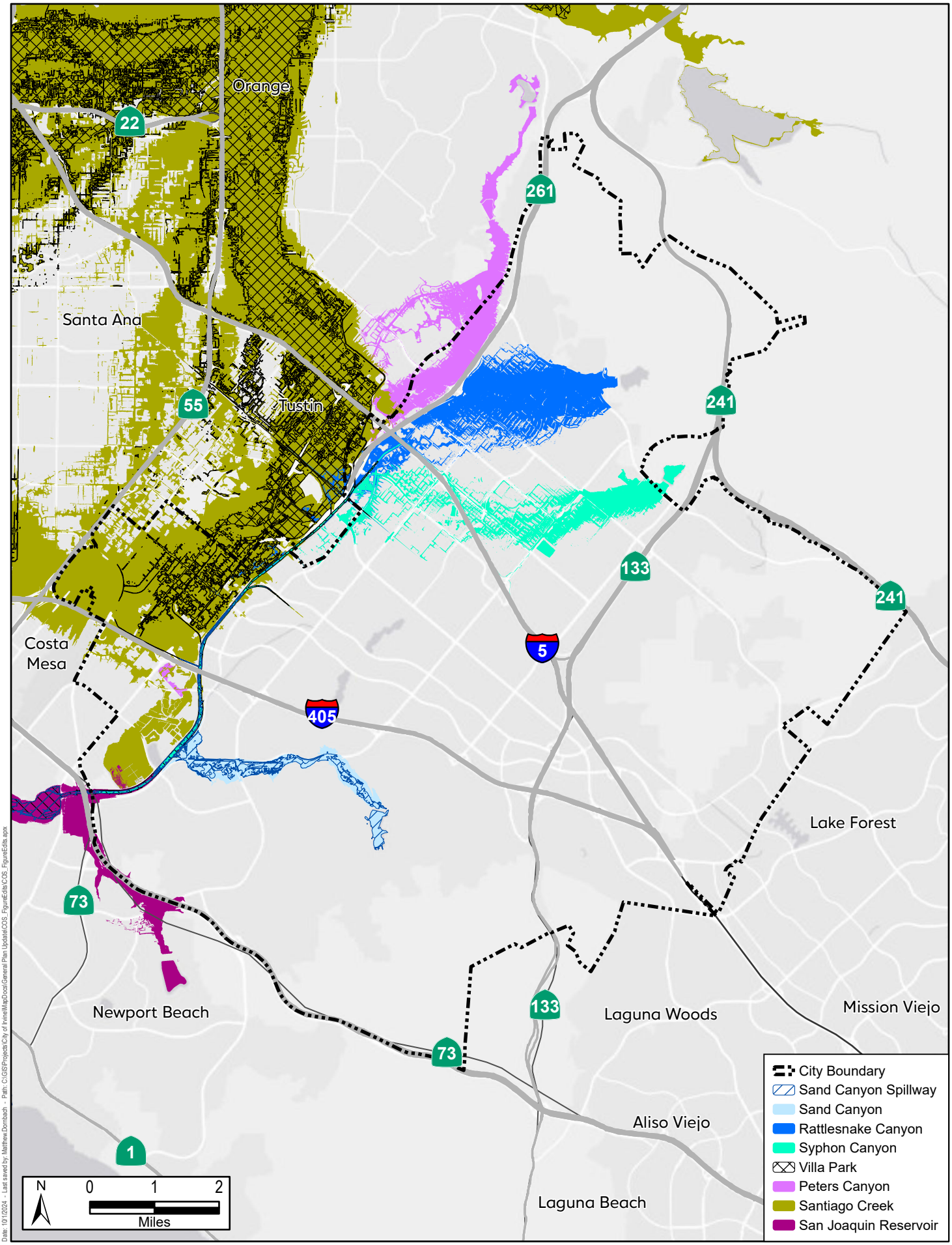
Irvine Lake and Santiago Creek Dam Outlet Tower and Spillway
Source: Irvine Ranch Water District

Table 1. Dams with Potential to Inundate Areas of Irvine

Dam Name	Owner/Operator	Year Built	Volume Water Impounded (acre-feet)
Rattlesnake Canyon Reservoir	Irvine Ranch Water District	1959	1,480
Sand Canyon Reservoir	Irvine Ranch Water District	1912	768
Syphon Canyon Reservoir	Irvine Ranch Water District	1966	535
Peters Canyon Reservoir	County of Orange	1932	626
Santiago Dam	Irvine Ranch Water District and Serrano Water District	1931	25,000
San Joaquin Reservoir	Irvine Ranch Water District	1966	>3,000
Villa Park Dam	Orange County Flood Control District	1963	>15,000

Figure 12 below identifies the potential dam inundation areas in and adjacent to Irvine. This figure shows the areas downstream that would be inundated by an unintentional breach from a dam's reservoir. The areas that could flood in the case of a dam breach are not necessarily the same areas that could be inundated by a 100-year or 500-year flood (Figure 12).

Figure 12. Dam Inundation Areas in Irvine



Source: California Water Authority 2019, 2020, 2021; Orange County 2023; City of Irvine 2023.

SEA LEVEL RISE

Globally, sea levels are rising because of two factors caused by human-induced climate change. The first factor is the thermal expansion of the oceans. As ocean temperatures warm, the water in the ocean expands and occupies more volume, resulting in a rise in sea levels. The second factor contributing to global sea level rise is the additional volume of water added to the oceans from the melting of mountain glaciers and ice sheets on land. It is predicted that if all the ice on earth were to melt, ocean levels would rise by approximately 225-265 feet above present-day levels (USGS 2022). The rate at which sea levels will rise is largely dependent on the feedback loop between the melting of the ice, which changes the land cover from a reflective ice surface, and the open ocean water, which absorbs more of the sun's energy and increases the rate of ice melt.



Cliffs in Dana Point
Source: Orange County Register

Areas of Concentration

INLAND FLOODING



Inland flooding in Huntington Beach
Source: OC Register

Any physical assets located within the mapped flood zone boundaries can expect to be inundated if precipitation exceeds the storm drain infrastructure design capacity in these areas. Electronic or mechanical equipment on the ground could become waterlogged and nonfunctional. The City has several key underpasses beneath major freeways and rail lines that, if flooded, could impact circulation throughout the City. In addition, the City has key locations along Sand Canyon Avenue, Jamboree Road, Culver Drive, and Jeffrey Road that require pump stations to ensure these underpasses do not fill with water. Figure 13 identifies the physical assets in Irvine located within the 100-year and 500-year flood zones. Assets within the 100-year flood zone include 55 bridges and 3 recreation support facilities within the City. Assets located within the 500-year flood zone account for 6 critical facilities (including 4 bridges) and 2 recreation support facilities within the City.

The threat of a flood primarily affects those residents living within the 100-year and 500-year flood zones. Many of these zones are located along drainages within the City. Flooding could inundate curb cuts as well as sidewalks. Any people in Irvine who walk, or bike may encounter mobility issues if they do not have access to an alternative means of transportation. Seniors, persons with disabilities, and low-income persons are those most likely to be threatened. Additionally, persons who are experiencing homelessness may be caught outside during flood conditions without any shelter. Even a floodwater depth of six inches may render any makeshift structures uninhabitable during the flood event. Possessions such as sleeping bags or electronic devices may be damaged or swept away by the floodwaters.

Flooding may temporarily stop any type of transportation in the City. Debris carried by floodwaters can block roadways, hinder access for vehicles, and potentially affect emergency response services. Rushing water only one foot deep is enough to carry small vehicles. A severe flood situation may prevent people who own smaller vehicles from driving to work, leading to reduced economic activity. Severe flooding that causes serious damage to homes and businesses may also result in reduced economic activity until repair work is completed.



Road closure in Ventura due to flooding
Source: Los Angeles Times

Flood events are measured by their likelihood of occurrence. For instance, a 100-year flood is a flood that has a 1 in 100 (1.0%) chance of occurring in any given year and a 500-year flood is a flood that has a 1 in 500 (0.2%) chance of occurring in any given year. Portions of the City are located within the 100-year flood zone and the 500-year flood zone. The 100-year and 500-year floodplains in Irvine are not contiguous areas, but rather consist of various pockets across the City, most of which are within major drainages, including San Diego Creek, Serrano Creek, Borrego Canyon Wash, Agua Chinon Wash, Bee Canyon Wash, Peters Canyon Wash, and Sand Canyon Wash.

Any physical assets located within these mapped boundaries can expect to be inundated if enough precipitation were to fall exceeding the storm drain infrastructure design capacity in these areas. For example, flooding could impact transportation mobility throughout the City if the City's underpasses beneath major freeways and rail lines become flooded. To prevent potential flooding, Irvine has more than a dozen detention or retarding basins, generally located on, or adjacent to, drainages within the City. Floodplain mapping studies are provided by the National Flood

Insurance Program. Irvine participates in the program by adopting FEMA-approved floodplain studies, maps, and regulations.

There is no indication that the severe rainfall that leads to flooding will abate in the future, either in Irvine or the greater region of Southern California. While Irvine may experience prolonged periods of dry or wet years, flood events will likely continue to impact the City. For areas within the 100-year and 500-year flood hazard zones, the likelihood of flooding to occur on an annual basis is 1% and 0.2%, respectively.

Climate change is expected to alter the frequency of intense precipitation events throughout California, including Irvine. Climate models predict that intense rainfall will occur more frequently (perhaps twice as often by the end of the 21st century) and potentially drop more rain (up to 40% more). Additionally, the state's streams and rivers will swell more in some years from earlier and faster spring snowmelt caused by higher temperatures. Scientists suggest the combination of these factors could lead to a 50% increase in runoff in future years, challenging the capacity of the state's existing reservoirs, canals, levees, and other flood control systems, and increasing the risk of inland flooding. These projected changes likely mean that Irvine will experience more frequent and more intense flooding, potentially leading to erosion, dam failure, landslide, tree mortality, and other potential hazards.

DAM INUNDATION

Various factors, such as the amount of water released, distance from the dam failure site, and the topography of the surrounding land, influence the extent to which physical assets in Irvine are threatened by dam failure. Some reservoirs, like Peters Canyon Dam or San Joaquin Reservoir, simply hold less water or are in remote locations that reduce the threat to physical assets in the City. Other reservoirs, like Villa Park Dam or Santiago Canyon Dam, have large storage capacities that could potentially lead to widespread inundation, particularly in northern Irvine, if the reservoir waters are released due to a dam breach.


Peters Canyon Dam

Figure 14 shows which critical facilities and facilities of concern would be impacted in each dam failure scenario. Based on this analysis, the greatest number of facilities impacted by dam inundation would occur because of a failure of either Rattlesnake Canyon or Villa Park Dam, both of which could affect 32 facilities within the City.

The greatest amount of people would potentially be affected by failure of the Rattlesnake Canyon Dam. Both the Sand Canyon and Villa Park Dams would impact populations that have a lower median household income than the Citywide population. The Sand Canyon dam has the potential

to affect a significant number (42.1%) of households with one member aged 65+ population. In addition, all dams would impact a higher percentage of populations living with a disability.

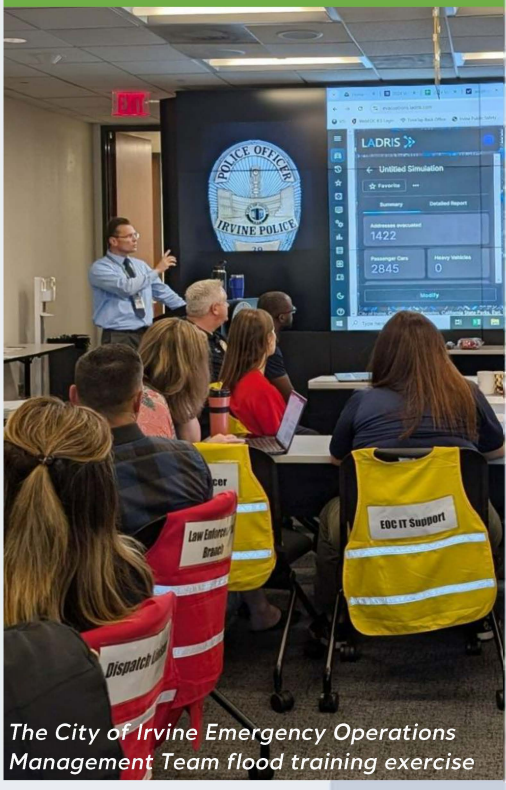


Traffic moving through storm runoff in Costa Mesa
Source: OC Register

Floodwaters would quickly inundate downstream portions of the City, disrupting utilities, such as water, power, and heating, as well as other services such as communications or transportation infrastructure, especially vulnerable bridges within the City. Street lighting and traffic signals may be temporarily disabled if the inundation area interferes with the electronic systems that control them.

Rapid inundation of water may sweep up debris, which could block roads, impeding the flow of traffic. Water would likely inundate roadways and other low-lying, flat areas, such as parking lots, open spaces, and school yards, causing mobility in these areas to be restricted or even impossible in severe scenarios. Any unprotected or unhoused mechanical or electronic equipment that is not properly elevated would become waterlogged and inoperable until crews are able to conduct repairs or replacement, if necessary.

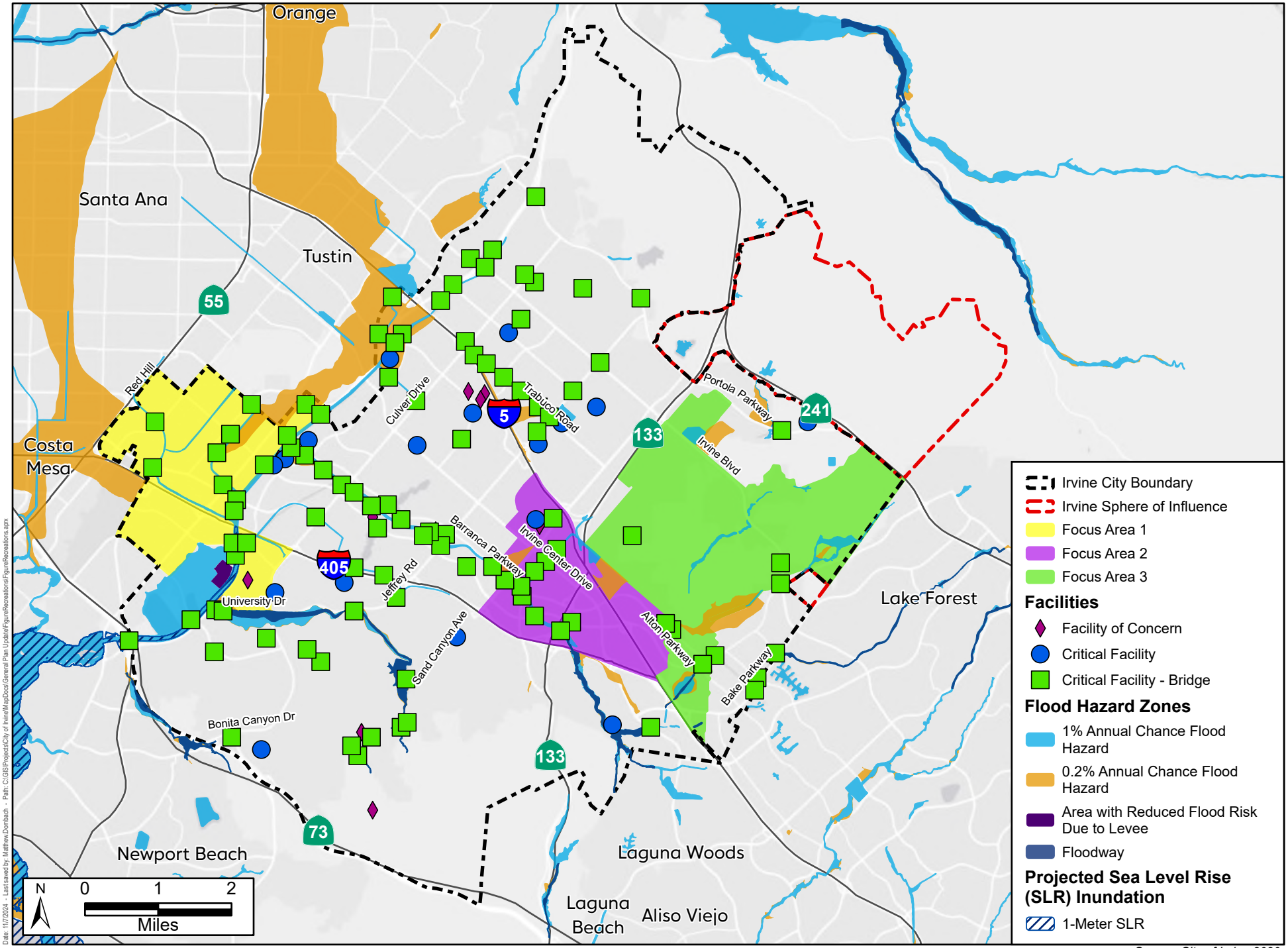
Due to the presence of several dams in and near Irvine, many residents and businesses could be at risk of inundation in the case of significant dam failure. All dams identified in Table 1 and Figure 14 are considered to have an "Extremely High Downstream Hazard" classification due to the proximity to homes and businesses. Some of the potential consequences of dam failure from these facilities are death or injury, displacement of people from their homes, damage to existing public and private buildings, damage to infrastructure, loss of services from utilities, loss of government services, and economic losses. The California Division of Safety of Dams (DSOD) requires periodic evaluation of dams based on confirmed or unconfirmed safety issues, probability of failure, and the potential consequences. All dams that may impact Irvine currently meet satisfactory conditions regarding dam safety.



The City of Irvine Emergency Operations Management Team flood training exercise

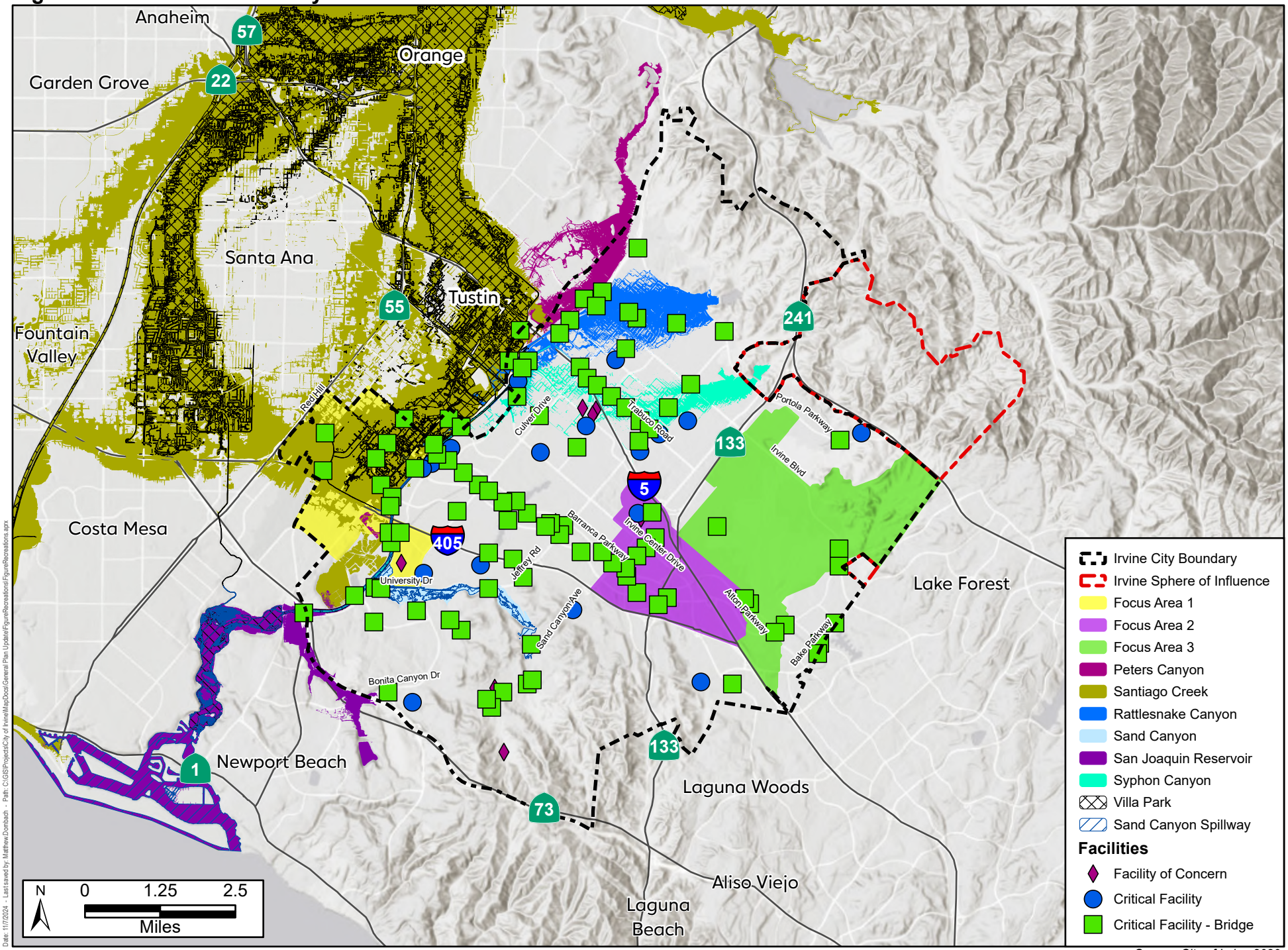
Climate change could increase the risk of a dam failure in the future. More intense rainstorms may increase the likelihood that reservoir infrastructure could become overwhelmed, including the dams that control floodwaters from inundating Irvine and the rest of Orange County. Indirectly, increased climate change-induced rains may cause more erosion which could compromise the structural integrity of the dam or the foundation it sits on. For these reasons, monitoring of changing precipitation regimes and conditions is recommended to ensure future conditions are better understood.

Figure 13. Flood Hazard Physical Threat in Irvine



Source: City of Irvine 2020.

Figure 14. Dam Inundation Physical Threat in Irvine



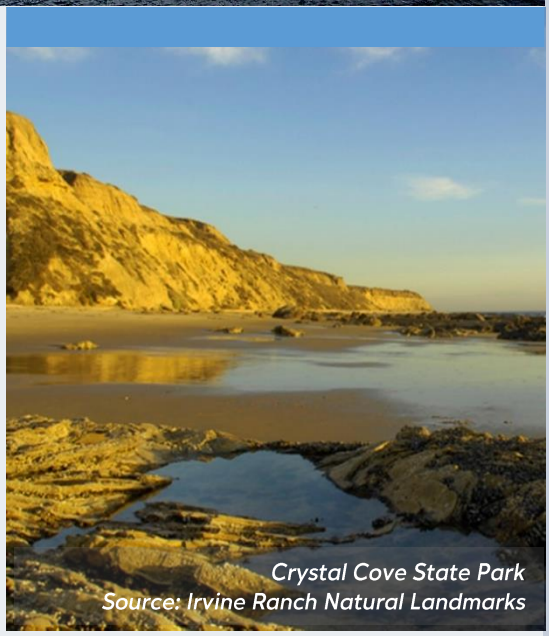
Source: City of Irvine 2020.



Source: Rising Seas in California Report

SEA LEVEL RISE

While Irvine is not considered a coastal community, the City's drainage infrastructure connects to the ocean and may be tidally influenced. In the event future sea level rise affects drainage infrastructure, it could impact future flooding within the City. As an inland community that has coastally influenced drainage infrastructure, the potential influence of sea level rise on flood control infrastructure should be addressed. As identified in the LHMP, a small portion of the flood control infrastructure in the northwestern corner of the City may be influenced by future sea level rise. Specifically, the USGS Coastal Storm Modeling System (CoSMoS) identifies coastal inundation along San Diego Creek associated with sea level rise and a 100-year storm scenario. However, most of the City would not be affected by this hazard given its inland location. Water pipes, wastewater pipes, and wastewater pump stations have a low- to medium-vulnerability to coastal flooding and high vulnerability to coastal erosion. Therefore, flooding would not have a severe impact on underground pipes or pump stations, but erosion could compromise the functionality of the system.



Crystal Cove State Park
Source: Irvine Ranch Natural Landmarks

WILDFIRE

Existing Conditions


Silverado Fire of 2020

As previously mentioned, the Orange County Fire Authority provides fire prevention and response services within the City. Wildfires are primarily sparked by lightning, accidents, or arson. The topography of the foothills of the Santa Ana Mountains and San Joaquin Hills in Irvine is extremely conducive to wildfires. The community is bordered by natural, undeveloped hillsides/mountains to the northeast and open space areas to the southwest. In between these two areas is most of the City's developed area. A majority of these natural, undeveloped areas are classified as Very High Fire Hazard Severity Zones (FHSZ) by the California Department of Forestry and Fire Protection (CAL FIRE). In the northeastern portion of the City, this zone extends throughout the Santa Ana Mountain range, which extends into Riverside County to the east (Figure 15). The Very High FHSZs delineate the regulatory requirement that triggers compliance with Government Code Section 65302 (g)(3) [also known as SB 1241]. The entire City of Irvine is designated local responsibility area (LRA) – there are no state or federal responsibility areas within the City.

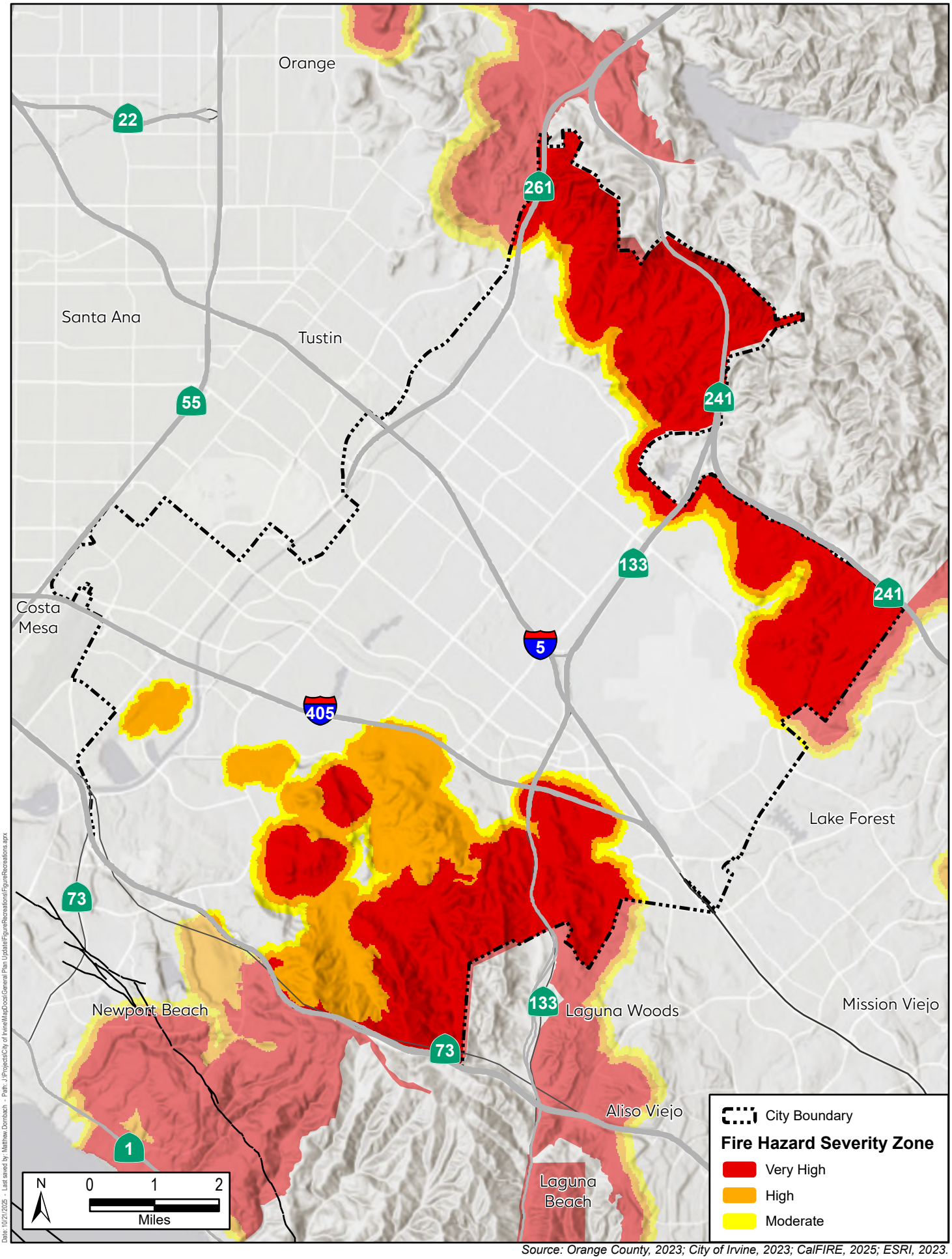
Developed areas of the City adjacent to High or Very High FHSZs are referred to as the Wildland Urban Interface (WUI). Typically, the WUI is impacted if adequate fuels are combined with dry conditions and strong winds. The ignition of a wildfire may occur if power lines located around overgrown trees cause a spark and catch the tree on fire. These types of incidents are the main impetus for the State's Public Safety Power Shutoff (PSPS) program.

Several historical wildfires in the Santa Ana Mountains and San Joaquin Hills have impacted Irvine (Table 2), resulting in evacuations and indirect effects from smoke and traffic congestion.

Table 2. Historic Wildfires in Irvine (1948–2023)

Fire Name	Start Date	Size (acres)
Green River	1948	53,080
Paseo Grande	1967	51,077
Gypsum Fire	October 8, 1982	20,142
Loma Ridge	1984	1,435
Laguna Fire	October 26, 1993	14,338
Baker	October 12, 1997	6,320
Shady Canyon Fire	September 8, 2001	26
Santiago Fire	October 20, 2007	28,430
Fossil Fire	September 14, 2019	16
Silverado	October 25, 2020	12,469
Bond	December 2, 2020	6,681

Figure 15. Fire Hazard Severity Zones in Irvine



Source: Orange County, 2023; City of Irvine, 2023; CalFIRE, 2025; ESRI, 2023.

Areas of Concentration

Figure 16 identifies 6 critical facilities and 1 facility of concern within the Very High FHSZ. While these areas have a high degree of vulnerability to wildfire, other areas of the City may also be susceptible due to ember cast.

Outside of the property owners directly impacted by a wildfire event, wildfires can also impact seniors and persons with disabilities. These groups may have limited mobility, be immuno-compromised, and/or not receive notifications regarding current conditions and evacuation requirements. For example, a senior who lives alone may not be aware that a wildfire is burning close to their residence, and they have been ordered to evacuate if those notifications were sent in manner that doesn't reach them. Persons with disabilities may require special mobility devices or caregiver assistance to go outside, which may not arrive as quickly as needed. Other groups with increased threat levels include people with lower-incomes, renters, and the homeless. These groups may not possess enough financial resources to rebuild their homes or search for new homes in the aftermath of a fire.

The City of Irvine currently has 11 circuits that could be affected by future PSPS events. Identifying key locations for sheltering and comforting of residents during these events will become a major priority for Irvine. In addition, outreach with residents and businesses to help them prepare for future PSPS events is important for community resilience and adaptation.

The history of wildfires in Orange County and the presence of Very High FHSZs in and around the community mean that such events are very likely in the future. The risk is expected to remain highest in the foothills of the Santa Ana Mountains and San Joaquin Hills, which have the right conditions for wildfire incidents.

Climate change is expected to cause an increase in temperatures as well as more frequent and intense drought conditions. This will likely increase the amount of dry vegetation available for fuel, increasing the risk of wildfire statewide. In the foothills of the Santa Ana Mountains and San Joaquin Hills, which are already highly prone to wildfires, climate change is expected to increase the number of acres burned annually. Moreover, increases in fuel supplies could cause wildfires to move faster or spread into more-developed areas, which could increase the threat to Irvine.

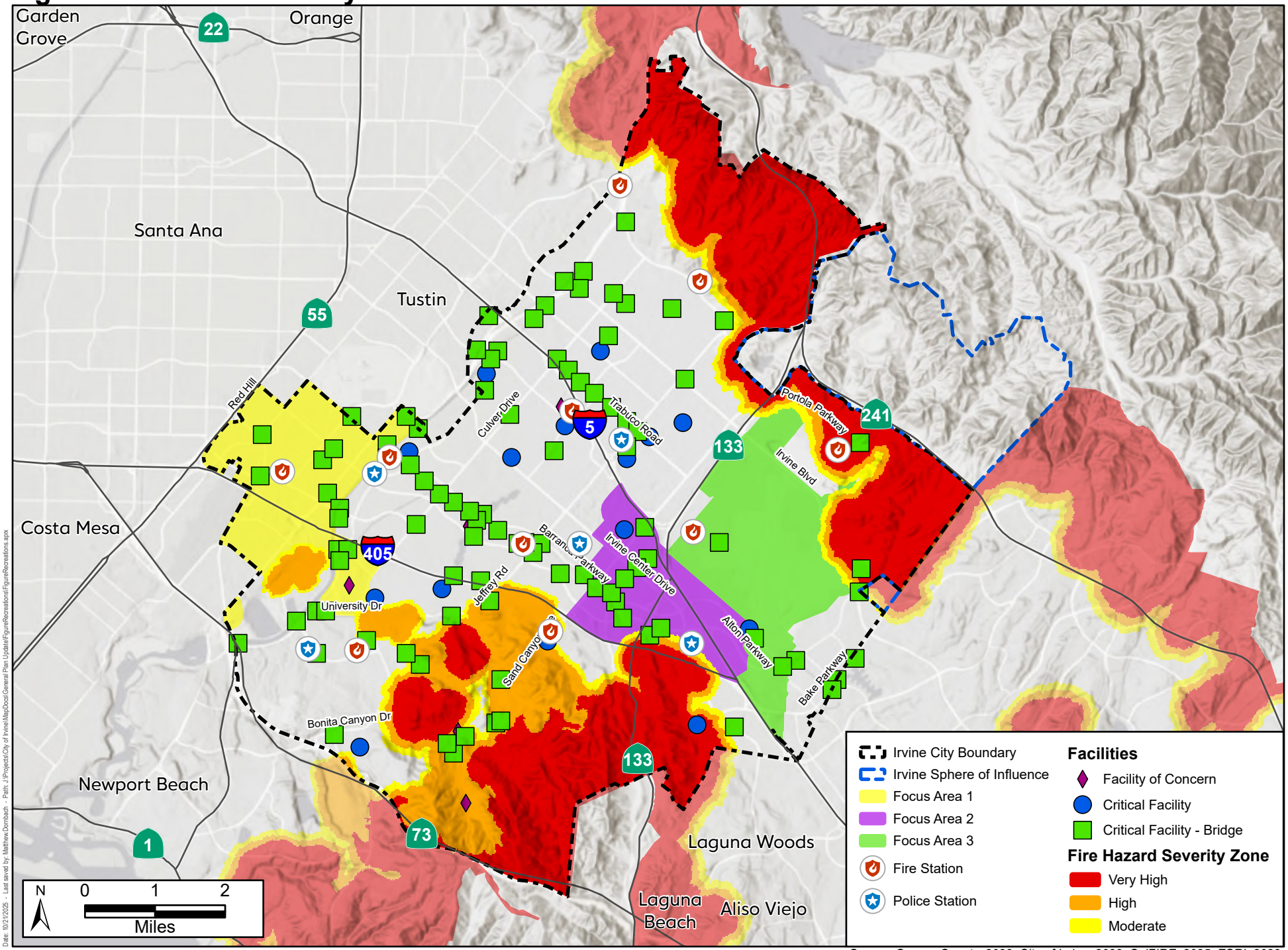


Silverado Fire



Silverado Fire Response

Figure 16. Fire Hazard Physical Threat in Irvine



Source: Orange County, 2023; City of Irvine, 2023; CalFIRE, 2025; ESRI, 2023.

DROUGHT

Existing Conditions

A drought is a period in which water supplies become scarce. This can occur for a variety of reasons; in California, droughts occur when precipitation and snow are limited for an extended period. A drought may also occur when infrastructure connecting communities to long-distance water sources begin to fail. This can occur due to deferred maintenance or may be the result of a natural disaster. Given Irvine's location, any drought that is significant enough to reduce water supply to Southern California may have an impact on the City. The City's water supplies are provided by the Irvine Ranch Water District (IRWD), which has taken significant steps towards reducing water supply scarcity during a drought. Therefore, the City may not feel the effects of drought in the same way other cities in Southern California may experience drought.



Crop field suffering from drought

Availability of water resources is important to meet the City's water demand and to provide water for fighting fires. Peak load water supply requirements for the City are consistent with those required by IRWD, as shown in Table 3.

Areas of Concentration

Reduced water supply and availability due to drought is not anticipated to threaten any of the City's physical assets. It is possible that any water delivery infrastructure not used or used less than usual may fall into some degree of disrepair if maintenance is deferred. Lower water pressures may cause some aged water pipes to release rust particles into the water supply.

Residents and business owners in the City may experience financial costs associated with water conservation efforts. Those who have less access to financial resources, such as low-income households or seniors, may be harder hit if higher water fees are imposed during a severe drought event.

An exceptional drought may lead to restricted water use for residents or businesses in the City. Trees that are not properly adapted to lower levels of irrigation could die, which would alter the City's aesthetic appearance. For more specific information on tree health, please refer to the Tree Mortality discussion under Diseases and Pests. Any open spaces with extensive lawns may also start to die, turning brown in color, which could discourage residents from using these parks and open spaces.



View of mountain with snowcaps

Drought will continue to be a foreseeable event in the future of California, including Irvine. Since most droughts are almost entirely contingent on global weather phenomena, which vary from year-to-year, it is impossible to predict either the frequency or severity of future drought events in Irvine. Droughts that result from infrastructure failure are equally impossible to predict since the circumstances that lead to infrastructure failure are unique to each situation.

Climate change is anticipated to abate drought in certain situations but could also intensify and exacerbate it in other cases. For example, climate change-intensified weather patterns, like the El Niño (warm and wet) phase of the El Niño Southern Oscillation (ENSO), may bring more rain to Southern California and Irvine, which would abate drought conditions. In other years, climate change may prolong the La Niña (cold and dry) phase of ENSO, which could lead to longer periods with no precipitation in California.

Climate change is also expected to increase the average temperature and cause more frequent and prolonged heat waves in California and Irvine. During these events, water supplies may be diverted for cooling functions in the City. Hotter temperatures may also lead to increased surface water evaporation, which could lead to greater water consumption. If a drought were to occur during a future heat wave, it could place the City's water supply under strain.



Extreme heat warning sign posted on a road

From a regional perspective, warmer overall temperatures in California are anticipated to lead to a reduction in statewide water supplies. Much of California's water comes from melted snow in the High Sierra. As the average temperature grows warmer with climate change, the amount of precipitation that falls as snow is expected to shift towards rain. As less snow falls, the amount of melted water from the snowpack in the Sierra Nevada will decrease, reducing the water that will flow into the reservoirs and aqueducts that supply Southern California. This could place strain on the City's imported water supply, leading to greater reliance on Orange County's local groundwater. If regional water agencies do not account for increased groundwater withdrawal, Irvine and the greater Orange County region could experience subsidence as a result (refer to *Geologic Hazards* above).

SEVERE WEATHER

Severe weather includes extreme heat, extreme precipitation, and severe wind.



Existing Conditions

EXTREME HEAT

Extreme heat is a period when temperatures are abnormally high relative to a designated location's normal temperature range. There are generally three types of extreme heat events:

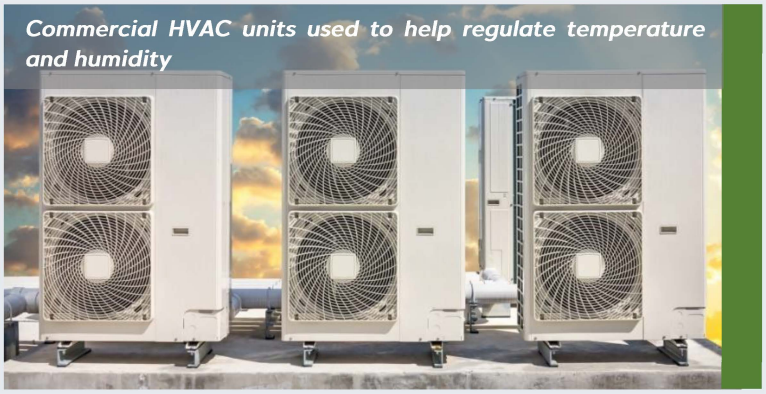
- Extreme Heat Days: a day during which the maximum temperature surpasses 98% of all historic high temperatures for the area, using the time between April and October from 1961 to 1990 as the baseline. The minimum threshold for an extreme heat day in Irvine is 93.2 degrees Fahrenheit (°F).
- Warm Nights: a day between April and October when the minimum temperature exceeds 98% of all historic minimum daytime temperatures observed between 1961 to 1990. The minimum threshold for a warm night in Irvine is 66.4°F.
- Extreme Heat Waves: a successive series of extreme heat days and warm nights where extreme temperatures do not abate. While no universally accepted minimum length of time for a heat wave event exists, Cal-Adapt considers four, successive extreme heat days and warm nights to be the minimum threshold for an extreme heat wave.

Extreme heat events will feel different from region-to-region since different areas have different historic high temperatures. For example, an extreme heat day on the coast will feel different than an extreme heat day in the High Desert. The reason for this is how humidity plays a factor in the

perceived heat that people feel. Humid conditions will make a day feel hotter than non-humid conditions, even though the temperature may be the same.

Buildings with dark pavement will absorb more heat than the surfaces with vegetation or lighter materials, which are better at reflecting the sun's energy. This urban heat island effect is strongest during hot periods when the sun is strongest.

Extreme heat poses several dangers to public health. The human body is vulnerable to long periods of high temperatures and will eventually enter a state of heat exhaustion and dehydration if exposure to heat is extended. If exposure to high temperatures is particularly prolonged to the point that internal body temperature surpasses 105°F, heat stroke may occur, and organ failure and even death may soon follow without intervention.



Commercial HVAC units used to help regulate temperature and humidity

EXTREME PRECIPITATION

During severe weather events such as strong storms, rain can fall at such a high rate that it cannot drain away fast enough. The resulting heavy rain can cause flooding, leading to inundation and potential damage to buildings, road networks, public areas, utilities, and other critical pieces of infrastructure (*refer to Flooding above*). In California, heavy rainfall events are often short, intense bursts of rain, but in some cases heavy rain can persist for multiple days.

SEVERE WIND

Wind is the movement of air caused by differences in atmospheric temperature. High pressure air will naturally move to areas of low pressure. Usually, the distance between these high- and low-pressure zones is far; however, on occasion these low- and high-pressure zones may be near one another. When this happens, air will flow dramatically, creating high-speed winds. In Southern California, the most common type of severe wind event is called the Santa Ana winds. High pressure over Nevada and Utah, often during the fall and winter months, forces air down from the high desert toward the ocean. As the winds descend, they heat up and increase in speed. Irvine is often affected by Santa Ana winds blowing through the Santa Ana Mountain range.

When winds are fast enough, they can carry particulate matter and aggravate the respiratory health of those who have allergies. High winds can cause property damage to homes, public facilities, utilities, and other infrastructure. They can also uproot or topple mature trees or pick up debris and send it careening through the air. This debris can injure or even kill bystanders who may find themselves stranded outside. High speed winds can also deposit this debris in the middle of rights-of-way, such as roads, freeways, and railways, blocking exit routes for would-be evacuees or impeding access to first responders trying to reach wounded people. Additionally, Santa Ana winds are a leading cause of wildfires in California (refer to *Wildfire* above).

Areas of Concentration

EXTREME HEAT

Very high temperatures can cause roads to deform and buckle as concrete expands in the heat, especially in areas that have not been maintained well. Power lines and other sections of the electrical grid are less effective in higher temperatures and may suffer damage due to stress during extreme heat events.

A heat event can be relatively harmless for those with a reliable means for staying hydrated and cool and can be deadly for others. Young children, the elderly, or people suffering from serious medical conditions are physiologically more vulnerable to heatstroke. Some senior citizens also take medicines that can make it harder for their bodies to maintain a safe internal temperature, creating an additional threat from extreme heat events. Young children may not be aware of the signs of dehydration or ways of protecting themselves from heatstroke. People living in homelessness are at a high risk of health complications during heat waves, especially if they are unsheltered. During a heat wave, these people are very vulnerable to heatstroke, especially if they are unable to reach a cooling center.

Sudden spikes in heat can catch people by surprise. Stores can rapidly sell out of fans, air-conditioning units, or drinking water during a heatwave. Lower-income households or those with limited mobility may be unable to acquire enough insulation or cooling devices without significant advance preparations. This can be further compounded by the threat of PSPS events, during which extreme heat impacts may affect larger portions of the City and populations that wouldn't be viewed as vulnerable under normal circumstances. Extreme heat events occur in Irvine a few times each year. It is considered highly likely for extreme heat events to occur and to increase in the future.



City of Irvine Public Works & Sustainability Department staff applying DuraShield Solar Reflective to help protect streets from the damage of extreme heat

The primary effect of climate change is warmer average temperatures. As climate change accelerates in the 21st century, it is anticipated that extreme heat events will become more frequent and intense in California, including Irvine. In Irvine specifically, the projected average number of extreme heat days per year could increase from 4 to 12, assuming global greenhouse gas emissions peak around 2040, then decline. If global greenhouse gas emissions continue to rise until 2100, the number of extreme heat days could increase to as many as 25 days per year. The number of warm nights could increase from 4 to 41 assuming an emissions peak and decline in 2040 but could increase to as many as 86 if emissions continue to rise until 2100.

EXTREME PRECIPITATION

Rain could damage any structures with poorly constructed roofs and could also erode the soil around building foundations. Heavy rain could also lead to flash flooding, which would damage unelevated structures in flood zones. Heavy rains are most likely to cause damage to structures located on slopes, and along stream courses, where the risk of erosion is the highest. Landslides triggered by heavy rains would damage any structures located below the landslide's starting point.



Pedestrian crossing the street during a rainstorm

Rain events pose a threat to any groups in Irvine who are not able to access adequate shelter. People who are homeless most often live in tents or informal structures that may protect against minor rains but are inadequate against a heavy rain event. Flash flooding during a heavy rain event could sweep away any informal dwellings located within drainages and stream courses. Additionally, vulnerable populations living in older homes that have outdated building materials may experience damage during significant rain events. If affected groups have limited incomes or lack the resources to make necessary repairs or maintain the structures, retrofit of these structures may be hindered.

There is no indication that rainfall or severe rain hazards will abate either in Irvine or the greater region of Southern California in the future. While Irvine may experience prolonged periods of dry or wet years, the probability they will occur again in the future is highly likely and anticipated to increase in the future.

Climate change is expected to alter rainfall patterns in Southern California, including Irvine. As the climate warms, rain events are predicted to become more intense and less frequent. It is likely that Irvine will experience more rain inundation events that lead to flooding and erosion, as well as increase the threat of dam failure, tree mortality, and other potential hazards.

SEVERE WIND

Intense winds likely present the greatest threat to physical structures, particularly from trees or branches that fall on buildings and cause substantial damage. Older structures that have deferred maintenance or have not been retrofitted for high wind conditions may suffer greater damage in comparison to newer/updated structures. Utility lines and wooden utility poles face an elevated threat from wind, as do buildings without reinforced roofs.



Fallen tree from severe wind in Orange County
Source: OC Register

Another physical threat associated with severe wind is wildfire impacts and the recent practice of electric utilities conducting PSPS activities. During high wind events, these shutoffs may impact structures that rely on electricity for normal operations.



Events such as severe winds and winter weather can harm people throughout Irvine but have a greater effect on the safety of homeless persons and persons who work outdoors. Lower-income households, who may not be able to afford homes built or retrofitted to withstand powerful winds, could also have difficulty coping or recovering from heavy winds or storms.

Given Irvine's history of severe wind events, it is very likely that wind events will continue to impact the City. The most probable source of wind events in the future will likely originate from the Santa Ana winds or extreme storms.

It is anticipated that the atmospheric rivers that deliver storms to Southern California may intensify because of climate change. While the average number of storms in Southern California will remain the same, storms are expected to increase in strength by 10 to 20%%. This increase in storm intensity may also bring more intense winds to the Southern California region, including Irvine. It is not yet known if climate change will affect the frequency or intensity of Santa Ana wind events.

DISEASES AND PESTS

The discussion of diseases and pests includes epidemic/pandemic/vector-borne diseases, agricultural pests, and tree mortality.

Existing Conditions



A disease is a serious type of illness that affects an organism (e.g., trees, the human body) to the degree that normal activities can become more hampered, difficult, or even impaired.

Pests are organisms whose presence is generally considered a nuisance due to the public health and property damage they can cause. These organisms can be vectors, or transmitters, of disease which are spread by pests to animals and humans. Occasionally, the disease may spread first to an intermediary, like a domesticated animal, where it may evolve into a form that can survive in humans. These kinds of vector-borne diseases are known as zoonoses. Apart from posing risks to public health, pests can also damage property, such as utility infrastructure, trees, or other landscaped areas, either by directly consuming the plant material or spreading infectious diseases.

EPIDEMIC/PANDEMIC/VECTOR-BORNE DISEASE

There are two general classifications to describe the geographic spread of disease. An epidemic is an infectious disease that spreads beyond a localized area, reaching people throughout a large region. A pandemic is an infectious disease that spreads around the world. When a disease is described as vector-borne, it refers to the medium of infection, which is through a third-party organism (i.e., mosquito) known as a vector. Both epidemic and pandemic disease can be described as vector-borne if infection takes place through a vector.

The following are some examples of diseases and pests that could affect the population of Irvine:

- Influenza (the flu)
- COVID-19
- West Nile Virus
- Zika Virus
- Mosquitoes, mice, rats, and small rodents

The Orange County Health Care Agency is the regional health jurisdiction providing preventative and responsive health care services for Orange County, including the City of Irvine.


View of crop fields

AGRICULTURAL PESTS

In areas where agricultural production occurs, the presence of pests can impact the quality and quantity of products harvested. Orange County has over 19,000 acres of land under agricultural production. Within Irvine, approximately 1,323 acres of land are designated for agricultural use, which is scattered throughout the City. Agricultural pest damage is typically measured in the amount of crop loss caused by the pest.

TREE MORTALITY

The entirety of a city's trees is generally referred to as an urban forest. These trees may be publicly owned and maintained or privately owned. Urban forests represent important assets for a city as they provide shade, which helps keep the community cool during hot weather, as well as provide aesthetic beauty to a community. Trees are also known to help humans feel calm and less stressed. Tree mortality refers to the death of numerous tree specimens in a forest, including urban forests. Like other living beings, trees are also subject to vector-borne diseases spread by pests.

Pests that are currently afflicting trees in Orange County include the following:

- Asian Citrus Psyllid (ACP)
- Gold Spotted Oak Borer (GSOB)
- Invasive Shot Hole Borer (ISHB)

The City follows the UC Integrated Pest Management guidelines for shot hole boring pests.

Areas of Concentration

EPIDEMIC/PANDEMIC/VECTOR-BORNE DISEASE

To some degree, diseases affect everyone in Irvine, whether the impact is a mild inconvenience or more severe. Generally, seniors, infants, pregnant women, and people with weakened immune defenses experience the greatest risk. Lower-income persons may also be more threatened than others by diseases since they may not be able to afford medical treatment. Persons with disabilities or those who live alone may experience greater vulnerability to an illness since they may be unable to access treatment. Pregnant women are especially threatened by the Zika virus since it may cause their infants to be born with microcephaly, which is shown to cause health problems for infants.

Since diseases only affect the human body, an epidemic, pandemic, or vector borne disease would not directly threaten physical assets in Irvine. However, a major outbreak of disease could overwhelm the capacity of medical facilities in Irvine and in the surrounding area, potentially leading to greater inaccessibility of medical services and shortage of medical personnel in the region. A major outbreak could also incapacitate large amounts of the City's and region's workforce, inhibiting the regional economy of Orange County and Southern California. Services such as telecommunications, utilities, recreation, and commerce may become restricted or even entirely unavailable for a period.



City of Irvine and MemorialCare COVID-19 Vaccination Clinic

While any location in Irvine is susceptible to experiencing the spread of disease, locations where many people gather are more likely to facilitate the spread of disease. In Irvine specifically, there are two large hospitals (i.e., Kaiser Permanente Orange County – Irvine Medical Center and Hoag Hospital) serving high populations of individuals with infectious diseases. In addition, large commercial and employment areas, like the Irvine Spectrum, Irvine Business Complex, and University of California (UC) Irvine, are highly trafficked by many people, which could increase the spread of disease.

Vector-borne diseases can only be spread where there is a link between the pest and the human population that could be infected. Any pools or other bodies of standing water in Irvine likely pose an increased risk of being bitten by a mosquito and infected by a mosquito-borne disease to anyone who regularly spends time near these locations.

Zoonoses can be spread in any location where there is regular contact between animals and humans. The most common places for zoonoses to develop are livestock farms or other similar agricultural facilities. While Irvine has agricultural uses, these uses do not include significant amounts of animals.

AGRICULTURAL PESTS

According to the Orange County Agricultural Commissioner, the three main pests impacting agriculture in Orange County include the Light Brown Apple Moth, Glassy-winged sharpshooter, and Asian Citrus Psyllid (ACP; which can infect citrus trees with a bacterium that causes a serious plant disease called Huang Long Bing [HLB]).

Since agricultural pests would be limited to agricultural properties within the City as well as ornamental plantings (citrus trees, bushes/shrubs, etc.), it is expected that some of these assets could be impacted in the future. This future impact is not anticipated to affect the City's residents, businesses, or critical facilities significantly.



Source: California Department of Water Resources

It is anticipated that agricultural property owners would actively monitor agricultural pest issues and coordinate with the Orange County Agricultural Commission. With over 1,300 acres of agricultural land in the City that could generate over $6 million in revenue based on county agricultural production values, any loss in value could impact the local economy.

Agricultural pests may cause significant issues in conjunction with particular climate conditions. During excessive droughts, plants may be stressed, which can create favorable conditions for pests to thrive. In addition, excessively wet winters and springs could create conditions where plants grow molds and fungus that impact crop yields or require additional treatments by farmers.

TREE MORTALITY

The City of Irvine Public Works Landscape Maintenance Division maintains over 76,000 trees across 1,700 acres of parks, greenbelts, and street landscapes in the City. Any tree has the potential to be infested by pests which could result in the tree's death. A serious outbreak of pests in Irvine could threaten the City's urban forest, leading to an episode of intense tree mortality throughout all areas of Irvine that are landscaped with trees. These areas include parks, landscaped parkways, and street medians, schools, as well as private homes or businesses.

Based on the City's current inventory of trees, the City estimates the value of their tree assets at approximately $181 million. Part of the tree inventory process is the identification of impacted trees that require monitoring and/or removal. Understanding that a portion of this inventory will require replacement every year, trees that are damaged due to pests should be treated as quickly as possible to reduce the threat to healthy trees.

Trees could also die because of other hazards or multiple hazards could combine to cause tree mortality. Additionally, if dead trees located within the City are not felled immediately, they may pose a threat to other physical assets when compounded with other hazards. For example, dead trees are more prone to catching fire than living trees, which can intensify the risk that surrounding physical assets could experience flashover.



Given the aesthetic beauty that healthy trees add to homes and businesses, Irvine residents who experience tree mortality on their property may be potentially threatened by decreased property values. Higher-income property owners in Irvine may be able to absorb the costs of tree loss and afford to replant any lost trees. Lower-income property owners, on the other hand, are less likely to be able to afford the cost of replanting lost trees without assistance.

Tree mortality also reduces the amount of shade in each area, potentially increasing the impacts of urban heat island effect. As a result, groups that are threatened by higher heat levels may be impacted by an onset of tree mortality. Such groups include seniors, children, families with pets, and laborers who spend long periods of time outside. Lower income households who turn to active cooling methods, such as air conditioning, may be burdened by increased energy costs.

Urban forestry has been demonstrated to increase mental health and reduce levels of depression and anxiety among residents. If large sections of Irvine's urban forest were to suddenly start dying, whether it be from drought or invasive pests, higher levels of stress and anxiety may result.

AIRPORT HAZARDS

Existing Conditions

An aircraft *accident* refers to an occurrence associated with the operation of an airborne vehicle, such as an airplane, helicopter, or airship, that:

- Occurs between when the first boarding person enters the aircraft – with intention of flight – and the last person disembarks.
- Results in death or serious injury, or
- Causes substantial damage to the aircraft.

An aircraft *incident* is an occurrence – other than an accident– associated with the operation of an aircraft that affects or could affect the safety of operations. Accidents or incidents could be the result of human error, inclement weather, deferred maintenance, design flaw, equipment failure, or, in a worst-case scenario, a collision.



View of a plane's wing in mid-flight

Irvine itself has no airports within its boundaries, but numerous regional and international airports are in the City's surroundings and the airways above the City are highly trafficked. The following outlines airports near Irvine and includes their distance from Irvine's City Center:

- John Wayne Airport/Santa Ana Airport (SNA), 4.3 miles, located between the cities of Costa Mesa, Irvine, and Newport Beach
- Fullerton Municipal Airport (FMA), 19.7 miles
- Long Beach Municipal Airport (LGB), 22.9 miles
- Ontario International Airport (ONT), 41.6 miles
- Los Angeles International Airport (LAX), 42.2 miles

In addition to the public airports that operate in the region, the Joint Forces Training Base Los Alamitos is also located within 18 miles of the City. This facility is actively used for military training purposes; however, the frequency and number of flights is anticipated to be lower than other adjacent airports, such as the John Wayne Airport.

The John Wayne Airport, which borders the City of Irvine to the southwest, has experienced aircraft accidents and incidents in the past. According to the National Transportation Safety Board, there were 62 accidents and 6 incidents reported at John Wayne Airport over a 36-year period (between 1982 and 2018), or an average of 2 aircraft accidents/incidents per year. Over this period, less than 10% of individuals involved in an aircraft accident suffered an injury.

Areas of Concentration

The risk associated with aircraft incidents is similar to other parts of Orange County and Southern California. Any structures located within the Airport Environs Land Use Plan planning boundary for John Wayne Airport are at an elevated risk to aircraft incidents, predominantly associated with landing, take off, and approach activities. Beyond this planning boundary, the risk associated with

aircraft incidents is limited to flyover activities above the City. These incidents have the potential to send the bodies of the aircraft or falling debris crashing down, which could damage any structures or physical assets lying below.

Typically, populations located near John Wayne Airport would have a higher probability of being impacted versus populations located in the southern portions of the City. The intensity recommendations and development standards identified in the Airport Environs Land Use Plan for John Wayne Airport for developments within the planning boundary help to ensure the density of people and height of buildings within these areas is designed to reduce unnecessary exposure to these hazards. Nevertheless, given the potential for falling debris, all persons in Irvine may be threatened by an aircraft incident. If future events occur in Irvine, it is assumed that lower-income persons may not be able to recover as easily (e.g., afford repairing the damage to their homes, purchasing new automobiles to replace any destroyed, etc.).



View of plane takeoff over airport tarmac

Depending on the severity of the aircraft incident, some services in the City could be temporarily disrupted. For example, falling debris from an aircraft incident could damage or destroy a section of the power transmission lines in the City, resulting in partial or complete outages of utilities services to the sections of the City. Debris could also fall onto a roadway and obstruct the normal flow of traffic through Irvine. A more severe aircraft incident, in which an entire aircraft crashes into a section of the City would likely ignite a blaze impacting the area where the plane went down. Areas of the City affected by the crash may be closed until authorities deem it safe for employees to return, resulting in loss of economic activity in the City.

Given the high volume of air traffic in the area, the possibility of an aircraft incident occurring in Irvine will continue to exist. Based on historic events, it is anticipated that future impacts will be similar in nature. Implementation of the Airport Environs Land Use Plan for John Wayne Airport can reduce aircraft hazards. This plan identifies the height restrictions and safety zones that require land use restrictions to minimize potential impacts associated with aircraft incidents. Future land use decisions that adhere to these restrictions and plan accordingly will help reduce future impacts associated with aircraft incidents. While these efforts can assist in reducing impacts on the ground, there is little that can be done to reduce the impacts associated with aircrafts flying overhead under normal flight conditions.

There is no direct link between aircraft incidents and climate change; it is not anticipated that future hazards would be affected by changing climatic conditions.

Emergency Evacuation Route Analysis

A variety of hazard scenarios could require an evacuation in parts of Irvine. These emergency situations could be caused by either natural or human-made events, such as wildfires, floods, or earthquake. An Emergency Evacuation Route Analysis (Appendix B) was prepared to identify evacuation capacity and network connectivity in Irvine in addition to meeting the requirements associated with the following legislative updates:

- **AB 747** (2019) requires the City to update the Safety Element of its General Plan to identify evacuation routes and assess the capacity, safety, and viability of those routes under a range of emergency scenarios.
- **SB 99** (2019) requires the City to identify residential developments in hazard areas that do not have at least two emergency evacuation routes (i.e., neighborhoods or households within a hazard area that have limited accessibility).
- **AB 1409** (2021) requires the City to identify evacuation locations.

The Emergency Evacuation Route Analysis supporting this Safety Element utilizes updated data from the City's interactive web map of evacuation management zones (EMZs) and evacuation routes, consistent with evacuation routes identified in the City's LHMP. Evacuation route viability is largely determined by the location of the hazard. Because Irvine is surrounded by Very High FHSZs to the south, northeast, east, and north/northwest, the City considered the following four wildfire scenarios: (1) a fire originating in the south, (2) a fire originating in the northeast, (3) a fire originating in the east, and (4) a fire originating in the northwest. Evacuation route viability is also assessed for flood hazards due to the presence of flood zones and landslide susceptibility areas in Irvine. Residential parcels lacking at least two points of egress were also identified in the Emergency Evacuation Route Analysis to further identify potential vulnerabilities in Irvine. The results of the analysis indicate that residents closest to the southern, northern, and eastern extents of the City are most vulnerable given the distance and number of roads needed to traverse to access an outbound road (Appendix B):

- **Wildfire (originating in the area south of the City):** The residential parcels in the southern region of the City are the most vulnerable in the event of a wildfire from the south; however, these residents have more than two viable evacuation routes in this scenario.
- **Wildfire (originating in the area northeast of the City):** The residential parcels in the northern and eastern regions of the City are the most vulnerable in the event of a wildfire from the northeast; however, these residents have more than two viable evacuation routes in this scenario.
- **Wildfire (originating in the area east of the City):** The residential parcels in the northern and eastern regions of the City are the most vulnerable in the event of a wildfire from the east; however, these residents have more than two viable evacuation routes in this scenario.
- **Wildfire (originating in the area northwest of the City):** The residential parcels in the northern region of



Silverado Fire response

the City are the most vulnerable in the event of a wildfire from the northwest; however, these residents have more than two viable evacuation routes in this scenario.

- **Flood (extreme precipitation):** Under the flood hazard scenario, which conservatively assumes all roadways within a FEMA flood hazard zone are not viable, the residential parcels in the southern region of Irvine have only one viable evacuation route (Sunnyhill Road to Turtle Rock Drive) given that Shady Canyon Drive would be inundated to the west and east of Copper Creek (road).
- **Landslide:** The residential parcels in the northernmost, eastern, and southernmost extents of the City are the most vulnerable in the event of a landslide; however, these residents have more than two viable evacuation routes in this scenario.



Silverado Fire evacuation map

Evacuation locations for Irvine residents would be dependent on the type and location of hazardous event affecting Irvine and would be determined by the City's Emergency Operations Center and first responders on site during emergency situations. For example, if a wildfire occurs northeast of Irvine, residents would be directed to evacuate to community centers and City buildings in the southern and western portions of Irvine, such as the City of Irvine Civic Center or to areas west of the City, such as Huntington Beach and Long Beach. Evacuation locations would consist of places in Irvine that residents are familiar with, such as parks, community centers, schools, libraries, City department buildings, or churches.


Emergency response during Silverado Fire

GOALS, OBJECTIVES, POLICIES, AND IMPLEMENTATION MEASURES



Emergency response in the City of Irvine

Certain natural conditions and human activities in Irvine create risks to individuals and properties within the community. Unreasonable risk from such hazards can be reduced or avoided through implementation of the Safety Element. In consideration of these efforts, the City has identified the following issues for consideration:

How can the City reduce the risk to life and property associated with aircraft operations adjacent to the City?

How can the City reduce the probability of fire, non-seismic geologic, flood, and air operation hazards?

What actions can the City take to reduce the severity of hazards (i.e., reducing the loss of life and personal property) when natural disasters occur?

The Objectives and Policies within this Element reflect the community's intent to provide and foster a safe community for all its residents, that include:

- Protect and prepare the community for natural and human-caused hazards.
- Improve the community's resilience to seismic and geologic hazards by ensuring the integrity of the built environment.
- Anticipate the risks and mitigate the effects that flood hazards pose to the community.
- Safeguard the community from the threat of urban and wildfire hazards.
- Protect the community from the threat of drought and extreme heat.
- Protect the community from hazards related to diseases and pests.
- Protect and improve resilience of the community from the effects of climate change.

The objectives are overall statements of the City's goals and consist of broad statements of purpose and direction pertaining to the community's safety. The policies serve as guidelines for reducing the risk and vulnerability associated with natural and human activity hazards and directs and maximizes community emergency preparedness.

The City's LHMP includes hazard mitigation actions related to natural and human-caused, seismic, geologic, flood, and urban and wildfire hazards, as well as risks related to drought and extreme heat, diseases and pests, and climate change. These hazard mitigation actions meet the requirements of Government Code Section 65302.15 and are incorporated by reference into the Safety Element.

In addition, the Safety Element has formulated the following goals, objectives, policies, and actions to respond to these safety issues. The policies were developed to support the goals and are identified by lettering (e.g., Policy J-1[a]). The implementation actions were developed to support goals and policies and are identified numerically.

Goal 1: Protect and prepare the community for natural and human-caused hazards.

Objective S-1: Hazard Preparedness and Occurrence

POLICIES:

Policy (a): Expand participation in the Irvine Community Emergency Response Team (CERT) program for residents and businesses, including offering training in a variety of languages.

Policy (b): Coordinate with Caltrans and Orange County Transit Authority for inspection and maintenance of primary evacuation routes.

Policy (c): Coordinate with regional transit providers to identify alternative routes, stops, and modes of transit if normal infrastructure is damaged or closed as a result of extreme events.

Policy (d): Encourage collaboration with local and regional partners to support business resiliency through preparedness education, trainings, and resources.

Policy (e): Update the City's Local Hazard Mitigation Plan every five years, to ensure consistency and relevancy of hazards and issues within the City, and to maintain consistency with State and/or federal legislation.

Policy (f): Update the Irvine Power Outage Response Plan (annex to the Emergency Operations Plan) to identify back-up energy technologies that are more resilient to climate impacts and communications locations for critical facilities, critical infrastructure (e.g., traffic signals), sensitive uses, and community lifelines (including water, sewer, telecommunications).

Policy (g): Continuously update response procedures for first responder departments to properly address new hazard events as they emerge.

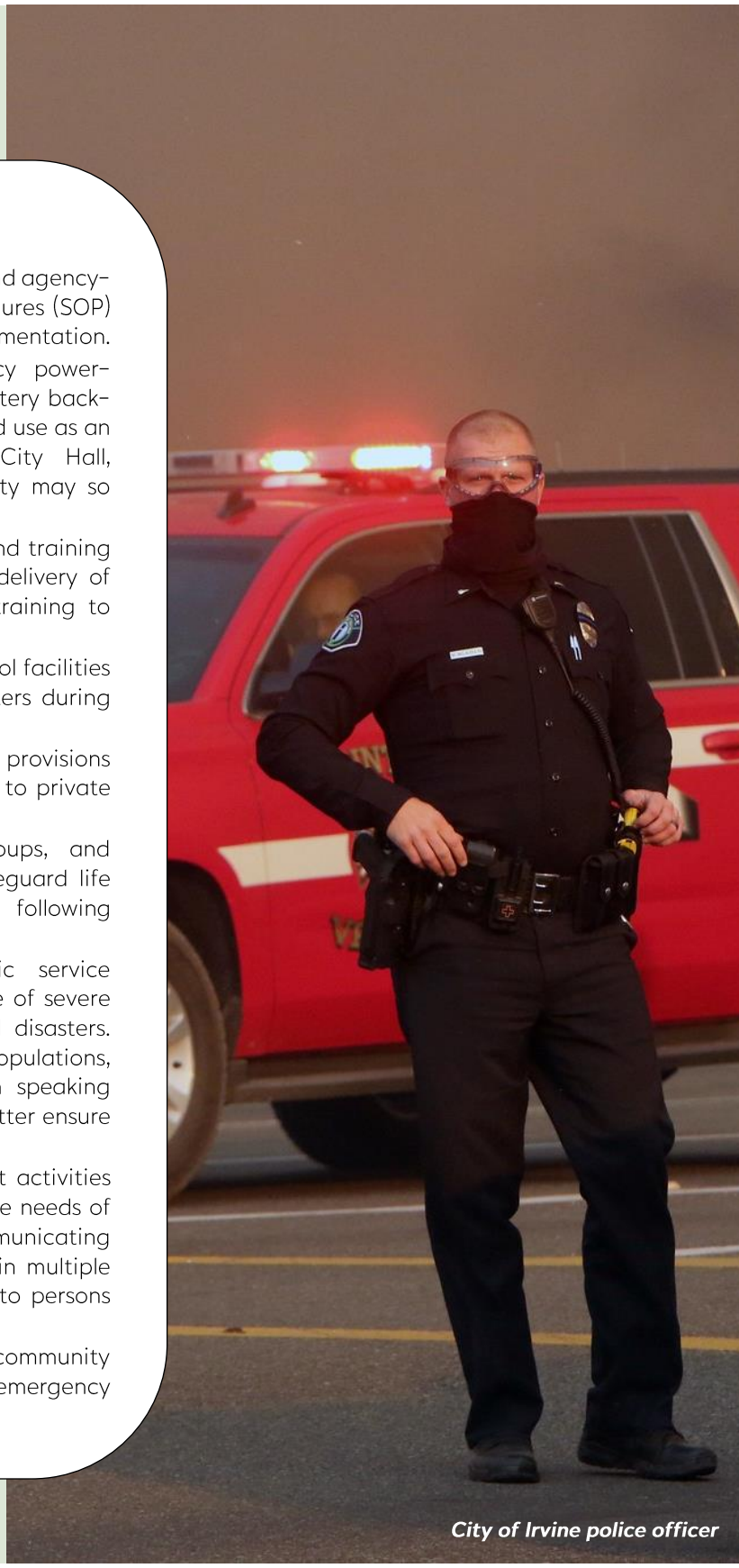
Policy (h): Encourage community members to sign-up for disaster alerts.

Policy (i): Identify opportunities to expand access to emergency and evacuation notices via multiple sources, including voice, text, siren, radio, and outdoor broadcasts.

Policy (j): Increase understanding of all energy storage technologies including critical features such as storage capacity, efficiency, duration of power, lifestyle impacts, and realistic function to provide long-term, reliable sources of power during grid outages.

IMPLEMENTATION MEASURES:

- Develop and maintain detailed City department and agency-specific checklists and standard operation procedures (SOP) to support Irvine Emergency Operations Plan implementation.
- Identify and maintain at least one emergency power-generating station (with priority for solar and battery back-up power) in all critical facilities that the City could use as an emergency public assembly area, such as City Hall, Community Centers, and any others that the City may so designate in the future.
- Conduct regular emergency preparedness drills and training exercises for City staff including the continued delivery of Community Emergency Response Team (CERT) training to City employees.
- Work with local school districts to ensure that school facilities can act as evacuation sites and overnight shelters during major emergencies.
- Ensure that community evacuation plans include provisions for community members who do not have access to private vehicles or are otherwise unable to drive.
- Educate City staff, residents, community groups, and businesses regarding appropriate actions to safeguard life and property before, during, and immediately following emergencies.
- Ensure residents are notified through public service announcements and emergency alerts in advance of severe weather (e.g., extreme heat) events and natural disasters. Focus on media methods that target vulnerable populations, such as elderly, sick, lower-income, non-English speaking populations, or persons with limited mobility to better ensure they have adequate time to prepare.
- Continue to ensure that emergency management activities are conducted equitably and are responsive to the needs of all community members, primarily by communicating emergency plans in many different formats and in multiple languages. Ensure that information is accessible to persons with disabilities, access, and functional needs.
- Educate all community members about community evacuation zones, plans, protocols, and maps for emergency preparedness and evacuation.



City of Irvine police officer

Goal 2: Improve the community's resilience to seismic and geologic hazards by ensuring the integrity of the built environment.

Objective S-2: Seismic and Geologic Hazards

POLICIES:

Policy (a): Coordinate with Irvine Ranch Water District and Orange County Water District on emergency water storage and distribution following a liquefaction or landslide event.

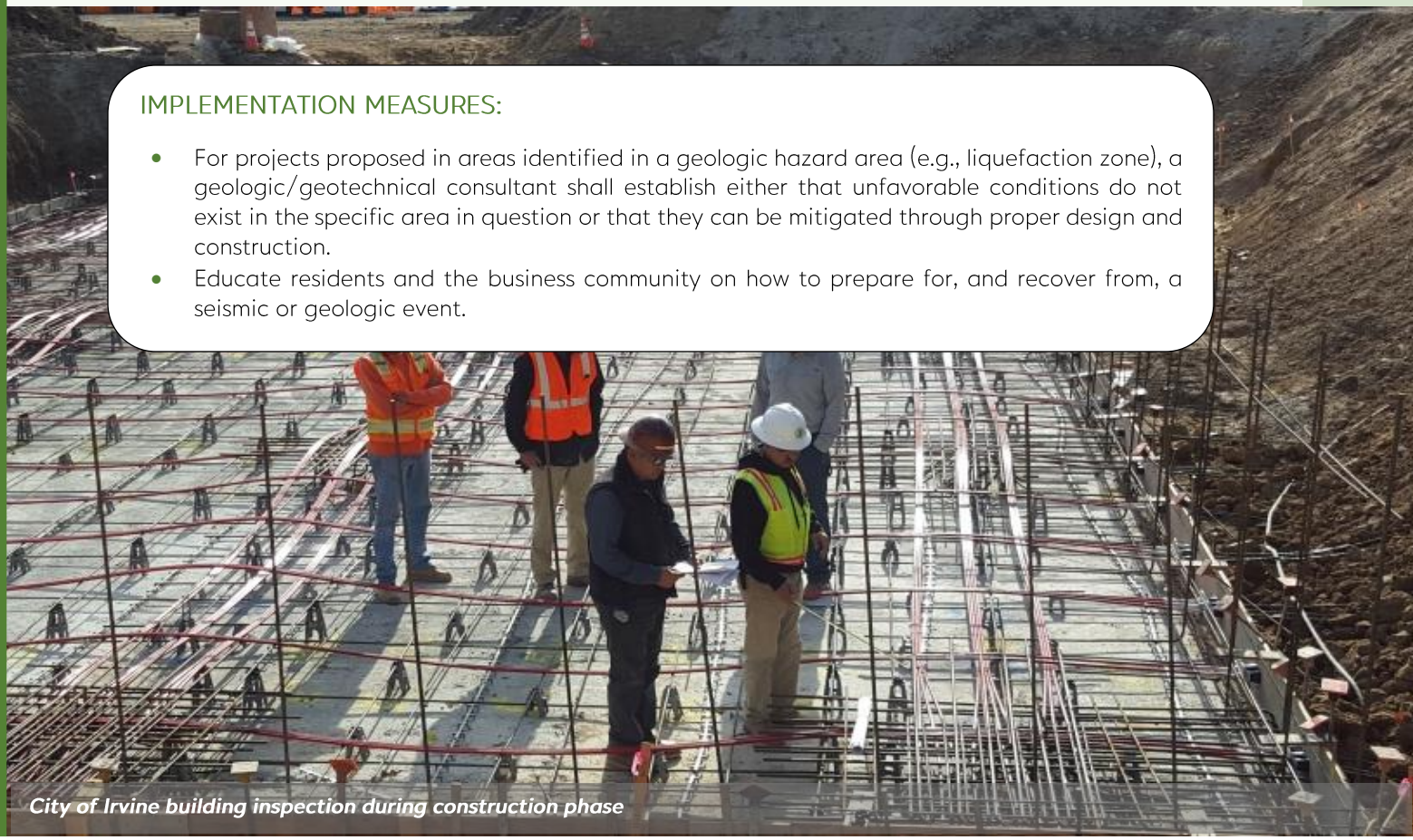
Policy (b): Coordinate groundwater management with Orange County Water District to avoid subsidence impacts in Irvine.

Policy (c): Promote the strengthening of planned utilities, the retrofit and rehabilitation of existing weak structures and lifeline utilities, and the relocation or strengthening of certain critical facilities to increase public safety and minimize potential damage from seismic and geologic hazards.

Policy (d): Encourage replanting bare or disturbed areas after landslides to reduce erosion.

IMPLEMENTATION MEASURES:

- For projects proposed in areas identified in a geologic hazard area (e.g., liquefaction zone), a geologic/geotechnical consultant shall establish either that unfavorable conditions do not exist in the specific area in question or that they can be mitigated through proper design and construction.
- Educate residents and the business community on how to prepare for, and recover from, a seismic or geologic event.



City of Irvine building inspection during construction phase

Goal 3: Anticipate the risks and mitigate the effects that flood hazards pose to the community.

Objective S-3: Flood Hazards

POLICIES:

Policy (a): Work with Orange County Flood Control District to ensure flood control facilities are adequately provided and maintained.

Policy (b): Collaborate with partner agencies and municipalities to align green infrastructure projects (i.e., projects that allow for the filtration of stormwater where it falls) and develop regulations for watersheds across jurisdictions to reduce impervious hard surfaces.

Policy (c): Support efforts of other organizations and academic institutions to conduct studies of the impact combined riverine and coastal flooding, groundwater intrusion, and increased precipitation has on flood risk and vulnerability.

Policy (d): Support efforts of other organizations and academic institutions to inventory and map vegetation on hillsides with a specific focus on improving hillside stability in the case of extreme rainfall and seasonal erosion.

Policy (e): Develop or update a long-term plan to address current and future flood risk to critical facilities.

Policy (f): Continue to partner with Orange County Public Works to proactively disseminate information from the "H2OC Stormwater Program" to educate home and small business owners on regulations and highlight the role that engaged residents can play in assisting with community-based stormwater management.

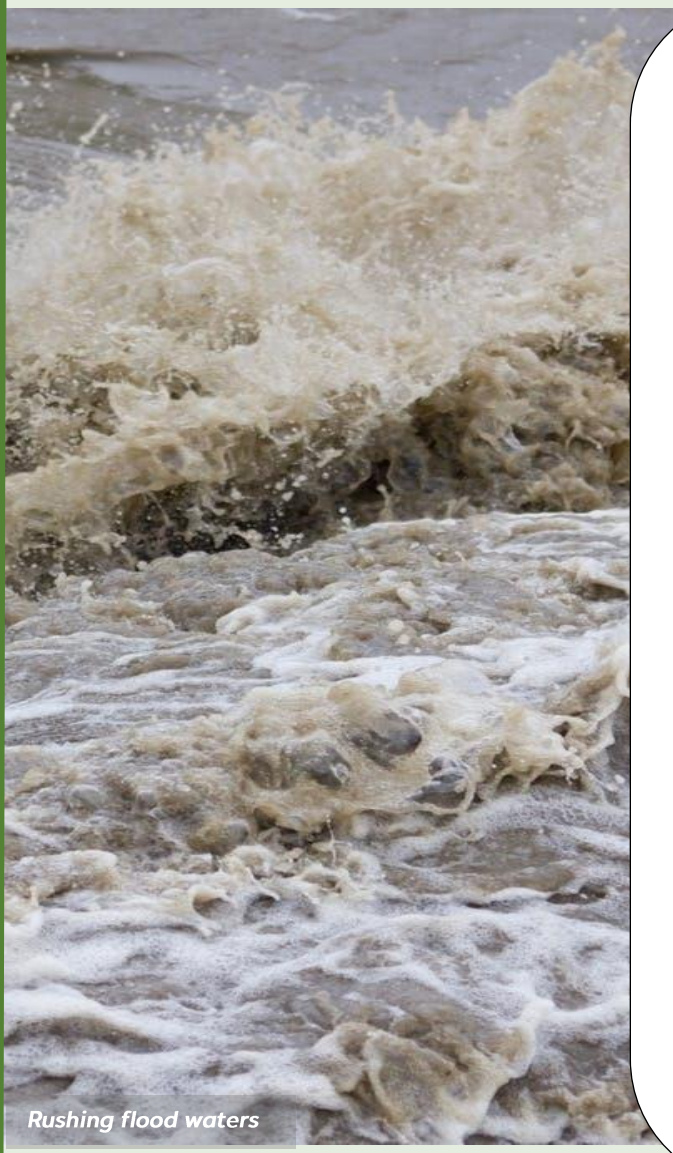
Policy (g): Ensure resilience and long-term functionality of stormwater and sewer systems.

Policy (h): Encourage the use of climate-smart landscaped surfaces (e.g., permeable pavement, stormwater parks, green streets) in new and existing developments to reduce runoff, minimize flood hazards, and maintain existing drainage ways.

Policy (i): Continue to encourage the implementation of low-impact development (e.g., rain gardens and rainwater harvesting) to reduce flood risk, filter pollutants, and replenish groundwater over time.

Policy (j): Continue to promote the application of nature-based solutions (e.g., greenways, tree trenches) to improve resilience and preserve biodiversity.

Policy (k): Coordinate with other agencies to increase the public awareness of flooding, stormwater management, and drought management issues and techniques for residents to mitigate those challenges on their property.



Rushing flood waters

IMPLEMENTATION MEASURES:

- Update City procedures to encourage climate-smart irrigation and implementation of Low Impact Development (LID) standards for new development to reduce the amount of stormwater runoff.
- Include improvement of drainage ways and flood control facilities in Irvine's Capital Improvements Program to lessen recurrent flood problems.
- Conduct frequent cleanings of storm drain intakes before and during the rainy season.
- Require that future transportation infrastructure projects consider current and future flood risk and align the projected lifespan of the project with best available science.
- Provide residents, businesses, and neighborhood organizations storm evacuation procedures and shelter-in-place guidelines to grow community resilience.
- Provide flood emergency supplies and resources; including, but not limited to, items such as water main repair parts, generators, pumps, sandbags, road clearing, medical, and communication.
- Provide sandbags for residents and businesses, including prefilled sandbags for individuals who may be unable to fill them on their own.
- When constructing new roadways medians, install storm water capture technologies, as feasible.
- When reviewing new development applications, require integration of green infrastructure techniques (i.e., projects that allow for filtration of stormwater where it falls) into site design, as feasible.

Goal 4: Safeguard the community from the threat of urban and wildfire hazards.

Objective S-4: Wildfire Hazards

POLICIES:

Policy (a): Coordinate with regional partners to explore and deploy fire detection cameras as part of a wildfire monitoring network.

Policy (b): Coordinate with surrounding municipalities and Orange County to enhance evacuation and emergency management protocols, agreements, and processes.

Policy (c): Coordinate with City of Irvine and Orange County Fire Authority first responders to create a rapid response plan to secure hospital, nursing, and assisted living facilities, especially those located within fire hazard severity zones.

Policy (d): Work with the Irvine Ranch Water District to ensure the long-term integrity of water supplies for the City.

Policy (e): Continue to work with the Orange County Health Care Agency Department of Public Health and other applicable health care agencies to convey notifications to the public regarding recommendations for outdoor activities, cancelled sporting events, and other recommendations for public health and safety during periods of poor air quality.

Policy (f): Encourage public and private landowners to minimize the risk of wildfire moving from wildland areas to developed properties or from property-to-property by increasing structural hardening measures (e.g., fire-rated roofing and fire-resistant construction materials and techniques), maintaining and improving defensible space on site, and supporting vegetation management in adjacent undeveloped areas.

Policy (g): Encourage existing non-conforming development to update to contemporary fire safe standards (e.g., road standards, vegetative hazards).

Policy (h): Encourage removal of highly flammable vegetation with little to no biological value in Very High, High, and Moderate Fire Hazard Severity Zones and replant with fire-adapted specimens.

Policy (i): Promote the proper maintenance and separation of power lines and efficient response to fallen power lines in accordance with Title 14 CCR Division 1.5 Chapter 7 Article 4 (Fire Prevention Standards for Electric Utilities).

Policy (j): Encourage the use of underground power lines for replacement power lines, where feasible.

Policy (k): Ensure that all new development and redevelopment in the Very High Fire Hazard Severity Zone is developed in compliance with minimum structural fire protection standards in the adopted edition of the California Fire and Building Codes, applicable state or local fire safety and defensible space regulations or standards, and any applicable fire protection or risk reduction measures identified in locally adopted plans.

Policy (l): Ensure future neighborhoods are designed with adequate fire access and evacuation egress in the event of an emergency.

Policy (m): Avoid expanding new residential development, essential public facilities, and critical infrastructure in areas subject to extreme threat or high risk, such as Very High Fire Hazard Severity Zones, or areas classified by the California Department of Forestry and Fire Protection as having an Extreme Threat classification on Fire Threat Maps, unless all feasible risk reduction measures have been incorporated into project designs or conditions of approval. Example risk reduction measures include, but are not limited to, fuel modification zones or defensible space, structure hardening, enclosed foundations, and highly visible street signs and property addresses.

Policy (n): Ensure adequate water supply for fire suppression and ensure that the water supply is protected from wildfire impacts, including providing back-up power, with priority for solar and battery storage back-up supplies.

Policy (o): Ensure future neighborhoods are designed with sufficient water pressure to maintain fire flow.

Policy (p): Encourage the use of underground power lines for new developments.

Policy (q): Ensure that private development subject to the California Environmental Quality Act evaluate hazard impacts to ensure adequate evacuation in the event of an emergency, and if required, develop standards for the protection of the community.

Policy (r): Review development proposals and coordinate with regional transportation agencies to ensure that multiple evacuation routes are available under a range of scenarios and identify alternative routes that are accessible to people without life-supporting resources.

Policy (s): Coordinate with fire protection, emergency service, and water providers to reassess fire hazards and future availability of water supplies after wildfire events to adjust fire prevention and suppression needs, as necessary, for both short- and long-term fire prevention.

Policy (t): Coordinate evaluations for redevelopment of areas that have been burned after a large fire.

Policy (u): Continue the long-term maintenance of fire reduction projects; including but not limited to, a roadside fuel reduction plan, defensible space clearances (including fuel breaks) around structures, subdivisions, and other developments in the Very High Fire Hazard Severity Zone.

Policy (v): Maintain established response time standards for fire and life safety service.

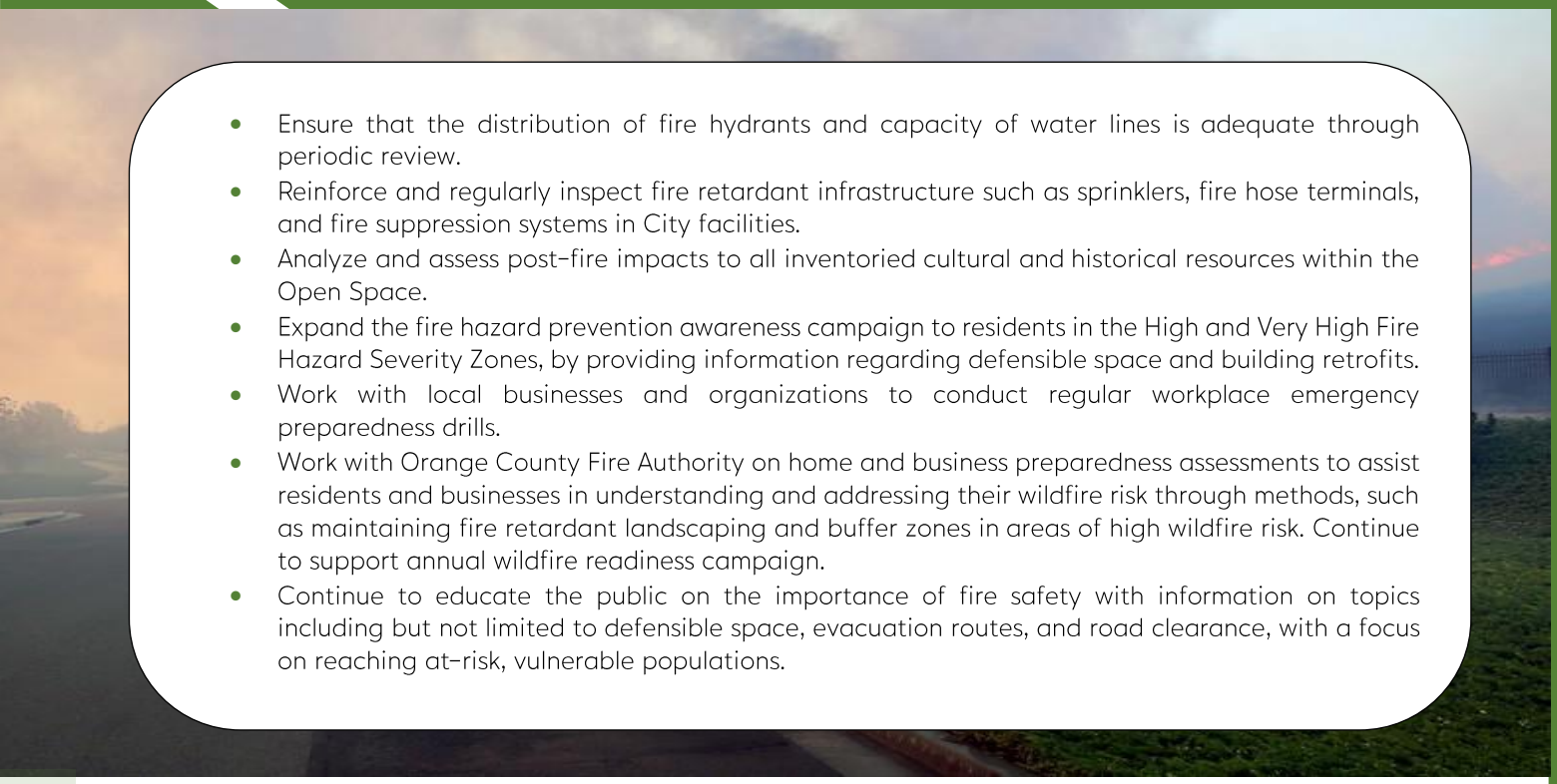
Policy (w): Encourage the continued development, implementation, and public awareness of fire prevention programs.

IMPLEMENTATION MEASURES:

- Increase resilience of existing development in high-risk areas built prior to modern fire safety codes or wildfire hazard mitigation guidance.
- Support state legislation that would provide tax incentives to encourage the repair or demolition of structures that could be considered fire hazards.
- Provide ongoing maintenance of vegetation clearance on public and private roads.
- During the development review process, require vegetation management (including vegetation health) to change fire behavior, increase the success of fire suppression, support defensible space (including ember-resistant zones), incorporate ecological objectives, and consider other hazards, topography, and wildland-urban interface characteristics.
- Require that all signage, including home and street addressing, remain publicly visible.
- Continue to involve the Orange County Fire Authority in the review of development applications to minimize fire hazards. Consideration shall be given to adequate emergency access, driveway widths, turning radii, fire hydrant.
- Continue to require fire prevention planning and defensible space in all new development within Very High Fire Hazard Severity Zones or wildland-urban interface.
- During the development review process, continue to require that all new development projects have an adequate water supply (e.g., sprinklers, fire hose terminals, and fire suppression systems) to meet the fire protection needs of future occupants.
- Review development proposals and coordinate with regional transportation agencies to ensure that multiple evacuation routes are available under a range of scenarios and identify alternative routes that are accessible to people without life-supporting resources.
- Use and refine hillside weed abatement program using goats or other livestock to reduce fuel loads in fire-prone areas, when feasible.
- Routinely participate in the update of the Orange County Community Wildfire Preparedness Plan for areas within the Very High, High, and Moderate Fire Hazard Severity Zones.
- Following extended drought periods, coordinate with partners to clear dead vegetation in flood control facility footprints, railroad rights-of-way, parks, and open spaces, where feasible.
- Conduct regular emergency preparedness drills and training exercises with Orange County Fire Authority personnel for City staff.
- Expand participation in the Irvine Community Emergency Response Team (CERT) program for residents and businesses.



Silverado Fire in Irvine



- Ensure that the distribution of fire hydrants and capacity of water lines is adequate through periodic review.
- Reinforce and regularly inspect fire retardant infrastructure such as sprinklers, fire hose terminals, and fire suppression systems in City facilities.
- Analyze and assess post-fire impacts to all inventoried cultural and historical resources within the Open Space.
- Expand the fire hazard prevention awareness campaign to residents in the High and Very High Fire Hazard Severity Zones, by providing information regarding defensible space and building retrofits.
- Work with local businesses and organizations to conduct regular workplace emergency preparedness drills.
- Work with Orange County Fire Authority on home and business preparedness assessments to assist residents and businesses in understanding and addressing their wildfire risk through methods, such as maintaining fire retardant landscaping and buffer zones in areas of high wildfire risk. Continue to support annual wildfire readiness campaign.
- Continue to educate the public on the importance of fire safety with information on topics including but not limited to defensible space, evacuation routes, and road clearance, with a focus on reaching at-risk, vulnerable populations.

Goal 5: Protect the community from the threat of drought and extreme heat.

Objective S-5: Drought and Extreme Heat

POLICIES:

Policy (a): Collaborate with federal, State, and local agencies and organizations to explore alternative water sources (e.g., desalinization) and improve capacity in consideration of increased demand and drought.

Policy (b): Continue to support Irvine Ranch Water District's recycled water program and explore opportunities to enhance water recycling.

Policy (c): Continue to support and participate in the development of a regional and local drought contingency plan.

Policy (d): Encourage drought-tolerant native landscaping, low-flow water fixtures beyond the state minimum code, and daytime watering restrictions on properties throughout the City to reduce water consumption.

Policy (e): Explore the feasibility of recycled water distribution for residential uses on all lot sizes.

Policy (f): Protect groundwater supply against contamination, degradation, or loss due to flooding.

Policy (g): Promote a system for rapidly detecting, reporting, and repairing water leaks in public facilities and the water conveyance system.

Policy (h): Promote nature-based methods and best management practices (BMPs) (e.g., bioswales, rain gardens, natural ground cover) through the City's stormwater program to promote groundwater infiltration and reduce the impacts of drought.

Policy (i): Support regional partners in education and outreach efforts focused on water conservation measures (e.g., water reuse, water use, and irrigation efficiency) for City residents.

Policy (j): Collaborate with State and regional agencies and organizations to share best practices for addressing heat impacts.

Policy (k): Explore mechanisms to improve the energy reliability of municipal facilities to withstand increased energy demands.

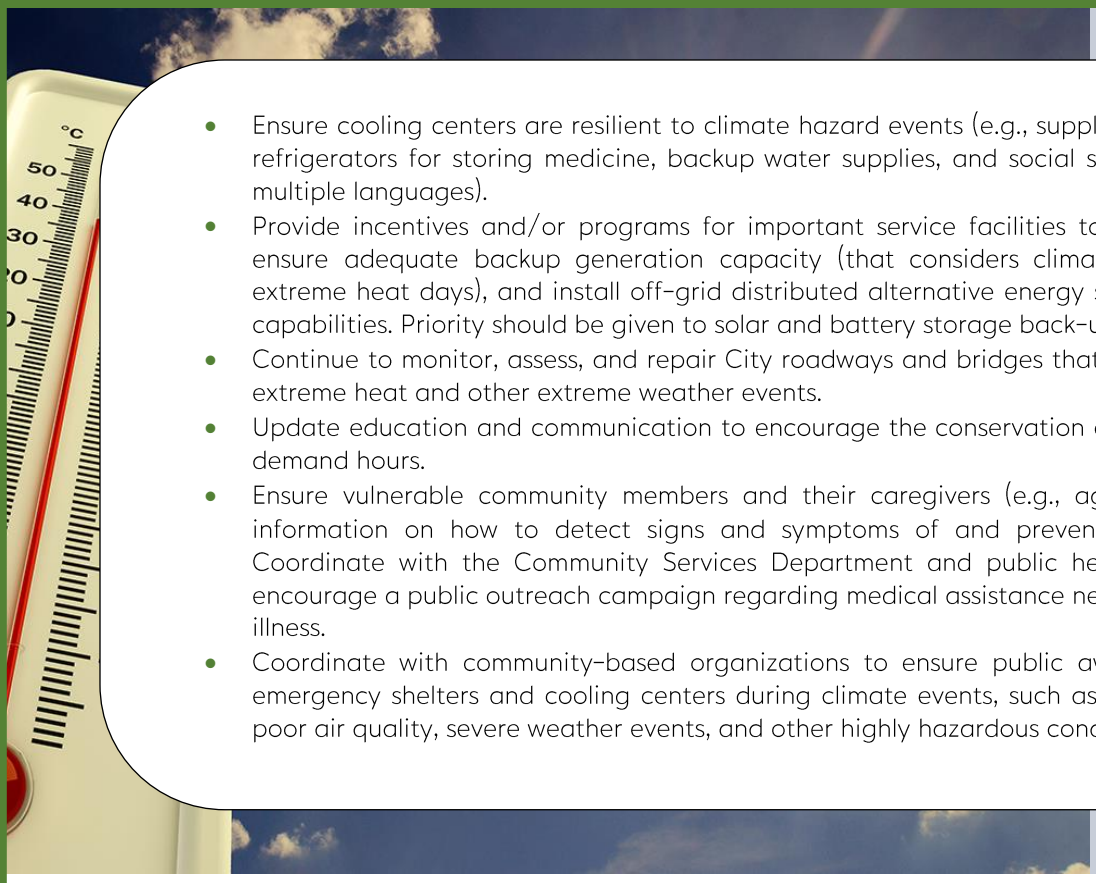
Policy (l): Ensure adequate power availability during peak demand (e.g., extreme heat events).

Policy (m): Ensure vulnerable community members and their caregivers (e.g., aging, elderly, ill) have information on how to detect signs and symptoms of and prevent heat-related illness.

Policy (n): Promote adequate protection for outdoor workers and people experiencing homelessness from extreme conditions.

IMPLEMENTATION MEASURES:

- Continue to implement the City of Irvine's Model Water Efficient Landscape Ordinance for private and public projects.
- Limit non-drought-tolerant landscaping to recreational fields and in instances where no feasible drought-tolerant alternatives exist.
- Require drought-tolerant and resilient landscaping for public properties, parks, yards, and grounds.
- During the development review process, encourage the installation of dual plumbing and high-efficiency appliances, developing a program to repair leaks, landscaping with native and drought-tolerant plant species, and using recycled water to irrigate plants, to reduce indoor and outdoor potable water use in new and existing public and private developments.
- Explore programs to expand access to limited water resources for at-risk, vulnerable populations (e.g., people experiencing homelessness).
- Update the City's stormwater program to promote groundwater infiltration and reduce the impacts of drought by encouraging nature-based methods and best management practices (BMPs) (e.g., bioswales, rain gardens, natural ground cover) in City and private development projects.
- Provide information to the community on water efficiency and conservation efforts.
- Work with regional and local health agencies to evaluate extreme heat warning thresholds and protocols and incorporate enhanced extreme heat preparedness into local operations.
- Work with energy providers to assess grid vulnerabilities related to extreme heat-caused power outages and mitigation plans to address. This could take the form of microgrids and battery storage, renewable natural gas, or hydrogen fuel cell backup generators for critical buildings, sensitive uses, and sensitive populations.
- Provide working water refill stations at public facilities, parks, and bus shelters.
- Explore potential City-owned locations for cooling centers for use during extreme heat events. Cooling centers should be air-conditioned, accessible to all members of the public, compliant with the American Disabilities Act, have access to restrooms and water, have available seating for all guests, be close to public transportation routes, and include battery storage back-up.
- Continue expedited review of building permits for solar equipment and electric vehicle charging stations.



- Ensure cooling centers are resilient to climate hazard events (e.g., supply cooling centers with refrigerators for storing medicine, backup water supplies, and social services information in multiple languages).
- Provide incentives and/or programs for important service facilities to assess power needs, ensure adequate backup generation capacity (that considers climate projections during extreme heat days), and install off-grid distributed alternative energy systems with islanding capabilities. Priority should be given to solar and battery storage back-up.
- Continue to monitor, assess, and repair City roadways and bridges that may be impacted by extreme heat and other extreme weather events.
- Update education and communication to encourage the conservation of energy during peak demand hours.
- Ensure vulnerable community members and their caregivers (e.g., aging, elderly, ill) have information on how to detect signs and symptoms of and prevent heat-related illness. Coordinate with the Community Services Department and public health organizations to encourage a public outreach campaign regarding medical assistance needed for heat-related illness.
- Coordinate with community-based organizations to ensure public awareness of available emergency shelters and cooling centers during climate events, such as extreme heat events, poor air quality, severe weather events, and other highly hazardous conditions.

Goal 6: Protect the community from hazards related to diseases and pests.

Objective S-6: Diseases and Pests

POLICIES:

Policy (a): Coordinate with surrounding jurisdictions, local health care providers, businesses, schools, the Orange County Health Care Agency, the California Department of Public Health, and the Centers for Disease Control to ensure community members have information about current public health trends or issues, free and low-cost healthcare options, treatments, and where to find local healthcare facilities.

Policy (b): Coordinate with the Orange County Mosquito and Vector Control District to ensure community members have information on best practices for mosquito-proofing homes and businesses and how to avoid mosquito bites.

IMPLEMENTATION MEASURES:

- Update education and communication and continue to work with residents, business owners, and utilities to remove dead, dying, and diseased trees weakened by disease/pests.
- Update education and communication on best practices for vector control.

Goal 7: Improve the community's resiliency to climate change–related hazards by incorporating the best available science into community planning.

Objective S-7: Climate Change Resiliency and Adaptation

POLICIES:

Policy (a): Coordinate with transportation agencies to identify local and regional transportation corridors that are at risk from climate change effects while using the best available science and resilient design features to improve resiliency to extreme climate events.

Policy (b): Encourage the consideration of climate projections and the impacts associated with them in City planning documents, policies, programs, and ordinances as they are reviewed or updated.

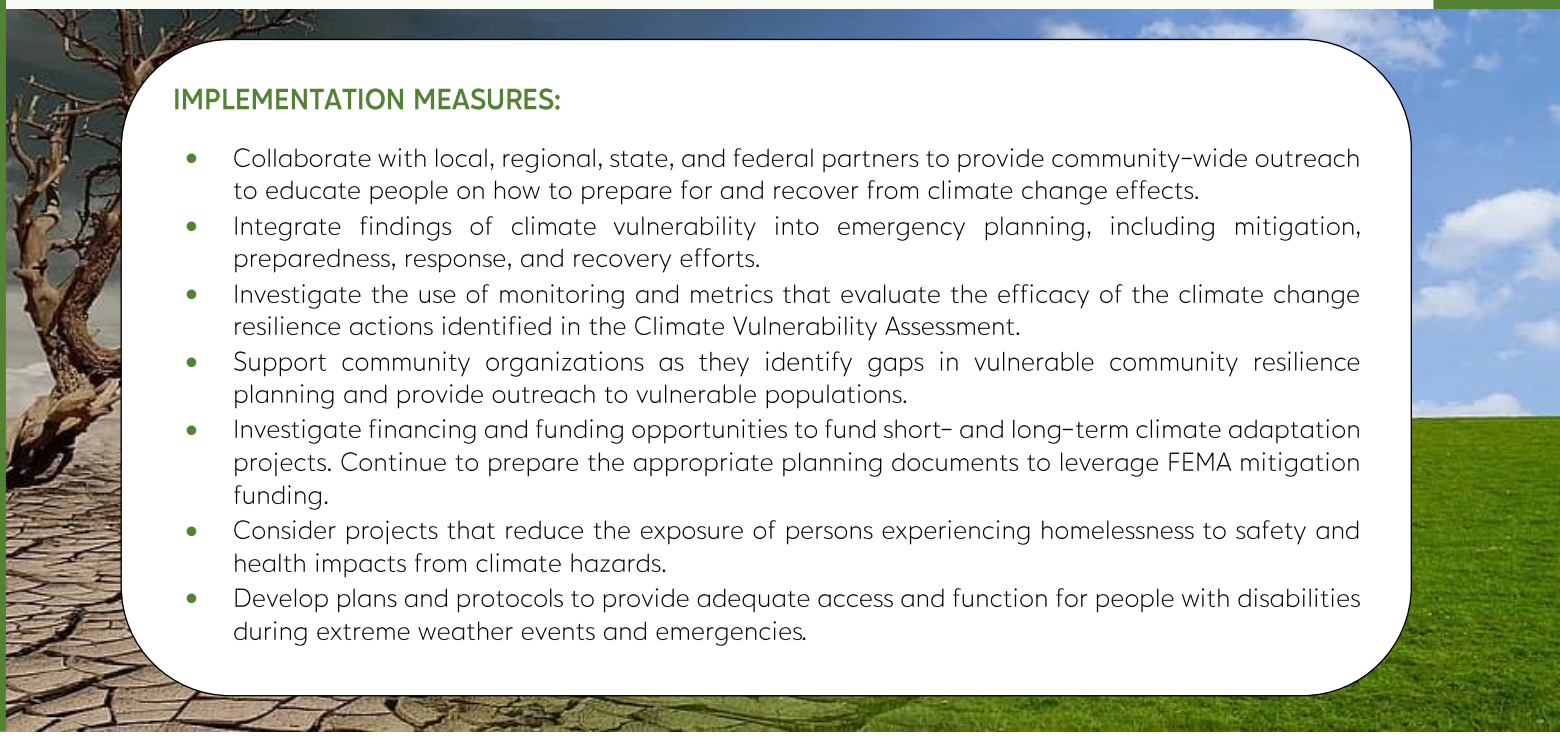
Policy (c): Encourage regional utility providers to enhance the preparedness, protection, and resilience of water, energy, and telecommunications infrastructure.

Policy (d): Encourage multimodal and local access upgrades to improve capacity and the resilience of the transportation network.

Policy (e): Continue to encourage public outreach campaigns for climate awareness to help community members understand potential risks, solutions, and opportunities to address climate impacts.

Policy (f): Continue coordination with important community assets (e.g., schools, and businesses) to ensure community members understand and plan for extreme weather events and emergencies.

Policy (g): Support climate adaptation and resilience-related community groups to increase their engagement in climate change adaptation-related activities.



IMPLEMENTATION MEASURES:

- Collaborate with local, regional, state, and federal partners to provide community-wide outreach to educate people on how to prepare for and recover from climate change effects.
- Integrate findings of climate vulnerability into emergency planning, including mitigation, preparedness, response, and recovery efforts.
- Investigate the use of monitoring and metrics that evaluate the efficacy of the climate change resilience actions identified in the Climate Vulnerability Assessment.
- Support community organizations as they identify gaps in vulnerable community resilience planning and provide outreach to vulnerable populations.
- Investigate financing and funding opportunities to fund short- and long-term climate adaptation projects. Continue to prepare the appropriate planning documents to leverage FEMA mitigation funding.
- Consider projects that reduce the exposure of persons experiencing homelessness to safety and health impacts from climate hazards.
- Develop plans and protocols to provide adequate access and function for people with disabilities during extreme weather events and emergencies.

RESOURCES:

- 2020 City of Irvine Local Hazard Mitigation Plan (certified December 17, 2020)
- City of Irvine Emergency Operations Plan (September 2022)

APPENDICES:

- Appendix A – Draft City of Irvine Climate Vulnerability Assessment and Adaptation Framework (February 2023)
- Appendix B – Emergency Evacuation Route Analysis (March 2024)

APPENDIX A

Appendix A - Draft City of Irvine Climate Vulnerability Assessment and Adaptation Framework (February 2023)

CITY OF IRVINE

CLIMATE VULNERABILITY ASSESSMENT

DRAFT

February 2023

ORGANIZATION

This document includes the following chapters:

Chapter 1- Introduction

This chapter describes climate adaptation planning and the applicable State requirements as they relate to this Vulnerability Assessment and Adaptation Framework.

Chapter 2 – Community Profile

This chapter provides a description of the City's general environment and demographics. Special emphasis is made to reveal disadvantaged communities and vulnerable populations.

Chapter 3 – Vulnerability Assessment

This chapter includes forecasts of each of the five climate-related hazards. It also maps where those hazards are most likely to affect the City of Irvine and which areas are most vulnerable to these changes.

This chapter evaluates the City's current capacity to address the five climate-related hazards. This includes an assessment of the City's current policies and programs and how they address the ability to respond to hazard events.

Chapter 4 – Adaptation Framework: Recommendations to Improve Resilience

This chapter includes potential strategies and policy recommendations to increase the City's ability to adapt to hazards and meet the needs of its vulnerable communities.

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ACRONYMS

ACS = United States Census American Community Survey

APG 2.0 = California Adaptation Planning Guide 2.0

CEC = California Energy Commission

CAL FIRE = California Department of Forestry and Fire Protection

CF = Critical Facilities

CNRA = California Natural Resources Agency

CalOES = California Office of Emergency Services

CoSMoS = Coastal Storm Modeling System

FEMA = Federal Emergency Management Act

FHSZ = Fire Hazard Severity Zones

FOC = Facilities of Concern

IRWD = Irvine Ranch Water District

LHMP = Local Hazard Mitigation Plan

MWD = Metropolitan Water District

NOAA = National Oceanic and Atmospheric Administration

OCFA = Orange County Fire Authority

OCTA = Orange County Transportation Authority

OCWD = Orange County Water District

OEHHA = California Office of Environmental Health Hazard Assessment

OPC = Ocean Protection Council

OPR = Office of Planning & Research

SCAG = Southern California Association of Governments

USGS = United States Geological Service

UHI = Urban Heat Island

UHIE = Urban Heat Island Effect

UHII = Urban Heat Island Index

UWMP = Urban Water Management Plan

VHFHSZ = Very High Fire Hazard Severity Zones

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CHAPTER 1. INTRODUCTION

According to the State of California's Legislative Analyst's Office:

> *"Addressing the widespread impacts of climate change represents a significant challenge for the state. A changing climate presents California with five key climate hazards: (1) higher temperatures and extreme heat events, (2) more severe wildfires, (3) more frequent and intense droughts, (4) flooding due to extreme precipitation events, and (5) coastal flooding and erosion from sea-level rise. These hazards will threaten public health, safety, and well-being—including from life-threatening events, damage to public and private property and infrastructure, and impaired natural resources."*[1]

To address the potential impacts from these hazardous events on the community, the City of Irvine is expanding upon their climate action and hazard mitigation planning efforts to focus on climate change adaptation by understanding the community's vulnerabilities to climate hazards and explore strategies to reduce the vulnerability to projected climate change effects, increase the local capacity to adapt, and build resilience.

This vulnerability assessment and adaptation framework follow goals outlined in the City of Irvine's Safety Element and Local Hazard Mitigation Plan (LHMP) that correspond with climate adaptation planning, specifically:

Safety Element (2015)

"Minimize the danger to life and property from manmade and natural hazards, including fire hazards, flood hazards, non-seismic geologic hazards and air hazards."

City of Irvine Local Hazard Mitigation Plan (2020)

The City's Local Hazard Mitigation Plan (LHMP) was developed to broadly increase resilience in Irvine. The following key goals were developed for the City's LHMP:

- Protect against threats from natural hazards to life, injury, and property damage for Irvine residents and visitors.
- Increase public awareness of potential hazard events.
- Preserve critical services and functions by protecting key facilities and infrastructure.
- Protect natural systems from current and future hazard conditions.
- Coordinate mitigation activities among City departments, neighboring jurisdictions, and with federal agencies, and
- Prepare for long-term change in hazard regimes.

The purpose of this effort is to expand upon the City's previous work to provide more detail regarding community assets and vulnerable population impacted by climate change and lays the groundwork to form policies and programs to support climate resilience.

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[1] Legislative Analyst's Office (LAO). 2022. Budget and Policy Post. Climate Change Impacts Across California Crosscutting Issues. April 5, 2022. https://lao.ca.gov/Publications/Report/4575. Accessed April 11, 2022.

Regulatory Drivers and Guidance for Climate Adaptation Planning

The report includes a Vulnerability Assessment and Adaptation Framework, which could be incorporated into the City's General Plan Safety Element, in compliance with SB 379, Government Code section 65302(g)(4)[2] and the Office of Planning & Research's (OPR) General Plan Guidelines.

According to SB 379, general plan safety elements must address climate change vulnerability, adaptation strategies, and emergency response strategies. SB 379 states:

> *"This bill would, upon the next revision of a local hazard mitigation plan on or after January 1, 2017, or, if the local jurisdiction has not adopted a local hazard mitigation plan, beginning on or before January 1, 2022, require the safety element to be reviewed and updated as necessary to address climate adaptation and resiliency strategies applicable to that city or county. The bill would require the update to include a set of goals, policies, and objectives based on a vulnerability assessment, identifying the risks that climate change poses to the local jurisdiction and the geographic areas at risk from climate change impacts, and specified information from federal, state, regional, and local agencies."*

As specified in Government Code section 65302(g)(4)(A) vulnerability assessments must identify the risks that climate change poses to the local jurisdiction and the geographic areas at risk from climate change impacts, utilizing federal, state, regional, and local climate vulnerability documentation such as APG 2.0 and the Cal-Adapt climate tool created by the California Energy Commission (CEC) and University of California, Berkeley Geospatial Innovation Facility. Other sources of information include data from local agencies regarding their adaptive capacity and historical data on natural events and hazards. Per Government Code section 65302(g)(4)(B), adaptation policies, goals, and objectives are to be developed based on findings from the vulnerability assessment. Additionally, Government Code section 65302(g)(4)(C) requires jurisdictions to create a set of feasible implementation measures to reduce climate change impacts on new or proposed land uses.

Assembly Bill 162 (2007)

Assembly Bill 162 requires that, upon the next revision of the housing element on or after January 1, 2009, cities and counties address flood hazards and safety in the land use, conservation, safety, and housing elements of their general plans.

Senate Bill 1241 (2012)

Senate Bill 1241 revised the safety element requirements to require all cities and counties whose planning area is within the state responsibility area (SRA) or very high fire hazard severity zones (VHFHSZs), as defined by CAL FIRE, to address and incorporate specific information regarding wildfire hazards and risk, and policies and programs to address and reduce unreasonable risks associated with wildfire. Upon the next revision of the housing element on or after January 1, 2014, the bill requires those cities and counties to review and update the safety element to consider the advice in the Office of Planning and Research's most recent publication of "Fire Hazard Planning, General Plan Technical Advice Series" as well as: information regarding fire hazards, a set of goals, policies, and objectives

[2] SB 379 was enacted to integrate climate change adaptation into California's general plan process.

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based on identified fire hazards, and a set of feasible implementation measures designed to carry out those goals, policies, and objectives.

Senate Bill 1035 (2018)

Senate Bill 1035 requires regular updates to the safety element chapter of the general plan. New information regarding flood and fire hazards must be included and climate change adaptation and resilience must be addressed as part of the update. After 2022, safety elements must be updated upon each revision of the housing element or local hazard mitigation plan, but no less often than once every 8 years. Housing element revisions are typically on 4–8-year cycles and LHMP revisions are on 5-year cycles.

Senate Bill 99 (2019)

Senate Bill 99 requires that, upon the next revision of the housing element on or after January 1, 2020, the safety element must be updated to include information identifying residential developments in hazard areas that do not have at least two emergency evacuation routes (i.e., points of ingress and egress).

Senate Bill 747 (2019)

Senate Bill 747 requires that, upon the next revision of a LHMP on or after January 1, 2022, or beginning on or before January 1, 2022, if a local jurisdiction has not adopted a LHMP, the safety element must be reviewed and updated as necessary to identify evacuation routes and their capacity, safety, and viability under a range of emergency scenarios. If a LHMP, emergency operations plan, or other document that fulfills commensurate goals and objectives, a local agency may use that information in the safety element to comply with this requirement by summarizing and incorporating by reference such a plan or other document into the safety element.

Consistent with Government Code 65302(g)(4)(A), the following vulnerability assessment and adaptation framework also takes guidance from:

California's Fourth Climate Assessment (2018)

California Natural Resources Agency (CNRA), OPR, and CEC prepared California's Fourth Climate Assessment in 2018. The Climate Assessment was designed to presents findings in the context of existing climate science, including strategies to adapt to climate impacts and key research gaps needed to spur additional progress on safeguarding California from climate change.

Safeguarding California Plan (2018)

CNRA released an update to the Safeguarding California Plan in 2018, providing a roadmap for State government action to build climate resiliency. The Safeguarding California Plan presents overarching strategies and outlines ongoing actions and cost-effective and achievable next steps to make California more resilient to climate change.

Ocean Protection Council State Sea Level Rise Guidance (2018)

Between 2017 and 2018, the Ocean Protection Council (OPC) released two reports that update their understanding of sea level rise science and best practices for planning and addressing anticipated

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impacts. The reports synthesize recent evolving research on sea level rise science and provides higher level recommendations for how to plan for and address sea level rise impacts, notably including a set of projections recommended for use in planning, permitting, investment, and other decisions.[3]

California Adaptation Planning Guide (2020)

The California Office of Emergency Services (Cal OES) released the second version of the Adaptation Planning Guide in 2020 - APG 2.0 - which includes updated guidance, an increased focus on equity and outreach, and best practices. The APG is designed to help local government, regional entities, and climate organizations incorporate best practices and current science and research into their adaptation plans.[4]

LOCAL AND REGIONAL CLIMATE PLANNING

This vulnerability assessment and adaptation framework also draws upon existing efforts in the region to address climate change. These documents include, but are not limited to:

- City of Irvine General Plan Safety Element (Amended 2015)
- City of Irvine Local Hazard Mitigation Plan (2020)
- California Department of Transportation (Caltrans) Climate Change Vulnerability Assessment District 12 Technical Report (2019)
- Southern California Adaptation Planning Guide (APG) (2020)
- Southern California Association of Governments (SCAG) Climate South California Climate Adaptation Framework SB379 Compliance Curriculum for Local Jurisdictions (2021)
- Southern California Association of Governments (SCAG) Climate Risk & Vulnerability Assessment Tool for SB 379 Safety Element Updates
- Office of Planning and Research Defining Vulnerable Communities in the Context of Climate Adaptation (2018)

Methodology and Planning Process

The APG 2.0 provides a four-step process that communities can use to plan for climate change. The APG is designed to be flexible and guide communities in adaptation planning.

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[3] Ocean Protection Council (OPC). 2018. State of California Sea-Level Rise Guidance: 2018 Update.
[4] California Governor's Office of Emergency Services (Cal OES). California Adaptation Planning Guide. June 2020.



Source: California Governor's Office of Emergency Services, 2020.

Phases of the Adaptation Planning Process include:

- Phase 1, Explore, Define, and Initiate:

  This phase includes scoping the process and project, such as identifying the potential climate change effects and important physical, social, and natural assets in the community.

- Phase 2, Assess Vulnerability:

  This phase includes analysis of exposure to, sensitivity of, and adaptive capacity to respond to climate effect to determine physical and social vulnerability.

- Phase 3, Define Adaptation Framework and Strategies:

  This phase focuses on creating an adaptation framework and developing adaptation strategies based on the results of the vulnerability assessment. The adaptation strategies are the community's potential response to the vulnerability assessment.

- Phase 4, Implement, Monitor, Evaluate, and Adjust:

  In this phase, the adaptation framework is implemented, consistently monitored, and evaluated, and adjusted based on continual learning, feedback, and/or triggers.

The purpose of this report is to document Step 1 through Step 3. The vulnerability assessment and development of adaptation measures follows the approach recommended by APG 2.0.

The vulnerability assessment identifies projected climate change exposures for the city at mid- to late-century timeframes. In addition to identifying the City's exposure to the effects of climate change, the vulnerability assessment evaluates the sensitivity of key population groups and major community elements to climate change and associated hazards.

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CHAPTER 2. COMMUNITY PROFILE

The City of Irvine is located in southern Orange County, adjacent to the cities of Newport Beach, Lake Forest, Tustin, Santa Ana, Laguna Hills, Laguna Woods, and Laguna Beach. Situated at the foothills of the Santa Ana Mountains to the east, the San Joaquin Hills to the west and south, and the low-lying flatlands of central Orange County to the north, the City has a diverse geographic setting. Located approximately five miles south of the City of Santa Ana (Orange County Seat), the City is in a key job center for both Orange County and southern California.[5]

According to the US Census American Community Survey (ACS), in 2019 the City of Irvine had a population of almost 263,000. **Table 2-1: Demographics** displays the demographics in the City of Irvine and Orange County from 2019[6]. As shown in the table, the median household income for City residents is 13 percent greater than that for the region. Even with a greater median household income, compared with the region, a larger percentage of residences rent their home, and more are living below the poverty level. The number of households with a person living with a disability is 37 percent less for Irvine residences as compared to Orange County.

Table 2-1: Demographics

	Irvine	Orange County
Total Population[1]	262,665	3,168,044
Percent of residents that are children (less than 10 years)[2]	10.4%	11.7%
Percent of households that have people 65+ years[1]	20.6%	29.8%
Percentage of households with at least one person living with a disability[1]	12.3%	19.6%
Median age[2]	34.0	36.2
Total households[1]	94,490	1,037,492
Median household income[2]	$113,097	$97,972
Percent of rental households[2]	48.7%	40.7%
Percent of household income below poverty level[1]	13.1%	9.9%

Note: Percentage values rounded to nearest tenth decimal.
Source: US Census Bureau, ACS 2015 - 2019[1], US Census Bureau 2010 Summary File 1, ESRI Forecasts 2021[2]

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Vulnerable Communities

Compared to the region, the City's population age distribution skews slightly younger than the region. (**See Table 2-2: Age Distribution Comparison**). This may be partially due to the large educational institution population. 12.6 percent of the population is aged 65 years and older, although 20.6 percent of Irvine households have a resident that is aged 65 years and older.

[5] City of Irvine. 2015a. General Plan Safety Element.
[6] Data for vulnerable populations was extracted from a combination of US Census Bureau American Community Survey 2015 – 2019 estimates and ESRI's Business Analyst 2021 forecasts. Data sources have been noted in each demographic table.

Table 2-2: Age Distribution Comparison

	Irvine	Orange County
Under 5	5.1%	5.7%
5 - 14	13.0%	12.4%
15 - 24	15.7%	12.9%
25 - 34	17.0%	15.1%
35 - 44	14.5%	13.3%
45 - 54	12.7%	12.7%
55 - 64	11.4%	12.3%
Over 65	12.6%	15.6%

Note: Percentage values rounded to nearest tenth decimal.
Source: US Census Bureau 2010 Summary File 1, ESRI Forecasts 2021.

In California, those persons of retirement age (i.e., 65 years and older) are expected to grow more than twice as fast as the total population and this growth will vary by region. This means that people are living longer, and the number of older persons is increasing. This trend is also evident in Irvine, where the percent of the population aged 65 years and older grew by 43 percent from 2010 to 2021.

The racial and ethnic composition of a population may affect housing needs because of cultural preferences associated with different racial/ethnic groups. Cultural influences may reflect preference for a specific type of housing and household structure. Research has shown that number and share of Americans living in multigenerational family households have continued to rise. In 2016, a record 64 million people, or 20 percent of the U.S. population, lived with multiple generations under one roof. The Asian and Hispanic populations are more likely than whites to live in multigenerational family households.[7]

Table 2-3: Race and Ethnicity shows that, according to the 2015-2019 ACS, the ethnic distribution of the Irvine's population was predominantly White, not Hispanic or Latino, and Asian Alone with each group representing approximately 44 percent of the population. Approximately 11.6 percent of the city's population was of Hispanic origin. While Orange County has larger percentage of the population identifying as White, not Hispanic or Latino (55.6 percent), it also has a much larger share of the population identifying as Hispanic or Latino origin (34.2 percent).

Table 2-3: Race and Ethnicity

	Irvine	Orange County
White Alone (Not Hispanic or Latino)	44.7%	55.6%
Black Alone (Not Hispanic or Latino)	2.2%	1.9%
American Indian Alone (Not Hispanic or Latino)	0.2%	0.6%
Asian Alone (Not Hispanic or Latino)	43.6%	21.9%
Pacific Islander Alone (Not Hispanic or Latino)	0.2%	0.3%
Some Other Race Alone (Not Hispanic or Latino)	3.1%	14.8%
Two or More Races (Not Hispanic or Latino)	6.0%	4.9%
Hispanic Origin (Any Race)	11.6%	34.2%

Note: Percentage values rounded to nearest tenth decimal.

Source: US Census Bureau 2010 Summary File 1, ESRI Forecasts 2021.

[7] Cohn, D'Vera and Jeffrey S. Passel. 2018. *A record 64 million Americans live in multigenerational households.* Pew Research Center. April 5, 2018. https://www.pewresearch.org/fact-tank/2018/04/05/a-record-64-million-americans-live-in-multigenerational-households. Accessed April 28, 2022.

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The Irvine community is diverse with multiple languages spoken. As shown in **Table 2-4: English Proficiency and Languages Spoken at Home Among Residents 5 Years and Older - Irvine**, the majority of residents aged 5 years and older are fluent in English. However, over 16,000 residents or about 6.5 percent of the population are not fluent in English. In response, the City implements programs intended to communicate information to the diverse community of residents and workers with different backgrounds. The City of Irvine's website offers translation for 81 languages to provide information for the diverse community members.[8] The Irvine Police Department's Policy 345 provides guidance to members when communicating with individuals with limited English proficiency (LEP) to reasonably ensure that LEP individuals have meaningful access to law enforcement services, programs, and activities, while not imposing undue burdens on its members.[9]

Table 2-4: English Proficiency and Languages Spoken at Home Among Residents 5 Years and Older - Irvine

	Number of Speakers	Percent Not Fluent in English
English Only	122,128	-
Spanish	15,502	5.9%
Indo-European Languages	27,602	9.7%
Asian and Pacific Island Languages	74,197	15.9%
Other Languages	7,094	13.2%

Note: Percentage values rounded to nearest tenth decimal.

Source: US Census Bureau, American Community Survey 2015 - 2019, ESRI 2022

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2.1 VULNERABLE POPULATIONS

Climate change disproportionately affects those with existing disadvantages. Low-income communities and communities of color often live in areas with conditions that expose them to more severe hazards, such as higher temperatures and worse air quality. These communities also have fewer financial resources to adapt to these hazards. For instance, low-income populations are already disproportionately burdened by energy bills and may reduce air conditioning usage out of concerns about cost. People with chronic medical conditions are often more physiologically susceptible to negative health impacts from extreme heat and poor air quality, and those with mobility issues are particularly at risk. Many of the above risk factors are often present in older adults, who are more likely to have a limited income, chronic health conditions, and mobility limitations, and are more likely to experience social isolation.[10]

Factors such as age, physical and mental condition, socioeconomic status, access to key services, and other factors affect the ability of people to prepare for and protect themselves and their property from a climate-related event. Even though hazard events may impact all parts of the city with equal severity, individuals may experience the effects differently.

[8] City of Irvine. 2022a. Home Page. https://www.cityofirvine.org/. Accessed May 3, 2022.

[9] City or Irvine. n.d. Policy 345. Limited English Proficiency Services.

[10] Hall, Alex, Neil Berg, Katharine Reich. (University of California, Los Angeles). 2018. Los Angeles Summary Report. California's Fourth Climate Change Assessment. Publication number: SUM-CCCA4-2018-007.

Disadvantaged Communities

According to the California Office of Environmental Health Hazard Assessment (OEHHA) a community is considered disadvantaged based on its pollution burden and sensitive populations. OEHHA provides the CalEnviroScreen tool to evaluate and map disadvantaged communities. The dataset helps identify California communities that are most affected by specific sources of pollution, and where people are often especially vulnerable to pollution's effects. The dataset uses environmental, health, and socioeconomic information to produce scores for every census tract in the state that are mapped using a scale based on the pollution burden of the location. The higher the percentage, the greater the burden and the higher likelihood of environmental justice concerns.

CalEnviroScreen calculates scores for two groups of indicators: Pollution Burden (e.g., PM2.5 concentrations, diesel PM emissions, adjacency to solid waste sites) and Population Characteristics (e.g., asthma emergency department visits, linguistic isolation, low-income households). **Figure 2-1: CalEnviroScreen 4.0** shows the combined Pollution Burden scores, which is made up of indicators from the Exposures and Environmental Effects components of the CalEnviroScreen model. Pollution Burden represents the potential exposures to pollutants and the adverse environmental conditions caused by pollution. Compared to all census tracts in the state, those tracts in Irvine are all in the bottom half, meaning the population of Irvine has lower pollution burden compared to other areas in the state. As a result, OEHHA does not identify any census tract in the City as containing disadvantaged communities.

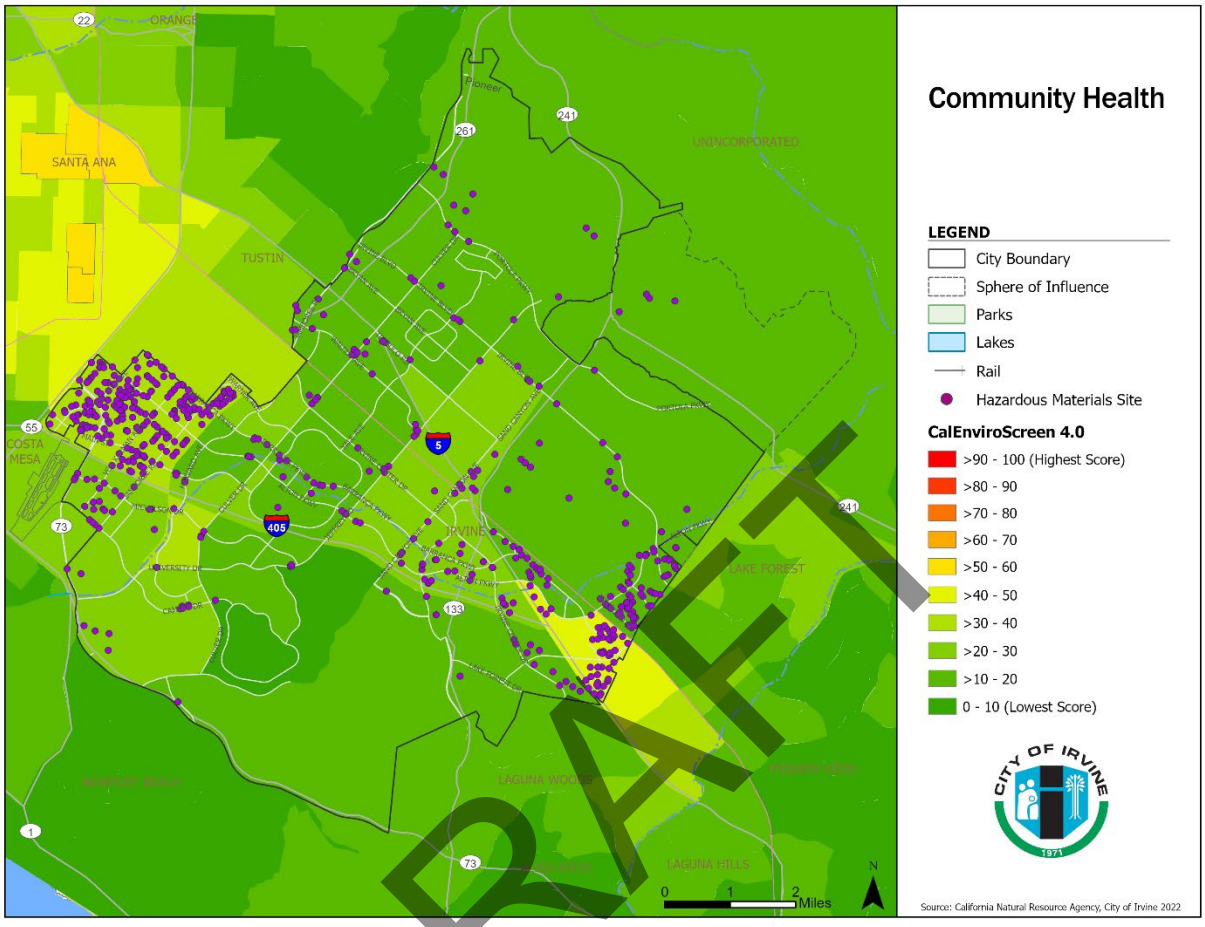
While the City does not have state-defined disadvantaged communities, the City still has populations that are vulnerable to climate hazard events. Each section covering a different climate hazard within the Vulnerability Assessment contains an analysis of social sensitivity using the following criteria to assess the potential impact to vulnerable populations:

- Disability status: Persons with disabilities may often have reduced mobility and experience difficulties living independently. As a result, they may have little or no ability to prepare for and mitigate hazard conditions without assistance from others. An estimated 12.3 percent of Irvine households contain at least one person with a disability.
- Income levels: Lower-income households are less likely to have the financial resources to implement mitigation activities on their residences. They may also struggle with having the necessary time to find and access educational resources discussing hazard mitigation strategies. Furthermore, lower-income households are less likely to be able to afford moving to areas that are safer or less at risk of being impacted by a hazard. The national poverty limit standard for the U.S. for a four-person family is an income of $26,200 or less. In Irvine, between 2015 and 2019, an estimated 13.1 percent of households had an income that was considered below the poverty level. An estimated, 2.6 percent of households received food stamps or qualified for the Supplemental Nutrition Assistance Program (SNAP).[11]
- Seniors (individuals at least 65 years of age): Seniors are more likely to have reduced mobility, physical and/or mental disabilities, and lower income levels, all of which may decrease their ability to prepare for and mitigate a hazard event.

[11] United States Census Bureau (US Census). 2010. 2010 Summary File 1, ESRI Forecasts 2021. Accessed May 5, 2022.

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Figure 2-1: CalEnviroScreen 4.0



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Homeless Population

The homeless are highly susceptible to impacts from direct and indirect climate effects including extreme heat events, air pollution from wildfires, and precipitation-driven or coastal flooding. Throughout Orange County, homelessness has become a substantial issue. Previous factors contributing to the rise in people experiencing homelessness included the general lack of housing affordable to lower-income people, increases in the number of people whose incomes fall below the poverty level, reductions in public subsidies, the de-institutionalization of those with mental illness, and increasing substance abuse issues. The increase in the number of layoffs and the loss of employment during the COVID-19 pandemic have likely contributed to an increase in this population because these effects resulted in the inability to afford housing. The impact of the COVID-19 on homelessness in Orange County will likely continue when eviction moratoriums are lifted, which could result in a further increase in people experiencing homelessness. According to the SCAG pre-certified data, 130 individuals are experiencing homelessness in Irvine, with three individuals (2 percent) who are sheltered and 127 individuals (or 98 percent) who are unsheltered.[12]

[12] City of Irvine. 2021a. 6th Cycle 2021-2029 Housing Element – Second Draft. November 19, 2021.

In Orange County, homelessness is addressed regionally by the Orange County Continuum of Care (COC), an umbrella organization that brings together government agencies and community-based nonprofit organizations in a coordinated effort to meet the urgent needs of people experiencing homelessness or that are in imminent danger of experiencing homelessness. The County of Orange Health Care Agency is the collaborative applicant, and 2-1-1 OC is the Homeless Management Information System lead agency.

Both Irvine and Orange County currently have a number of existing programs to assist individuals experiencing homelessness, including shelters, provided by Orange County.

2.2 MAJOR COMMUNITY ELEMENTS

The City provides the educational, employment, recreational, and cultural opportunities of a large city and, since its incorporation in 1971, has grown to include strong, diverse residential and business communities. At 50 years old, Irvine is a relatively young city; however, it is continuing its history of master planning through redevelopment of the former El Toro Marine Corps Air Station into the Great Park Neighborhoods and through the redevelopment of underutilized commercial and industrial uses into much needed housing.[13]

The identification of assets potentially affected by climate change related events follows FEMA's LHMP Guidance categorizing community elements as follows:

Essential Services

Fire and Emergency Services

The City contracts with the Orange County Fire Authority (OCFA) to provide fire protection and emergency services in the community. OCFA is a regional fire service agency that serves 23 Orange County cities and all unincorporated areas and protects over 1.6 million residents from its 71 fire stations located throughout the county.[14]

There are eleven (11) strategically located fire stations in the City of Irvine, which allow firefighters and paramedics to provide timely responses to emergencies and to efficiently respond to volume demand.[15]

Police Services

The Irvine Police Department is comprised of six (6) distinct Divisions which operate under the direction and management of the Chief of Police. Each Division contains unique and specialized Bureaus, Units, and Sections responsible for overseeing and maintaining the programs of the Department. The Divisions are as follows:

- Administration, including the Office of the Chief of Police, public information officer and support services.
- Business Services, including budget/grant office, communications (9-1-1 dispatch), technology support, regulatory affairs, technical services, property, and custody.
- Operations, including patrol and criminal investigations.

[13] City of Irvine. 2022a. https://www.cityofirvine.org/. Accessed May 3, 2022.
[14] City of Irvine. 2022e. Public Safety. https://www.cityofirvine.org/irvine-gives/public-safety. Accessed May 2, 2022.
[15] Orange County Fire Authority (OCFA). 2022b. https://ocfa.org/AboutUs/FireStations.aspx. Accessed May 2, 2022.

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- Support Services, including emergency management, traffic/special events, and community outreach.
- Office of Professional Development, including Academy and POST training section, firearms and range section and recruitment, personnel, and hiring section.
- Office of Professional Standards, including Internal Affairs, risk management. and worker's compensation.[16]

Transportation Systems

The City of Irvine is served by multiple modes of transportation including bus, light rail, train, biking, and walking. The Street & Right-of-Way Maintenance Division maintains 470 centerline miles of roadway, over 1,155 linear miles of curb and gutter, 900 miles of sidewalk, approximately 5,600 catch basins well as access ramps, traffic signs, pavement markings, and street striping (Irvine 2022f). Partners like the Orange County Transportation Authority (OCTA), Amtrak, iShuttle, Spectrumotion all work together to provide the transportation network in the City of Irvine.

Active Transportation Options

- Biking. The City of Irvine provides a system of 113.24 miles of off-street bikeway trails and 286.42 lane miles of on-street bikeways.[17]
- The iShuttle, operated and managed by the OCTA, serves residents, employees and employers in the Irvine Spectrum Area and the Irvine Business Complex by taking commuters and residents to and from work and home.
- ACCESS is OCTA's shared-ride service for people who are unable to use the regular, fixed-route bus service because of functional limitations caused by a disability. These passengers must be certified by OCTA to use the ACCESS system by meeting the Americans with Disabilities Act (ADA) eligibility criteria.
- The Irvine Station, located in the Spectrum area of the City, is a growing transportation hub in South Orange County.
- The Irvine Transportation Network is a "one-stop shop" for transportation information for anyone living in, working in, or traveling through the Irvine Business Complex (IBC).
- TRIPS is a transportation service available to Irvine residents (18 and older) who are unable to drive due to permanent physical and/ or cognitive disability.
- Amtrak is an intercity rail system throughout the nation with several stops throughout Orange County and Southern California.
- Metrolink is a commuter rail system throughout Southern California linking communities to employment and activity centers. It provides reliable transportation and mobility for the entire region while creating less congested roadways and more livable communities.
- Spectrumotion helps Irvine Spectrum employees find the best possible way to commute to work.
- Mobility Guide: The City of Irvine offers a variety of transportation options for seniors and special needs population.

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[16] City of Irvine. 2022b. Police. https://www.cityofirvine.org/ipd-divisions-bureaus-units. Accessed May 2, 2022.
[17] Transportation. https://www.cityofirvine.org/work/transportation. Accessed May 2, 2022.

Lifeline Utility systems

Infrastructure plays a vital role in mitigating the effects of hazard events. When infrastructure fails, it can exacerbate the extent of certain hazards or create complications for rescue workers trying to reach victims. For example, fallen utility poles, because of high winds or seismic activity, can obstruct roadways and prevent emergency vehicles from reaching affected areas. The following are brief descriptions of major infrastructure in the city that may be affected by climate-related hazards:

Electricity

Irvine receives its electrical supply from Southern California Edison. There are seven substations located within the City connecting 220kV and 66 kV powerlines that run both east to west and north to south. These lines bring power to Irvine and the surrounding cities and provide connection to other regional power sources as well.13 These connections help Irvine access auxiliary electricity sources, should any of its immediate infrastructure fail. However, a larger and more regional failure of the power grid would likely disrupt power transmission to Irvine for an extended time period until power can be restored.[18]

Water Supply

Approximately 35 percent of Irvine's drinking water is purchased from the Metropolitan Water District (MWD) of Southern California. This imported water comes from the Colorado River via the Colorado River Aqueduct and from Northern California via the State Water Project. The remaining 65 percent of Irvine's drinking water supply comes from Irvine Ranch Water District's (IRWD) local groundwater wells in the Orange County Groundwater Basin, managed by the Orange County Water District (OCWD). These wells range in depth from 400 to 2,000 feet and extract high quality water. The blend of imported and groundwater vary according to the time of year and the customer's geographical location within the District.[19]

Wastewater Capacity

The City of Irvine's wastewater conveyance and treatment is provided by IRWD. IRWD conveys all of sewage from the City of Irvine to their Michelson Water Recycle Plant (MWRP) and Los Alisos Water Recycle Plant except for the small area known as the Irvine Business Complex, which is conveyed to Orange County Sanitary District. The Irvine Business Complex is roughly bounded by San Diego Creek to the east, CA-78 to the south, Warner Ave. the north, and the City of Irvine's boundary to the west. IRWD is actively planning to address conveyance and treatment issues over the planning period and has laid out a progressive and comprehensive plan.[20]

Stormwater Management

The Public Drainage Program is responsible for the maintenance and upkeep of City public drainage facilities. The Program's responsibilities include the annual inspection and cleaning of all City storm drains and catch basins, erosion control of slopes along City open channels and other City drainage facilities, cleaning of debris and clearance of drainage systems after storm events and the prevention of standing water issues/concerns in City right-of-way areas. The Clean Water Program has two goals: maintain water quality and protect beaches, lagoons and creeks from illicit discharges, sewage spills and other pollutants.[21]

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[18] City of Irvine. 2020. Local Hazard Mitigation Plan. October.
[19] City of Irvine. 2022. https://www.cityofirvine.org/community-development/water-quality. Accessed May 2, 2022.
[20] City of Irvine. 2021a. 6th Cycle 2021-2029 Housing Element – Second Draft. November 19, 2021.
[21] City of Irvine. 2022. https://www.cityofirvine.org/public-works-department/public-drainage. Accessed May 2, 2022.

Waste Management

Waste Management of Orange County provides all residential/multi-family refuse, recycling, and green waste service as well as bulky item and Christmas tree collection.

Hazardous Materials

The threat that hazardous materials pose to human health depends on the type of material, frequency, and duration of exposure, and whether chemicals are inhaled, penetrate skin, or are ingested, among other factors. Exposure to hazardous materials can result in short- or long-term effects, including major damage to organs and systems in the body, or death. Hazardous waste is any material with properties that make it dangerous or potentially harmful to human health or the environment. Hazardous materials can also cause health risks if they contaminate soil, groundwater, and air, potentially posing a threat long after the initial release.[22]

Hazardous materials can cause damage to physical assets in Irvine if they are released into the environment. Corrosive hazardous materials can damage the exteriors of any buildings or structures designated as a critical facility or facility of concern by the city. Flammable hazardous materials can potentially start fires and may cause any nearby critical facilities to flashover. Sites that are closer to the origin for the release of the hazardous materials are more at threat than those that are further away. Figure 2-2: Critical Facilities and Hazardous Materials Sites shows hazardous materials sites identified in the city.

Economic Elements

Irvine Spectrum

The Irvine Spectrum is one of the City of Irvine's two major business centers. It is comprised of 5,000 acres, 38 million square feet of commercial space, and 3,500 companies that employ nearly 80,000 people. The City's major retail center, the Irvine Spectrum Center, is comprised of 1.2 million square feet and more than 130 stores, restaurants, and entertainment venues.11 This location is major attraction in the City due to its convenient location between I-5 and I-405 and draws a significant amount of visitors and employees from outside the City.

Irvine Business Complex

The Irvine Business Complex is a 2,800-acre area in the western part of the City containing industrial, commercial office, and residential uses. The zoning in this part of the City allows for over 15,000 base residential units, non-residential uses (commercial, office, industrial), and hospitality uses. This area of the City is a major economic hub as a significant of amount of people enter the City every day to work in the businesses within this complex.[23]

Natural Resource Areas

The City features 20 developed community park sites totaling over 387 acres and six special facilities totaling 55.1 acres. In total, 39 public neighborhood parks and vista points totaling 178.6 acres and many private neighborhood parks are in Irvine. Moreover, the City has off-street bicycle trails totaling over 63 miles. In addition to parks, the City is in a league of its own when it comes to trails and preserved open spaces.

[22] City of Irvine. 2020. Local Hazard Mitigation Plan. October.
[23] City of Irvine. 2020. Local Hazard Mitigation Plan. October.

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The Jeffrey Open Space Trail, Bommer Canyon, and Quail Hill are a few of the treasured areas that have been preserved in connection with Irvine's historic Open Space Initiative and are examples of the extraordinary recreational opportunities available to residents. Among these community park facilities, the Orange County Great Park, currently being developed, will consist of over 1,300 acres of parkland, and will serve the residents of Irvine and the region with significant amenities, open space, and passive and active recreational facilities and enhance the living environment surrounding residences in the area.[24]

Institutional Uses

Several higher education institutions are in the City, including the University of California, Irvine; Concordia University; Irvine Valley College; University of Southern California (Orange County Center); and campuses of University of La Verne and Pepperdine University.[25] Combined enrollment for these schools is over 41,000 students, which can greatly increase the City's daytime population, impact roadways, and community services.[26]

CRITICAL FACILITIES AND FACILITIES OF CONCERN

Essential Facilities are further categorized as Critical Facilities (CF) and Facilities of Concern (FOC) and consist of properties and structures that play important roles in government operations and the services they provide to the community. Examples of CFs and COFs include local government offices and yards, community centers, public safety buildings like police and fire stations, schools, and any other properties a city has deemed essential for its operations. CFs may also serve dual roles if a city designates them as points of public assembly during an emergency. CFs are often owned by the City, but many are also owned and operated privately, such as some utilities and telecommunication infrastructure.

The Hazard Mitigation Planning Committee for the 2020 LHMP Update identified 213 CFs or FOC in Irvine that fall into 6 different categories based on their function or characteristics. Table 2.5: Critical Facilities and Facilities of Concern shows the number of CFs and FOC in each category, the total estimated value of the facilities in each category, and examples of the facilities in each. Appendix D of the LHMP has a complete list of the CFs and FOC. Figure 2-2: Critical Facilities and Hazardous Materials Sites shows the locations of CFs and FOC (and hazardous materials sites) in Irvine that were mapped. Some facilities were not mapped due to security concerns.

The potential loss value is the total insured value of the CFs that fall within the hazard zone. It is intended to provide the ballpark estimate of the cost of replacement if the property is completely or severely damaged. Actual costs of repair could be smaller or larger than the provided estimate. The data was provided by the City's Property Schedule and therefore, information for facilities not owned by the City are not shown (e.g., bridges, private buildings). In some instances, replacement cost information was not made available. Where this occurs "N/A" has been used within the table.

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[24] City of Irvine, 6th Cycle 2021-2029 Housing Element – Second Draft. November 19, 2021.
[25] City of Irvine. 2021a. 6th Cycle 2021-2029 Housing Element – Second Draft. November 19, 2021.
[26] City of Irvine. 2020. Local Hazard Mitigation Plan. October.

Table 2.5: Critical Facilities and Facilities of Concern

Category	Number of Facilities		Examples	Potential Loss*,[27]
	Critical	Concern		
City Vital Operations	4	1	City Hall, Police Station, Operations Support	$99,520,918
City Community Centers	12	0	Community Centers	$32,171,675
City Resident Services	4	5	Senior Centers, Animal Shelter, Daycare, Other Community Facilities	$13,173,434
City Recreation Support	0	21	Parks, Recreation Amenities, Sports Complexes, and support facilities	$56,969,379
Bridges	120	0	Overpasses and underpasses	$166,687,247
Schools	0	46	Irvine Unified School District and Tustin Unified School District Facilities	N/A
Total	**140**	**73**		**$368,522,653**

* Based on the City of Irvine insured replacement values

City of Irvine Adaptive Capacity to Climate-Related Hazards

The City of Irvine has implemented programs or partnered with external agencies to prepare, respond, and help the community recover from manmade and natural hazards, including those that are climate related. The following programs improve the overall adaptive capacity of the City:

Prepare Irvine

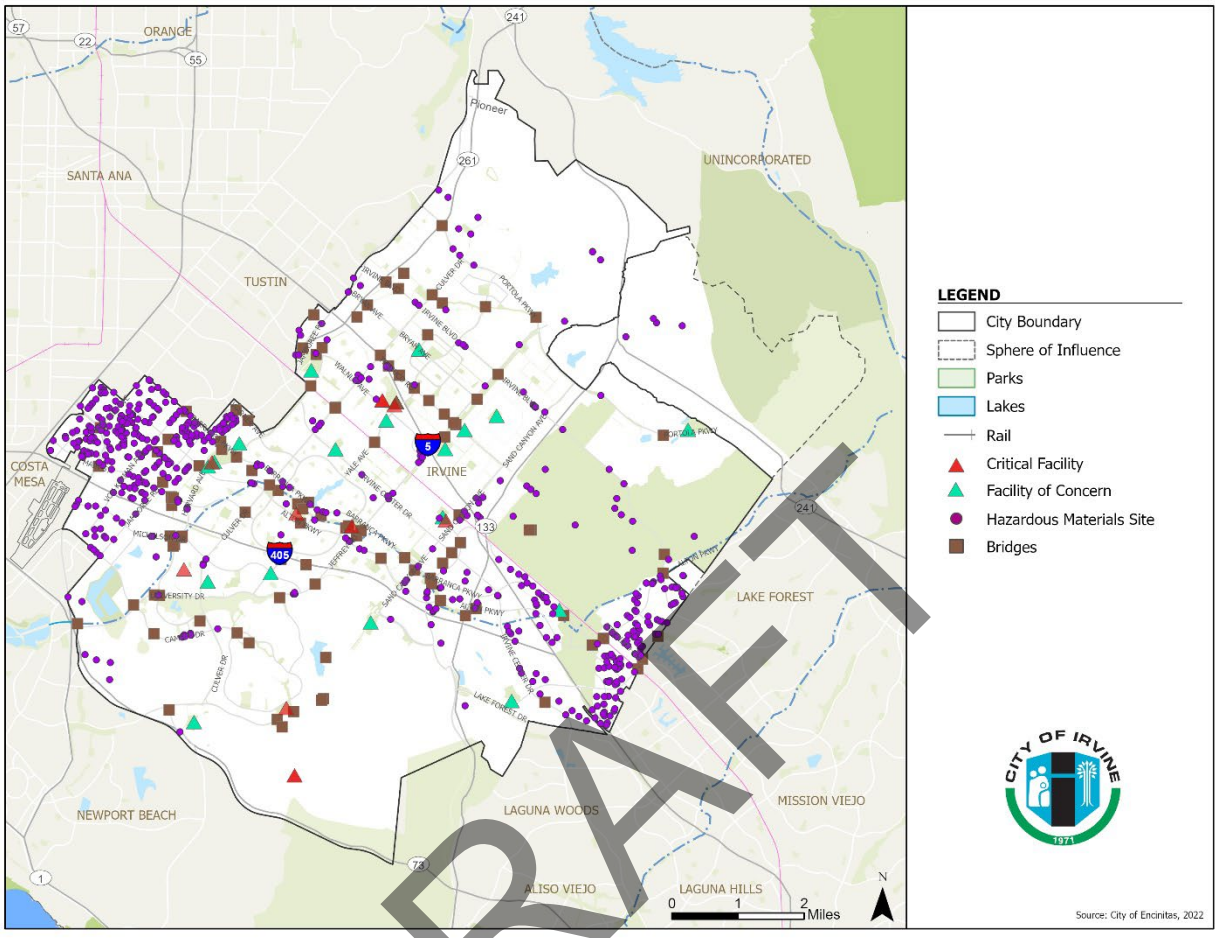
The Irvine Police Department Office of Emergency Management mobilizes local first responders for hazardous events but recognizes that they cannot reach everyone in our City right away. In times of disaster, a trained and informed public is better prepared to protect themselves, their families, their workplace, and their neighbors.[28]

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[27] City of Irvine. October 2019. 2018-2019 Statement of Values

[28] City of Irvine. 2022. Prepare Irvine. https://www.cityofirvine.org/prepare. Accessed May 3, 2022.

Figure 2-2: Critical Facilities and Hazardous Materials Sites



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AlertOC

AlertOC is a mass notification system designed to keep Orange County informed of emergencies that may require immediate lifesaving actions. Time-sensitive voice and text messages from the City of Irvine will be sent to city residents and workers warning of hazardous events, including wildfire.[29]

AB 38

As of July 1, 2021, a seller of a property that is located in a high or very high fire hazard severity zone as identified by the Director of Forestry and Fire Protection must provide to the buyer documentation stating that the property is in compliance with local vegetation management ordinances.[30]

[29] AlertOC. 2022. https://member.everbridge.net/453003085613900/login. Accessed May 3, 2022.
[30] State of California. 2019. AB38, Wood. Fire safety: low-cost retrofits: regional capacity review: wildfire mitigation. https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201920200AB38. Accessed May 3, 2022.

CERT

Irvine's Community Emergency Response Team (CERT) is a program designed to prepare citizens to help themselves, their families, and their neighbors in the event of a catastrophic disaster. Because professional emergency service personnel will not be able to help everyone immediately, CERT training can make a difference in saving lives and protecting property in our community. The training includes the basic skills important in disaster response, such as disaster medical operations, fire suppression, and light search and rescue.[31]

IDEC

The Irvine Disaster Emergency Communications (IDEC) is an organized team of over 60 experienced, trained and dedicated amateur radio operators (Hams). Members routinely volunteer their time and extensive radio communication skills to augment normal methods of communications used by the Irvine Police Department in times of emergencies or major disasters.

Translation Services

The City of Irvine's website offers translation for 81 languages to provide information for the diverse community members.[32]

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[31] City of Irvine. 2022. https://www.cityofirvine.org/irvine-gives/public-safety. Accessed May 2, 2022.
[32] City of Irvine. 2022. https://www.cityofirvine.org/. Accessed May 3, 2022.

CHAPTER 3. VULNERABILITY ASSESSMENT

Addressing the widespread impacts of climate change represents a significant challenge for the state. A changing climate presents California with five key climate hazards: (1) higher temperatures and extreme heat events, (2) more severe wildfires, (3) more frequent and intense droughts, (4) flooding due to extreme precipitation events, and (5) coastal flooding and erosion from sea-level rise. These hazards will threaten public health, safety, and well-being—including from life-threatening events, damage to public and private property and infrastructure, and impaired natural resources.[33]

Follow state guidance, this report provides an assessment of the city's vulnerabilities to climate change. It identifies and describes the climate hazards and other climate effects that may affect the city in the future. The vulnerability assessment follows the process outlined in Phase 2 of APG 2.0 and is composed of the following three steps:

- Exposure: The purpose of this step is to understand is to characterize the city's exposure to current and projected climate hazards. Existing hazards that can be worsened by the effects of climate change are identified and described, based on historical data, including the City's LHMP. Climate data are used to develop projections for how existing hazards are expected to change by mid- and late century from future climate change.

- Sensitivity: This step will characterize potential future climate impacts to community populations and assets. Using historical data, research from regional and state reports on climate impacts, this step explores how sensitive vulnerable populations and assets may be affected by the projected impacts of climate change hazards.

- Adaptive Capacity: The City and its supporting agencies, and countywide organizations have already taken steps to build resilience and protect sensitive populations and assets from hazards. Thus, the purpose of this step is to characterize to characterize Irvine's current capability to cope with the projected impacts from climate hazards to vulnerable populations and assets. The adaptive capacity of the City to adapt to each of the identified climate impacts is determined through a review of existing plans and programs.

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3.1 EXISTING HAZARDS

The LHMP provides a comprehensive understanding of hazards, including those worsened by climate change. It evaluates emerging climate risks, sea-level rise, coastal storms, erosion, floods, landslides, wildfires, extreme heat, and drought/water supply hazards. Three major existing hazards that are anticipated to become more frequent or severe because of climate change are wildfires, landslides, and flooding.

[33] California Legislative Analyst's Office (LAO). 2022. Budget and Policy Post. Climate Change Impacts Across California Crosscutting Issues. April 5, 2022. https://lao.ca.gov/Publications/Report/4575. Accessed April 11, 2022.

3.1.1 FLOODING

Historical documents show that damaging floods occurred in the Los Angeles Basin in 1884, 1916, 1927, 1937, 1938, 1969, and 1997. The last one included the inundation of the lowlands in the Santiago Hills, EL Toro, San Joaquin Marsh, and Upper Newport Bay areas. It is expected that future developments will be protected from 100-year floods by the continuation of measures which alleviate flood hazards, such as channels, retention basins, and drains.[34]

3.1.2 WILDFIRES AND SMOKE

The topography of the foothills of the Santa Ana Mountains and San Joaquin Hills in Irvine is extremely conducive to wildfires. The community is bordered by natural, undeveloped hillsides/ mountains to the northeast and open space areas to the southwest. In between these two areas is most the City's developed areas. Over the past two decades, Irvine has been impacted by fires in or adjacent to the city such as the Santiago Fire in 2007, Freeway Complex Fire in 2008, the Canyon Fire in 2017, and the Silverado Fire in 2020.

3.1.3 GEOLOGIC AND SEISMIC HAZARDS

Liquefaction occurs when seismic energy shakes an area with low-density, fine grain soil, like sand or silt, is also saturated with water. When the shaking motion reaches these areas, it can cause these loosely packed soils to suddenly compact, making the waterlogged sediment behave more like a liquid than solid ground. During liquefaction events, the liquified soil can lose its stability which can cause damage to buildings and infrastructure built upon it. In severe cases, buildings may completely collapse. Pipelines or other utility lines running through a liquefaction zone can be breached during an event, potentially leading to flooding or release of hazardous materials.

Although earthquakes are not explicitly a climate hazard, climate change could potentially cause them to become more destructive because of an increased risk of liquefaction—the process by which semi-saturated or saturated sediment loses structural competency under intense shaking.[35] Rising groundwater associated with sea level rise can increase the amount of saturated sediment and the risk of liquefaction.

Landslides occur when earth on slopes become destabilized, typically after heavy rains, when the precipitation saturates the soil and makes it less stable, or when significant erosion from rainfall destabilizes the ground. Slopes that have recently burned face a greater risk from rain-induced landslides, as the fires burn up many of the trees, brush, and other vegetation that help stabilize the earth. Earthquakes may also be a source of landslides as the shaking can destabilize already loosened soils.

Major landslides have occurred throughout the Southern California region. For example, landslides were set off by the 1971 San Fernando and 1994 Northridge earthquakes. As a master planned community, the City of Irvine has taken numerous steps to mitigate landslide hazards as part of the development process. As a result, the City has not experienced significant landslide events.[36]

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[34] City of Irvine. 2015a. General Plan Safety Element.
[35] USGS. (n.d.-b). *Natural hazards: What is liquefaction?* https://www.usgs.gov/faqs/what-liquefaction. Accessed March 2022.
[36] City of Irvine. 2020. Local Hazard Mitigation Plan. October.

3.2 ANALYZING CLIMATE CHANGE

Climate change effects are categorized as direct or indirect. Direct effects are caused by the initial impacts of increased greenhouse gas (GHG) emissions, while indirect effects occur because of the direct effect(s). The direct climate change effects include changes in temperature and precipitation. The indirect effects, which can occur because of isolated changes or a combination of changes in the direct effects (e.g., temperature or temperature plus precipitation), include extreme heat events drought, wildfires, onshore flooding associated with large precipitation events, landslides, and coastal flooding and inundation resulting from sea level rise.

To assess the potential direct and indirect effects from climate change, APG 2.0 recommends using Cal-Adapt, a global climate simulation model data. Cal-Adapt addresses uncertainty surrounding potential GHG emissions with the use of Representative Concentration Pathways. The RCPs in this vulnerability assessment rely upon two future emissions scenarios: RCP 4.5 and RCP 8.5. RCP 4.5 represents a medium emissions scenario of GHG emissions and assumes emissions will rise, then even out near the middle of the century, and decrease to below 1990 levels by the end of the 21st century. RCP 8.5 is a high emissions scenario where GHG emissions continue to increase through the end of the 21st century.[37]

Cal-Adapt also includes ten global climate models, downscaled to local and regional resolution using the Localized Constructed Analogs statistical technique. Four of these models were selected by California's Climate Action Team Research Working Group as priority models for research contributing to California's Fourth Climate Change Assessment2. Projected future climate from these four models can be described as producing:

- A warm/dry simulation (HadGEM2-ES),
- A cooler/wetter simulation (CNRM-CM5),
- An average simulation (CanESM2), and
- The model simulation that is most unlike the first three for the best coverage of different possibilities (MIROC5).

3.2.1 DIRECT EFFECTS OF CLIMATE CHANGE

There are two primary direct effects of climate change: changes to temperature and changes to precipitation. These changes include increases or decreases in temperature and precipitation. They also include changes in the frequency, duration, and intensity of changes to these patterns.

CHANGES IN TEMPERATURE

Observations over the past century indicate that temperature has increased across southern California. Based on 1896-2015 temperature records for the California South Coast NOAA Climate Division, which encompasses the City of Irvine, California's Fourth Climate Change assessment for the Los Angeles region reports significant trends in annual average, maximum, and minimum temperature around 0.16°C per decade.

[37] Bedsworth et al. 2018. Statewide Summary Report. California's Fourth Climate Change Assessment. Publication number: SUMCCCA4-2018-013.

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Every month has experienced significant positive trends in monthly average, maximum, and minimum temperature. Monthly average and minimum temperatures have increased the most in September and monthly maximum temperatures have increased the most in January, with each trend exceeding 0.2°C per decade.[38]

According to Cal-Adapt, the historic, observed (1961-1990) annual average maximum temperature for the Irvine was 72.0°F, and the historic, observed annual average minimum temperature was 50.5°F. As shown in **Table 3-1: Change in Annual Average Temperature**, both are projected to increase by mid-century and further increase by the end of the century. The annual average maximum temperature in the city is projected to be 75.7°F by mid-century and 76.4°F by the end of the century under the medium emissions scenario. Under the high emissions scenario, the annual average maximum temperature in the study area is projected to be 76.6°F by mid-century and 79.6°F by the end of the century. This equates to an increase in temperatures of 4.4°F to 7.6°F by the end of the 21st century, according to the medium or high emissions scenario.[39]

Table 3-1: Change in Annual Average Temperature

Annual Average Temperature	Historic Annual Average Temperature (1961 - 1990)	Medium Emissions (RCP 4.5)		High Emissions (RCP 8.5)	
		Mid-Century	End-Century	Mid-Century	End-Century
Maximum	72.0	75.7	76.4	76.6	79.6
Minimum	50.5	53.8	54.7	54.9	57.9
F = degrees Fahrenheit					

California Energy Commission. 2022. CalAdapt. Local Climate Change Snapshot for Irvine: Annual Average Maximum and Minimum Temperature. https://cal-adapt.org/tools/local-climate-change-snapshot. Accessed April 28, 2022.

Annual Average Minimum Temperature

According to Cal-Adapt, the annual average minimum temperature is projected to increase in Irvine (Table 3-1. Change in Annual Average Temperature), consistent with the projected trend of overall warming for the region. Under the RCP 4.5 scenario, average minimum temperatures are projected to increase by approximately 4.2°F by 2100. Under the RCP 8.5 scenario, an increase of approximately 7.4°F for average minimum temperatures by 2100 is projected. With increasing minimum temperatures, it is anticipated that the city will experience warmer conditions throughout the year; however, this does not preclude severe winter weather events from occurring.

Changes in Precipitation

Precipitation over the Los Angeles region, including the City of Irvine is highly variable from year to year and only about five storms each year make up 50 percent of the annual precipitation total according to California's Fourth Climate Change assessment for the Los Angeles region. Natural climate variability phenomena, such as the El Niño-Southern Oscillation, can influence the amount of precipitation that the region receives, but there are no clear trends in historical precipitation for this region.[40]

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[38] Hall, Alex, Neil Berg, Katharine Reich. (University of California, Los Angeles). 2018. Los Angeles Summary Report. California's Fourth Climate Change Assessment. Publication number: SUM-CCCA4-2018-007.
[39] California Energy Commission. 2022. Cal-Adapt Data Download Tool: LOCA Downscaled CMIP5 Climate Projections. https://cal-adapt.org/data/download/. Accessed April 28, 2022.
[40] Hall, Alex, Neil Berg, Katharine Reich. (University of California, Los Angeles). 2018. Los Angeles

Annual Average Precipitation Levels

According to Cal-Adapt, annual projected precipitation levels in the city are expected to experience modest change by the end of the century. **Table 3-2: Change in Annual Average Precipitation** identifies estimated annual average precipitation levels. The results of these projections suggest that during average years, precipitation levels will be similar to conditions currently experienced within the city, with a potential increase in average annual rain at the end of the century under the RCP 8.5 scenario.

Table 3-2: Change in Annual Average Precipitation

Historic Annual Average Precipitation (1961 - 1990)	Medium Emissions (RCP 4.5)		High Emissions (RCP 8.5)	
	Mid-Century	End-Century	Mid-Century	End-Century
13.3	13.2	13.2	13.0	14.5

CalAdapt. Local Climate Change Snapshot for Irvine: Annual Average Precipitation. https://cal-adapt.org/tools/local-climate-change-snapshot. Accessed May 2, 2022.

3.2.2 INDIRECT EFFECTS OF CLIMATE CHANGE

This analysis addresses five indirect effects of the projected changes to temperature and changes to precipitation: Extreme heat events, drought, wildfire and smoke, flooding, and liquefaction.

Mental Health

Before focusing on the indirect effects of changes in temperature and precipitation, it is important to note that the impacts from climate change such as fires and floods can have acute mental health impacts. As reported in the state's 4th Climate Change Assessment, there are potential links between extreme weather events and anxiety and depression, post-traumatic stress disorder, and suicide.[41]

3.2.2.1 EXTREME HEAT EVENTS

Extreme heat events are a period when temperatures are abnormally high relative to a designated location's normal temperature range. Extreme heat events are one of the leading weather-related causes of death in the United States—from 1999 through 2009, extreme heat exposure caused more than 7,800 deaths.[42] There are generally three types of extreme heat events:

- Extreme Heat Days: a day during which the maximum temperature surpasses 98 percent of all historic high temperatures for the area, using the time between April and October from 1961 to 1990 as the baseline.
- Warm Nights: a day between April to October when the minimum temperature exceeds 98 percent of all historic minimum daytime temperatures observed between 1961 to 1990.
- Extreme Heat Waves: a successive series of extreme heat days and warm nights where extreme temperatures do not abate. While no universally accepted minimum length of time for a heat wave event exists, Cal-Adapt considers four, successive extreme heat days and warm nights to be the minimum threshold for an extreme heat wave.

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Summary Report. California's Fourth Climate Change Assessment. Publication number: SUM-CCCA4-2018-007.

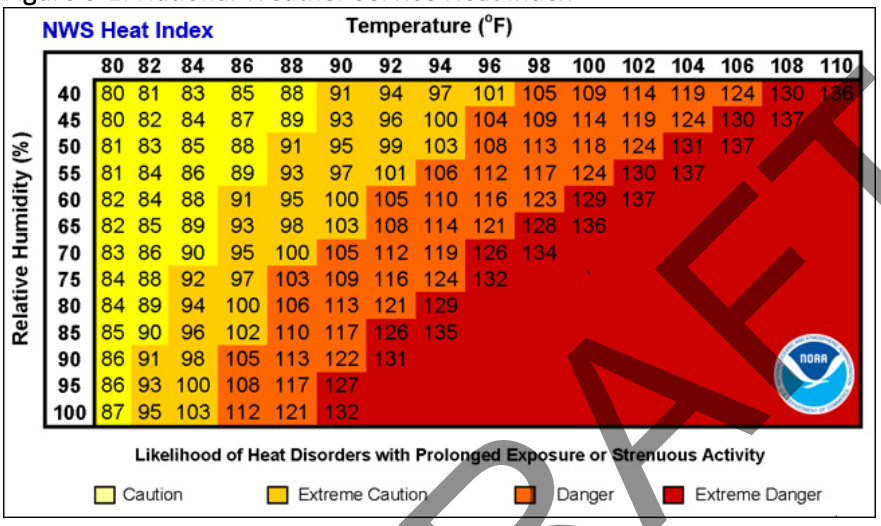
[41] Hall, Alex, Neil Berg, Katharine Reich. (University of California, Los Angeles). 2018. Los Angeles
Summary Report. California's Fourth Climate Change Assessment. Publication number: SUM-CCCA4-2018-007.

[42] United States Global Change Research Program, 2016: The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment. A. Crimmins, J. Balbus, J. L. Gamble, C. B. Beard, J. E. Bell, D. Dodgen, R. J. Eisen, N. Fann, M. D. Hawkins, S. C. Herring, L. Jantarasami, D. M. Mills, S. Saha, M. C. Sarofim, J. Trtanj, and L. Ziska, Eds.

Extreme heat events will feel different from region to region since different areas have different historic high temperatures. For example, an extreme heat day on the coast will feel different than an extreme heat day in the High Desert. The reason for this is how humidity plays a factor in the perceived heat that people feel. Humid conditions will make a day feel hotter than non-humid conditions, even though the temperature may be the same. The difference between the perceived temperature and the actual temperature is known as the "heat index."

To illustrate the effect of the heat index, a 90-degree day with 50 percent humidity feels like 95°F whereas a 90°F day with 90 percent humidity feels like 122°F. **Figure 3-1: National Weather Service Heat Index** shows National Oceanic and Atmospheric Administration (NOAA)'s National Weather Service Heat Index.[43]

Figure 3-1: National Weather Service Heat Index



Source: National Oceanic and Atmospheric Administration National Weather Service Heat Index.

Historical Extreme Heat Events

Local data from within Irvine is generally available using the Tustin Irvine Ranch National Weather Service Cooperative Network station. The data indicates that the average maximum temperature for the area from all years between 1902 and 2003 is 85.2°F, occurring in the month of August.[44] Given that the minimum threshold for an extreme heat day in Irvine is 93.2°F, it is rare that the temperature exceeds this threshold on a regular basis. Still, extreme heat events have occurred in the region which occasionally impact the City as well. Some significant historic extreme heat events include:

- September 1963, the temperature reached 113°F at the now defunct El Toro Air Force Base and the surrounding region was hot as well, including coastal areas. Temperatures in Carlsbad and Oceanside reached 108°F. School children and employees were sent home due to the heat and some agricultural crops were destroyed.

[43] National Oceanic and Atmospheric Administration (NOAA)'s National Weather Service Heat Index. https://www.weather.gov/safety/heat-index. Accessed March 31, 2022.
[44] Western Regional Climate Center. 2020. Tustin Irvine Ranch, California (049087). https://wrcc.dri.edu/cgi-bin/cliMAIN.pl?ca9087. Accessed May 3, 2022.

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- April 1989, daily high temperature records were set for all weather monitoring stations in Southern California. Los Angeles and Riverside set records at 106°F and 104°F respectively.[45]

More recent extreme heat events have also affected the greater region surrounding Irvine:

- On October 23, 2017, Southern California experienced two extreme heat days. The weather monitoring station at Long Beach Airport indicated that temperatures reached 105°F that day.[46]
- Throughout July 2018, extreme heat waves occurred throughout Southern California, including Irvine. The hottest day of the heat waves occurred on July 6 when temperatures reached 114°F in Santa Ana, CA. A second but less intense extreme heat wave occurred on July 25 where regional temperatures went above 100°F in places like Burbank. While local temperature data for Irvine is not available the weather monitoring station at nearby Long Beach Airport indicates that the temperature reached 95°F that day.[47]
- On Sunday, September 6, 2020, the temperature at John Wayne Airport Station measured 104°F.[48]
- For two consecutive days, on April 7-8, 2022, the temperature at John Wayne Airport Station measured 100°F.[49]

Unusually hot days and multi-day heat waves are a natural part of day-to-day variation in weather. As the Earth's climate warms, however, hotter-than-usual days and nights are becoming more common and heat waves are expected to become more frequent and intense. Increases in these extreme heat events can lead to more heat-related illnesses and deaths, especially if people and communities do not take steps to adapt.[50]

Vulnerability to Extreme Heat Events

Exposure

The Fourth Assessment indicates that Southern California can expect longer and hotter heat wave, with continued future warming over the region.[51] Annual mean maximum temperature could increase by 7.6°F by 2100 (see **Table 3-1: Change in Annual Average Temperature**).[52] As illustrated in **Table 3-3: Change in Number of Extreme Heat Days** the annual number of extreme heat days (over 92.1°F) in the City could increase up to 19 days by 2100.[53]

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[45] National Oceanic and Atmospheric Administration. May 2017. "A History of Significant Weather Events in Southern California." https://www.weather.gov/media/sgx/documents/weatherhistory.pdf

[46] Weather Underground. 2019. Long Beach Airport, California – October 2017. https://www.wunderground.com/history/monthly/us/ca/long-beach/KLGB/date/2017-10. Accessed May 3, 2022.

[47] Climate Signals. December 2018. Southern California Heat Wave July 2018. https://www.climatesignals.org/events/southern-california-heat-wave-july-2018. Accessed May 3, 2022.

[48] Weather Underground. 2020. John Wayne Airport, California – September 6, 2020. https://www.wunderground.com/history/monthly/us/ca/costa-mesa/KSNA/date/2020-9. Accessed May 3, 2022.

[49] Weather Underground. 2020. John Wayne Airport, California – April 7 - 8, 2022-4. Accessed May 3, 2022.

[50] Sarofim, M.C., S. Saha, M.D. Hawkins, D.M. Mills, J. Hess, R. Horton, P. Kinney, J. Schwartz, and A. St. Juliana. 2016. Chapter 2: Temperature-related death and illness. In: The impacts of climate change on human health in the United States: A scientific assessment. U.S. Global Change Research Program.

[51] Southern California Association of Governments. Southern California Climate Adaptation Planning Guide. October 2020.

[52] California Energy Commission. 2022. CalAdapt. Local Climate Change Snapshot for Irvine: Annual Average Maximum Temperature. https://cal-adapt.org/tools/local-climate-change-snapshot. Accessed April 28, 2022.

[53] California Energy Commission. 2022. CalAdapt. Local Climate Change Snapshot for Irvine: Extreme Heat Days. https://cal-adapt.org/tools/local-climate-change-snapshot. Accessed April 28, 2022.

Table 3-3: Change in Number of Extreme Heat Days

Number of Extreme Heat Days*	Historic Annual Average Extreme Heat Days (1961 - 1990)	Medium Emissions (RCP 4.5)		High Emissions (RCP 8.5)	
		Mid-Century	End-Century	Mid-Century	End-Century
	4	8	10	10	23

*Number of days in a year when daily maximum temperature is above a threshold temperature of 92.1 °F.
Note: Threshold temperature used in this tool is location specific. It is defined as the 98th percentile value of historical daily maximum/minimum temperatures (from 1961–1990, between April and October) observed at a location.

Source: California Energy Commission. CalAdapt. Local Climate Change Snapshot for Irvine: Extreme Heat Days. https://cal-adapt.org/tools/local-climate-change-snapshot. Accessed April 28, 2022.

Warm Nights

An atmospheric Urban Heat Island (UHI) is defined as warmer air in urban areas than in the surrounding areas and may be small and non-existent during the day and most intense at night and during the winter due to the slow release of heat from urban infrastructures. Atmospheric UHI causes human discomfort during the night and like surface UHI (See Extreme Heat Events, Sensitivity: Social), can have negative public health impacts.[54]

Warm night temperatures affect the ability of a community and its residents to effectively cool down from extreme heat days. If temperatures remain higher than normal during the night, the compounding impacts from high daytime temperatures can be highly detrimental to public health.

According to Cal-Adapt, a warm night event in Irvine is a night when the evening temperature exceeds 65.5°F. Table 3-4: Change in Number of Warm Nights identifies the projected average number of warm nights that would occur each year under the RCP 4.5 and RCP 8.5 scenarios. By 2100, an estimated 35 to 72 warm nights (RCP 4.5 and RCP 8.5, respectively) could be experienced (compared to only four days annually based on observed historical conditions). Based on these projections, the city can anticipate increased demand - towards the end of the century - for cooling centers and calls for service from vulnerable populations, which are expected to be disproportionately impacted by extreme heat conditions.

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Table 3-4: Change in Number of Warm Nights

Number of Warm Nights*	Historic Annual Average Warm Nights (1961 - 1990)	Medium Emissions (RCP 4.5)		High Emissions (RCP 8.5)	
		Mid-Century	End-Century	Mid-Century	End-Century
	4	25	35	34	72

*Number of days in a year when daily minimum temperature is above a threshold temperature of 65.5 °F.
Note: Threshold temperature used in this tool is location specific. It is defined as the 98th percentile value of historical daily maximum/minimum temperatures (from 1961–1990, between April and October) observed at a location.

Source: California Energy Commission. CalAdapt. Local Climate Change Snapshot for Irvine: Warm Nights. https://cal-adapt.org/tools/local-climate-change-snapshot. Accessed April 28, 2022.

[54] Southern California Association of Governments. Southern California Climate Adaptation Planning Guide. October 2020.

Sensitivity: Major Community Elements

The impacts of extreme heat events will be most severely felt in highly developed areas of the city that are intensely paved and surrounded by buildings constructed of dark (heat absorbing) materials without the cooling benefits of tree shade. Urbanized areas can experience higher temperatures, greater pollution, and negative health effects, especially during summer months than rural communities. This phenomenon is known as the Urban Heat Island Effect (UHIE). Urban heat islands are created by a combination of heat-absorptive surfaces (e.g., dark pavement and roofing), heat-generating activities (e.g., automobile engines and industrial generators), and the absence of "green spaces" (vegetative surfaces that provide evaporative cooling). During extreme heat days and heatwaves, asphalt and darker surfaces reduce nighttime cooling (as retained heat is released from these surfaces). The UHIE is known to intensify extreme heat days and heatwaves.

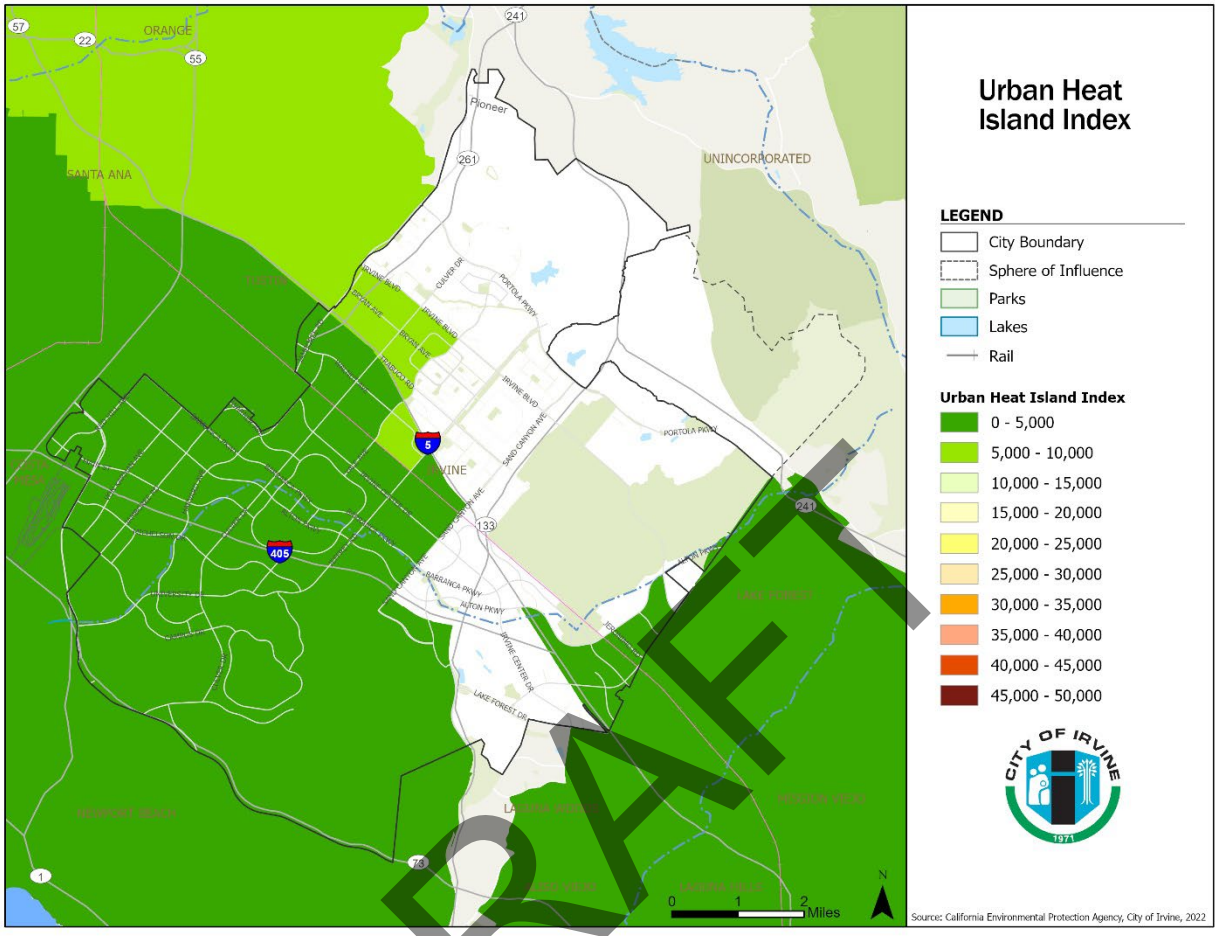
An Urban Heat Island Index (UHII) can be calculated by atmospheric modeling, as a temperature differential over time between an urban census tract and nearby upwind rural reference points at a height of two meters above ground level, where people experience heat. The modeling covered 182 warm season days from 2006 and 2013, with one-hour timesteps, so the UHII is the sum of 24 * 182 = 4,368 hourly temperature differences. Since 2020, the index is also reported in degree-hours per day on a Celsius scale – a measure of heat intensity over time, calculated by dividing the UHII by 182 days. An increase of one degree over an eight-hour period would equal eight degree-hours, as would an increase of two degrees over a four-hour period.[55]

As illustrated in **Figure 3-2: Urban Heat Island Index**, the city is not severely impacted by the UHIE that may intensify extreme heat days and heatwaves. However, even without a large UHIE, the city is still projected to have extreme heat days and many types of infrastructure are affected by extreme heat, including roads and rails.

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[55] California Environmental Protection Agency. 2022. Urban Heat Island Interactive Maps. https://calepa.ca.gov/urban-heat-island-interactive-maps-2. Accessed April 12, 2022.

Figure 3-2: Urban Heat Island Index



Source: California Environmental Protection Agency. 2022

Sensitivity: Major Community Elements

Transportation Systems

High temperatures increase the risk of pavement deterioration, depending on the paving materials and the traffic load of a given road.[56,57] The type of pavement used is typically based on historical climate conditions; the increasing occurrence of frequent and prolonged extreme heat outside of historical norms will present challenges to the roadway system.[58]

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[56] Daniel, J.S., J.M. Jacobs, E. Douglas, R.B. Mallick, and K. Hayhoe. 2014. Impact of climate change on pavement performance: Preliminary lessons learned through the Infrastructure and Climate Network (IC Net). dot:10.1061/9780784413326.001.
[57] Rowan, E., C. Evans, M. Riley-Gilbert, R. Hyman, R. Kafalenos, B. Beucler, B. Rodehorst, A. Choate, and P. Schultz. 2013. Assessing the sensitivity of transportation assets to extreme weather events and climate change. Transportation Research Record: Journal of the Transportation Research Board 2326(1):16—23. doi:10.3141/2326-03.
[58] Holsinger, H. 2017. Preparing for change. FITWA-HRT-17-002. Public Roads 80(4). McLean, VA: Office of Research, Development, and Technology, Federal High Administration. https://highways.dot.gov/public-roads/januaryfebruary-2017/preparing-change. Accessed April 11, 2022.

Extreme heat may also cause pavement heave and damage to transportation infrastructure and functioning.[59] Extreme heat is also problematic for rail systems, as railroad tracks exposed to high temperatures are at risk of warping or buckling.[60]

Lifeline Utility Systems

As heat waves worsen, energy systema will need to adapt to help communities and businesses cope with rising temperatures. Access to air conditioning will be vital for vulnerable populations, even life saving for the elderly, young children, and those with pre-existing health conditions. However, increased cooling needs for both air conditioning and refrigeration will place significant stress on the power system during periods of extreme heat. And if that power comes from fossil-fired power plants, there may also be an increase in soot, smog, and other forms of air pollution with the associated public health consequences.[61] Impacts on electricity resources from climate hazards can include stress and physical damage to the electricity generation, transmission, and distribution system.

Transmission facilities face increasing climate change-related risks because of increased frequency of wildfires, severe wind, and the extreme heat. Extreme heat and drought can add stress to transmission systems, resulting in system failure. Electrical infrastructure may fail due to increased electrical loads and stress from longer periods of increased operation. A 2011 study found that just one extra day with temperatures above 90 F increases annual household energy use by 0.4 percent.[62]

Higher temperatures can reduce the water supply in California from reduced precipitation and snowpack and earlier snowmelt.[63]

Economic Elements

Laborers in weather-exposed industries such as construction and agriculture are the most prone to extreme heat impacts, even if they work fewer hours when it is hotter. Workers are less productive when it's hotter out.[64] Exposure to high temperatures may affect worker safety by increasing rates of workplace injuries[65] and it may also affect the performance and productivity of workers.[66] Higher temperatures tend to reduce growth in many industries that involve substantial indoor work, including retail, services, and finance.

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[59] Guo Y, Gasparrini A, Li S, Sera F, Vicedo-Cabrera AM, de Sousa Zanotti Stagliorio Coelho M, et al. (2018) Quantifying excess deaths related to heatwaves under climate change scenarios: A multicountry time series modelling study. PLoS Med 15(7): e1002629.

[60] Magill, B. 2014. "Sun kinks" in railways join the list of climate change's toll. Scientific American, June 2. www.scientificamerican.com/article/sun-links-in-railways-Join-the-list-of-climate-change-s-toll. Accessed April 11, 2022.

[61] Abel, D.W., T. Holloway, M. Harkey, P. Meter, D. Ahl, V.S. Limaye, and J.A. Patz. 2018. Air-quality-related health impacts from climate change and from adaptation of cooling demand for buildings in the eastern United States: An interdisciplinary modeling study. PLOS Medicine 15(7):1—27.dot:10.1371/journal.pmed.1002599.

[62] Deschênes, Olivier and Michael Greenstone. 2011. Climate Change, Mortality, and Adaptation: Evidence from Annual Fluctuations in Weather in the US. American Economic Journal: Applied Economics Vol. 3 No. 4 October 2011

[63] U.S. Environmental Protection Agency. 2016. What Climate Change Means for California. https://www.epa.gov/sites/production/files/2016-09/documents/climate-change-ca.pdf

[64] Lemione, Derek. 2021. 4 ways extreme heat hurts the economy. Cornell University Alliance for Science. August 3. https://allianceforscience.cornell.edu/blog/2021/08/4-ways-extreme-heat-hurts-the-economy. Accessed May 6, 2022.

[65] Park, J., Pankratz, N., & Behrer, A. (2021). Temperature, Workplace Safety, and Labor Market Inequality. IZA Discussion Paper No. 14560

[66] Cui, W., Cao, G., Park, J. H., Ouyang, Q., & Zhu, Y. 2013. Influence of indoor air temperature on human thermal comfort, motivation and performance. Building and environment, 68, 114-122.

An 1°F increase in the average summer temperature is associated with a reduction in the annual growth rate of state-level output of 0.15 to 0.25 percentage points and rising temperatures could reduce U.S. economic growth by up to one-third over the next century.[67]

This increase in electricity use on hot days stresses electric grids right when people depend on them most, as seen in California during recent heat waves. Blackouts can be quite costly for the economy, as inventories of food and other goods can spoil and many businesses either have to run generators or shut down. For instance, the 2019 California blackouts cost an estimated $10 billion.[68]

Natural Resource Areas

Extreme temperatures — as opposed to warmer average temperatures — are the catalyst for a growing number of extinctions. In 2002, researchers looked at 538 plant and animal species at 581 sites around the world that had been previously surveyed. The goal was to understand what aspect of climate change was the most serious threat to biodiversity. They found that 44 percent of the species at the sites had gone locally extinct, and that the culprit was an increase in the temperature of the hottest days of the year.[69]

Birds suffer more than other animals as they are diurnal and exposed to the hottest part of the day. Small mammals live underground and are generally nocturnal. Insects are small and can take advantage of smaller habitat niche although some insects have taken a heat hit as well. A recent study found that the number of areas that native bumblebees occupy has plummeted 46 percent in North America and 17 percent in Europe compared to surveys taken from 1901 to 1974. Those bee-less areas were also places with a high degree of climate variation, especially higher temperatures. "Climate change is related to the growing extinction risk that animals are facing around the world," lead author Peter Soroye said, because of "hotter and more frequent extremes in temperatures."[70]

Water stress induced mortality processes such as hydraulic failure or carbon starvation are caused by extreme heat (and drought). Many trees operate at or near their tolerance limit for water stress and may not be able to acclimate or acclimate fast enough to keep pace with the changing climate.[71] Even if such stresses do not directly kill trees themselves, they can increase vulnerability to mortality from pests as witnessed by the large-scale forest dieback from bark beetle outbreaks taking place across North America.[72]

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[67] Colacito, Riccardo; Bridget Hoffmann, Toan Phan. 2018. Temperature and Growth: A Panel Analysis of the United States. Journal of Money, Credit, and Banking. December 3. https://doi.org/10.1111/jmcb.12574. Accessed May 6, 2022.
[68] Wara, Michael. 2019. Impacts of Wildfire on Electric Grid Reliability. Senate Energy and Natural Resources Committee Testimony. December 19.
[69] Roman-Palacios, Cristian and John J Wiens. 2020. Recent responses to climate change reveal the drivers of species extinction and survival. Proceedings of the National Academy of Sciences. February 10. https://doi.org/10.1073/pnas.1913007117
[70] Soroye, Peter. Tim Newbold, Jeremy Kerr. 2020. Climate change contributes to widespread declines among bumble bees across continents. Science. February 7. Pp. 685-688. DOI: 10.1126/science.aax8591.
[71] Williams I N, Torn M S, Riley W J and Wehner M F 2014 Impacts of climate extremes on gross primary production under global warming Environ. Res. Lett
[72] Hicke J A, Meddens A J H, Allen C D and Kolden C A 2013 Carbon stocks of trees killed by bark beetles and wildfire in the western United States Environ. Res. Lett.

Sensitivity: Vulnerable Populations

Higher temperatures and extreme heat can lead to heat cramps, heat exhaustion, heat stroke, respiratory illness, and increase the risk of heat-related mortality in addition to expansion of vector-borne disease.[73] Whereas a heat event can be relatively harmless for those with a reliable means for staying hydrated and cool, it can be deadly for others. Young children, the elderly, or people suffering from serious medical conditions are physiologically more vulnerable to heatstroke. Some senior citizens also take medicines that can make it harder for their bodies to maintain a safe internal temperature, creating an additional threat from extreme heat events. Young children may not be aware of the signs of dehydration or ways of protecting themselves from heatstroke.

Surface UHI can cause urban surface areas to become 50 to 90 degrees Fahrenheit warmer than the air temperature and is present at all hours of the day and the night, but is most intense during the day and in the summer. Due to changes in the sun's intensity, its magnitude varies with seasons. Surface UHI contributes to human discomfort during the day and an increase in energy demand for air conditioning. If a person does not have access to air conditioning, the daytime heat can lead to heat-related illnesses.[74]

Sudden spikes in heat can catch people by surprise. Stores can rapidly sell out of fans, air-conditioning units, or drinking water during a heatwave. Lower-income households or those with limited mobility may be unable to acquire enough insulation or cooling devices without significant advance preparations. This can be further compounded by the threat of Public Safety Power Shutoff events. During these events, extreme heat impacts may affect larger portions of the City and populations that wouldn't be viewed as vulnerable under normal circumstances.[75]

Figure 3-3: Heat Health Action Index displays the Heat Health Action Index from the California Natural Resources Agency's California Heat Assessment Tool (CHAT). CHAT uses a dataset that was designed to investigate how the frequency of HHEs will change throughout the 21st century. The HHAI is a statistically weighted result of social (e.g., education, income, linguistic isolation), health (e.g., asthma, percent low birth weight), and environmental (e.g., pollution, tree canopy) indicators and is intended to represent overall heat vulnerability. Represented by US Census Tract, the range is from 0 to 100, with lower scores representing less heat vulnerability. All census tracts are projected to have low vulnerability to heat which corresponds to Cal-Adapts projections for the number of Extreme Heat Days through the end of the century (see Table 3-3: Change in Number of Extreme Heat Days).

While the general population may be less vulnerable to extreme heat events, people have unique and individual thresholds. Extreme heat events including heat waves can lead to illness and death, particularly among older adults, the very young, and other vulnerable populations. People living in homelessness are at a high risk of health complications during heat waves, especially if they are unsheltered. According to data counts by the OC Health Care Agency, in 2017, there were approximately 4,800 individuals experiencing homelessness in the county, with over 50 percent unsheltered, approximately 25 percent in emergency shelters, and 20 percent in transitional shelters.[76] During a heat wave, these people are very vulnerable to heatstroke, especially if they are unable to reach a cooling center.

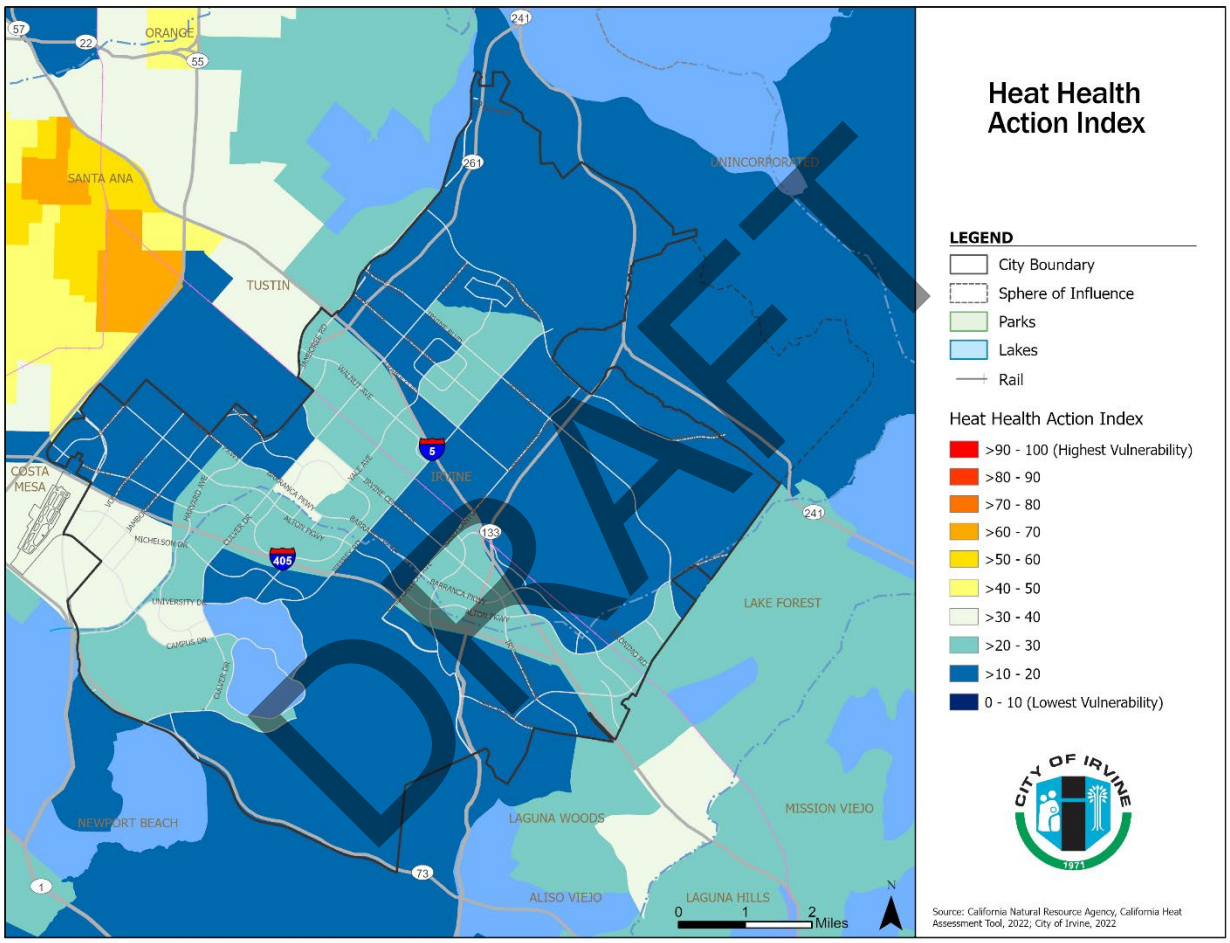
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[73] Southern California Association of Governments. 2020. Extreme Heat & Public Health Report. September.
[74] Southern California Association of Governments. 2020. Extreme Heat & Public Health Report. September.
[75] City of Irvine. 2020. Local Hazard Mitigation Plan. October.
[76] OCGov. 2017. Orange County Point in Time Count 2017: Homelessness in Orange County. http://www.ocgov.com/civicax/filebank/blobdload.aspx?BlobID=64596

Adaptive Capacity

Current research indicates that most people can adapt biologically and physically to incremental increases in average normal temperatures. children, pregnant women, and older adults are more susceptible to adverse effects because they are less able to regulate their body temperatures. Other at-risk groups include individuals working outdoors, outdoor athletes, the socially isolated and those with incomes below the federal poverty level, as well as communities of color. Continuous exposure to increased heat over time will impact how individuals are able to work and play both now and in the future.[77]

Figure 3-3: Heat Health Action Index



Regulation and Planning

California is dedicated to addressing the climate change impacts on transportation infrastructure, including funding and research initiatives as well as department- and agency-led projects to assess climate-related vulnerabilities and plan for more climate-resilient transportation infrastructure.

[77] National Institute of Heath, National Institute of Environmental Health Sciences. 2022. *Temperature-related Death and Illness*. https://www.niehs.nih.gov/research/programs/climatechange/health_impacts/heat/index.cfm#footnote1 Accessed April 7, 2022.

- Chapter 5 of 2017 (SB 1, Beall) Provided $20 Million for Climate Adaptation Planning Grants to prepare for and reduce damage from climate change impacts on transportation infrastructure.
- Chapter 118 of 2016 (AB 2800, Quirk) Established the Climate-Safe Infrastructure Working Group to convene a working group consisting of engineers, scientists, and architects to examine how to incorporate climate change impact data into state infrastructure planning, design, construction, operations, and maintenance.
- Agency (CalSTA) Developed Climate Action Plan for Transportation Infrastructure. Developed in response to Executive Order N-19-19, which called for CalSTA to leverage discretionary state transportation funds to reduce GHG emissions in the transportation sector and adapt to climate change.

Renewable energy and electricity storage technologies can add flexibility to the electricity grid. Together with microgrids, renewables can support increased grid resilience and reliability in the face of extreme weather. Electricity storage also has the potential to replace fossil-fired "peaking" power plants, which are called upon in times of high demand for electricity such as during extreme heat events.[78]

The City has addressed extreme heat in planning documents such as their Local Hazard Mitigation Plan, Urban Forestry Policy, and Cool Blocks Program. The City also has regulations and programs in place that are beneficial during extreme heat events by limiting further potential public health impacts. The plans and programs for the City and supporting agencies are described in Chapter 2: City of Irvine Adaptive Capacity to Climate-Related Hazards, in addition to those below:

City of Irvine Local Hazard Mitigation Plan (2020)

The 2020 LHMP included mitigation actions to decrease the risks associated with extreme heat, including:

- Notify residents through public service announcements a couple of days in advance of a severe weather event. Focus on media methods that target vulnerable populations, such as elderly, sick, lower-income, or persons with limited mobility to better ensure they have adequate time to prepare.
- Implement a tree-planting program to diversify tree age and increase shaded areas in the City to reduce the effects of the urban heat island effect.
- Expand use of public facilities (libraries, community centers, etc.) as warming/cooling centers for vulnerable populations during extreme weather events, and assess facility needs in order to automatically open these facilities as extreme weather centers when conditions require.
- Promote passive cooling design (brise soleil, long roof overhangs, locating windows away from southern facades, etc.) in new developments during the design review process.
- Upgrade HVAC within City facilities to more efficient systems that may include split systems or decentralized systems that allow for heating and cooling the spaces needed, not entire buildings.
- Evaluate the long-term capacity of designated cooling centers and shelters in the City to provide enough relief from extreme heat. Assess the need to expand services as the frequency, length, and severity of future heatwaves potentially change as a result of climate change.

[78] Abel, D.W., T. Holloway, M. Harkey, P. Meter, D. Ahl, V.S. Limaye, and J.A. Patz. 2018. Air-quality-related health impacts from climate change and from adaptation of cooling demand for buildings in the eastern United States: An interdisciplinary modeling study. PLOS Medicine 15(7):1—27. dot:10.1371/journal.pmed.1002599.

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Urban Forestry Policy (2009)

Trees are a source of shade, air conditioning and other environmental benefits, and yield both a high quality of life and economic benefits to the community, including enhanced property values. An urban forest is an integral part of the city's infrastructure providing significant ecological, social, and economic benefits including improved air quality, reduced erosion and stormwater runoff, energy conservation, improved health, and enhanced livability. The Irvine Public Works Department's Landscape Maintenance Division is guided by an Urban Forestry Policy (2009) to provide for orderly inventorying, inspection, trimming, removal, and planting to promote the health and safety of the community.[79]

Cool Block Program (2021)

Developed and funded by the Empowerment Institute, the Cool City Challenge (CCC) initiative is a $1 million grant competition among California cities to develop the most innovative pathways to carbon neutrality, including the Cool Block program which requires recruitment of 200 Cool Block team leaders to lead their neighbors through a shared learning program to improve sustainability and quality of life in their own neighborhoods, with an eye toward rapid expansion across the city.

The Cool Block program also reduces climate emissions and utility bills while building resiliency and local emergency preparedness against climate disasters such as extreme heat, floods, wildfires, and extreme storm events that are already worsening considerably worldwide. The strategy developed through the CCC will identify and incentivize innovative climate solutions, create bottom-up change from the demand side (consumers) and connect it to top-down change from the supply-side (business, technology, and policy adoption). The resultant community synergy can empower social, environmental, and economic outcomes not previously imagined possible.[80]

3.2.2.2 DROUGHT + WATER SUPPLY

Warmer temperatures also contribute to more frequent and intense droughts by leading to a decline in and faster melting of winter snowpack, greater rates of evaporation, and drier soils. These conditions decrease the amount of spring and early summer snowmelt runoff upon which the state historically has depended for its annual water supply, while they increase the demand for irrigation water in both agricultural and urban settings. The period of 2012 through 2015 represents the state's four driest consecutive years on record in terms of statewide precipitation, and 2021 was the third driest single year. Moreover, 2022 already experienced the driest consecutive January and February in the Sierra Nevada, based on records dating back over one hundred years.

Drought may lead to water-related problems. When rainfall is less than normal for weeks, months, or years, the flow of streams and rivers declines, water levels in lakes and reservoirs fall, and the depth to water in wells increases. If dry weather persists and water-supply problems develop, the dry period can become a drought.[81]

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[79] City of Irvine. 2009. Public Works Department Urban Forestry Policy. March 17.
[80] City of Irvine. 2021. https://www.cityofirvine.org/cool-block-program. Accessed May 2, 2022.
[81] United States Geological Survey. 2022. California Water Sciences Center. California Drought. https://ca.water.usgs.gov/california-drought/what-is-drought.html. Accessed April 12, 2022.

As a result, droughts have widespread impacts across the state, including mandatory water use restrictions, reductions in agricultural crop production, over-pumping of groundwater which damages infrastructure from land sinking and dries up domestic well and degraded habitats for fish and wildlife.[82]

Historical Drought Events

The 2007–2011 California drought marked the beginning of increased restrictions on State Water Project (SWP) pumping from the Bay-Delta due to environmental considerations. In April 2007, MWD notified its member agencies that it expected challenges in meeting demands due to insufficient imported water supplies from the SWP and the Colorado River. To meet demands, MWD announced that it would implement shortage-related actions consistent with its Water Surplus and Drought Management Plan.

In January 2014, Governor Brown proclaimed a state of emergency throughout California, calling for increased conservation across the state.

On March 1, 2022, the California Department of Water Resources reported, "Statewide, the snowpack is 63 percent of average for this date. With only one month left in California's wet season and no major storms in the forecast, Californians should plan for a third year of drought conditions."[83]

Vulnerability to Drought

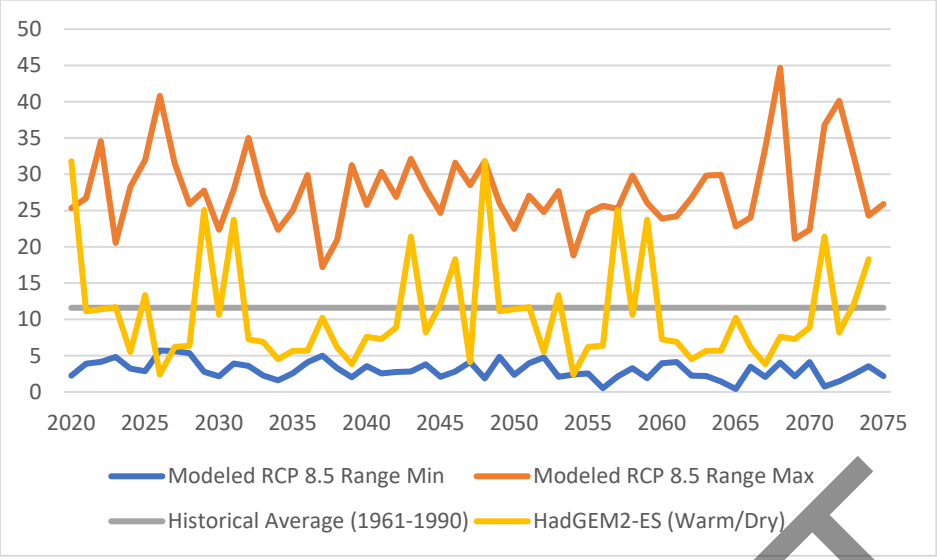
Exposure

As shown in Table 3-2: Change in Annual Average Precipitation, under both the medium and high emissions scenarios, Irvine is not expected to experience significant changes in average precipitation. California, and by default the City, has been experiencing prolonged periods of drought. Recent research suggests that extended drought occurrence (a "mega-drought") could become more pervasive in future decades. An extended drought scenario is predicted for all of California from 2025 to 2075 under the HadGEM2-ES simulation and high emissions scenario. The extended drought scenario is based on the average annual precipitation between 1961 and 1990 of 10.9 inches. As shown in **Figure 3-4: Projected Drought Conditions**, under the projected drought scenario between 2025 and 2075, Irvine's precipitation would decrease by 2.7 inches; with the variability in annual precipitation would be between 2.4 and 25.1 inches for the HadGEM 2-ES model.[84]

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[82] State of California, Legislative Analyst's Office. 2022. Budget and Policy Post. Climate Change Impacts Across California Crosscutting Issues. April 5, 2022. https://lao.ca.gov/Publications/Report/4575. Accessed April 11, 2022.
[83] California Department of Water Resources. 2022. Statewide Snowpack Falls Well Below Average Following Consecutive Dry Months. March 1, 2022. https://water.ca.gov/News/News-Releases/2022/March-22/March-2022-Snow-Survey. Accessed April 12, 2022.
[84] California Energy Commission. Cal-Adapt. 2022. Extended Drought Scenarios, Precipitation by Water Year for Irvine. https://cal-adapt.org/tools/extended-drought/#lat=33.0450&lng=-117.2539&boundary=place&climvar=Wildfire. Accessed April 28, 2022.

Figure 3-4: Projected Drought Conditions



Source: California Energy Commission. CalAdapt. Local Climate Change Snapshot for Irvine: Extended Drought Scenarios. https://cal-adapt.org/tools/local-climate-change-snapshot. Accessed April 28, 2022.

Sensitivity: Major Community Elements

Drought will continue to be a foreseeable event in the future of California, including Irvine. Since most droughts are almost entirely contingent on global weather phenomena, which vary from year to year, it is impossible to predict either the frequency or severity of future drought events in Irvine. Droughts that result from infrastructure failure are equally impossible to predict since the circumstances that lead to infrastructure failure are unique to each situation.[85]

As vegetation changes because of drought conditions, the animal species that depend on certain plant communities for food supply and habitat may be affected. The projected increase in the duration of droughts through the end of the century may threaten ecosystems as species become weak due to limited access to water and become susceptible to disease, pest, and decay.[86]

Climate change is anticipated to abate drought in certain situations but, on the other hand, could also intensify and exacerbate it in other cases. In some cases, climate change-intensified weather patterns, like El Niño-Southern Oscillation (ENSO), may bring more rain to California and Irvine which would abate drought conditions. In other years, climate change may also prolong the *La Niña* phase of ENSO which could lead to longer periods with no precipitation in California.

Lifeline Utility Systems

Climate change is also expected to increase the average temperature and cause more frequent and prolonged heat waves in California and Irvine. During these events, water supplies may be diverted for cooling functions in the City.

[85] City of Irvine. 2020. Local Hazard Mitigation Plan. October.
[86] California Natural Resources agency, Governor's Office of Planning and Research, and California Energy Commission. 2019. California's Fourth Climate Change Assessment; San Diego Region Report. Available: https://www.energy.ca.gov/sites/default/files/2019-11/Reg_Report-SUM-CCCA4-2018-009_SanDiego_ADA.pdf. Accessed April 12, 2022.

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Hotter temperatures may also lead to increased surface water evaporation which could lead to greater water consumption. If a drought were to occur during a future heat wave, it could place the water supply under strain.

From a regional perspective, warmer overall temperatures in California are anticipated to lead to a reduction in statewide water supplies. Much of California's water comes from melted snow in the High Sierra. As the average temperature grows warmer with climate change, the amount of precipitation that falls as snow is expected to shift towards rain. As less snow falls, the amount of melted water from the snowpack in the Sierra Nevada will decrease, reducing the water that will flow into the reservoirs and aqueducts that supply Southern California. This could place strain on the City's imported water supply, leading to greater reliance on Orange County's local groundwater. If regional water agencies, like OCWD, do not account for increased groundwater withdrawal, Irvine and the greater Orange County region could experience subsidence as a result.

Economic Elements

The water sector is central to public health and the economy. Water utilities ensure a reliable supply of clean water to communities and ecosystems and contribute significantly to the resilience of many other sectors, including agriculture, energy, and manufacturing. Drought can result in impacts to water utility operations, including:

- Loss of water pressure and water supply
- Poor water quality from the source that may require additional treatment to meet drinking water standards
- Inability to access alternative and supplementary water sources because of high demand by and competition from other users
- Increased customer demand
- Increased costs and reduced revenues related to responding to drought impacts.

Within Irvine, approximately 1,323 acres of land are designated for agricultural use, which is scattered throughout the City (Irvine 2020). These farmers may be impacted in future drought conditions by increased cost for water, lower water quality, and the introduction of potential pests that may expand during a drought.

Drought, as well as recreationists' negative perceptions of drought, fire bans, or wildfires, may result in decreased visitations, cancellations in hotel stays, a reduction in booked holidays, or reduced merchandise sales. Reduced revenues in the sector can negatively impact the livelihood of small outdoor recreation businesses that have limited resources to manage the financial burden of drought. This, in turn, impacts the mental health of small business owners, staff, and communities. [87] A continued drought combined with elevated temperatures could impact the operations of the Great Park's Farm + Food Lab and Farmer's Market.

Natural Resource Areas

When a drought occurs, the existing pressures on the ecosystem's natural water supplies are amplified. If the ecosystem's water needs aren't considered in water allocation decisions, then this already vulnerable ecosystem may be pushed beyond the threshold at which it can recover.

[87] National Integrated Drought Information Systems. Water Utilities. https://www.drought.gov/sectors/water-utilities. Accessed May 5, 2022.

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The ecosystem will begin to function differently, leading to a loss in the critical services it once provided humans—such as purifying water and air, preventing erosion, and providing recreation opportunities.[88] An exceptionally severe drought could dramatically reduce the amount of water available for landscaping in Irvine and deprive trees of the irrigation they require for their survival (Irvine 2020).

Droughts can also lead to the expansion of territory for existing pests and introduction of new pests. Pests that are currently afflicting trees in Orange County include the following:

- Asian Citrus Psyllid: Carries a plant disease known as Huanglongbing, or citrus-greening disease, which kills citrus trees. Parts of the City of Irvine are in the quarantine area for this pest.
- Gold Spotted Oak Borer: Burrow into oak trees which kills the tree over time.
- Invasive Shot Hole Borer: Burrow into all kinds of native trees in all kinds of settings, including urban areas. These insects carry the Fusarium Dieback fungus which kills the tree.[89]

Any tree has the potential to be infested by pests that could result in the tree's death. This means all areas of Irvine that are landscaped with trees could experience tree mortality. These areas include parks, landscaped parkways and street medians, schools, as well as private homes or businesses.[90]

Sensitivity: Vulnerable Populations

Droughts are unlikely to cause serious social threats to households in Irvine, though residents and business owners in the City may experience financial costs associated with water conservation efforts. Those who have less access to financial resources, such as low-income households or seniors, may be harder hit if higher water fees are imposed during a severe drought event.[91]

Adaptive Capacity

The city's reliance on various in internal and regional water resources, including the IRWD and the OCWD, will remain a critical issue for the city's resilience to drought periods.

City of Irvine

The City has addressed drought in planning documents such as their LHMP, Water Management Program, and Urban Water Master Plan. The City also has regulations and programs in place that are beneficial during drought events by limiting further potential public health impacts. The plans and programs for the City and supporting agencies are described in Chapter 2: City of Irvine Adaptive Capacity to Climate-Related Hazards, in addition to those below:

<u>City of Irvine Local Hazard Mitigation Plan (2020)</u>

The 2020 LHMP included mitigation actions to decrease the risks associated with drought, including:

- Coordinate closely with IRWD on water use and water conservation efforts throughout the City.

[88] National Integrated Drought Information Systems. Ecosystems. https://www.drought.gov/sectors/ecosystems. Accessed May 5, 2022.
[89] Orange County Fire Authority. 2018. Ready, Set, Go, Newsflash! https://www.ocfa.org/Uploads/SafetyPrograms/OCFA%20Newsflash_Tree%20Pests_3-Page%20Version.pdf
[90] City of Irvine. 2020. Local Hazard Mitigation Plan. October.
[91] City of Irvine. 2020. Local Hazard Mitigation Plan. October.

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- Update "Division 7 - Sustainability in Landscaping "of the Irvine Municipal Code of Ordinances and the Master Streetscape & Landscape Design Manual to reflect the latest advances in best practices in landscape design that reduce water use within the City.
- Encourage drought tolerant native landscaping, low-flow water fixtures beyond the state minimum code, and daytime watering restrictions on properties throughout the city to reduce water consumption.
- Use drought-tolerant plants when installing new or retrofitting City-owned landscapes. Limit turf that is not drought tolerant to recreational fields and lawns, and only in instances where no feasible drought-tolerant alternatives exist.

City of Irvine Water Management Program (2009)

The Irvine Public Works Department's Landscape Maintenance Division is guided by a Water Management Program (2009). The policy directs City staff to use smart controller technology, crop coefficients, weather data, and field observations to accurately water the landscape. with the purpose of "apply[ing] the least amount of water necessary to maintain healthy plant material."[92]

City of Irvine Water Quality Ordinance

The Water Quality Ordinance (No. 10-06) gives the City of Irvine adequate legal authority as may be necessary to carry out the requirements of the NPDES Permit and accomplish the requirements of the Clean Water Act.[93]

Irvine Ranch Water District

To manage the water supply for Irvine, the IRWD is guided by the following plans and programs:

Urban Water Management Plan (Draft 2020)

IRWD's Urban Water Management Plan (UWMP) identifies imported and local water supplies needed to meet future demands, including groundwater recovery and water recycling, as well as IRWD's current and planned conservation measures. This helps to ensure that IRWD can provide the service area with a reliable supply of high-quality water to meet current and future demands. The UWMP is updated every five years and submitted to the California Department of Water Resources. The prior 2015 UWMP was adopted by IRWD's Board in 2016.

Water Shortage Contingency Plan (2021)

IRWD's Water Shortage Contingency Plan provides a series of response actions that IRWD may implement in the event of a water shortage due to drought or emergency. It assumes that under a Climate Change scenario, that the anticipated Water Bank Usage would be 7,300 to 11,500 acre feet per year.

The District obtains a majority of its water through groundwater (52 percent) and imported water (14 percent). To ensure a reliable water supply during times of drought, regulatory constraints and other emergencies, the District maintains a diverse water supply portfolio that also includes the following:

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[92] City of Irvine. 2009. Public Works Department Water Management Program. March 17.
[93] City or Irvine. 2010. City Council Ordinance No. 10-06. Water Quality. July 13.

Recycled Water

IRWD produces about a quarter of our supply by capturing water that normally would run out to sea, treating it, and reusing it for irrigation and other non-potable, or non-drinking, uses. We also supplement our supplies by cleaning non-potable groundwater to make it suitable for irrigation. Every gallon of recycled water and cleaned groundwater we use saves a gallon of drinking water.

Water Banking

Strand Ranch Water Banking Project

Located in Kern County, the Strand Ranch Water Banking Project improves IRWD's water supply reliability by capturing low-cost water available during wet years for use during periods of drought or critical need. Using a system of 502 acres of constructed groundwater recharge ponds on Strand Ranch, IRWD can store up to 50,000 acre-feet in the Water Bank and may recharge or recover up to 17,500 acre-feet in any single year.

Kern Fan Groundwater Storage Project

IRWD is partnering with Rosedale-Rio Bravo Water Storage District in the development of the Kern Fan Groundwater Storage Project, which will provide substantial water supply reliability benefits to the agencies. IRWD and Rosedale are actively pursuing both State and Federal funding for the project. Following are links to important documents related to securing State of California Water Storage Investment Program funding and Federal Water Infrastructure Improvements for the Nation (WIIN) Act Funding.

Water Storage Investment Program

On July 24, 2018, the California Water Commission voted to conditionally award the Kern Fan Project $67.5 million. IRWD and Rosedale are now working to complete additional requirements outlined in the program regulations in order to execute a final funding agreement and receive funds.

Water Supply Reliability Program

IRWD has purchased property in Riverside County that is located within the Palo Verde Irrigation District. Ownership of this land will eventually become another element of IRWD's long-term program to increase water supply reliability for its customers during droughts and other potential water supply interruptions. This land is currently farmed by a tenant farmer; IRWD expects to continue with the practice.

Orange County Water District

OCWD believes the best way to mitigate drought is to increase water supply. Examples of how OCWD is increasing local water supplies and securing long-term water reliability, include expansion of the groundwater replenishment system, a forecast-informed reservoir operation, sustainable management of the groundwater basin, implementation of a Santa Ana River conservation and conjunctive use program, and exploration of ocean desalination.[94]

[94] Orange County Water District. 2022. Drought in California. https://www.ocwd.com/learning-center/drought/. Accessed May 4, 2022.

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Metropolitan Water District

Water Surplus and Drought Management (WSDM) Plan

Diversifying the region's water supplies and developing adequate and healthy water storage reserves have proven to be the backstop for water supply reliability. These actions have also contributed to improved seismic resilience for the region. Stored water reserves provide certainty for meeting the needs of the region's vast service area when traditional sources of supply are challenged by drought, climate change, seismic events, and other risks. It is critical that these storage resources be developed, managed, and enhanced.

MWD's WSDM Plan, which defines a regional water management strategy for MWD and its member agencies, has focused on using storage to manage water supplies and enhance reliability since 1999. The WSDM Plan includes the following guiding principle: MWD will encourage storage of water during periods of surplus and work jointly with its member agencies to minimize the impacts of water shortages on the region's retail consumers and economy during periods of shortage.

Water Supply Allocation Plan

When continued drought, earthquakes, or other natural disasters lead to shortages of supplies, MWD distributes a limited amount of water through its Water Supply Allocation Plan (WSAP). First developed in 2008, Metropolitan's WSAP takes a basic premise --to fairly distribute a limited amount of water supply-- and applies it through a detailed methodology to reflect a range of local conditions and needs of the region's retail water consumers. In particular, under severe drought conditions or a potential seismic event that impacts imported conveyance systems, it may be necessary and prudent to call for greater reductions in the use of limited water supplies and to reduce reliance on storage reserves. The WSAP has 10 levels of water supply allocations, each corresponding to a five percent reduction of supply. A Level 2 allocation, for example, represents a reduction of approximately 10 percent in overall water supply available to each member agency. The level of WSAP reduction implemented would correlate to the severity of the seismic event.

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3.2.2.3 WILDFIRE + SMOKE

Wildfire in southern California is influenced by a multitude of factors: a dry and warm Mediterranean climate with periodic episodes of Santa Ana winds and droughts, the type and spatial distribution of vegetation (along with dead/ dry vegetation caused by pests), varying topography, large urban-wildland interfaces, past fire suppression attempts, and human activities.[95]

According to the state's Fourth Climate Change Assessment, by 2100, the frequency of extreme wildfires burning over 25,000 acres could increase by nearly 50 percent. As with other climate hazards, the state already is beginning to experience an increase in severe wildfires. Most of California's largest and most destructive wildfires have occurred in recent decades. This pattern has been particularly notable in the last few years, which have seen some of the worst wildfires in the state's recorded history. Five of the twenty most destructive wildfires in the state's history occurred in 2020 alone, with an additional two in 2021. [96]

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[95] Hall, Alex, Neil Berg, Katharine Reich. (University of California, Los Angeles). 2018. Los Angeles Summary Report. California's Fourth Climate Change Assessment. Publication number: SUM-CCCA4-2018-007.

[96] State of California, Legislative Analyst's Office. 2022. Budget and Policy Post. Climate Change Impacts Across California Crosscutting Issues. April 5, 2022. https://lao.ca.gov/Publications/Report/4575. Accessed April 11, 2022.

Not only do high-severity wildfires take lives and level homes, businesses, and community infrastructure, they also destroy fish and wildlife habitats. Moreover, intense wildfires can also impair air quality throughout the state. The Los Angeles Region Report as part of the to the state's Fourth Climate Change Assessment describes how the LA-Long Beach region already has some of the worst air quality in the country, ranking as the most polluted region in the United States for ozone and among the top 10 most polluted cities for year-round and short-term particle pollution. And, while air quality in the region has improved in recent decades, climate change threatens to reverse this trend. Higher future temperatures are likely to increase the production of ground-level ozone, a respiratory irritant that is a component of smog. Ground-level ozone is associated with various negative health outcomes, including reduced lung function, pneumonia, asthma, cardiovascular-related morbidity, and premature death.[97]

The City is composed of relatively flat land and hillsides along its northern and southern borders. The hillsides are an integral part of the community's image and identity, providing a visual backdrop, an environmental preserve, and a recreational resource. There are several open space areas within the city, characterized by shrubs and native trees. During the dry months, the wildfire risk in these open, vegetated areas can increase when exacerbated by occasional Santa Ana winds and elevated temperatures. Additionally, extreme weather conditions, such as high temperature, low humidity, and/or winds of extraordinary force, may cause an ordinary, localized fire to expand into a more intense and difficult to control wildfire. Currently, many homes within the city are in the urban-wildland interface, which is characterized by zones of transition between wildland and developed areas and often include heavy fuel loads that increase wildfire risk.

Historical Wildfire Events

- Freeway Complex Fire – a 2008 wildfire that burned parts of Yorba Linda, Anaheim, Brea, Chino Hills, and Diamond Bar. Over 30,000 acres were burned destroying 314 homes, 43 outbuildings, and 4 commercial structures. No fatalities were reported during this event (CAL FIRE 2018)
- Santiago Fire – Began on October 21, 2007, in the foothills north of Irvine and east of the City of Orange. Over 28,000 acres were burned, resulting in the destruction of 14 homes and 24 outbuildings. No fatalities were reported during this event.
- Canyon Fire – a 2017 wildfire that burned in the Anaheim Hills area of Orange County. In total the fire burned 9,217 acres, destroyed 25 structures, and damaged another 55. In total, 16,570 people were evacuated from their homes in Anaheim, Orange, and Tustin.[98]
- Silverado Fire starting on October 26, 2020, resulted in the evacuation of over one-third of the City's population.[99]

Vulnerability to Wildfire

Climate change will result in changes in precipitation patterns, increased temperature, and drought conditions. Wetter months may lead to increased vegetative growth while following periods of drought will allow for the vegetative growth to dry up creating greater amounts of fuel for fires. Climate change will also worsen existing severe wind events, which fuel the spread and intensity of

[97] Hall, Alex, Neil Berg, Katharine Reich. (University of California, Los Angeles). 2018. Los Angeles Summary Report. California's Fourth Climate Change Assessment. Publication number: SUM-CCCA4-2018-007.
[98] Graham, Jordan. 2017. "Canyon Fire 2 now 90 percent contained, full containment expected Tuesday". OC Register. Retrieved February 5, 2020.
[99] City of Irvine. 2021a. 6th Cycle 2021-2029 Housing Element – Second Draft. November 19, 2021.

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wildfires. Santa Ana wind events blow in an offshore direction in parts of Southern California and are caused by the formation of large high-pressure systems over eastern California, Nevada, and Utah, producing winds that are strong and extremely dry. Santa Ana winds have caused some of the region's most damaging wildfires and account for some of the worst extreme heat events. While future wind events are predicted to decrease, the intensity of a severe wind event over a shorter amount of time is predicted to increase.[100]

Future projections indicate that southern California may experience a larger number of wildfires and burned area by the mid-21st century under RCP8.5. Overall burned area is projected to increase over 60 percent for Santa Ana-based fires and over 75 percent for non-Santa Ana fires.[101]

Exposure

The potential for wildland fires represents a hazard where development is adjacent to open space or within proximity to wildland fuels. Steep hillsides and varied topography within portions of the city also contribute to the risk of wildland fires.

Wildfires are not measured on a specific scale and are usually classified by size (e.g., acres burned) or impact (buildings destroyed or damaged, injuries or deaths, cost of damage, etc.). The risk of wildfire is classified on a three-tier scale of fire hazard severity zones (FHSZs): very high, high, and moderate. These classes do not correspond to a specific risk or intensity of fire but are qualitative terms that consider many factors. Fire-prone areas are also classified by the agency responsible for fire protection. Federal Responsibility Areas (FRAs) fall to federal agencies such as the US Forest Service, the Bureau of Land Management, and the National Park Service. State Responsibilities Areas (SRAs) fall to the California Department of Forestry and Fire Protection (CAL FIRE), and Local Responsibility Areas (LRAs) fall to local governments.

CAL FIRE data was used to identify Very High Fire Hazard Severity Zones (VHFHSZ) in the city that are included in the LRA (See **Figure 3-5: Fire Hazard Severity Zones**) identifies the City's Critical Facilities and Facilities of Concern. All structures located within this fire zone are at an elevated risk to wildfire impacts.

Fire hazards are probable in the City due to large quantities of combustible vegetation, poor access to fire hazard areas, and lack of water supply for fire protection in fire hazard areas. Development within these zones is regulated through the Uniform Building Code and Uniform Fire Code. Requirements imposed as part of the development review process include fire lanes, fuel modification zones, fire retardant building materials, smoke detectors and automatic sprinkler systems, depending on the size and type of development. Special fire protection consideration is given to industries handling hazardous materials, multi-story buildings with high occupant levels, and large built-up areas with combustible roof coverings. High hazard areas are predominantly in the hilly portions of the City with volatile chaparral as the fuel source.[102]

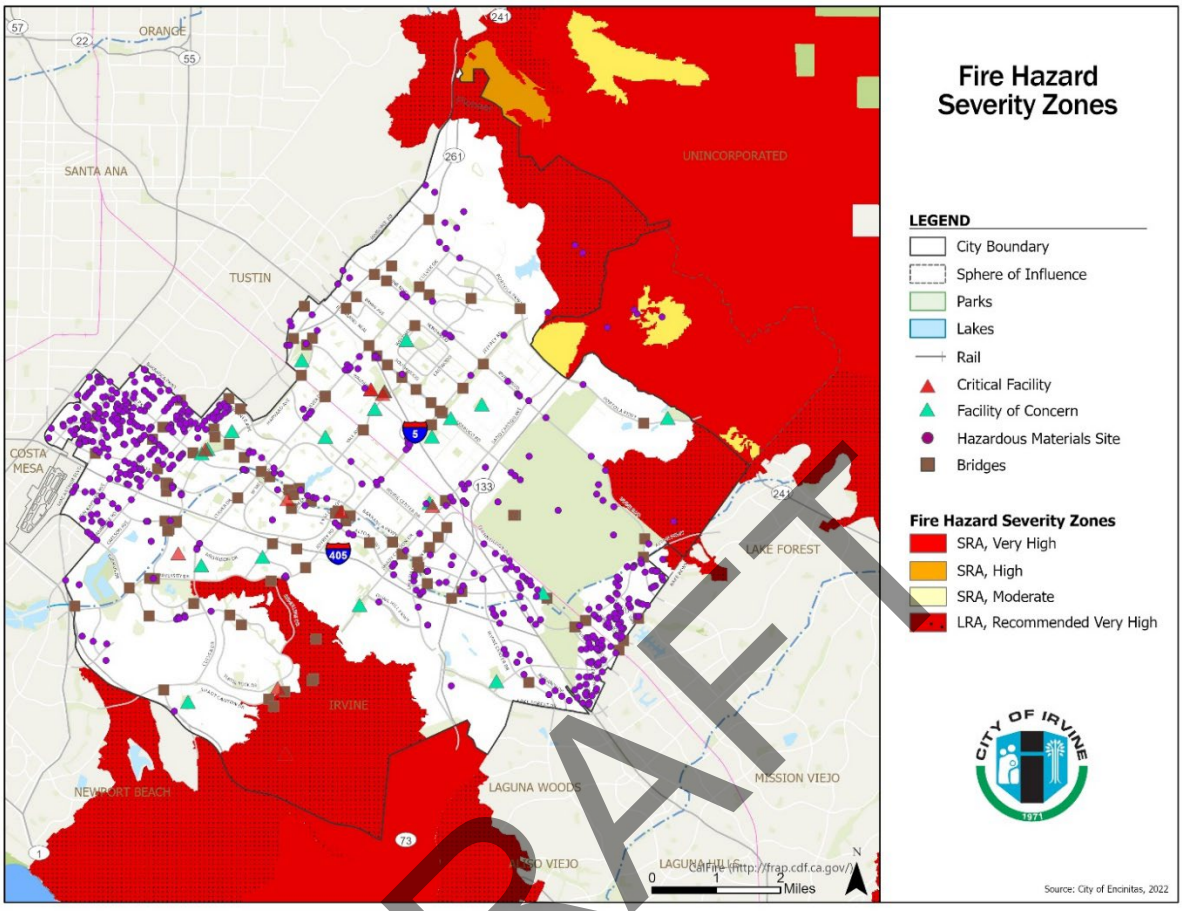
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[100] California Natural Resources agency, Governor's Office of Planning and Research, and California Energy Commission. 2019. California's Fourth Climate Change Assessment; San Diego Region Report. Available: https://www.energy.ca.gov/sites/default/files/2019-11/Reg_Report-SUM-CCCA4-2018-009_SanDiego_ADA.pdf. Accessed April 12, 2022.

[101] Hall, Alex, Neil Berg, Katharine Reich. (University of California, Los Angeles). 2018. Los Angeles Summary Report. California's Fourth Climate Change Assessment. Publication number: SUM-CCCA4-2018-007.

[102] City of Irvine. 2015a. General Plan Safety Element.

Figure 3-5: Fire Hazard Severity Zones



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Essential Facilities

Table 3-5: Critical Facilities and Facilities of Concern (Fire Hazard Severity Zone) identifies six Critical Facilities and one Facility of Concern within this zone, which could result in a potential loss of approximately $1.4 million. While these areas have a high degree of vulnerability to wildfire, other areas of the City may also be susceptible due to ember cast. These areas typically referred to as the Wildland Urban Interface (WUI) are vulnerable if the right conditions exist. Typically, the WUI is impacted if adequate fuels are combined with dry conditions and strong winds. Sometime the ignition of a wildfire may occur as a result if power lines located around overgrown trees cause a spark and catch the tree on fire. These types of incidents are the main impetus for the newly established Public Safety Power Shutoff (PSPS) program that is occurring throughout the State. The City of Irvine currently has 11 circuits that could be affected by future PSPS events.

Table 3-5: Critical Facilities and Facilities of Concern (Fire Hazard Severity Zone)

Category	Number of Facilities		Examples	Potential Loss*
	Critical	Concern		
City Vital Operations	-	-	City Hall, Police Station, Operations Support	$0
City Community Centers	-	-	Community Centers	$0
City Resident Services	-	-	Senior Centers, Animal Shelter, Daycare, Other Community Facilities	$0
City Recreation Support	-	1	Parks, Recreation Amenities, Sports Complexes, and support facilities	$168,300
Bridges	6	-	Overpasses and underpasses within the City	$1,256,640
Schools**	-	-	Irvine Unified School District and Tustin Unified School District Facilities	N/A
Total	**6**	**1**		**$1,424,940**

* Based on the City of Irvine insured replacement values

**Replacement Values unavailable

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As the frequency, severity and impacts of wildfire are sensitive to climate change as well as other factors, including development patterns, temperature increases, wind patterns, precipitation change and pest infestations, it is difficult to project exactly where and how fires will burn. Instead, climate models estimate increased risk to wildfires. The Keetch-Byram Drought Index (KBDI) represents a simplified proxy for favorability of occurrence and spread of wildfire but is not itself a predictor of fire. As shown in Table 3-6: City of Irvine KBDI > 600 (days), The city's risk to wildfire is projected to substantially increase by end of the century compared with the historic baseline. This will lead to an increased risk for areas in Irvine susceptible to wildfire and corresponding smoke.

Table 3-6: City of Irvine KBDI > 600 (days)

KBDI > 600 (days)	Historic KBDI > 600 (days) (1961 - 1990)	Medium Emissions (RCP 4.5)		High Emissions (RCP 8.5)	
		Mid-Century	End-Century	Mid-Century	End-Century
	15	51	61	61	108

Source: California Energy Commission. CalAdapt. Local Climate Change Snapshot for Irvine: Wildfire KBDI. https://cal-adapt.org/tools/local-climate-change-snapshot. Accessed April 28, 2022.

KBDI is cumulative. The KBDI values increase on dry and warm days and decrease during rainy periods. In California we would expect KBDI to increase from the end of the wet season (spring) into the dry season (summer & fall). The list below explains what values of KBDI represent:

0–200	Soil moisture and fuel moistures are high, low wildfire risk.
200–	Soil and fuels start to dry, average wildfire risk.
400–	Onset of drought with moderate to serious wildfire risk.
600–	Severe drought, extreme wildfire risk and increased wildfire occurrence.

Climate change is expected to cause an increase in temperatures as well as more frequent and intense drought conditions. This will likely increase the amount of dry plant matter available for fuel, increasing the risk of wildfire statewide. In the foothills of the Santa Ana Mountains and San Joaquin Hills, which are already highly prone to wildfires, climate change is expected to increase the number of acres burned annually. Based on the RCP 8.5 scenario, with the CanESM2 model, the annual average of area burned could increase to an average of 212.5 hectares by the end of the century, which is an increase of 35 hectares from the annual mean for 1961-1990.[103] However, increases in fuel supplies could cause wildfires to move faster or spread into more-developed areas, which could increase the threat to Irvine.

These are unique challenges for the City as 29 percent of households in the Fire Hazard Severity Zone have at least one individual age 65 years and older. Additionally, almost 15 percent of households have at least one person living with a disability. Challenges that these populations face include potential inability to access emergency supplies, evacuate, or receive and understand emergency information. The effects of climate change hazards can result in infrastructure disruptions including power outages. Such events could result in additional health hazards for the elderly or persons with disabilities who rely on power to sustain medical equipment/assistive technology use.

According to **Table 3-7: Fire Hazard Severity Zone Vulnerable Populations,** residents living in the VHFHSZ have a median income that is approximately $23,000 higher than the city-wide figure, more households with at least one person living with a disability, and fewer residents living under the poverty limit. Compared to citywide households, there is a substantially larger number of households in the fire hazard zone with a resident aged 65 years and older.

Table 3-7: Fire Hazard Severity Zone Vulnerable Populations

	FHSZ	Irvine
Total Population[1]	7,641	262,665
Percent of residents that are children (less than 10 years)[2]	11.5%	10.4%
Percent of households that have people 65+ years[1]	29.0%	20.6%
Percentage of households with at least one person living with a disability[1]	14.9%	12.3%
Median age[2]	36.9	34.0
Total households[1]	3,491	94,490
Median household income[2]	$136,305	$113,097
Percent of rental households[2]	46.1%	48.7%
Percent of household income below poverty level[1]	9.4%	13.1%

Source: US Census Bureau, American Community Survey (ACS) 2015 - 2019[1], US Census Bureau 2010 Summary File 1, ESRI Forecasts 2021[2]

As shown in **Table 3-8: English Proficiency and Languages Spoken at Home Among Residents 5 Years and Older - FHSZ**, the majority of the estimated 7.231 residents in the Very High Fire Hazard Severity Zone aged 5 years and older are fluent in English. 4.2 percent of the population residing in the VHFHSZ are not fluent in English.

[103] Cal-Adapt. 2022. Modeled Annual Area Burned under a High Emissions (RCP 8.5) Scenario and Central Population Growth scenario: Irvine, California. https://cal-adapt.org/tools/wildfire. Accessed May 5, 2022.

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Table 3-8: English Proficiency and Languages Spoken at Home Among Residents 5 Years and Older - FHSZ

	Number of Speakers	Percent Not Fluent in English
English Only	4,263	-
Spanish	339	5.6%
Indo-European Languages	464	4.1%
Asian and Pacific Island Languages	2,023	13.1%
Other Languages	142	0%

Note: Percentage values rounded to nearest tenth decimal.

Source: US Census Bureau, American Community Survey 2015 - 2019, ESRI 2022

Sensitivity: Major Community Elements

Transportation Systems

Wildfire could damage roads in several ways. Unsafe conditions and damage could lead to road closures. Typical asphalt mixtures could ignite or melt/excessively soften. Debris from fires and subsequent landslides could block roads.[104,105] Most major roads have sidewalks that create a small defensible space as well as development of the surrounding areas. Roads can be damaged by increased traffic of heavy vehicles, and vehicles that exceed weight limits, used during emergency response or recovery efforts. Costs associated with transportation infrastructure losses include repair costs, clean-up costs, and costs related to service disruptions.[106]

Lifeline Utility Systems

Additionally, wildfire can cause direct and indirect damage to electrical infrastructure. Direct exposure to fire can sever transmission lines, and heat and smoke can affect transmission capacity. Other impacts of climate change also threaten electricity infrastructure, including wildfires that can destroy poles and towers carrying transmission lines.[107]

Wildfire events can physically damage water infrastructure including pipes, water meters, dams, spillways, and other structures and equipment. Costs associated with water infrastructure losses include repair costs, clean-up costs, and costs related to service disruptions.

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[104] Carvel, R., & Torero, J. (2006). The Contribution of Asphalt Road Surfaces to Fire Risk in Tunnel Fires: Preliminary Findings. Proceedings of the International Conference on Risk and Fire Engineering for Tunnels, Stations, and Linked Underground Spaces (pp. 83-87). Hong Kong: Tunnel Management International.

[105] Cannon, S., & DeGraff, J. (2009). The Increasing Wildfire and Post-Fire Debris-Flow Threat in Western USA, and Implications for Consequences of Climate Change. In K. Sassa, & P. Canuti, Landslides - Disaster Risk Reduction (pp. 177-190). Verlag Berlin Heidelberg: Springer.

[106] Feo, Teresa J., Amber J. Mace, Sarah E. Brady, and Brie Lindsey. 2020. The Costs of Wildfire in California An Independent Review of Scientific and Technical Information. California Council on Science and Technology. ISBN Number: 978-1-930117-66-2.

[107] Davis, M., and S. Clemmer. 2014. Power failure: How climate change puts our electricity at risk—and what we can do. Cambridge, MA: Union of Concerned Scientists. https://www.ucsusa.org/sites/default/files/2019-10/Power-Failure-How-Climate-Change-Puts-Our-Electricity-at-Risk-and-What-We-Can-Do.pdf. Accessed April 11, 2022.

Mitigation actions specifically to reduce water infrastructure losses primarily include infrastructure hardening and defensible space. Water infrastructure damage can also cause contamination of drinking water supplies that can pose a risk to public health.[108]

Wildfires can damage or destroy gas, electric, and telecommunications infrastructure including poles, towers, lines, pipes, and other physical assets.[109] Damage is primarily caused by direct exposure to the flames and heat from the fire, but carbon build-up and particulate matter from wildfire smoke can also damage components used to deliver electricity.[110] Furthermore, flame retardants and firefighting techniques used to suppress fires can also damage utility infrastructure.[111]

Economic Elements

Wildfire can lead to the loss of buildings and infrastructure that may need to be repaired from damage or replaced if destroyed. Additional economic losses include the value of personal property or inventory that was damaged along with the home or commercial building, costs associated with temporary accommodations or service disruptions, and costs related to toxic material and debris cleanup. When infrastructure losses cause service disruptions, the costs can be borne by customers and communities far from the perimeter of the wildfire.[112]

Natural Resource Areas

Furthermore, because of historical forest management trends over the past century, increased temperatures, and more frequent drought, California wildfires are characteristically hotter and more intense as compared to naturally occurring fire regimes. As such, soil structure and moisture retention are damaged leading to increased susceptibility to erosion or landscapes. If Irvine's foothills become covered with dry, overgrown vegetation because of drought condition, extreme heat events and high winds increase the threat of wildfires.

Beyond direct damage to physical property and harmful effects on public safety, wildfires also result in secondary impacts: a major consequence of wildfires is post-fire flooding and debris flow. The risk of floods and debris flows after fires increases due to vegetation loss and soil exposure. These flows are a risk to life because they can occur with little warning and can exert great force on objects in their path.

Wildfires could alter hydrology by changing vegetation, increasing runoff, and resulting in more sediment that could block drainage and damage structures.[113] This impact would be caused by upstream factors; wildfires are unlikely to directly burn and/or damage outfalls themselves due to construction materials and placement near bodies of water.

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[108] Feo, Teresa J., Amber J. Mace, Sarah E. Brady, and Brie Lindsey. 2020. The Costs of Wildfire in California An Independent Review of Scientific and Technical Information. California Council on Science and Technology. ISBN Number: 978-1-930117-66-2.

[109] California Governor's Office of Emergency Services (Cal OES) 2018. California State Hazard Mitigation Plan.https://www.caloes.ca.gov/HazardMitigationSite/Documents/002-2018%20SHMP_FINAL_ ENTIRE%20PLAN.pdf

[110] Aspen Environmental Group. (2008). Sunrise Powerlink Project Attachment 1A: Effect of Wildfires on Transmission Line Reliability. Retrieved from https://www.cpuc.ca.gov/Environment/info/aspen/sunrise/deir/apps/a01/App%201%20ASR%20z_Attm%201A-Fire%20Report.pdf

[111] Sathaye, J., Dale, L., Larsen, P., Fitts, G., Koy, K., Lewis, S., & Lucena, A. (2011). Estimating Risk To California Energy Infrastructure From Projected Climate Change. LBNL-4967E, 1026811. https://doi.org/10.2172/1026811

[112] Feo, Teresa J., Amber J. Mace, Sarah E. Brady, and Brie Lindsey. 2020. The Costs of Wildfire in California An Independent Review of Scientific and Technical Information. California Council on Science and Technology. ISBN Number: 978-1-930117-66-2.

[113] U.S. DOT. 2018. Transportation Climate Change Sensitivity Matrix. U.S. Department of Transportation. Retrieved from https://toolkit.climate.gov/tool/transportation-climate-change-sensitivity-matrix

Conservation areas and open space in the city provide crucial ecosystem services such as the provisioning of clean air and water and climate regulation. If conservation areas are damaged, endangered species could be at increased risk species survival. If habitats of sensitive species are subject to frequent disturbance or destruction, resources may be needed to conserve these species. In addition, in the event of damage, more insects, pests, or invasive species.

Community parks are used for recreation, exercise, as gathering spaces, and sites of natural, historical, tribal cultural, and archaeological resources. Loss of or damage to community parks would interfere with their ability to serve these various functions.

Sensitivity: Vulnerable Populations

Wildfires are major public health concern as they can cause immediate health impacts through burns, injuries, and heat stress. However, a wildfire can influence the health outcomes of an area larger than the burn area because the associated smoke can travel long distances and worsen the air quality for extended periods. Wildfires can be a significant contributor to air pollution in both urban and rural areas and have the potential to significantly impact public health through particulates and volatile organic compounds in smoke plumes. Wildfires are a major source of particulate matter, which is an air pollutant that increases one's risk for respiratory illnesses, cardiovascular disease, negative birth outcomes, and premature death.[114] Wildfire smoke contains numerous primary and secondary pollutants, including particulates, polycyclic aromatic hydrocarbons, carbon monoxide, aldehydes, organic compounds, gases, and inorganic materials with toxicological hazard potentials.[115] Wildfire smoke also increases exposure to ground level ozone and toxic chemicals (e.g., pesticides, plastics, and paints) released from burned building and other man-made materials. Individuals sheltering in place are also at risk of exposure to hazardous air quality because wildfire smoke penetrates homes, particularly older homes.[116] Beyond these immediate health impacts, the stress, displacement, and loss of home and community from wildfires can cause significant mental health impacts, such as anxiety, depression, and post-traumatic stress disorder.[117]

Outside of the property owners directly impacted by a wildfire event, wildfires can also impact seniors and persons with disabilities. During hazard events such as wildfires, flooding, or extreme storms, the elderly, and other vulnerable populations such as persons with disabilities may require additional assistance to adequately respond. These groups may have limited mobility, be immuno-compromised, and/or not receive notifications regarding current conditions and evacuation requirements. For example, a senior who lives alone may not be aware that a wildfire is burning close to their residence and they have been ordered to evacuate if those notifications were sent in manner that doesn't reach them.

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[114] Bell, J.E., S.C. Herring, L. Jantarasami, C. Adrianopoli, K. Benedict, K. Conlon, V. Escobar, J. Hess, J. Luvall, C.P. Garcia-Pando, D. Quattrochi, J. Runkle, and C.J. Schreck, III, 2016: Ch. 4: Impacts of Extreme Events on Human Health. The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment. U.S. Global Change Research Program, Washington, DC, 99–128.

[115] Künzli, N. et al. 2006. Health effects of the 2003 Southern California wildfires on children. Am J Respir Crit Care Med. 174:1221-8.

[116] Rudolph, L., Harrison, C., Buckley, L. & North, S. (2018). Climate Change, Health, and Equity: A Guide for Local Health Departments. Oakland, CA and Washington D.C., Public Health Institute and American Public Health Association.

[117] Hanigan, Ivan C., Colin D. Butler, Philip N. Kokic, and Michael F. Hutchinson. 2012. "Suicide and Drought in New South Wales, Australia, 1970–2007." Proceedings of the National Academy of Sciences of the United States of America 109 (35): 13950–55.

Persons with disabilities may require special mobility devices or caregiver assistance to go outside which may not arrive as quickly as needed. Other groups with increased threat levels include people with lower-incomes, renters, and the homeless. These groups may not possess enough financial resources to rebuild their homes or search for new homes in the aftermath of a fire.[118]

As shown in Table 3-8: English Proficiency and Languages Spoken at Home Among Residents 5 Years and Older - FHSZ, the majority of the estimated 7.231 residents in the Very High Fire Hazard Severity Zone aged 5 years and older are fluent in English. While 4.2 percent of the population residing in the VHFHSZ are not fluent in English, the City implements programs intended to communicate information to the diverse community of residents and workers with different backgrounds including the City of Irvine's website offers translation for 81 languages[119] and the Irvine Police Department is prepared to communicate with individuals with limited English proficiency[120]

Adaptive Capacity

The City has addressed wildfire in planning documents such as their Local Hazard Mitigation Plan, Emergency Management Plan, and Evacuation Plan (Annex XIII). The City also has regulations and programs in place that are beneficial during wildfires by limiting further potential public health impacts. The plans and programs for the City and supporting agencies are described in Chapter 2: City of Irvine Adaptive Capacity to Climate-Related Hazards, in addition to those below:

City of Irvine Local Hazard Mitigation Plan (2020)

The 2020 LHMP included mitigation actions to decrease the risks associated with wildfires, including:

- Promote the proper maintenance and separation of power lines and efficient response to fallen power lines.
- Remove highly flammable vegetation in Very High, High, and Moderate Fire Hazard Severity Zones and replant with fire-adapted specimens.
- Create a hillside weed abatement pilot program using goats or other livestock to reduce fuel loads in fire-prone areas.
- Routinely participate in the update of the Orange County Community Wildfire Preparedness Plan for areas within the Very High, High, and Moderate Fire Hazard Severity Zones.
- Create a rapid response plan from among Irvine's and Orange County's first responders to secure hospital, nursing, and assisted living facilities, especially those located within fire hazard severity zones.
- Reinforce and regularly inspect fire retardant infrastructure such as sprinklers, fire hose terminals, and fire suppression systems in City facilities.
- Coordinate with partners to clear dead vegetation in flood control facility footprints, railroad rights-of-way, parks, and open spaces, especially during and after a drought episode.
- Expand the fire hazard prevention awareness campaign to residents in the High and Very High Fire Hazard Severity Zones.
- Work with OCFA on home preparedness assessments to assist more residents in understanding and addressing their wildfire risk.

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[118] City of Irvine. 2020. Local Hazard Mitigation Plan. October.
[119] City of Irvine. 2022. https://www.cityofirvine.org/. Accessed May 3, 2022.
[120] City of Irvine. n.d. Policy 345. Limited English Proficiency Services.

- Require all new development in Very High, High, and Moderate Fire Hazard Severity Zones to use noncombustible building materials such as masonry, brick, stucco, concrete, steel, or others as appropriate. Establish zones of defensible space around homes in Very High, High, and Moderate Fire Hazard Severity Zones.[121]

Orange County Fire Authority

For urban areas within the City, the OCFA is able to satisfy fire and basic life safety goals by having a first due unit on scene within a five-minute response time 80 percent of the time. Advanced life support response goals are within eight minutes 80 percent of the time. The service demand for areas considered suburban, rural, or undeveloped typically can expect increased response time goals of up to 15-20 minutes. In order to mitigate the impact of longer response times in these areas, certain building and fire codes are applied at time of development. Some of these may include automatic fire sprinklers, fire retardant building materials, and other special response enhancements unique to the development.[122]

Orange County Fire Authority – Ready, Set, Go Program

The City of Irvine participates in the CAL FIRE/OCFA "Ready, Set, Go!" program to help property owners property prepare well in advance of a wildfire to increase safety and protect property. This program provides comprehensive information on how to improve structure resistance to wildfires and prepare people to be ready to leave early in a safe manner.[123]

3.3.2.4 FLOODING

A flood occurs when land that does not normally have bodies of water becomes suddenly inundated with water. Flooding can occur after periods of heavy rainfall, whether it occurs as a single extreme episode or as a series of storms. Drainages and stream courses may flood their banks and shores if their capacity is exceeded by rainwater. When heavy rainfall hits an area where the ground is already saturated, the risk of flooding is high. In developed areas, the presence of pavement and other impervious surfaces means that the ground is less able to absorb water. As a result, rainwater must be carried away in storm channels or waterways.[124]

Floods pose several threats to communities and public safety. Flooding can cause property damage, destroy homes, and carry away vehicles or other large debris. Topsoil and vegetation can be swept away by floodwaters, leading to erosion. Floodwaters may impede the movement of victims fleeing a flood or of first responders attempting to reach people in need of help.[125]

Climate models predict that California will experience less frequent but more intense storm patterns in the coming decades, including the state's precipitation more frequently falling as rain rather than snow compared to historical trends. Additionally, the state's streams and rivers will swell more in some years from earlier and faster spring snowmelt caused by higher temperatures.

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[121] City of Irvine. 2020. Local Hazard Mitigation Plan. October.
[122] City of Irvine. 2015a. General Plan Safety Element.
[123] Orange County Fire Authority. 2022. Ready, Set, Go. https://www.ocfa.org/RSG/Ready. Accessed May 3, 2022.
[124] City of Irvine. 2020. Local Hazard Mitigation Plan. October.
[125] City of Irvine. 2020. Local Hazard Mitigation Plan. October.

Scientists suggest the combination of these factors could lead to a 50 percent increase in runoff in future years, challenging the capacity of the state's existing reservoirs, canals, levees, and other flood control systems, and increasing the risk of inland flooding. Floods cause significant risk to human life, and damage roads, buildings, and other infrastructure.[126]

FLOODING

Increases in temperature and precipitation can lead to extreme precipitation events and sea level rise that could lead to flooding in the City. In the context of climate change for Irvine, this analysis categorizes flood types according to climate effect: Onshore flooding caused by precipitation-driven events and coastal flooding. The following describes the types of floods within each category.

Onshore Flooding from Precipitation-Driven Events

- **Inland flooding** occurs when moderate precipitation accumulates over several days, intense precipitation falls over a brief period, or a river overflow because of an ice or debris jam or dam or levee failure.
- A **flash flood** is caused by heavy or excessive rainfall in a brief period, generally less than six hours. Flash floods are usually characterized by raging torrents after heavy rains that rip through riverbeds, urban streets, or mountain canyons. They can occur within minutes or a few hours of excessive rainfall.

Coastal Flooding

- A **coastal flood**, or chronic inundation of land areas along the coast, is caused by higher-than-average high tide and worsened by heavy rainfall and onshore winds (i.e., wind blowing landward from the ocean).
- **Storm surge** is an abnormal rise in water level in coastal areas, over and above the regular astronomical tide, caused by forces generated from a severe storm's wind, waves, and low atmospheric pressure.[127]

The following analyses describe onshore flooding and coastal flooding vulnerabilities resulting from projected climate change for the city of Irvine.

Onshore Flooding from Precipitation Events

Variability in the climate is likely to result in changes to the frequency, intensity, and duration of precipitation events causing heavy rainfall, thunderstorms, and hail. Like other California regions, the high year-to-year variability of precipitation in Irvine is severely affected by extreme precipitation events (days having precipitation at or exceeding the 95th percentile), which accounts for 80 percent of the year-to-year variability.[128]

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[126] State of California, Legislative Analyst's Office. 2022. Budget and Policy Post. Climate Change Impacts Across California Crosscutting Issues. April 5, 2022. https://lao.ca.gov/Publications/Report/4575. Accessed April 11, 2022.
[127] NOAA National Severe Storms Laboratory. *Severe Weather 101.* https://www.nssl.noaa.gov/education/svrwx101/floods/types. Accessed April 6, 2022.
[128] Jennings, M.K., D. Cayan, J. Kalansky, A.D. Pairis, D.M. Lawson, A.D. Syphard, U. Abeysekera, R.E.S. Clemesha, A. Gershunov, K. Guirguis, J.M. Randall, E.D. Stein, S. Vanderplank. (San Diego State University). 2018. San Diego County Ecosystems: Ecological Impacts of Climate Change on A Biodiversity Hotspot. California's Fourth Climate Change Assessment, California Energy Commission. Publication number: CCCA4- EXT-2018-010.

Most of the heaviest events occur during winter. While days with measurable precipitation become less frequent in Southern California, extreme precipitation events are anticipated to intensify. It is predicted that the state will experience prolonged periods of drought followed by extreme precipitation (See Section 3.2.2.2: Drought).

For Irvine, projections show only a slight change in average annual rainfall through the end of the century (Table 3-2: Change in Annual Average Precipitation). Globally, climate change is anticipated to lead to more variability in the intensity of rainfall events from year to year and longer transitions between droughts and deluges.[129] Historically, the City has experienced an average of about 1.5 extreme precipitation events per year. Under the medium emissions scenario, the city is still expected to experience 1.5 extreme precipitation events per year through the end of the century. Under the high emissions scenario, the City is expected to experience a little over 1.5 extreme precipitation events per year by mid-century and the late century.[130]

The primary concern for precipitation-driven hazards is flooding. Areas of Irvine already experiencing flooding when there are heavy rainfall events could find that flooding increases in the future. However, the forecasted changes in Maximum 1-Day Precipitation, the greatest amount of daily rain or snow (over a 24-hour period) for each year, are not anticipated to be substantially differ from historic records (see **Table 3-9. Change in Maximum 1-Day Precipitation**). Therefore, impacts from flooding caused by the largest precipitation-driven events should not be dramatically different than what the community currently experiences.

Table 3-9. Change in Maximum 1-Day Precipitation

Maximum 1-Day Precipitation	Historic Maximum 1-Day Precipitation (1961 - 1990)	Medium Emissions (RCP 4.5)		High Emissions (RCP 8.5)	
		Mid-Century	End-Century	Mid-Century	End-Century
	1.387	1.505	1.542	1.584	1.605

Source: California Energy Commission. CalAdapt. Local Climate Change Snapshot for Irvine: Maximum 1-Day Precipitation. https://cal-adapt.org/tools/local-climate-change-snapshot. Accessed April 28, 2022.

Historical Onshore Flooding Events

- February 6 – 8, 1998. Heavy rain. Up to 3" rainfall over all of Southern California. Catastrophic and widespread flooding, especially in Newport Beach and Irvine. Lots of property damage in southern Orange County. Evacuations and swift water rescues. Landslides, mud slides, and sink holes. Roads, bridges, and railroads damaged.[131]
- April 21, 2001. Mud, rockslides, and minor flooding occurred over highways and Interstates along and through the mountains and foothills. At elevations above 4000 feet, 2-4 inches of snow fell. [132]
- In January 2011, California received a Presidential Declaration for the Severe Winter Storms, Flooding, and Debris and Mud Flows that occurred over a nearly three-week period. During this incident, the State of California incurred well over $75 million in damages, of which over $36 million occurred within Orange County. Much of the damage impacted private and public property, as well as critical infrastructure.

[129] Swain, D. L. (2018). Increasing precipitation volatility in twenty-first-century California. Nature Climate Change.
[130] California Energy Commission. Cal-Adapt Extreme Precipitation Events Tool. Available: https://cal-adapt.org/tools/extremeprecipitation/. Accessed April 28, 2022.
[131] National Weather Service. 2017. A History of Significant Weather Events in Southern California.
[132] NCEI. Storm Events Database. https://www.ncdc.noaa.gov/stormevents/. Accessed May 2, 2022.

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- In 2014 heavy rains affecting most of Southern California caused flooding on a section of Bastanchury Road that was nearly a foot deep. Nearby weather stations reported that more than an inch of rain had fallen in a span of three hours.
- In September 2015, flooding of roadways caused severe traffic congestion across Southern California, including Orange County. In the City of Los Angeles, 7,300 people lost power for most of the day, and there more than 500 traffic collisions across the entire region as a result of the road conditions.
- 2017 Winter Storms[66] included three storms over six days inundating southern California. Heavy rains, combined with already saturated soil, produced flash flooding across much of Orange County. Streets flooded with 1 to 3 feet of water in Huntington Beach, Santa Ana, and Newport Beach (Irvine 2020).

Exposure

Flood zones are geographic areas that the Federal Emergency Management Act (FEMA) has defined according to varying levels of flood risk. These zones are depicted on a community's Flood Insurance Rate Map (FIRM) or Flood Hazard Boundary Map. Each zone reflects the severity or type of flooding in the area. In Irvine the 100-year and 500-year floodplains are not contiguous areas but consist instead of various pockets across the city. Most of these areas fall within the major drainages within the City, which include:

- San Diego Creek
- Serrano Creek
- Borrego Canyon Wash
- Agua Chinon Wash
- Bee Canyon Wash
- Peters Canyon Wash
- Sand Canyon Wash

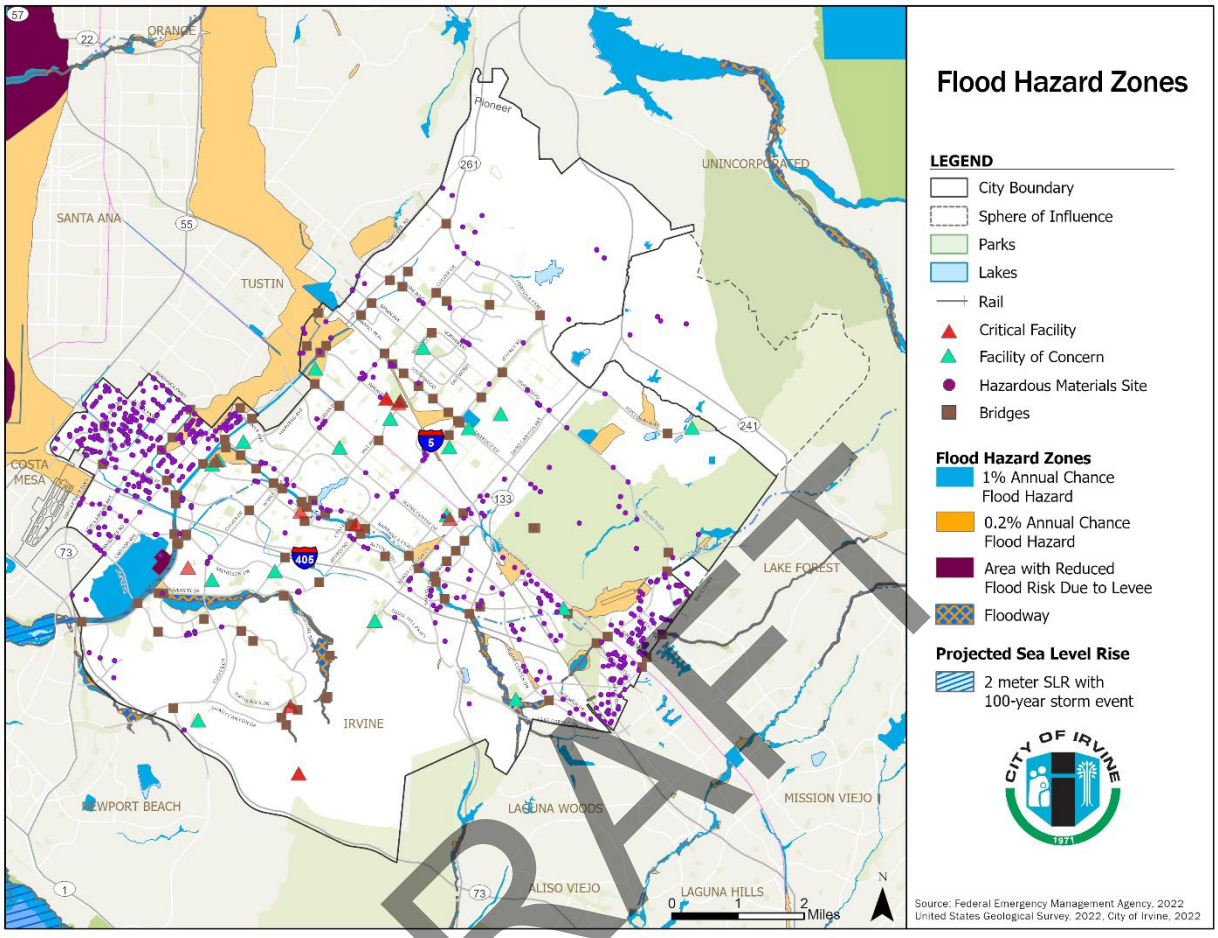
Figure 3-6: Flood Hazard Zones shows the mapped flood hazard zones for 100-year and 500-year flood events in Irvine. This map also depicts the 1-meter sea level rise data, which suggests that sea level rise may affect drainage along San Diego creek. To prevent potential flooding, Irvine has more than a dozen detention or retarding basins, generally located on, or adjacent to drainages within the City. Use of these facilities is intended to reduce downstream erosion by storing water for a limited period. These strategies can also assist with dam inundation impacts.

Floodplain mapping studies are provided by the National Flood Insurance Program. Irvine participates in the program by adopting FEMA-approved floodplain studies, maps, and regulations. These studies may be funded through federal grants; state, city, and regional agencies; and private parties. The program is designed for flood insurance and floodplain management applications.[133]

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[133] City of Irvine. 2020. Local Hazard Mitigation Plan. October.

Figure 3-6: Flood Hazard Zones



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Portions of the City are located within the 100-year flood zone (1.0 percent Annual Chance of Flooding) and the 500-year flood zone (0.2 percent Annual Chance of Flooding). Any physical assets located within these mapped boundaries can expect to be inundated if enough precipitation were to fall exceeding the storm drain infrastructure design capacity in these areas. Electronic or mechanical equipment on the ground could become waterlogged and nonfunctional. The City has several key underpasses beneath major freeways and rail lines, that if flooded could impact circulation throughout the City.

In addition, the City has key locations along Sand Canyon Avenue, Jamboree Road, Culver Drive, and Jeffrey Road that require pump stations to ensure these underpasses do not fill with water. **Figure 3-6: Flood Hazard Zones** identifies the 100-year and 500-year FEMA flood zone designations. **Table 3-10: Critical Facilities and Facilities of Concern (100-Year Flood)** identifies the physical assets in Irvine located within the 100-year flood zone. Assets include 55 bridges and three City Recreation Support facilities. Potential losses associated with this flood zone could amount to over $130 million. This estimate also includes three assets that have the potential to be impacted by 1 meter of sea level rise. These three bridges are located along San Diego Creek and have a replacement value of over $40 million. In addition, **Table 3-11: Critical Facilities and Facilities of Concern (500-Year Flood)** identifies the additional assets located within the 500-year flood zone, which account for six CFs and two FOC that account for over $12.5 million in additional assets exposed to flooding within the City.

Table 3-10: Critical Facilities and Facilities of Concern (100-Year Flood)

Category	Number of Facilities		Examples	Potential Loss*
	Critical	Concern		
City Vital Operations	-	-	City Hall, Police Station, Operations Support	$0
City Community Centers	-	-	Community Centers	$0
City Resident Services	-	-	Senior Centers, Animal Shelter, Daycare, Other Community Facilities	$0
City Recreation Support	-	3	Parks, Recreation Amenities, Sports Complexes, and support facilities	$17,390,145
Bridges	55	-	Overpasses and underpasses within the City	$113,203,067
Schools	-	-	Irvine Unified School District and Tustin Unified School District Facilities	N/A
Total	**55**	**3**		**$130,593,212**

* Based on the City of Irvine insured replacement values

** Includes three bridges that may be affected by Sea Level Rise ($40,571,700)

*** Replacement Values unavailable

Table 3-11: Critical Facilities and Facilities of Concern (500-Year Flood)

Category	Number of Facilities		Examples	Potential Loss*
	Critical	Concern		
City Vital Operations	-	-	City Hall, Police Station, Operations Support	$0
City Community Centers	1	-	Community Centers	$462,067
City Resident Services	1	-	Senior Centers, Animal Shelter, Daycare, Other Community Facilities	$2,148,923
City Recreation Support	-	2	Parks, Recreation Amenities, Sports Complexes, and support facilities	$1,499,624
Bridges	4	-	Overpasses and underpasses within the City	$8,450,960
Schools**	-	-	Irvine Unified School District and Tustin Unified School District Facilities	N/A
Total	**6**	**2**	**-**	**$12,561,574**

* Based on the City of Irvine insured replacement values

**Replacement Values unavailable

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Table 3-12: Flooding - Vulnerable Populations shows the proportions of Irvine's vulnerable populations who are likely to face a greater threat from a flood event in the City. Median household income in the 100-year flood zone is significantly higher than the citywide average. In addition, households with one member aged 65 years and older is significantly lower (4.8 percent) than the citywide average (19.5 percent). The demographics for the 500-year flood zone are like the 100-year flood zone statistics, with exception to a lower median household income and a higher percentage of households with one member aged 65 years and older.

Table 3-12: Flooding - Vulnerable Populations

	100-Year Flood	500-Year Flood	City of Irvine
Total Population[1]	370	7,635	262,665
Percent of residents that are children (less than 10 years)[2]	19.1%	10.3%	10.4%
Percent of households that have people 65+ years[1]	16.5%	12.6%	20.6%
Percentage of households with at least one person living with a disability[1]	12.1%	7.9%	12.3%
Median age[2]	36.4	35.5	34.0
Total households[1]	141	2,685	94,490
Median household income[2]	$156,785	$98,260	$113,097
Percent of rental households[2]	33.3%	-[3]	48.7%
Percent of household income below poverty level[1]	12.1%	12.0%	13.1%

Source: US Census Bureau, American Community Survey (ACS) 2015 - 2019[1], US Census Bureau 2010 Summary File 1, ESRI Forecasts 2021[2], Data discrepancy – no value provided for rental occupied housing units.

As shown in Table 3-13: English Proficiency and Languages Spoken at Home Among Residents 5 Years and Older – 100-Year Flood and Table 3-14: English Proficiency and Languages Spoken at Home Among Residents 5 Years and Older – 500-Year Flood, the majority of the estimated the residents in the 100-year or 500-year flood zones aged 5 years and older are fluent in English. 7.7 percent of residents in the 100-year flood zone and 6 percent of residents in the 500-year flood zone are not fluent in English.

Table 3-13: English Proficiency and Languages Spoken at Home Among Residents 5 Years and Older – 100-Year Flood

	Number of Speakers	Percent Not Fluent in English
English Only	138	-
Spanish	2	0%
Indo-European Languages	32	6.3%
Asian and Pacific Island Languages	177	15.3%
Other Languages	2	0%

Note: Percentage values rounded to nearest tenth decimal.

Source: US Census Bureau, American Community Survey 2015 - 2019, ESRI 2022

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Table 3-14: English Proficiency and Languages Spoken at Home Among Residents 5 Years and Older – 500-Year Flood

	Number of Speakers	Percent Not Fluent in English
English Only	3,145	-
Spanish	282	4.6%
Indo-European Languages	999	2.4%
Asian and Pacific Island Languages	2,427	14.5%
Other Languages	255	13.3%

Note: Percentage values rounded to nearest tenth decimal.

Source: US Census Bureau, American Community Survey 2015 - 2019, ESRI 2022

COASTAL FLOODING AND INUNDATION

Coastal Flooding

While Irvine is not considered a coastal community, their drainage infrastructure connects to the ocean and may be tidally influenced. In the event future sea level rise affects drainage infrastructure, it could impact future flooding within the City. As an inland community that has coastally influenced drainage infrastructure another concern that should be addressed is the potential influence of sea level rise on flood control infrastructure. In the case of Irvine, a small portion of the flood control infrastructure in the northwestern corner of the City may be influenced by sea level rise in the future.

According to OPC's *State of California Sea-Level Rise Guidance: 2018 Update*, based on projected sea-level rise for Los Angeles, there is a 0.5 percent probability that Irvine could experience between 0.7 feet of sea level rise by 2030, 1.8 feet by 2050, 6.7 feet by 2100 under the high emissions, RCP 8.5 scenario.[134]

These projections were used to select corresponding localized sea level rise modeling thresholds produced by the United States Geological Service (USGS) through their Coastal Storm Modeling System version 3.0 (CoSMoS). CoSMoS produces projections of coastal flooding and inundation that could result from sea level rise and storms while factoring in changes in beaches and the retreat of cliffs and bluffs along the California coast.[135]

The OPC projections were translated to the closest data available from CoSMoS. Based on this data selection process, the following sea level rise projections were used to estimate the exposure from daily average flooding and storm surge (100-year) flooding: 0.25 meters of sea level rise (2030 timeframe), 0.5 meters (2050 timeframe), and 2.0 meters of sea level rise (2100 timeframe).[136]

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[134] Ocean Protection Council. 2018. State of California Sea-Level Rise Guidance: 2018 Update.

[135] USGS. (n.d.). Coastal Storm Modeling System (CoSMoS). https://www.usgs.gov/centers/pcmsc/science/coastal-storm-modeling-system-cosmos?qtscience_center_objects=0#qt-science_center_objects. Accessed April 6, 2022.

[136] Sea level rise (SLR) projections from the Ocean Protection Council (OPC) were provided in feet. The United States Geological Survey's CoSMoS 3.0 model used to map the extent of flooding operates using the metric system. The OPC SLR projections (with associated timeframes) were matched to the closest value in CoSMoS for use in the analyses. As a result, the scenario elevations from CoSMoS may differ from the OPC projections.

Storm surge (100-year storm) flooding was used to estimate exposure to more severe but periodic flooding and represents the extent of flooding that would occur during a 100-year (one percent annual chance) storm assuming each sea level rise scenario. The storm surge flooding scenario is not additive to the daily flooding scenario.

Exposure

Table 3-15: Critical Facilities and Facilities of Concern (0.25-meter, 1 meter, and 2-meter SLR, both with and without 100-Year Storm Event) illustrates only the extent of flooding that would occur during a 100-year (one percent annual chance) storm at 2 meters because it represents the most severe case for the City and yet still had no impact on Critical Facilities, Facilities of Concern, or hazardous materials sites, or homes. Three bridges would be affected by projected sea level rise, but as they are concrete or pre-stressed concrete intended for water use, the effect of increased water levels should be minimal.

Table 3-15: Critical Facilities and Facilities of Concern (0.25-meter, 1 meter, and 2-meter SLR, both with and without 100-Year Storm Event)

Category	Number of Facilities		Examples	Potential Loss*
	Critical	Concern		
City Vital Operations	-	-	City Hall, Police Station, Operations Support	$0
City Community Centers	-	-	Community Centers	$0
City Resident Services	-	-	Senior Centers, Animal Shelter, Daycare, Other Community Facilities	$0
City Recreation Support	-	-	Parks, Recreation Amenities, Sports Complexes, and support facilities	$0
Bridges	3	-	Overpasses and underpasses within the City	$ 40,571,700
Schools	-	-	Irvine Unified School District and Tustin Unified School District Facilities	N/A
Total	**3**	**-**		$ 40,571,700

* Based on the City of Irvine insured replacement values

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Sensitivity: Major Community Elements

Transportation Systems

Flooding may temporarily stop any type of transportation in the City. Debris carried by floodwaters can block roadways, hinder access for vehicles, and potentially affect emergency response services. Rushing water only one foot deep is enough to carry small vehicles. The city has key underpasses beneath major freeways and rail lines, that if flooded could impact circulation throughout the city.[137]

[137] City of Irvine. 2020. Local Hazard Mitigation Plan. October.

Lifeline Utility Systems

Water pipes, wastewater pipes, and wastewater pump stations show low to medium vulnerability to coastal flooding and high vulnerability to coastal erosion. Flooding would not have a severe impact on underground pipes or pump stations, but erosion could compromise the functionality of the system.

In addition, flooding in watersheds could impact water quality by bringing more nutrients and total dissolved solids into the water supply.

Electronic or mechanical equipment on the ground could become waterlogged and nonfunctional.

Hazardous Materials

Flood water may have high levels of raw sewage or other hazardous substances. During a flood, underground storage tank (UST) systems may become displaced or damaged and release their contents into the environment, causing soil, surface water, and groundwater contamination. Flooding events can generate tons of debris, including building rubble, soil and sediments, green waste (e.g.., trees and shrubs), personal property, ash, and charred wood.[138]

Economic Elements

A severe flood situation where the maximum anticipated flood depth of one foot is realized, may prevent people who own smaller vehicles from driving to work, leading to reduced economic activity. Severe flooding that causes serious damage to homes and businesses may also result in reduced economic activity until repair work is completed.

Natural Resources Areas

Storm events could cause erosion on trails. Periodic flooding may temporarily limit access to parks, but once flood waters recede the park should be usable again with limited clean up.

Precipitation-driven flooding has the potential to impact habitats. Increased precipitation patterns could encourage the growth of invasive species.

Sensitivity: Vulnerable Populations

The threat of a flood will primarily affect those residents living within the 100-year and 500-year flood zones. Many of these zones are located along drainages within the City. Floodwaters in these areas are anticipated to rise to more than a maximum of one foot. Flooding of this type would likely inundate curb cuts as well as sidewalks to some extent. Any people in Irvine who walk or bike as their main form of transportation may encounter greater difficulties with their mobility if they do not have access to an alternative means of transportation. Seniors, persons with disabilities, and low-income persons are those most likely to be threatened.

In a flood event, any people in Irvine who walk or bike as their main form of transportation may encounter greater difficulties with their mobility if they do not have access to an alternative means of transportation. Seniors, persons with disabilities, and low-income persons are those most likely to be threatened.

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[138] United States Environmental Protection Agency. 2022. https://www.epa.gov/natural-disasters/flooding. Accessed May 6, 2022.

Flooding is the second most deadly weather-related hazard in the United States, which can be attributed mostly to drowning. Other effects can include building damage, mold, and respiratory damage.[139]

Additionally, persons who are experiencing homelessness may be caught outside during flood conditions without any shelter. Though floodwaters in Irvine are not expected to exceed a depth of one foot, even a floodwater depth of six inches may render any makeshift structures uninhabitable during the flood event. Possessions such as sleeping bags or electronic devices may be damaged or swept away by the floodwaters. Factors that make people sensitive to flooding are related to their ability to evacuate or escape the flood.[140]

As shown in **Table 3-13: English Proficiency and Languages Spoken at Home Among Residents 5 Years and Older – 100-Year Flood** and **Table 3-14: English Proficiency and Languages Spoken at Home Among Residents 5 Years and Older – 500-Year Flood**, the majority of the estimated the residents in the 100-year or 500-year flood zones aged 5 years and older are fluent in English. While 27 of the 351 residents in the 100-year flood zone and 423 of the 7,108 residents in the 500-year flood zone are not fluent in English, the City implements programs intended to communicate information to the diverse community of residents and workers with different backgrounds including the City of Irvine's website offers translation for 81 languages[141] and the Irvine Police Department is prepared to communicate with individuals with limited English proficiency[142]

Adaptive Capacity

The City has addressed flooding in planning documents such as their Local Hazard Mitigation Plan, Emergency Management Plan, and Evacuation Plan (Annex XIII). The City also has regulations and programs in place that are beneficial during flooding by limiting further potential public health impacts. The plans and programs for the City and supporting agencies are described in Chapter 2: City of Irvine Adaptive Capacity to Climate-Related Hazards, in addition to those below:

City of Irvine Local Hazard Mitigation Plan (2020)

The 2020 LHMP included mitigation actions to decrease the risks associated with flooding, including:

- Investigate permeable paving and use landscaped swales for new and replacement of City-owned hardscaped areas.
- Encourage the use of porous surfaces on new and significantly retrofitted residential and commercial developments to reduce runoff.
- Conduct frequent cleanings of storm drain intakes, especially before and during the rainy season.
- Update the City's Master Plan of Drainage on a regular basis to incorporate new data and/or address emerging issues.
- Analyze if new critical facilities can be built a minimum of 1 foot higher than the anticipated 500-year flood elevation height, to determine where it is feasible.
- Retrofit roadway medians to capture storm water during rain events.
- Prioritize retrofit improvements along major arterials/ roadways throughout the City.

[139] Hall, A., N. Berg, and K. Reich. 2018. Los Angeles Summary Report. California's Fourth Climate Change Assessment. University of California, Los Angeles. Publication number: SUM-CCCA4-2018-007.
[140] City of Irvine. 2020. Local Hazard Mitigation Plan. October.
[141] City of Irvine. 2022. https://www.cityofirvine.org/. Accessed May 3, 2022.
[142] City of Irvine. n.d. Policy 345. Limited English Proficiency Services.

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- Evaluate City assets and resources to ensure effective response (accepting evacuees) during a tsunami evacuation incident.

Floodplain Districts

While there is limited physical or social vulnerability to onshore precipitation-driven flooding, the City is well prepared to adapt to future effects of climate change related to flooding. The City recognizes that the flood hazard areas of the City of Irvine are subject to periodic inundation which results in loss of life and property, health and safety hazards, disruption of commerce and governmental services, extraordinary public expenditures for flood protection and relief, and impairment of the tax base, all of which adversely affect the public health, safety, and general welfare. In addition, these flood losses are caused by uses that are inadequately elevated, floodproofed, or protected from flood damage. The cumulative effect of obstructions in areas of special flood hazards which increase flood heights and velocities also contributes to the flood loss.

In response, the City of Irvine has adopted floodplain management regulations with the purpose of "promot[ing] the public health, safety, and general welfare, and to minimize public and private losses due to flood conditions in specific areas." The City applies a Floodplain District designation to all areas identified as flood channels and floodplains on maps published by the Federal Emergency Management Agency, Federal Insurance Administration, and flood insurance rate maps designating the floodway/ floodplain areas. Any development within this zone is required to incorporate a series of improvements or modifications to ensure the ability of structures to withstand periodic flooding.[143]

Municipal Code

The City of Irvine's construction codes are based upon the California Code of Regulations, Title 24 that includes the California Administrative Code, Building Code, Residential Code, Electrical Code, Mechanical Code, Plumbing Code, Energy Code, Historical Building Code, Fire Code, Existing Building Code, Green Building Standards Code, and California Referenced Standards Code. They are the minimum necessary to protect the public health, safety, and welfare of the City's residents.

3.3.2.5 GEOLOGIC AND SEISMIC HAZARDS

In the context of climate change vulnerability, increased liquefaction and heightened possibility of landslide events are a concern. Both hazards an indirect effect of increased precipitation and flooding because soils must be saturated with water for liquefaction or landslides to occur.

- Liquefaction occurs when seismic energy shakes an area with low-density, fine grain soil, like sand or silt, which is also saturated with water. When the shaking motion reaches these areas, it can cause these loosely packed soils to suddenly compact, making the waterlogged sediment behave more like a liquid than solid ground.
- Landslides occur when earth on slopes become destabilized, typically after heavy rains, when the precipitation saturates the soil and makes it less stable, or when significant erosion from rainfall destabilizes the ground. Slopes that have recently burned face a greater risk from rain-induced landslides, as the fires burn the trees, brush, and other vegetation that help stabilize the earth.

[143] City of Irvine. 1995. Municipal Code, Division 5- Overlay Districts, Chapter 5-2- Floodplain District. https://library.municode.com/ca/irvine/codes/zoning?nodeId=ZOOR_DIV5OVDI_CH5-2FLDI_S5-2-1STAU. Accessed May 3, 2022.

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Earthquakes may also be a source of liquefaction and landslides as the shaking can destabilize already loosened soils. Southern California is considered as one of the most seismically active regions in the United States because the faulting is dominated by the compression regime associated with the "big bend" of the San Andreas Fault Zone.

While no active faults (Alquist-Priolo Special Study Zones) are located within Irvine, there are several regional faults within Alquist-Priolo Special Study Zones near the City that could result in seismic hazards should an earthquake occur along one of them. While earthquake faults have been located in the City, they are not considered active (shown movement at the surface in the past 13,000 years) and therefore do not require delineation within a special study zone.[144]

Historical Earthquake Events

- The largest recent fault rupture near Irvine was the 1994 Northridge earthquake, a 6.7 Mw event approximately 56 miles from Irvine, and the most destructive earthquake in the United States in nearly 100 years. This event killed sixty people, injured more than 7,000, left 20,000 people homeless and damaged more than 40,000 buildings in Los Angeles, Ventura, Orange, and San Bernardino Counties. Damage to Angel Stadium occurred as a result of this event.[145]
- More recently and closer to the City, a 5.1 Mw earthquake occurred in La Habra in 2014. This event caused fault rupturing adjacent to but not directly on the Puente Hills and Whittier faults (Graves n.d.).
- Most recently a significant swarm of earthquakes in the Ridgecrest area occurred on July 4th and 5th 2019. Three tremors ranging from 5.4 to 7.1 Mw occurred within the Eastern California shear zone, a region of distributed faulting associated with motion across the Pacific-North America plate boundary, and an area of high seismic hazard.[146]

VULNERABILITY

Exposure

Liquefaction potential is predominantly located within the northern portion of the City, as well as along stream courses in the Santa Ana foothills and San Joaquin Hills. **Table 3-16: Critical Facilities and Facilities of Concern (Liquefaction)** identifies the areas susceptible to liquefaction and location of CFs and FOC. Give the extent of the liquefaction zone and density of City facilities, this hazard poses the greatest potential loss. Over $233 million in City assets composed of 78 CFs and 30 FOC are located within these areas. Potential losses include 70 bridges and 20 schools in the City of Irvine.

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[144] City of Irvine. 2020. Local Hazard Mitigation Plan. October.
[145] 2022. M 6.7 - 1km NNW of Reseda, CA (Northridge Earthquake) Overview. Accessed May 6, 2022. https://earthquake.usgs.gov/earthquakes/eventpage/ci3144585/executive
[146] 2022. M 7.1 - 2019 Ridgecrest Earthquake Sequence Overview https://earthquake.usgs.gov/earthquakes/eventpage/ci3144585/executive. Accessed May 6, 2022.

Table 3-16: Critical Facilities and Facilities of Concern (Liquefaction)

Category	Number of Facilities		Examples	Potential Loss*
	Critical	Concern		
City Vital Operations	2	-	City Hall, Police Station, Operations Support	$56,786,352
City Community Centers	4	-	Community Centers	$3,331,110
City Resident Services	2	3	Senior Centers, Animal Shelter, Daycare, Other Community Facilities	$9,029,015
City Recreation Support	-	7	Parks, Recreation Amenities, Sports Complexes, and support facilities	$31,486,344
Bridges	70	-	Overpasses and underpasses within the City	$132,520,697
Schools**	-	20	Irvine Unified School District and Tustin Unified School District Facilities	N/A
Total	**78**	**30**		**$233,153,518**

* Based on the City of Irvine insured replacement values

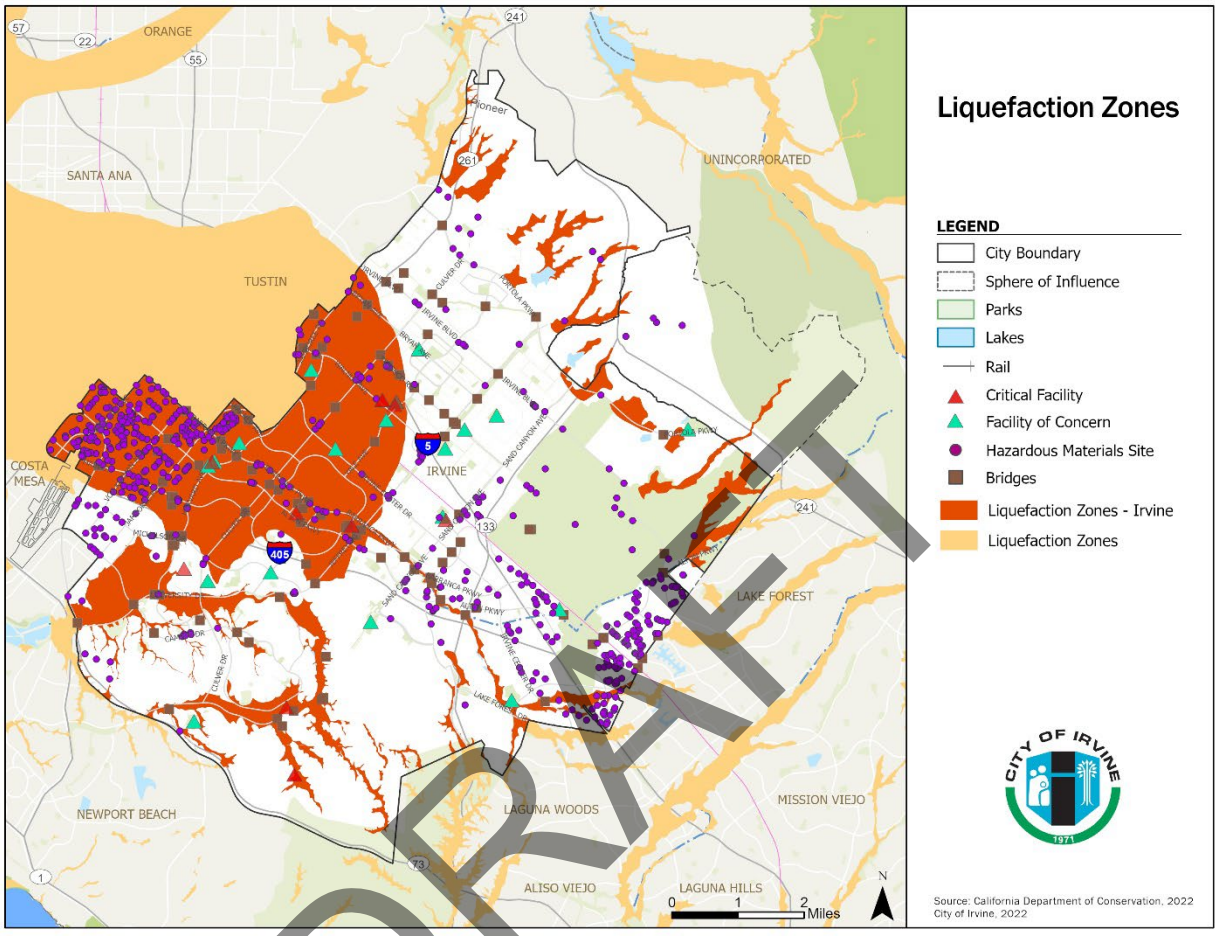
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A large proportion of the City's population (over 37 percent) face the threat of impact due to liquefaction. Thankfully, much of the construction that has occurred over the years throughout the City has taken liquefaction into consideration. Newer buildings constructed in these areas are anticipated to contain moderate- and high-income tenants that would have greater amounts of disposable income to use during recovery after an incident. However, lower income residents and residents located in areas of older construction may be impacted greater due to the lack of financial resources need to make repairs and/or the cost associated with retrofitting older buildings.

Figure 3-7: Liquefaction Zones highlights areas with potential for liquefaction, specifically along the City boundary and in the northern center of the City, primarily in low-lying zones.[147] In Irvine, there may be a potential for liquefaction in areas with loose sandy soils combined with a shallow groundwater table, which typically are in alluvial river valleys/basins and floodplains. The underlying dataset combine existing liquefaction areas from local maps, National Earthquake Hazards Reduction Program which rates soils from hard to soft and known hydric soils from the United States Department of Agriculture Soil Survey to identify the potential areas where liquefaction may occur.[148]

[147] City of Irvine. 2021a. 6th Cycle 2021-2029 Housing Element – Second Draft. November 19, 2021.
[148] City of Irvine. 2020. Local Hazard Mitigation Plan. October.

Figure 3-7: Liquefaction Zones



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Table 3-17: Liquefaction Zones – Vulnerable Populations compares the populations within the liquefaction hazard zones with city wide populations. This hazard zone covers the largest population and number of households by far, which have a median household income that is approximately $3,000 higher than the Citywide figure. Persons living with a disability is approximately 25 percent higher than the City average, while households with a member aged 65 years and older is approximately 20 percent higher than the City average.

Table 3-17: Liquefaction Zones – Vulnerable Populations

	Liquefaction	Irvine
Total Population[1]	96,491	262,665
Percent of residents that are children (less than 10 years)[2]	9.9%	10.4%
Percent of households that have people 65+ years[1]	24.0%	20.6%
Percentage of households with at least one person living with a disability[1]	15.0%	12.3%
Median age[2]	36.0	34.0
Total households[1]	34,164	94,490
Median household income[2]	$108,995	$113,097
Percent of rental households[2]	53.2%	48.7%
Percent of household income below poverty level[1]	11.4%	13.1%

Source: US Census Bureau, ACS 2015 - 2019[1], US Census Bureau 2010 Summary File 1, ESRI Forecasts 2021[2]

As shown in **Table 3-18: English Proficiency and Languages Spoken at Home Among Residents 5 Years and Older – Liquefaction Zones**, the majority of the estimated the residents in the liquefaction zone aged 5 years and older are fluent in English. 6.6 percent of residents in the liquefaction zone are not fluent in English.

Table 3-18: English Proficiency and Languages Spoken at Home Among Residents 5 Years and Older – Liquefaction Zones

	Number of Speakers	Percent Not Fluent in English
English Only	46,225	-
Spanish	5,294	5.8%
Indo-European Languages	10,497	10.9%
Asian and Pacific Island Languages	25,627	15.5%
Other Languages	536	17.2%

Note: Percentage values rounded to nearest tenth decimal.

Source: US Census Bureau, American Community Survey 2015 - 2019, ESRI 2022

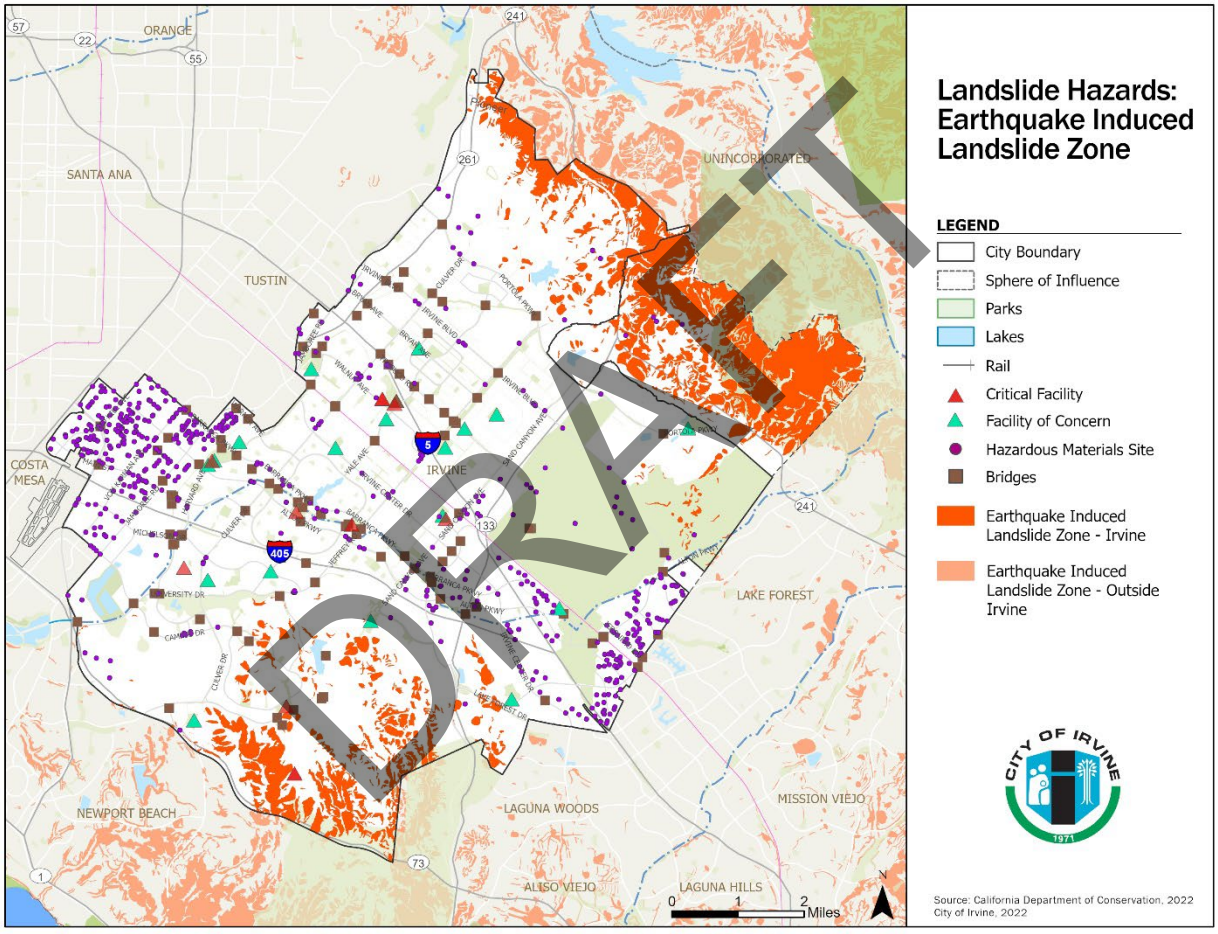
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Landslides

Landslides occur when earth on slopes become destabilized, typically after heavy rains, when the precipitation saturates the soil and makes it less stable, or when significant erosion from rainfall destabilizes the ground. Slopes that have recently burned face a greater risk from rain-induced landslides as the fires burn up many of the trees, brush, and other vegetation that help stabilize the earth. Earthquakes may also be a source of landslides as the shaking can destabilize already loosened soils. There is the potential for landslides in the steeper portions of the foothills of the Santa Ana Mountains to the northeast of the City and the San Joaquin Hills to the southwest of the City. These areas are characterized with steep topography and geologic units that can become unstable. Figure 3-8: Earthquake Induced Landslide Zone identifies the areas of the City that are considered vulnerable to seismic induced landslides. Even these areas, however, are designated as having a moderately low risk of landslides due to seismic conditions, and a low likelihood of a landslide under other conditions (Dept. of Conservation 1976). While no definitive scale for measuring landslides exists, landslide events are usually measured using the amount of material that is displaced (i.e., the cubic feet of earth that moved).

Given the topography and geologic units within the foothills of the Santa Ana Mountains and San Joaquin Hills, it is anticipated that landslide risk will remain high in those areas. However, the City requires mitigation of these types of conditions, which reduces landslide potential in the developed areas of the City. Regarding seismic activity, as **Figure 3-8: Earthquake Induced Landslide Zone** illustrates areas of the foothills of the Santa Ana Mountains and San Joaquin Hills that have the potential to fail during an earthquake. Destabilization of slopes and hills due to intense rainstorms also has the potential to cause future landslides. These can be further exacerbated after a wildfire, where vegetation becomes loosened and therefore more susceptible to becoming part of a future landslide. Overall, the probability of future occurrence within Irvine is considered occasional.[149]

Figure 3-8: Earthquake Induced Landslide Zone



As shown in **Table 3-19: Earthquake-Induced Landslide Zone - Vulnerable Populations** less than one percent of the city' households are potentially exposed to this landslide hazards. The demographics of vulnerable populations differ from those of the entire city, with a 40 percent increase in people aged 65 years and older, consistent with a higher median age.

[149] City of Irvine. 2020. Local Hazard Mitigation Plan. October.

However, with only one-third of the number of total City households living below the poverty level, a greater percentage of homeowners, and an equivalent household income, the vulnerable populations may better resources to adequately adapt to a hazardous situation or reside in a structure with adequate safety measures in place.

Table 3-19: Earthquake-Induced Landslide Zone - Vulnerable Populations

	Landslide	Irvine
Total Population[1]	1,999	262,665
Percent of residents that are children (less than 10 years)[2]	12.7%	10.4%
Percent of households that have people 65+ years[1]	28.3%	20.6%
Percentage of households with at least one person living with a disability[1]	12.6%	12.3%
Median age[2]	38.8	34
Total households[1]	612	94,490
Median household income[2]	$116,840	$113,097
Percent of rental households[2]	31.1%	48.7%
Percent of household income below poverty level[1]	4.2%	13.1%

Source: US Census Bureau, American Community Survey (ACS) 2015 - 2019[1], US Census Bureau 2010 Summary File 1, ESRI Forecasts 2021[2]

As shown in **Table 3-20: English Proficiency and Languages Spoken at Home Among Residents 5 Years and Older – Landslide Zone**, the majority of the estimated the residents in the earthquake induced landslide zone aged 5 years and older are fluent in English. 10.2 percent of residents in the earthquake induced landslide zone are not fluent in English.

Table 3-20: English Proficiency and Languages Spoken at Home Among Residents 5 Years and Older – Landslide Zone

	Number of Speakers	Percent Not Fluent in English
English Only	1,065	-
Spanish	84	3.6%
Indo-European Languages	104	2.9%
Asian and Pacific Island Languages	553	32.4%
Other Languages	5	0%

Note: Percentage values rounded to nearest tenth decimal.

Source: US Census Bureau, American Community Survey 2015 - 2019, ESRI 2022

Sensitivity: Major Community Elements

Liquefaction and Landslides

As climate change is anticipated to change the usual precipitation patterns in Southern California, including Irvine, periods of both rain and drought are anticipated to become more intense and frequent. Therefore, climate change could, depending on the circumstances, increase the future risk of liquefaction in Irvine.

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Essential Facilities

During liquefaction events, the liquified soil can lose its stability which can cause damage to buildings and infrastructure built upon it. In severe cases, buildings may completely collapse. (See Figure 3-7: Liquefaction Zones and Figure 3-8: Earthquake Induced Landslide Zone).

Transportation Systems

Services and mobility may be disrupted during and following a liquefaction event. Sidewalks, roadways, and pipelines may become fractured and disjointed as a result of the liquefying soils. Roads and sidewalks may be usable in some form, but a severe liquefaction event may render them impassible until they are repaired. Landslides may block roadways causing long-term disruptions to the roadway network, infrastructure systems and city capabilities.

Lifeline Utility Systems

Broken gas and water pipelines would result in utilities outages in Irvine homes and businesses. Since these are underground, the duration of the outage could likely be extended until the pipelines are excavated and replaced by utility operators. Damage to power lines is unlikely since the power lines themselves are not rigid structures and can move if any of the transmission towers experience slight leaning.[150]

Underground utility lines in slide-prone areas or above-ground lines built on or above them, can be damaged in a landslide, causing service outages.

Hazardous Materials

Pipelines or other utility lines running through a liquefaction zone can be breached during an event, potentially leading to flooding or release of hazardous materials. The shaking of the ground can also damage or destroy underground utilities or pipelines, potentially leading to releases of hazardous materials as well as flooding if water lines are breached. Sinking of the ground could also reduce the distance to the groundwater table, which could raise the risk of contamination from hazardous materials.[151]

Economic Elements

Homes may be damaged and mid-rise office buildings in the Centerpointe Complex would likely be rendered unsafe for occupancy if they experience any leaning or structural damage resulting from the liquefaction. Homes and businesses are typically damaged or destroyed by landslides. In addition to potentially causing significant injuries or fatalities, this can cause economic harm and create a need for long-term emergency sheltering and temporary housing until these buildings can be reconstructed.

In consideration of future degradation of structures, the City will want to monitor the quality of older housing stock to ensure it is still safe in a liquefaction event. The U. S. Department of Housing and Urban Development may consider units substandard if they were built before 1940. Fortunately for the City, less than one percent of housing units were built before 1940.[152]

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[150] City of Irvine. 2020. Local Hazard Mitigation Plan. October.
[151] City of Irvine. 2020. Local Hazard Mitigation Plan. October.
[152] US Census. 2020 ACS 5-Year Estimates Data Profiles/Housing Characteristics. https://data.census.gov/cedsci/table?tid=ACSDP5Y2020.DP04&g=0400000US06_1600000US0636770&hidePreview=true. Accessed May 3, 2022.

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Irvine is a relatively new master-planned community with multiple homeowners' associations that monitor the external physical and property conditions of housing units throughout the City. The median year structures were built was 1998.[153]

Natural Resource Areas

Landslides could affect sensitive ecological areas around the community, causing localized harm to the region's ecosystem, although widespread disruptions are unlikely.[154]

Sensitivity: Vulnerable Populations

As shown in Table 3-18: English Proficiency and Languages Spoken at Home Among Residents 5 Years and Older – Liquefaction and Table 3-20: English Proficiency and Languages Spoken at Home Among Residents 5 Years and Older – Landslide, the majority of the estimated the residents in the liquefaction or earthquake induced landslide zones aged 5 years and older are fluent in English. While 5,815 of the 88,179 residents in the liquefaction zone and 185 of the 1,811 residents in the earthquake induced landslide zone are not fluent in English, the City implements programs intended to communicate information to the diverse community of residents and workers with different backgrounds including the City of Irvine's website offers translation for 81 languages[155] and the Irvine Police Department is prepared to communicate with individuals with limited English proficiency[156]

Adaptive Capacity

The City has addressed geologic and seismic events in planning documents such as their Local Hazard Mitigation Plan, Emergency Management Plan, and Evacuation Plan (Annex XIII). The City also has regulations and programs in place that are beneficial during geologic and seismic events by limiting further potential public health impacts. The plans and programs for the City and supporting agencies are described in Chapter 2: City of Irvine Adaptive Capacity to Climate-Related Hazards, in addition to those below:

City of Irvine Local Hazard Mitigation Plan (2020)

The 2020 LHMP included mitigation actions to decrease the risks associated with liquefaction and landslides, including:

- Coordinate with Irvine Ranch Water District and the Navy on subsidence monitoring in areas of active groundwater extraction and work with water utilities to develop strategies based on the amount and severity of subsidence occurring.
- Consider reducing land use densities in areas of significant landslide threat and identify strategies for existing development downstream of these hazard areas.
- Encourage the installation of resilient (seismically appropriate) piping for new or replacement pipelines, in close coordination with local water, natural gas, and other providers.
- Assess soft story conditions for apartment buildings constructed prior to 1980.
- Conduct an educational campaign and incentives to encourage the use of reinforced chimneys, anchored rooftop-mounted equipment, window film, and other preventative measures to reduce damage at private buildings.

[153] Irvine Ranch Water District. 2021. 2020 Water Shortage Contingency Plan. June 28.
[154] City of Irvine. 2020. Local Hazard Mitigation Plan. October.
[155] City of Irvine. 2022. https://www.cityofirvine.org/. Accessed May 3, 2022.
[156] City of Irvine. n.d. Policy 345. Limited English Proficiency Services.

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- Educate community groups and industry representatives assist in outreach to residents and businesses to obtain earthquake insurance through the California Earthquake Authority.
- To the extent feasible, construct all new and significantly retrofitted City-owned facilities to remain operational in the event of a major earthquake.
- Improve local understanding of the threat of a major earthquake by conducting a city-wide scenario modeling potential loss of life and injuries, destroyed and damaged structures, and interruptions to key services.
- Retrofit key critical City facilities with seismically rated window film treatments that ensure glass windows do not shatter during a strong seismic event. Promote retrofit of key community facilities not owned by the City.
- In coordination with Caltrans, update facilities condition assessments for bridges along evacuation routes to identify bridges that need seismic retrofitting. Consider pursuing highest standard improvement options (e.g., replacement instead of retrofitting) for bridges with seismic deficiencies.
- Pursue ground improvement projects, such as constructing a high strength capping layer, soil mixing, stone columns, soil wicks, chemical and pressure grouting, and other soil improvement techniques that reduce liquefaction susceptibility for key critical facilities in the event of an earthquake.
- Incentivize utilities to install flexible jointing and pipelines across fault segments located within the City. Ensure these pipelines have the necessary countermeasures to ensure breakage of lines is kept to a minimum and adequate shut off mechanisms to reduce exposure of pipeline contents to residents and businesses.

Hillside Overlay District

The purpose of the Hillside Overlay District is to provide regulations for the development of those areas in the City of Irvine and the sphere of influence which, due to their topography, require special consideration to assure that they are developed in a way that will substantially maintain their natural character and environmental and aesthetic values.[157]

Irvine Ranch Water District: Water Shortage Contingency Plan (2021)

IRWD's Water Shortage Contingency Plan provides a series of response actions that IRWD may implement in the event of a water shortage due to drought or emergency. It assumes that under a climate change scenario, that the anticipated Water Bank Usage would be 7,300 to 11,500 acre feet per year.[158] (See Drought: Adaptive Capacity

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[157] City of Irvine. 1994. Municipal Code, Division 5- Overlay Districts, Chapter 5-2- Floodplain District. https://library.municode.com/ca/irvine/codes/zoning?nodeId=ZOOR_DIV5OVDI_CH5-4HIOVDI. Accessed May 3, 2022.
[158] Irvine Ranch Water District. 2021. 2020 Water Shortage Contingency Plan. June 28.

3.3 VULNERABILITY SCORING

The goal of this step is to identify priority climate vulnerabilities based on systematic scoring. Vulnerability scores are based on the combination of potential impact and adaptive capacity and help identify the major climate vulnerabilities. The scoring process utilizes numerical values, yet is primarily qualitative in nature.

Potential impacts are ranked through a method known as "vulnerability scoring," which is the recommended method identified in the 2020 update of the California Adaptation Planning Guide (APG 2.0). Major community elements and vulnerable populations at risk for each climate change–related effects were previously discussed per hazard according to exposure, sensitivity, and adaptive capacity. These scores are then used to determine an overall vulnerability score.

Methodology

This analysis uses the 2020 Irvine LHMP Hazard Scoring FEMA-based methodology as a baseline to score exposure and sensitivity. For the LHMP, each hazard is assigned a score of 1 to 4. The four criteria are:

- Probability: The likelihood that the hazard will occur in Irvine in the future.
- Location: The size of the area that the hazard would affect.
- Maximum probable extent: The severity of the direct damage of the hazard to Irvine.
- Secondary impacts: The severity of indirect damage of the hazard to Irvine.

The 2020 LHMP Committee assigned a weighting value to each criterion, giving a higher weight to the criteria deemed more important, and multiplied the score for each criterion by the weighing factor to determine the overall score for each criterion. The weighting values were recommended by FEMA:

- Probability: 2.0
- Location: 0.8
- Maximum probable extent: 0.7
- Secondary impacts: 0.5

After calculating the total impact score for each hazard (sum of the location, maximum probable extent, and the secondary impact). FEMA guidance recommends multiplying the total impact score by the overall probability to determine the final score for each hazard. A final score between 0 and 12 is considered a low-threat hazard, 12.1 to 42 is a medium-threat hazard, and a score above 42 is considered a high-threat hazard as illustrated in Table 3-21: Criterion Scoring (LHMP).

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Table 3-21: Criterion Scoring (LHMP)

Probability		**Maximum Probable Extent**	
The estimated likelihood of occurrence based on historical data.		**The anticipated damage to a typical structure in the community. (Primary Impact)**	
Probability	**Score**	**Impact**	**Score**
Unlikely—less than a 1 percent chance each year.	1	Weak—little to no damage	1
Occasional—a 1 to 10 percent chance each year.	2	Moderate—some damage, loss of service for days	2
Likely—a 10 to 90 percent chance each year.	3	Severe—devastating damage, loss of service for months	3
Highly likely—more than a 90 percent chance each year.	4	Extreme—catastrophic damage, uninhabitable conditions	4
Location		**Secondary Impact**	
The projected area of the community affected by the hazard.		**The estimated secondary impacts to the community at large.**	
Affected Area	**Score**	**Impact**	**Score**
Negligible—affects less than 10 percent of the planning area.	1	Negligible—no loss of function, downtime, and/or evacuations	1
Limited—affects 10 to 25 percent of the planning area.	2	Limited—minimal loss of functions, downtime, and/or evacuations	2
Significant—affects 25 to 75 percent of the planning area.	3	Moderate—some loss of functions, downtime, and/or evacuations	3
Extensive—affects more than 75 percent of the planning area.	4	High—major loss of functions, downtime, and/or evacuations	4

Source. City of Irvine. 2020. Local Hazard Mitigation Plan. October.

To perform the climate vulnerability ranking, the APG scoring rubric (See Table 3-22: Potential Impact and Adaptive Capacity Scoring Rubric) was applied to the LHMP final Hazard Scores (See Table 3-23: Hazard Scores) so the potential impact and adaptive capacity of each Major Community Element could be compared. Scores of 0 – 20 were considered Limited Impact, scores of over 20 to 40 were considered Moderate Impact, and scores above 40 were considered High Impact.

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Table 3-22: Potential Impact And Adaptive Capacity Scoring Rubric (APG)

Score*	Potential Impact	Adaptive Capacity
Limited	Impact is unlikely based on projected exposure; would result in minor consequences to public health, safety, and/or other metrics of concern.	The population or asset lacks capacity to manage climate impact; major changes would be required.
Moderate	Impact is somewhat likely based on projected exposure; would result in some consequences to public health, safety, and/or other metrics of concern.	The population or asset has some capacity to manage climate impact; some changes would be required.
High	Impact is highly likely based on projected exposure; would result in substantial consequences to public health, safety, and/or other metrics of concern.	The population or asset has high capacity to manage climate impact; minimal to no changes are required.

Source: CalOES APG 2.0, Modified.

Table 3-23: Hazard Scores (LHMP)

Hazard Type*	Probability	Impact			Total Score	Potential Impact Score
		Location	Primary Impact	Secondary Impacts		
Seismic Hazards[1]	4	4	4	4	64.0	High
Wildfire	4	3	3	3	48.0	High
Drought	3	4	4	4	48.0	High
Extreme Heat[2]	3	4	2	2	33.6	Moderate
Geologic Hazards[3]	2	2	3	3	20.8	Moderate
Flooding[4]	2	3	2	2	19.2	Limited

*Climate Change considerations discussed as appropriate within this hazard.

[1] Seismic Hazards includes: Fault Rupture, Seismic Shaking, Liquefaction

[2] The original category was Severe Weather includes: Extreme Heat, Severe Wind, Rain

[3] Geologic Hazards includes: Expansive Soils, Landslides, Methane Containing Soils, and Subsidence

[4] Flooding includes a discussion regarding sea level rise

Source: Irvine LHMP 2020, modified.

Applying these generalized "Potential Impact Scores" from Table 3-23: Hazard Scores (LHMP) to the APG Vulnerability Score matrix (See Table 3-24: Vulnerability Score Matrix) produces an Irvine-focused vulnerability score for each Major Community Element and Vulnerable Population in Irvine by climate hazard (See Table 3-25: Climate Hazard Vulnerability Scores).

Note: The LHMP generalized the hazard impacts to the full community and this assessment considers subcomponents (i.e., Major Community Elements). Therefore, the "Potential Impact Scores" from the Table 3-23: Hazard Scores (LHMP) were considered only as a baseline. Additional information from this report's evaluation of Major Community Elements and Vulnerable Populations exposure and sensitivity to climate hazards may have altered the final climate vulnerability scores as shown in Table 3-25: Irvine Climate Hazard Vulnerability Scores.

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Table 3-24: Vulnerability Score Matrix

Potential Impacts	High	Moderate	Limited
High	3	4	5
Moderate	2	3	4
Limited	1	2	3

Adaptive Capacity

Source: CalOES APG 2.0

Table 3-25: Irvine Climate Hazard Vulnerability Scores

Liquefaction	**Impact**	**Adaptive Capacity**	**Score**
Essential Facilities	High	Moderate	4
Transportation Systems	High	Limited	5
Lifeline Utility Systems	High	Moderate	4
Hazardous Materials	High	Moderate	4
Economy	Moderate	High	2
Natural Resource Areas	Limited	High	3
Vulnerable Populations	Moderate	Moderate	3

Wildfire + Smoke	**Impact**	**Adaptive Capacity**	**Score**
Essential Facilities	High	Moderate	4
Transportation Systems	Moderate	High	2
Lifeline Utility Systems	High	Moderate	4
Hazardous Materials	High	Moderate	4
Economy	Moderate	Moderate	3
Natural Resource Areas	High	Limited	5
Vulnerable Populations	High	Moderate	4

Drought	**Impact**	**Adaptive Capacity**	**Score**
Essential Facilities	Limited	High	4
Transportation Systems	Limited	High	1
Lifeline Utility Systems	High	Moderate	4
Hazardous Materials	Limited	High	4
Economy	Moderate	Moderate	3
Natural Resource Areas	High	Limited	5
Vulnerable Populations	Limited	Moderate	2

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Table 3-25: Irvine Climate Hazard Vulnerability Scores (continued)

Extreme Heat	Impact	Adaptive Capacity	Score
Essential Facilities	Moderate	High	2
Transportation Systems	Moderate	Moderate	3
Lifeline Utility Systems	High	Moderate	4
Hazardous Materials	Moderate	Moderate	3
Economy	Moderate	Moderate	3
Natural Resource Areas	High	Limited	5
Vulnerable Populations	High	Limited	5

Landslide	Impact	Adaptive Capacity	Score
Essential Facilities	Limited	High	1
Transportation Systems	Moderate	High	2
Lifeline Utility Systems	Moderate	Moderate	3
Hazardous Materials	Limited	Moderate	2
Economy	Limited	High	1
Natural Resource Areas	Limited	High	1
Vulnerable Populations	Limited	High	1

Flooding	Impact	Adaptive Capacity	Score
Essential Facilities	Limited	High	1
Transportation Systems	Moderate	Moderate	3
Lifeline Utility Systems	Moderate	Moderate	3
Hazardous Materials	Limited	High	1
Economy	Limited	High	1
Natural Resource Areas	Limited	High	1
Vulnerable Populations	Limited	High	1

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CITY OF IRVINE

CLIMATE ADAPTATION FRAMEWORK

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February 2023

CLIMATE ADAPTATION FRAMEWORK

Preparing Irvine for the impacts of climate change requires significant investment in time and resources across all parts of the community, including businesses, health, emergency services, government, schools, infrastructure, culture, and natural resources. This chapter provides a list of 151 potential actions the City of Irvine can consider for future climate adaptation and resilience efforts. Actions are divided into climate hazard sections (and include a "City-wide" section), like the body of the Vulnerability Assessment as follows:

- Citywide (48 actions)
- Extreme Heat Events (23 actions)
- Drought (15 actions)
- Wildfire (27 actions)
- Flooding (22 actions)
- Liquefaction/Landslide (16 actions)

The hazard sections are organized by the following categories (not all categories apply to each hazard):

PLANNING AND COLLABORATION

The complexity and interconnectedness of climate change requires a significant investment in community engagement and education to increase awareness and resilience. In addition, land use, geography, and transportation network infrastructure necessitate comprehensive and multi-jurisdictional adaptation approaches and solutions in partnership with local, regional, and State partners. Programs that educate and inform residents, visitors, businesses, and local decision-makers can empower individuals to take actions to reduce risk for themselves. Programs that seek to bring community members together can create lasting connectivity among neighbors who can plan together to get out of harm's way.

HEALTHY COMMUNITIES

Climate change can affect the health of residents, workers, and tourist of Irvine. Impacts include respiratory impacts from smoke, heat-related illnesses, increasing allergies and asthma, food-borne and water-borne illnesses, and mental health impacts from extreme events. More frequent and severe storms, floods, heat waves, wildfires, and other extreme events create additional stresses to healthcare systems, employees, and infrastructure. Maintaining and improving the physical and mental health should be a top priority.

As climate-related hazards are expected to worsen in coming decades, the Irvine community will need to increase their preparation, response, recovery, and mitigation efforts. The intent is to strengthen safety nets by expanding and strengthening community preparedness and resilience through collaboration, education, and lasting partnerships that emphasize community well-being.

CLIMATE EQUITY

As discussed in the Vulnerability Assessment, Climate change does not affect all residents evenly. Climate hazards can disproportionality effect vulnerable populations that may have a more challenging time responding to hazard events because of age, language barriers, income, housing, or other characteristics. To address these differences, climate adaptation actions were developed to address the specific needs of those most vulnerable to hazards.

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EMERGENCY PREPAREDNESS

Emergency preparedness requires proactive planning, strong communication, and reliable and clear sources of information available through multiple channels. To minimize the impact of potential disasters for community members, the City plays a key role in making sure residents and visitors have the correct information about what to do and where to go in the event of a disaster. Individuals also have a responsibility in emergency preparedness, and should stay informed, prepare emergency kits, and otherwise take precautions to minimize risk to themselves and their families. In addition, clear evacuation protocol, planning, and practice are crucial factors for community preparedness.

Future planning efforts should focus on regional connectivity and communication, engaging the right regional partners in evacuation planning, optimizing the Irvine and Orange County evacuation protocols, and identifying key potential challenges in regional evacuations.

RESILIENT BUILDINGS

Irvine development includes a mix of buildings, including master-planned communities and neighborhoods of single- and multi-family homes, along with commercial and industrial buildings. Upgrades to business and residential structures to reduce fire-, flood-, geologic-, and seismic-related vulnerability can be combined with efforts to increase energy efficiency and reduce greenhouse gas emissions. Both objectives lead to meaningful climate action that save money and improve quality of life for residents and promote a sustainable economy.

RESILIENT INFRASTRUCTURE

Implementation and management of Irvine infrastructure will determine how well it can protect residents and accommodate or mitigate future climate and extreme weather impacts. As the City does not own directly owned or operated all the critical infrastructure (e.g., electricity, water, or telecommunications), it must work directly with those companies, agencies, and organizations to enhance the resilience of those systems. Continuous investment in transportation infrastructure may be needed to facilitate mobility throughout the City in both everyday life and in an emergency.

RESILIENT ECOSYSTEMS

Natural systems provide valuable functions to both residents and visitors in the form of ecosystem services (water storage, etc.) in the watershed and open space. Natural lands and open space are increasingly will be increasingly affected by climate change and will need to be managed for continued natural function. Some of the climate-related threats include pests and diseases that can affect native trees, drought that weakens vegetation, floods and large storms that knock down trees and destroy landscaping, and overall climate shifts that make existing vegetation incompatible with the new conditions.

Adaptation actions were developed to maintain and strengthen natural ecosystems by enhancing wildfire resistance and resilience; protecting and restoring native habitats and species; and enhancing ecosystem services.

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Notes on the Evaluation and Implementation of Climate Adaptation Actions

As part of the adaptation assessment process, potentially relevant adaptation actions were collected through research of Irvine planning documents (e.g., Local Hazard Mitigation Plan), other climate adaptation plans in the State of California, and from communities across the country. These actions were modified specifically for Irvine and should be updated accordingly as adaptation planning and implementation processes progress.[1]

Actions listed can be complementary, directly dependent on the implementation of another action (before or after), implemented in conjunction (or sequentially) with other actions, or mutually exclusive of one another (implementing one action negates the effectiveness or ability to implement another action).

The list of actions provided is not necessarily the full suite of actions that are appropriate for the City. Instead, this list provides the City with a suite of the most appropriate options to consider when working to achieve the community's current climate resiliency goals. As industry and best practices evolve, it is likely that additional actions will be considered (or removed from consideration) as adaptation planning progresses.

It is up to the City to discuss these actions with the community and take into consideration various factors to determine which actions get implemented. To determine if these actions were appropriate and suitable, the following three-part evaluation process can be implemented to evaluate each of the actions. This screening process should allow for quick filtering of actions that are not a good fit for the community, by considering whether the action(s):

- Will help the City achieve its resilience goals;
- Will be effective;
- Will be very costly; or
- Has low feasibility.

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Evaluation Terminology

Effectiveness is the extent to which the adaptation action achieves the desired outcomes. Considerations for effectiveness include, but are not limited to:

- Does the action reduce vulnerability, risk, or short- and long-term impacts of climate change and extreme weather events?
- What future losses will be avoided? Does the scale of the action meet the scale of the challenge?
- Is the approach equitable?

Cost-efficient is the extent to which the adaptation action makes efficient use of resources (funding, expertise, and staff time). Considerations for cost-efficiency include, but are not limited to:

- Does the effort and resources needed to implement the action match the intended result?

[1] Those actions pulled from Irvine planning documents are noted in the actions list and have not been modified.

- Are there co-benefits to implementation?
- Can the action be implemented in parallel with another action?

Feasibility is the extent to which the adaptation action can successfully be implemented. Considerations for feasibility include, but are not limited to:

- Is the appropriate technical, political, and community capacity in place to make the action successful?
- Is it deemed acceptable by all segments of the community?

Action Key

Each action is formatted as follows.

Action Code #: [Citywide (CW), Extreme Heat (EH), Drought (D), Wildfire (WF), Flooding (F), Liquefaction/Landslide (L) - Grouping Initials - #]:

ACTION (in bold).

● **Type of action:** Project/Policy/Program

● **Example Partners:** Internal City departments and external agencies that should be or considered for involvement in planning and implementation of the action. Some actions will require a lead and additional partners to successfully implement the action.

● **Estimated Cost:** *Low (<$100k), Medium ($100k - $1,000,000), High (>$1 million)*. These are potential cost ranges that are likely to change as actions are refined and improved prior to implementation.

● **Timeframe for Implementation:** *Ongoing, Near-term (<5 years), Medium-term (5-20 years), Long-term (>20 years)*. While most actions in the Adaptation Framework focus on the near-term, thought it may not be feasible or realistic to implement them within that time frame due to shifts in priority or capacity. A few actions have specific timeframes of effectiveness, but others can be implemented if or when deemed necessary.

Note: The numbering of actions is meant to serve as a coding system and make it easier to find actions. It does not represent priority or order of implementation.

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CITYWIDE ACTIONS (CW)

PLANNING AND COLLABORATION

CW-1: Collaborate with local and regional partners to support business resilience through emergency preparedness education, training, and resources.

- **Type of Action:** Program
- **Potential Partners:** Irvine Community Development Department, Irvine Office of Emergency Management, Irvine Chamber of Commerce, Local Businesses, Orange Chamber of Commerce and Visitor Bureau
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Near-term (<5 years)

CW-2: Continue coordination with important community assets (e.g., schools, businesses) to ensure staff, personnel, and community members understand the ramifications of, and are planning for, extreme weather events and emergencies.

- **Type of Action:** Program
- **Potential Partners:** Irvine Community Development Department, Irvine Office of Emergency Management, Irvine Unified School District Emergency Operations Center, Governor's Office of Emergency Services (Cal OES), FEMA's Youth Preparedness Programs, Red Cross, California Department of Education
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Ongoing

CW-3: Require that climate projections and the impacts associated with them are included in all City planning documents, policies, programs, and ordinances as they are reviewed or updated.

- **Type of Action:** Policy
- **Potential Partners:** Irvine Community Development Department, Irvine Public Works and Transportation Department
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Ongoing

CW-4: Update climate adaptation assessment to include monitoring and evaluation metrics that evaluate the efficacy of the climate change resilience actions.

- **Type of Action:** Project
- **Potential Partners:** Irvine Community Development Department, Irvine Public Works and Transportation Department
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Near-term (<5 years)

CW-5: Involve community groups and schools in monitoring trigger/threshold level indicators to determine when adaptation actions should be implemented or modified in response to changing indicators.

- **Type of Action:** Program
- **Potential Partners:** Irvine Environmental Programs, Irvine Community Development Department
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Near-term (<5 years)

CW-6: Modify the City Council Agenda process and/or report template to require inclusion of a statement about how a proposed project or program supports or addresses climate adaptation.

- **Type of Action:** Policy
- **Potential Partners:** Irvine Community Development Department, Irvine Office of Emergency Management, Irvine Public Works and Transportation Department,
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Near-term (<5 years)

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CW-7: Actively pursue financing and funding opportunities to fund short- and long-term adaptation implementation projects (e.g., ensure the City has the appropriate planning documents to leverage FEMA mitigation funding).

- **Type of Action:** Project
- **Potential Partners:** Irvine Community Development Department, Irvine Office of Emergency Management, Irvine Public Works and Transportation Department, FEMA, CalOES,
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Near-term (< 5 years)

CW-8: Continue to update the Local Hazard Mitigation Plan every five years to comprehensively plan for current and future natural and human-cased hazards within the City.

- **Type of Action:** Program
- **Potential Partners:** Irvine Office of Emergency Management, Irvine Community Development Department, Irvine Public Works and Transportation Department, CalOES, FEMA, CAL FIRE
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Near-term (< 5 years)

CW-9: Coordinate with regional health care facilities to ensure effective care to all City residents and regional travelers during an emergency.

- **Type of Action:** Program
- **Potential Partners:** Irvine Health and Human Services, Orange County Fire Authority, Orange County Health Care Agency, OC Access (OCTA)
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Near-term (< 5 years)

CW-10: Support regional healthcare providers as they develop climate change-related mental health and trauma treatment measures and incorporate them as appropriate into existing City plans, trainings, programs, and policies.

- **Type of Action:** Project
- **Potential Partners:** Irvine Health and Human Services, Orange County Health Care Agency, Irvine Office of Emergency Management
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Near-term (< 5 years)

CW-11: Establish relationships with representatives from the CDC about the Community Assessment for Public Health Emergency Response (CASPER) program in preparation for extreme weather events or natural disasters.

- **Type of Action:** Project
- **Potential Partners:** Irvine Health and Human Services, Irvine Office of Emergency Management, Centers for Disease Control and Prevention (CDC)
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Near-term (<5 years)

CW-12: Support regional (or county-wide) vulnerability assessment for the healthcare system (including dialysis clinics and pharmacies) and its ability to handle climate hazards (including non-climate hazards that may exacerbate risk).

- **Type of Action:** Program
- **Potential Partners:** Irvine Health and Human Services, Orange County Fire Authority, Orange County Health Care Agency, UCI Medical Center, Hoag Hospital, Health Centers, Senior Living Facilities, Community Service Centers, and California Department of Public Health
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Near-term (< 5 years)

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CW-13: Formalize partnerships with regional partners (e.g., the University of California and their Climate Stewards Program) to support climate literacy.

- **Type of Action:** Project
- **Potential Partners:** Irvine Health and Human Services, Irvine Community Development Department, University of California-Irvine, Climate Action Campaign
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Near-term (<5 years)

HEALTHY COMMUNITIES

CW-14: Expand upon existing climate awareness communications programs and campaigns that help community members understand potential risks, solutions, and opportunities to address climate impacts.

- **Type of Action:** Program
- **Potential Partners:** Irvine Environmental Programs
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Near-term (< 5 years)

CW-15: Publish a guide or online portal of actions that commercial and residential property owners can take to make their homes and buildings more resilient to climate change.

- **Type of Action:** Project
- **Potential Partners:** Irvine Office of Emergency Management, Irvine Community Development Department, Irvine Environmental Programs
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Near-term (<5 years)

CW-16: Continue to build the capacity of community groups (e.g., Neighborhood Action Plans, Earth Day Events, Cool Block Program) to increase their engagement in climate change adaptation related activities.

- **Type of Action:** Program
- **Potential Partners:** Neighborhood groups, Irvine Environmental Programs, Irvine Community Development Department
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Near-term (<5 years)

CW-17: Engage youth in the City's climate adaptation work through school education initiatives.

- **Type of Action:** Project
- **Potential Partners:** Irvine Environmental Programs, Irvine Community Development Department, Irvine Unified School District
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Near-term (<5 years)

CW-18: Reduce the exposure of persons experiencing homelessness to safety and health impacts from climate hazards.

- **Type of Action:** Project
- **Potential Partners:** Irvine Community Development Department, Irvine Health and Human Services, Orange County Homeless Prevention – Continuum of Care System
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Near-term (<5 years)

CLIMATE EQUITY

CW-19: Work with or support community organizations as they identify gaps in vulnerable community resilience planning and further engage vulnerable community members in wildfire risk, evacuation, and resilience work.

- **Type of Action:** Project

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● **Potential Partners:** Irvine Community Development Department, Irvine Health and Human Services, California Association of Community Health Workers
● **Estimated Cost:** Low (<$100k)
● **Timeframe for Implementation:** Near-term (<5 years)

CW-20: Complete an equity impact evaluation for climate action and adaptation planning and implementation processes.
● **Type of Action:** Project
● **Potential Partners:** Irvine Community Development Department, UCI Center for Environmental Health Disparities Research, Environmental Justice Orange County, Climate Action Campaign, Orange County Power Authority, Orange County Civic Engagement Table
● **Estimated Cost:** Low (<$100k)
● **Timeframe for Implementation:** Near-term (<5 years)

CW-21: Ensure that community evacuation plans include provisions for community members who do not have access to private vehicles or are otherwise unable to drive. (LHMP P5)
● **Type of Action:** Project
● **Potential Partners:** Irvine Office of Emergency Management, Irvine Health and Human Services, Irvine Police Department, Orange County Fire Authority, Orange County Health Care Agency, OC Access (OCTA), Orange County Social Services Agency – Independent Living Program
● **Estimated Cost:** Low (<$100k)
● **Timeframe for Implementation:** Ongoing

CW-22: Continue to ensure effective emergency notifications through multiple media formats, in at least English, Spanish, Mandarin, Farsi, Korean, and Vietnamese; about pending, imminent, or ongoing emergency events. Ensure that information is accessible to persons with disabilities and functional needs. (LHMP P6)
● **Type of Action:** Project
● **Potential Partners:** Irvine Office of Emergency Management, Irvine Health and Human Services, Irvine Police Department, Orange County Fire Authority, Orange County Health Care Agency, OC Access (OCTA), Orange County Social Services Agency – Independent Living Program, Orange County Deaf Equal Access Foundation, California Public Utilities Commission
● **Estimated Cost:** Low (<$100k)
● **Timeframe for Implementation:** Near-term (< 5 years)

CW-23: Promote the California Low-Income Home Energy Assistance Program (LIHEAP) and Low-Income Weatherization Program (LIWP) to ensure all residents, especially low-income residents, have access to and understand what resources are available.
● **Type of Action:** Project
● **Potential Partners:** Irvine Community Development Department, California Department of Community Services and Development
● **Estimated Cost:** Low (<$100k)
● **Timeframe for Implementation:** Medium-term (5-20 years)

CW-24: Consult with disability specialists to ensure that plans and protocols provide adequate access and function for people with disabilities.
● **Type of Action:** Project
● **Potential Partners:** Irvine Health and Human Services, Orange County Fire Authority, Orange County Health Care Agency, OC Access (OCTA), Orange County Social Services Agency – Independent Living Program, Orange County Deaf Equal Access Foundation, California Public Utilities Commission
● **Estimated Cost:** Low (<$100k)
● **Timeframe for Implementation:** Near-term (< 5 years)

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EMERGENCY PREPAREDNESS

CW-25: Support updates (if necessary) to ensure that the City and County emergency response plans reflect equitable approaches to emergency preparedness and fully address the needs of all residents (e.g., hearing/visually impaired).

- **Type of Action:** Program
- **Potential Partners:** Irvine Office of Emergency Management, Irvine Health and Human Services, Irvine Police Department, Orange County Fire Authority, Orange County Health Care Agency, OC Access (OCTA), Orange County Social Services Agency – Independent Living Program, Orange County Deaf Equal Access Foundation, California Public Utilities Commission
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Near-term (< 5 years)

CW-26: Educate all community members about evacuation protocols, maps, and procedures for emergency preparedness and evacuation.

- **Type of Action:** Program
- **Potential Partners:** Irvine Office of Emergency Management, Irvine Police Department, Orange County Fire Authority, Prepare Irvine, AlertOC, Irvine's Community Emergency Response Team
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Ongoing

CW-27: Coordinate regularly with surrounding municipalities and Orange County to enhance evacuation and emergency management protocols, agreements, and processes.

- **Type of Action:** Program
- **Potential Partners:** Irvine Office of Emergency Management, Irvine Police Department, Orange County Fire Authority, CAL FIRE
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Ongoing

CW-28: Work with local businesses and organizations to conduct regular workplace emergency preparedness drills. (LHMP P3)

- **Type of Action:** Program
- **Potential Partners:** Irvine Office of Emergency Management, Orange County Chamber of Commerce
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Ongoing

CW-29: Expand participation in the Irvine Community Emergency Response Team (CERT) program for residents and businesses. (LHMP P4)

- **Type of Action:** Project
- **Potential Partners:** Irvine Office of Emergency Management, Irvine Police Department, Orange County Fire Authority
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Ongoing

CW-30: Identify opportunities to expand access to emergency and evacuation notices via multiple sources, including voice, text, siren, radio, and outdoor broadcasts.

- **Type of Action:** Project
- **Potential Partners:** Irvine Office of Emergency Management, Irvine Police Department, Orange County Fire Authority, CAL FIRE
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Near-term (< 5 years)

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CW-31: Evaluate and enhance existing preparedness and evacuation programs (e.g., Prepare Irvine, AlertOC) to better educate, inform, and engage the public about emergency preparedness in the case of a disaster.
- **Type of Action:** Project
- **Potential Partners:** Irvine Office of Emergency Management, Irvine Police Department, Orange County Fire Authority, CAL FIRE
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Near-term (< 5 years)

CW-32: Strengthen community resilience through the development of neighborhood disaster plans.
- **Type of Action:** Project
- **Potential Partners:** Irvine Office of Emergency Management, Irvine Police Department, Orange County Fire Authority, Irvine Community Development Department
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Near-term (< 5 years)

CW-33: Ensure that emergency staging locations and temporary evacuation refuge areas are not situated in areas subject to temporary or permanent flooding or in high-risk wildfire zones.
- **Type of Action:** Project
- **Potential Partners:** Irvine Office of Emergency Management, Irvine Police Department, Orange County Fire Authority, Irvine Community Development Department, Governor's Office of Emergency Services (Cal OES), FEMA
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Near-term (< 5 years)

CW-34: Preserve and improve the transportation infrastructure to streamline traffic flow in case of an emergency evacuation by integrating sustainable methods (e.g., up-to-date traffic control centers, solar powered signs)
- **Type of Action:** Program
- **Potential Partners:** Irvine Office of Emergency Management, Irvine Police Department, Irvine Public Works and Transportation Department, Orange County Fire Authority, Irvine Community Development Department, Caltrans, Orange County Transit Authority
- **Estimated Cost:** High ($100k-$1 million)
- **Timeframe for Implementation:** Near-term (< 5 years)

CW-35: Continue agreements with local school districts to ensure that school facilities can act as evacuation sites during major emergencies. (LHMP P2)
- **Type of Action:** Policy
- **Potential Partners:** Irvine Office of Emergency Management, Irvine Unified School District
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Ongoing

CW-36: Develop formalized agreements (MOU's) with hotels, AirBnBs and other vacation rental services, and other commercial spaces to designate them as Red Cross facilities in the case of an emergency.
- **Type of Action:** Policy
- **Potential Partners:** Irvine Office of Emergency Management, Airbnb, Vrbo,
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Near-term (< 5 years)

RESILIENT BUILDINGS

CW-37: Identify opportunities to use school facilities as evacuation centers, cooling centers, and charging stations, during extreme heat or weather events.
- **Type of Action:** Project

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- **Potential Partners:** Irvine Office of Emergency Management, Irvine Community Development, Department Governor's Office of Emergency Services (Cal OES)
- **Estimated Cost:** Medium ($100k - $1 million)
- **Timeframe for Implementation:** Near-term (<5 years)

CW-38: Ensure that any new development provides adequate emergency response capabilities.
- **Type of Action:** Policy/Project
- **Potential Partners:** Irvine Office of Emergency Management, Irvine Police Department, Irvine Public Works and Transportation Department, Orange County Fire Authority, Irvine Community Development Department,
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Near-term (< 5 years)

CW-39: Ensure that all regional and City transportation plans reflect updated evacuation routes, strategies, and data.
- **Type of Action:** Project
- **Potential Partners:** Irvine Office of Emergency Management, Irvine Police Department, Irvine Public Works and Transportation Department, Orange County Fire Authority, Irvine Community Development Department, Caltrans, Orange County Transit Authority
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Near-term (< 5 years)

CW-40: Identify gaps in current communication pathways with vulnerable community members during planned (e.g., PSPS events) or unplanned power outages (with particular attention to those with developmental or physical disabilities).
- **Type of Action:** Project
- **Potential Partners:** Southern California Edison, California Public Utilities Commission, Irvine Office of Emergency Management
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Near-term (< 5 years)

CW-41: Complete detailed City evacuation planning maps and incorporate them into the Neighborhood Action Plans that include localized community refuge areas (that are not in locations vulnerable to climate hazards).
- **Type of Action:** Project
- **Potential Partners:** Irvine Office of Emergency Management, Irvine Police Department, Irvine Public Works and Transportation Department, Orange County Fire Authority, Irvine Community Development Department
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Near-term (< 5 years)

CW-42: Update evacuation and emergency plans and consider ways in which non-related climate stressors would impact evacuation planning (e.g., pandemics, earthquakes, terrorist attacks).
- **Type of Action:** Project
- **Potential Partners:** Irvine Office of Emergency Management, Irvine Police Department, Irvine Public Works and Transportation Department, Orange County Fire Authority, Irvine Community Development Department, CalOES, FEMA
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Near-term (< 5 years)

RESILIENT INFRASTRUCTURE

CW-43: Maintain at least one emergency power-generating station in all critical facilities that the City could use as an emergency public assembly area, such as City Hall, Community Centers, and any others that the City may so designate in the future. (LHMP P7)

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- **Type of Action:** Project
- **Potential Partners:** Irvine Office of Emergency Management, Department of Public Works and Transportation, SCE
- **Estimated Cost:** Medium ($100k - $1 million)
- **Timeframe for Implementation:** Ongoing

CW-44: Coordinate with regional and local transportation agencies to ensure redundancy of high-use transportation corridors to allow for continued access and movement in the event of an emergency.
- **Type of Action:** Program
- **Potential Partners:** Irvine Office of Emergency Management, Irvine Public Works and Transportation Department, Irvine Community Development Department, Caltrans, Orange County Transit Authority
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Near-term (< 5 years)

CW-45: Advocate for and work with regional utilities to enhance the preparedness, protection, and resilience of water, energy, and telecommunications infrastructure.
- **Type of Action:** Program
- **Potential Partners:** Irvine Office of Emergency Management, Southern California Edison, California Public Utilities Commission, Metropolitan Water District, Irvine Ranch Water District, Orange County Water District, Telecommunications Network Carriers (Verizon, T-Mobile, AT&T), Internet Providers.
- **Estimated Cost:** High (>$1 million)
- **Timeframe for Implementation:** Medium (5-20 years)

CW-46: Ensure that the City integrates transit agencies into the evacuation preparedness planning, comprehensive safety protocols, and emergency command structure.
- **Type of Action:** Project
- **Potential Partners:** Irvine Office of Emergency Management, Irvine Public Works and Transportation Department, Irvine Community Development Department, Orange County Transit Authority
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Near-term (< 5 years)

CW-47: Coordinate with regional and local transit providers to ensure that transit services can continue to operate during and after extreme events by coordinating with regional transit providers to identify alternative routes and stops if the primary infrastructure is damaged or closed.
- **Type of Action:** Project
- **Potential Partners:** Irvine Office of Emergency Management, Irvine Public Works and Transportation Department, Irvine Community Development Department, Caltrans, Orange County Transit Authority
- **Estimated Cost:** *Low (<$100k)*
- **Timeframe for Implementation:** Near-term (< 5 years)

CW-48: Enhance the capacity and resilience of the transportation network with multimodal and local access improvements.
- **Type of Action:** Project
- **Potential Partners:** Irvine Public Works and Transportation Department, Irvine Community Development Department, Orange County Transit Authority
- **Estimated Cost:** High (>$1 million)
- **Timeframe for Implementation:** Near-term (<5 years)

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EXTREME HEAT EVENTS (EH)

PLANNING AND COLLABORATION

EH-1: Collaborate with State and regional agencies and organizations to share best practices for addressing heat Impacts.

- **Type of Action:** Project
- **Potential Partners:** Irvine Office of Emergency Management, Irvine Health and Human Services, Irvine Community Development Department
- **Estimated Cost:** High (>$1 million)
- **Timeframe for Implementation:** Ongoing

EH-2: Notify residents through public service announcements a couple of days in advance of a severe weather event (e.g., extreme heat event). Focus on media methods that target vulnerable populations, such as the elderly, sick, lower-income, or persons with limited mobility to better ensure they have adequate time to prepare. (LHMP 11.01)

- **Type of Action:** Project
- **Potential Partners:** Irvine Office of Emergency Management, Irvine Public Works and Transportation Department, Irvine Community Development Department
- **Estimated Cost:** High (>$1 million)
- **Timeframe for Implementation:** Ongoing

EH-3: Work with regional and local health agencies to evaluate extreme heat warning thresholds and protocols and incorporate enhanced extreme heat preparedness into local operations.

- **Type of Action:** Project
- **Potential Partners:** Irvine Office of Emergency Management, Irvine Public Works and Transportation Department, Irvine Community Development Department
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Medium-term (5-20 years)

EH-4: Establish a City-wide Heat Alert Program (HAP) when weather forecasts predict heat waves or extreme heat days.

- **Type of Action:** Program
- **Potential Partners:** Irvine Office of Emergency Management, Irvine Public Works and Transportation Department, Irvine Community Development Department, Cal OES
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Near-term (< 5 years)

HEALTHY COMMUNITIES

EH-5: Educate vulnerable community members and their caregivers (e.g., aging, elderly, ill) to detect signs and symptoms of, and prevent heat-related illness. Emphasize the importance of immediate medical assistance for heat-related illnesses.

- **Type of Action:** Program
- **Potential Partners:** Irvine Health and Human Services
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Near-term (<5 years)

EH-6: Support and provide opportunities for alternative and/or flexible schedules, including remote working, for government and private outdoor workers.

- **Type of Action:** Program
- **Potential Partners:** Irvine Health and Human Services
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Near-term (<5 years)

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EH-7: Collaborate with local businesses and institutions to provide a "Cool Zone" area network (i.e., cooling centers).

- **Type of Action:** Program
- **Potential Partners:** Irvine Community Development Department, University of California-Irvine, California Natural Resources Agency
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Near-term (<5 years)

EH-8: Expand hours of operation of cooling centers during extreme heat events.

- **Type of Action:** Program
- **Potential Partners:** Irvine Office of Emergency Management, Irvine Community Development Department
- **Estimated Cost:** Medium ($100k - $1 million)
- **Timeframe for Implementation:** Medium-term (5-20 years)

EH-9: Expand the number of publicly operated cooling centers based on the need of vulnerable populations.

- **Type of Action:** Project
- **Potential Partners:** Irvine Community Development Department, Irvine Public Works and Transportation Department
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Near-term (<5 years)

EH-10: Provide working touchless water refill stations at public facilities, parks, and bus shelters.

- **Type of Action:** Program
- **Potential Partners:** Irvine Community Development Department, Irvine Public Works and Transportation Department, Irvine Environmental Programs, Metropolitan Water District, Irvine Ranch Water District, Orange County Water District
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Near-term (<5 years)

EH-11: Implement a tree-planting program to diversify tree age and increase shaded areas in the City to reduce the effects of the urban heat island effect. (LHMP 11.02)

- **Type of Action:** Project
- **Potential Partners:** Irvine Community Development Department, Irvine Public Works and Transportation Department
- **Estimated Cost:** Medium ($100k - $1 million)
- **Timeframe for Implementation:** Medium-term (5-20 years)

EH-12: Promote tourist activities that accommodate a warmer climate.

- **Type of Action:** Program
- **Potential Partners:** Irvine Community Development Department, Irvine Chamber of Commerce, Local Businesses, Orange Chamber of Commerce and Visitor Bureau
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Medium-term (5-20 years)

RESILIENT BUILDINGS

EH-13: Consider incentives and/or programs for important service facilities to assess power needs, ensure adequate backup generation capacity (that considers climate projections during extreme heat days), and install off-grid distributed alternative energy systems with islanding capabilities.

- **Type of Action:** Program
- **Potential Partners:** Irvine Office of Emergency Management, Irvine Public Works and Transportation Department, Irvine Community Development Department, Southern California Edison, California Public Utilities Commission

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- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Near-term (< 5 years)

EH-14: Partner with local school districts to ensure every school has adequate air conditioning.
- **Type of Action:** Program
- **Potential Partners:** Irvine Community Development Department, Irvine Unified School District
- **Estimated Cost:** Medium ($100k - $1 million)
- **Timeframe for Implementation:** Near-term (<5 years)

EH-15: Ensure cooling centers are resilient to climate hazard events (e.g., supply cooling centers with refrigerators for storing medicine, backup water supplies, and social services information in multiple languages.)
- **Type of Action:** Project
- **Potential Partners:** Irvine Office of Emergency Management, Irvine Community Development Department
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Near-term (<5 years)

EH-16: Modify building codes to encourage the implementation of heat reduction techniques.
- **Type of Action:** Policy
- **Potential Partners:** Irvine Community Development Department, Irvine Public Works and Transportation Department
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Near-term (<5 years)

EH-17: Promote and support the implementation of green roofs.
- **Type of Action:** Policy/Program
- **Potential Partners:** Irvine Community Development Department, Irvine Public Works and Transportation Department
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Near-term (<5 years)

EH-18: Promote passive cooling design (brise soleil, long roof overhangs, locating windows away from southern facades) in new developments during the design review process. (LHMP 11.04)
- **Type of Action:** Policy
- **Potential Partners:** Irvine Community Development Department, Irvine Public Works and Transportation Department
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Near-term (<5 years)

EH-19: Upgrade HVAC within City facilities to more efficient systems that may include split systems or decentralized systems that allow for heating and cooling the spaces needed, not entire buildings. (LHMP 11.05)
- **Type of Action:** Project
- **Potential Partners:** Irvine Community Development Department, Irvine Public Works and Transportation Department
- **Estimated Cost:** Medium ($100k - $1 million)
- **Timeframe for Implementation:** Near-term (<5 years)

RESILIENT INFRASTRUCTURE

EH-20: Coordinate with regional utilities to assess the vulnerability of critical infrastructure to extreme heat events.
- **Type of Action:** Program
- **Potential Partners:** Irvine Community Development Department, University of California-Irvine, California Natural Resources Agency
- **Estimated Cost:** Low (<$100k)

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- **Timeframe for Implementation:** Near-term (<5 years)

EH-21: Coordinate with regional and state transportation agencies to assess the vulnerability of transportation infrastructure to extreme heat events.
- **Type of Action:** Program
- **Potential Partners:** Irvine Community Development Department, University of California-Irvine, California Natural Resources Agency
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Near-term (<5 years)

RESILIENT ECOSYSTEMS

EH-22: Coordinate with regional partners to study the impact of climate change on ecosystem resilience, invasive species, ecosystem functions, and values in areas impacted by disease, fire suppression, and other ecosystem stressors.
- **Type of Action:** Program
- **Potential Partners:** Irvine Community Development Department, University of California-Irvine, California Natural Resources Agency
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Near-term (<5 years)

EH-23: Coordinate with regional partners to identify opportunities to restore ecosystem resilience, functions and values in areas impacted by disease, invasive species, fire suppression, climate change, and other ecosystem stressors.
- **Type of Action:** Program
- **Potential Partners:** Irvine Community Development Department, University of California-Irvine, California Natural Resources Agency
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Near-term (<5 years)

DRAFT

DROUGHT (D)

PLANNING AND COLLABORATION

D-1: Continue to support and participate in the development of a regional and local drought contingency plan.

- **Type of Action:** Project
- **Potential Partners:** Irvine Community Development Department, Irvine Public Works and Transportation Department, Metropolitan Water District, Irvine Ranch Water District, Orange County Water District
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Medium-term (5-20 years)

D-2: Support regional partners in education and outreach efforts focused on water conservation measures (e.g., water reuse, water use, and irrigation efficiency) for City residents.

- **Type of Action:** Project
- **Potential Partners:** Irvine Community Development Department, Irvine Public Works and Transportation Department, Irvine Environmental Programs, Metropolitan Water District, Irvine Ranch Water District, Orange County Water District
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Near-term (<5 years)

D-3: Update "Division 7 - Sustainability in Landscaping "of the Irvine Municipal Code of Ordinances and the Master Streetscape & Landscape Design Manual to reflect the latest advances in best practices in landscape design that reduce water use within the City. (LHMP 5.02)

- **Type of Action:** Project
- **Potential Partners:** Irvine Community Development Department, Irvine Public Works and Transportation Department, Metropolitan Water District, Irvine Ranch Water District, Orange County Water District
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Near-term (<5 years)

D-4: Encourage drought tolerant native landscaping, low-flow water fixtures beyond the state minimum code, and daytime watering restrictions on properties throughout the city to reduce water consumption. (LHMP 5.03)

- **Type of Action:** Project
- **Potential Partners:** Irvine Community Development Department, Irvine Public Works and Transportation Department, Metropolitan Water District, Irvine Ranch Water District, Orange County Water District
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Near-term (<5 years)

D-5: Use drought-tolerant plants when installing new or retrofitting City-owned landscapes. Limit turf that is not drought tolerant to recreational fields and lawns, and only in instances where no feasible drought-tolerant alternatives exist. (LHMP 5.04)

- **Type of Action:** Project
- **Potential Partners:** Irvine Community Development Department, Irvine Public Works and Transportation Department, Metropolitan Water District, Irvine Ranch Water District, Orange County Water District
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Near-term (<5 years)

D-6: Collaborate with federal, State, and local agencies and organizations to explore alternative sources (e.g., desalinization) and improve capacity in consideration of increased demand and drought.

- **Type of Action:** Project
- **Potential Partners:** Irvine Community Development Department, Irvine Public Works and Transportation Department, Metropolitan Water District, Irvine Ranch Water District, Orange County Water District, United States Bureau of Reclamation
- **Estimated Cost:** Medium ($100k - $1 million)
- **Timeframe for Implementation:** Medium-term (5-20 years)

DRAFT

HEALTHY COMMUNITIES

D-7: Develop a tree and shade master plan with a particular focus on climate resilient tree species.
- **Type of Action:** Project
- **Potential Partners:** Irvine Community Development Department, Irvine Public Works and Transportation Department
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Medium-term (5-20 years)

D-8: Benchmark residential and commercial water use (gallons per capita per day), set goals to reduce water use, and publicize results, especially during droughts.
- **Type of Action:** Program
- **Potential Partners:** Irvine Community Development Department, Irvine Public Works and Transportation Department, Irvine Environmental Programs, Metropolitan Water District, Irvine Ranch Water District, Orange County Water District
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Near-term (<5 years)

RESILIENT BUILDINGS

D-9: Promote a system for rapidly detecting, reporting, and repairing water leaks in public facilities and the water conveyance system.
- **Type of action:** Program
- **Potential Partners:** Irvine Community Development Department, Irvine Public Works and Transportation
- **Estimated Cost:** Medium ($100k - $1 million)
- **Timeframe for Implementation:** Near-term (<5 years)

D-10: Reduce indoor and outdoor potable water use in new and existing public and private developments.
- **Type of action:** Policy, Program
- **Potential Partners:** Irvine Community Development Department, Irvine Public Works and Transportation
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Near-term (<5 years)

RESILIENT INFRASTRUCTURE

D-11: Continue to support Irvine Ranch Water District's recycled water program and explore opportunities to enhance water recycling.
- **Type of Action:** Policy
- **Potential Partners:** Irvine Community Development Department, Irvine Public Works and Transportation Department, Metropolitan Water District, Irvine Ranch Water District, Orange County Water District
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Near-term (<5 years)

D-12: Explore the feasibility of recycled water distribution for residential use on all lot sizes.
- **Type of Action:** Project
- **Potential Partners:** Irvine Community Development Department, Irvine Public Works and Transportation Department, Irvine Ranch Water District, Orange County Water District
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Near-term (<5 years)

D-13: Protect groundwater supply against contamination, degradation, or loss due to flooding.
- **Type of Action:** Project

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- **Potential Partners:** Irvine Community Development Department, Irvine Public Works and Transportation Department, Irvine Ranch Water District, Orange County Water District
- **Estimated Cost:** Medium ($100k - $1 million)
- **Timeframe for Implementation:** Medium-term (5-20 years)

RESILIENT ECOSYSTEMS

D-14: Require native, fire-resistant species for public properties, parks, yards, and grounds.

- **Type of Action:** Policy
- **Potential Partners:** Irvine Community Development Department, Irvine Public Works and Transportation Department
- **Estimated Cost:** Medium ($100k - $1 million)
- **Timeframe for Implementation:** Near-term (<5 years)

D-15: Promote nature-based methods and BMPs (e.g., bioswales, natural ground cover) through the City's stormwater program.

- **Type of Action:** Policy
- **Potential Partners:** Irvine Community Development Department, Irvine Public Works and Transportation Department
- **Estimated Cost:** Medium ($100k - $1 million)
- **Timeframe for Implementation:** Near-term (<5 years)

DRAFT

WILDFIRE (WF)

PLANNING AND COLLABORATION

WF-1: Adopt thresholds for restricting certain activities (e.g., outdoor sporting events, working outdoors) in accordance with Air Quality Index thresholds set under the California Department of Industrial Relations' Division of Occupational Health and Safety emergency regulation (July 2019) to protect workers from wildfire smoke.

- **Type of Action:** Policy
- **Potential Partners:** Irvine Planning and Development Department, Irvine Public Works and Transportation Department, Irvine Health and Human Services, Cal/OSHA, South Coast Air Quality Management District
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Near-term (< 5 years)

WF-2: Routinely participate in the update of the Orange County Community Wildfire Protection Plan for areas within the Very High, High, and Moderate Fire Hazard Severity Zones. (LHMP 12.04)

- **Type of Action:** Program
- **Potential Partners:** Irvine Planning and Development Department, Irvine Public Works and Transportation Department, Irvine Health and Human Services, Cal/OSHA, South Coast Air Quality Management District
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Ongoing

WF-3: Conduct outreach to residents and businesses prior to the severe winds (Santa Ana Wind events) on proper tree maintenance and identification of potentially hazardous trees. (LHMP 11.07)

- **Type of Action:** Project
- **Potential Partners:** Irvine Planning and Development Department, Irvine Public Works and Transportation Department, Irvine Health and Human Services, Cal/OSHA, South Coast Air Quality Management District
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Ongoing

WF-4: Create a hillside weed abatement pilot program using goats or other livestock to reduce fuel loads in fire-prone areas. (LHMP 12.03)

- **Type of Action:** Program
- **Potential Partners:** Irvine Planning and Development Department, Irvine Public Works and Transportation Department, Irvine Health and Human Services, Cal/OSHA, South Coast Air Quality Management District
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Near-term (< 5 years)

WF-5: Coordinate with partners to clear dead vegetation in flood control facility footprints, railroad rights-of-way, parks, and open spaces, especially during and after a drought episode. (LHMP 12.07)

- **Type of Action:** Project
- **Potential Partners:** Irvine Planning and Development Department, Irvine Public Works and Transportation Department, Irvine Health and Human Services, Cal/OSHA, South Coast Air Quality Management District
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Ongoing

WF-6: Work with Orange County Fire Authority on home preparedness assessments to assist more residents in understanding and addressing their wildfire risk. (LHMP 12.09)

- **Type of Action:** Program
- **Potential Partners:** Irvine Planning and Development Department, Irvine Public Works and Transportation Department, Irvine Health and Human Services, Cal/OSHA, South Coast Air Quality Management District
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Ongoing

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WF-7: Coordinate with regional partners to explore and deploy fire detection cameras as part of a wildfire monitoring network.

- **Type of action:** Project
- **Potential Partners:** Irvine Office of Emergency Management, Irvine Public Works and Transportation Department, Irvine Community Development Department, Orange County Fire Authority, SoCal Edison, CalFire
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Near-term (< 5 years)

HEALTHY COMMUNITIES

WF-8: Integrate air quality and smoke tools (e.g., South Coast Air Quality Management District and EPA Smoke Ready Program) into operations planning.

- **Type of Action:** Program
- **Potential Partners:** South Coast Air Quality Management District, Environmental Protection Agency (EPA)
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Near-term (< 5 years)

WF-9: Ensure all City buildings have smoke and particulate filtration systems, specially dedicated emergency evacuation shelters and cooling centers.

- **Type of Action:** Project
- **Potential Partners:** Irvine Office of Emergency Management, Irvine Public Works and Transportation Department, Irvine Community Development Department
- **Estimated Cost:** Medium ($100k - $1 million)
- **Timeframe for Implementation:** Medium-term (5-20 years)

WF-10: Distribute low-cost smoke filtration systems to strategic locations (e.g., emergency evacuation shelters or homes) and provide guidance on how to use them.

- **Type of Action:** Project
- **Potential Partners:** Irvine Public Works and Transportation Department, Irvine Community Development Department, Orange County Fire Authority, CalFire
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Near-term (< 5 years)

WF-11: Enhance the City's strategic approach to reducing vegetation in hillside neighborhoods and along key evacuation routes.

- **Type of action:** Project
- **Potential Partners:** Irvine Office of Emergency Management, Irvine Public Works and Transportation Department, Irvine Community Development Department, Orange County Fire Authority
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Near-term (<5 years)

WF-12: Remove highly flammable vegetation in Very High, High, and Moderate Fire Hazard Severity Zones and replant with fire-adapted specimens. (LHMP 12.02)

- **Type of action:** Project
- **Potential Partners:** Irvine Office of Emergency Management, Irvine Public Works and Transportation Department, Irvine Community Development Department, Orange County Fire Authority
- **Estimated Cost:** Medium ($100k - $1 million)
- **Timeframe for Implementation:** Near-term (<5 years)

WF-13: Continue to promote and implement the Orange County Vegetation Management program to reduce wildfire risk.

- **Type of action:** Project
- **Potential Partners:** Irvine Office of Emergency Management, Irvine Public Works and Transportation Department, Irvine Community Development Department, Orange County Fire Authority

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- **Estimated Cost:** Medium ($100k - $1 million)
- **Timeframe for Implementation:** Near-term (<5 years)

WF-14: Expand the fire hazard prevention awareness campaign to residents in the High and Very High Fire Hazard Severity Zones. (LHMP 12.08)
- **Type of action:** Project
- **Potential Partners:** Irvine Office of Emergency Management, Irvine Public Works and Transportation Department, Irvine Community Development Department, Orange County Fire Authority
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Near-term (<5 years)

WF-15: Support neighborhoods in the Wildland/Urban Interface to become Firewise Recognized Communities.
- **Type of action:** Program
- **Potential Partners:** Irvine Office of Emergency Management, Irvine Public Works and Transportation Department, Irvine Community Development Department, Orange County Fire Authority, CAL FIRE
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Near-term (<5 years)

WF-16: Conduct a study that considers the feasibility, costs, benefits, and finance options for undergrounding electric power lines for neighborhoods in the Wildland/Urban Interface to supplement increased efforts initiated through Senate Bill No. 901.
- **Type of action:** Project
- **Potential Partners:** Irvine Office of Emergency Management, Irvine Public Works and Transportation Department, Irvine Community Development Department, Orange County Fire Authority, SoCal Edison, CalFire
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Near-term (<5 years)

EMERGENCY PREPAREDNESS

WF-17: Support effective implementation of the AlertOC system to warn residents of smoke hazards and inform them of actions they should take during an event (multiple languages, multiple media outlets).
- **Type of action:** Program
- **Potential Partners:** Irvine Office of Emergency Management, Irvine Public Works and Transportation Department, Irvine Community Development Department, Orange County Fire Authority, CalFire
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Near-term (<5 years)

WF-18: Provide ongoing risk communication regarding fire danger during fire seasons

Implement wildfire risk communication messaging that:
- Occurs throughout high wildfire risk season so people know in advance how to use masks and air purifiers and where to get them.
- Reaches non-English speaking individuals and those without cell phones.
- Educate people on severity of smoke impacts using easy-to-understand, comparative risk language, and
- Publicize fresh air centers—both City-designated and informal ones like movie theatres.

- **Type of action:** Program
- **Potential Partners:** Irvine Office of Emergency Management, Irvine Public Works and Transportation Department, Irvine Community Development Department, Orange County Fire Authority, CalFire
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Near-term (<5 years)

DRAFT

RESILIENT BUILDINGS

WF-19: Require all new development in Very High, High, and Moderate Fire Hazard Severity Zones to use noncombustible building materials such as masonry, brick, stucco, concrete, steel, or others as appropriate. Establish zones of defensible space around homes in Very High, High, and Moderate Fire Hazard Severity Zones. (LHMP 12.10)

- **Type of Action:** Policy
- **Potential Partners:** Irvine Planning and Development Department, Irvine Public Works and Transportation Department, Irvine Parks and Facilities Department, CAL FIRE, National Fire Prevention Association
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Ongoing

WF-20: Develop a drought-resistant and wildfire-resistant landscaping certification program for homeowners in Irvine.

- **Type of Action:** Program
- **Potential Partners:** Irvine Planning and Development Department, Irvine Public Works and Transportation Department Irvine Parks and Facilities Department, CAL FIRE, National Fire Prevention Association
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Near-term (<5 years)

WF-21: Support regional partners (e.g., Orange County Fire Authority's Ready, Set, Go Program) in their efforts to effectively educate residents about defensible space, vegetation management, and home hardening efforts.

- **Type of action:** Program
- **Potential Partners:** Irvine Office of Emergency Management, Irvine Public Works and Transportation Department, Irvine Community Development Department, Orange County Fire Authority, CalFire
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Near-term (<5 years)

WF-22: Seek opportunities to add wildfire home retrofit upgrades into other home financing mechanisms like those focused on energy efficiency.

- **Type of action:** Project
- **Potential Partners:** Irvine Office of Emergency Management, Irvine Public Works and Transportation Department, Irvine Community Development Department, Orange County Fire Authority, CalFire
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Near-term (<5 years)

WF-23: Reinforce and regularly inspect fire retardant infrastructure such as sprinklers, fire hose terminals, and fire suppression systems in City facilities. (LHMP 12.06)

- **Type of Action:** Program
- **Potential Partners:** Irvine Planning and Development Department, Irvine Public Works and Transportation Department Irvine Parks and Facilities Department, CAL FIRE, National Fire Prevention Association
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Ongoing

RESILIENT INFRASTRUCTURE

WF-24: Promote the proper maintenance and separation of power lines and efficient response to fallen power lines. (LHMP 12.01)

- **Type of Action:** Program
- **Potential Partners:** Irvine Planning and Development Department, Irvine Public Works and Transportation Department Irvine Parks and Facilities Department, CAL FIRE, National Fire Prevention Association
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Ongoing

DRAFT

RESILIENT ECOSYSTEMS

WF-25: Promote planting of tree types that capture and settle particles in the air during wildfire-smoke episodes.

- **Type of action:** Policy/Program
- **Potential Partners:** Irvine Public Works and Transportation Department, Irvine Community Development Department, Orange County Fire Authority
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Near-term (<5 years)

WF-26: Replant bare or disturbed hillside areas after wildfires to increase stability and reduce erosion that may lead to landslides.

- **Type of action:** Project
- **Potential Partners:** Irvine Public Works and Transportation Department, Irvine Community Development Department, Orange County Fire Authority
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Ongoing

WF-27: Coordinate with federal, State, and local agencies to establish ecological recovery programs.

- **Type of action:** Program
- **Potential Partners:** Irvine Public Works and Transportation Department, Irvine Community Development Department, California Department of Conservation, California Natural Resources Agency, California Department of Fish and Wildlife, United States Fish and Wildlife Service.
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Near-term (<5 years)

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FLOODING (F)

PLANNING AND COLLABORATION

F-1: Collaborate with partner agencies and municipalities to align green infrastructure projects and regulations for watersheds across jurisdictions to reduce impervious hard surfaces and require the integration of green infrastructure techniques into site design.

- **Type of action:** Project
- **Potential Partners:** Irvine Office of Emergency Management, Irvine Community Development Department, Governor's Office of Emergency Services (Cal OES), FEMA
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Near-term (< 5 years)

F-2: Support efforts of other organizations and academic institutions to conduct studies of the impact from combined riverine and coastal flooding, groundwater intrusion, and increased precipitation on flood risk and vulnerability.

- **Type of action:** Project
- **Potential Partners:** Irvine Community Development Department, Cal OES, FEMA, University of California-Irvine, California Natural Resources Agency
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Ongoing

F-3: Explore and implement Low Impact Development (LID) standards for new development to reduce impacts from stormwater runoff.

- **Type of action:** Project
- **Potential Partners:** Irvine Community Development Department, Irvine Department of Public Works and Transportation, Orange County Public Works
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Near-term (< 5 years)

HEALTHY COMMUNITIES

F-4: Provide residents, businesses, and neighborhood organizations storm evacuation procedures and shelter-in-place guidelines to grow community resilience.

- **Type of Action:** Project
- **Potential Partners:** Irvine Office of Emergency Management, Irvine Police Department, Orange County Fire Authority, Irvine Community Development Department
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Near-term (< 5 years)

F-5: Ensure that the City has an adequate supply of sandbags for residents and businesses, including prefilled sandbags for individuals who may be unable to fill them on their own. (LHMP P10)

- **Type of Action:** Program
- **Potential Partners:** Irvine Office of Emergency Management, Department of Public Works and Transportation
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Ongoing

F-6: Implement a public outreach program to increase the public awareness of flooding, stormwater management, and drought management issues and techniques for residents to mitigate those challenges on their property.

- **Type of Action:** Program
- **Potential Partners:** Irvine Office of Emergency Management, Irvine Community Development Department
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Near-term (<5 years)

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F-7: Support regional partners to inventory and map vegetation on hillsides with a specific focus on improving hillside stability in the case of extreme rainfall and seasonal erosion.

- **Type of action:** Program
- **Potential Partners:** Irvine Community Development Department, Irvine Department of Public Works and Transportation, Orange County Public Works
- **Estimated Cost:** Medium ($100k - $1 million)
- **Timeframe for Implementation:** Near-term (< 5 years)

F-8: Partner with Orange County Public Works to proactively disseminate information from the "H_2OC Stormwater Program" to educate home and small business owners on regulations and highlight the role that engaged residents can play to assist with community-based stormwater management.

- **Type of action:** Program
- **Potential Partners:** Irvine Community Development Department, Irvine Department of Public Works and Transportation, Orange County Public Works
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Near-term (< 5 years)

F-9: Coordinate with local/State/national agencies to create a certificate (online and hard copy) that improves resale property value and insurability for homes that have complied with flood-prevention regulations (LID stormwater management requirements, flood proofing), community rating standards, and building codes.

- **Type of Action:** Program
- **Potential Partners:** Irvine Community Development Department
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Medium-term (5-20 years)

RESILIENT BUILDINGS

F-10: Amend local codes and by-laws to mandate flood-proofing techniques in defined flood hazard zones and adjacent areas to protect them from future flood events.

- **Type of action:** Policy
- **Potential Partners:** Irvine Office of Emergency Management, Irvine Police Department, Orange County Fire Authority, Irvine Community Development Department, Governor's Office of Emergency Services (Cal OES), FEMA
- **Estimated Cost:** Medium ($100k - $1 million)
- **Timeframe for Implementation:** *Medium-term (5-20 years)*

F-11: Investigate permeable paving and use landscaped swales for new and replacement of City-owned hardscaped areas. (LHMP 6.01)

- **Type of Action:** Project
- **Potential Partners:** Irvine Community Development Department, Irvine Department of Public Works and Transportation
- **Estimated Cost:** Low (<$100k))
- **Timeframe for Implementation:** Near-term (< 5 years)

F-12: Encourage the use of porous surfaces on new and significantly retrofitted residential and commercial developments to reduce runoff. (LHMP 6.02)

- **Type of Action:** Policy
- **Potential Partners:** Irvine Community Development Department, Irvine Department of Public Works and Transportation
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Ongoing

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F-13: Analyze if new critical facilities can be built a minimum of 1 foot higher than the anticipated 500-year flood elevation height, to determine where it is feasible. (LHMP 6.05)

- **Type of Action:** Project
- **Potential Partners:** Irvine Community Development Department, Irvine Department of Public Works and Transportation
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Near-term (< 5 years)

RESILIENT INFRASTRUCTURE

F-14: Ensure completeness and availability of identified flood emergency supplies and resources; including, but not limited to items such as water main repair parts, generators, pumps, sandbags, road clearing, medical, and communication.

- **Type of action:** Project
- **Potential Partners:** Irvine Office of Emergency Management, Irvine Community Development Department, Governor's Office of Emergency Services (Cal OES), FEMA
- **Estimated Cost:** High (>$1 million)
- **Timeframe for Implementation:** *Medium-term (5-20 years)*

F-15: Develop or update long-term public works plan for critical facilities to address current and future flood risk.

- **Type of Action:** Project
- **Potential Partners:** Irvine Public Works and Transportation Department, Irvine Community Development Department
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Near-term (<5 years)

F-16: Require that future transportation infrastructure projects consider current and future flood risk and align the projected lifespan of the project with the best available science.

- **Type of Action:** Policy
- **Potential Partners:** Irvine Public Works and Transportation Department, Irvine Community Development Department
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Ongoing

F-17: Conduct frequent cleanings of storm drain intakes, especially before and during the rainy season. (LHMP 6.03)

- **Type of Action:** Program
- **Potential Partners:** Irvine Community Development Department, Irvine Department of Public Works and Transportation
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Ongoing

F-18: Update the City's Master Plan of Drainage on a regular basis to incorporate new data and/or address emerging issues. (LHMP 6.04)

- **Type of Action:** Project
- **Potential Partners:** Irvine Community Development Department, Irvine Department of Public Works and Transportation
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Near-term (< 5 years)

F-19: Ensure resilience and long-term functionality of stormwater and sewer systems.

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Conduct comprehensive visual and functional test monitoring and asset condition assessment. Model potential impacts to utility infrastructure under future flooding scenarios. Specifically:

- Consider the impact of rising groundwater levels and increasing salinity on buried utility infrastructure like sewer and stormwater pipes. Prioritize replacement of iron pipes with high-density polyethylene or other non-corrosive materials as appropriate.
- Consider the impact of flooding on electrical infrastructure (AMP), including utility poles.
- Develop and implement an asset management plan that prioritizes repairing or replacing infrastructure that flooding is likely to impact.

● **Type of action:** Program
● **Potential Partners:** Irvine Community Development Department, Irvine Public Works and Transportation
● **Estimated Cost:** High (>$1 million)
● **Timeframe for Implementation:** *Medium-term (5-20 years)*

F-20: Retrofit roadway medians to capture storm water during rain events. (LHMP 6.06)

● **Type of Action:** Project
● **Potential Partners:** Irvine Community Development Department, Irvine Department of Public Works and Transportation
● **Estimated Cost:** Low (<$100k)
● **Timeframe for Implementation:** Near-term (< 5 years)

F-21: Design and implement Bioswales as a stormwater runoff conveyance system.

● **Type of action:** Project
● **Potential Partners:** Irvine Community Development Department, Irvine Public Works and Transportation
● **Estimated Cost:** Medium ($100k - $1 million)
● **Timeframe for Implementation:** *Medium-term (5-20 years)*

F-22: Encourage rain gardens in public and private spaces.

● **Type of action:** Policy
● **Potential Partners:** Irvine Public Works and Transportation, Irvine Community Development Department
● **Estimated Cost:** Low (<$100k)
● **Timeframe for Implementation:** Near-term (< 5 years)

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LIQUEFACTION AND LANDSLIDE (L)

PLANNING AND COLLABORATION

L-1: Coordinate with Irvine Ranch Water District and the Navy on subsidence monitoring in areas of active groundwater extraction and work with water utilities to develop strategies based on the amount and severity of subsidence occurring. (LHMP 7.01)

- **Type of Action:** Project
- **Potential Partners:** Irvine Office of Emergency Management, Irvine Public Works and Transportation Department, Irvine Community Development Department
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Ongoing

L-2: Coordinate with Irvine Ranch Water District and Orange County Water District on emergency water storage and distribution following a liquefaction or landslide event.

- **Type of Action:** Project
- **Potential Partners:** Irvine Office of Emergency Management, Irvine Public Works and Transportation Department, Irvine Community Development Department
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Near-term (<5 years)

L-3: Coordinate with Caltrans and Orange County Transit Authority for inspection and maintenance of primary evacuation routes.

- **Type of Action:** Project
- **Potential Partners:** Irvine Office of Emergency Management, Irvine Public Works and Transportation Department, Irvine Community Development Department
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Near-term (<5 years)

L-4: Consider reducing land use densities in areas of significant landslide threat and identify strategies for existing development downstream of these hazard areas.
(LHMP 7.02)

- **Type of Action:** Project
- **Potential Partners:** Irvine Office of Emergency Management, Irvine Public Works and Transportation Department, Irvine Community Development Department
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Medium-term (5-20 years)

L-5: Improve local understanding of the threat of a major earthquake by conducting a city-wide scenario modeling potential loss of life and injuries, destroyed and damaged structures, and interruptions to key services. (LHMP 10.06)

- **Type of Action:** Project
- **Potential Partners:** Irvine Office of Emergency Management, Irvine Public Works and Transportation Department, Irvine Community Development Department
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Near-term (<5 years)

HEALTHY COMMUNITIES

L-6: Provide information to community groups and businesses about how to prepare for, and recover from, a seismic or geologic event.

- **Type of Action:** Project
- **Potential Partners:** Irvine Office of Emergency Management, Irvine Public Works and Transportation Department, Irvine Community Development Department

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- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Near-term (<5 years)

L-7: Educate community groups and industry representatives assist in outreach to residents and businesses to obtain earthquake insurance through the California Earthquake Authority. (LHMP 10.04)
- **Type of Action:** Project
- **Potential Partners:** Irvine Office of Emergency Management, Irvine Public Works and Transportation Department, Irvine Community Development Department
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Near-term (<5 years)

RESILIENT BUILDINGS

L-8: Assess soft story conditions for apartment buildings constructed prior to 1980. (LHMP 10.02)
- **Type of Action:** Project
- **Potential Partners:** Irvine Office of Emergency Management, Irvine Public Works and Transportation Department, Irvine Community Development Department
- **Estimated Cost:** Medium ($100k - $1 million)
- **Timeframe for Implementation:** Near-term (<5 years)

L-9: To the extent feasible, construct all new and significantly retrofitted City-owned facilities to remain operational in the event of a major earthquake. (LHMP 10.05)
- **Type of Action:** Project
- **Potential Partners:** Irvine Office of Emergency Management, Irvine Public Works and Transportation Department, Irvine Community Development Department
- **Estimated Cost:** High (>$1 million)
- **Timeframe for Implementation:** Ongoing

L-10: Conduct an educational campaign and incentives to encourage the use of reinforced chimneys, anchored rooftop-mounted equipment, window film, and other preventative measures to reduce damage at private buildings. (LHMP 10.03)
- **Type of Action:** Project
- **Potential Partners:** Irvine Office of Emergency Management, Irvine Public Works and Transportation Department, Irvine Community Development Department
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Near-term (<5 years)

L-11: Retrofit key critical City facilities with seismically rated window film treatments that ensure glass windows do not shatter during a strong seismic event. Promote retrofit of key community facilities not owned by the City. (LHMP 10.07)
- **Type of Action:** Project
- **Potential Partners:** Irvine Office of Emergency Management, Irvine Public Works and Transportation Department, Irvine Community Development Department
- **Estimated Cost:** High (>$1 million)
- **Timeframe for Implementation:** Ongoing

RESILIENT INFRASTRUCTURE

L-12: Encourage the installation of resilient (seismically appropriate) piping for new or replacement pipelines, in close coordination with local water, natural gas, and other providers. (LHMP 10.01)
- **Type of Action:** Project

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- **Potential Partners:** Irvine Office of Emergency Management, Irvine Public Works and Transportation Department, Irvine Community Development Department
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Ongoing

L-13: In coordination with Caltrans, update facilities condition assessments for bridges along evacuation routes to identify bridges that need seismic retrofitting. Consider pursuing highest standard improvement options (e.g., replacement instead of retrofitting) for bridges with seismic deficiencies. (LHMP 10.08)
- **Type of Action:** Project
- **Potential Partners:** Irvine Office of Emergency Management, Irvine Public Works and Transportation Department, Irvine Community Development Department
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Near-term (<5 years)

L-14: Pursue ground improvement projects, such as constructing a high strength capping layer, soil mixing, stone columns, soil wicks, chemical and pressure grouting, and other soil improvement techniques that reduce liquefaction susceptibility for key critical facilities in the event of an earthquake. (LHMP 10.09)
- **Type of Action:** Project
- **Potential Partners:** Irvine Office of Emergency Management, Irvine Public Works and Transportation Department, Irvine Community Development Department
- **Estimated Cost:** High (>$1 million)
- **Timeframe for Implementation:** Near-term (<5 years)

L-15: Incentivize utilities to install flexible jointing and pipelines across fault segments located within the City. Ensure these pipelines have the necessary countermeasures to ensure breakage of lines is kept to a minimum and adequate shut off mechanisms to reduce exposure of pipeline contents to residents and businesses. (LHMP 10.10)
- **Type of Action:** Project
- **Potential Partners:** Irvine Office of Emergency Management, Irvine Public Works and Transportation Department, Irvine Community Development Department
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Ongoing

RESILIENT ECOSYSTEMS

L-16: Replant bare or disturbed areas after landslides to reduce erosion.
- **Type of action:** Policy/Program
- **Potential Partners:** Irvine Public Works and Transportation Department, Irvine Community Development Department, Orange County Fire Authority
- **Estimated Cost:** Low (<$100k)
- **Timeframe for Implementation:** Ongoing

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APPENDIX B

Appendix B – Emergency Evacuation Route Analysis (March 2024)

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Emergency Evacuation Route Analysis

City of Irvine Safety Element

March 2024

Prepared for:

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Section 1 Background

A variety of hazard scenarios could require an evacuation in parts of the City of Irvine. These emergency situations could be caused by either natural or human-made events, such as wildfires, floods, or geologic or seismic hazards. The City of Irvine's Office of Emergency Management is responsible for ensuring emergency preparedness, response, and recovery activities for all populations within its jurisdiction. The City's 2022 Emergency Operations Plan (EOP) provides a resiliency framework for the City to prepare for, respond to, recover from, and mitigate against all hazards including natural, human-caused, and technological disasters, and national security emergencies. This Emergency Evacuation Route Analysis incorporates the City's EOP by reference.

The results of this analysis are intended to identify evacuation capacity and network connectivity in the City, in addition to meeting the requirements associated with the following legislative updates:

- **Assembly Bill (AB) 747[1] (2019)** requires the City to update the Safety Element of its General Plan to identify evacuation routes and assess the capacity, safety, and viability of those routes under a range of emergency scenarios.
- **Senate Bill (SB) 99[2] (2019)** requires the City to identify residential developments in hazard areas that do not have at least two emergency evacuation routes (i.e., neighborhoods or households within a hazard area that have limited accessibility).
- **AB 1409[3] (2021)** requires the City to identify evacuation locations.

Authoritative state guidance is being developed to determine the type and level of analysis that is mandated under AB 747, SB 99, or AB 1409.[4] This analysis evaluates the efficacy of existing evacuation routes under various hazard scenarios, in compliance with AB 747, and uses the methodology described below to identify residential developments without sufficient evacuation routes, in compliance with SB 99. Evacuation locations are provided below in compliance with AB 1409.

[1] An act to add Section 65302.15 to the California Government Code.
[2] An act to amend Section 65302 of the California Government Code.
[3] An act to add Section 65302.15 to the California Government Code.
[4] The Governor's Office of Planning and Research (OPR) issued the Draft Evacuation Planning Technical Advisory for public review April of 2023. The technical advisory provides guidance on compliance with AB 747, SB 99, and AB 1409.

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Section 2 Hazard Scenarios

Evacuation route proximity, safety, capacity, and viability are largely determined by the location of the hazard. The City is surrounded by Very High Fire Hazard Severity Zones (FHSZs) to the north, east, and south as shown in Figures 3 through 6 of this Emergency Evacuation Route Analysis. Therefore, the City considered four scenarios with wildfire originating in the south, northeast, east, and northwest). Evacuation route proximity, safety, capacity, and viability were also assessed for flood hazards because flood zones exist along the major drainages within the City, including San Diego creek in the west-central portion of Irvine (**Figure 7, Flood Residential Evacuation Vulnerability Score**). Lastly, evacuation route proximity, safety, capacity, and viability were assessed for a landslide event (**Figure 8, Landslide Residential Evacuation Vulnerability Score**) due to the presence of landslide susceptibility areas to the northeast and south of the City. Given the low likelihood of dam failure in the City, this hazard scenario was not considered in this Emergency Evacuation Route Analysis.

Seven hazard scenarios are considered in this analysis:

1. Baseline (no hazard location specified)
2. Wildfire (originating in the area south of the City)
3. Wildfire (originating in the area northeast of the City)
4. Wildfire (originating in the area east of the City)
5. Wildfire (originating in the area northwest of the City)
6. Flood (extreme precipitation)
7. Landslide

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Section 3 Data, Assumptions, and Definitions

The Emergency Evacuation Route Analysis utilizes updated data from the City's interactive web map of evacuation management zones (EMZs) and evacuation routes shown in **Figure 1, Evacuation Management Zone Map**.[5] Roads within the City are evaluated for evacuation route proximity, safety, capacity, and viability using the assumptions described below and methodology described in Section 4.

To develop a methodology that effectively evaluates the proximity, safety, capacity, and viability of evacuation routes and identifies residential areas that lack two evacuation routes, the following definitions and assumptions apply:

1. "Evacuation route vulnerability" refers to the reduced ability of people to evacuate under emergency conditions. Evacuation route vulnerability scores are calculated for each residential parcel (see Section 4, Methodology, for a discussion of how evacuation route vulnerability scores are calculated). Lower values indicate lower levels of vulnerability, while higher values indicate greater evacuation route vulnerability.
2. For the purposes of this assessment, evacuation route viability and safety are interchangeable as those routes determined to be unsafe due to hazardous conditions are also determined to be unviable.
3. "Capacity" is defined by the ability of a road to accommodate traffic volume. In this analysis, road type (local, collector, arterial, or highway/freeway) is used as an indicator of road capacity.
    - "Local" roads are streets that are primarily used to gain access to property. Proximity to local roads was not considered a significant determinant of evacuation vulnerability.
    - "Collector" roads are considered low-to-moderate capacity roads that serve to move traffic from local streets to arterial roads.
    - An "arterial" road is a high-capacity urban road. The primary function of an arterial road is to deliver traffic from collector roads to highways/freeways, which are the highest capacity evacuation route.
4. This analysis relies on the EMZs and evacuation routes identified in the City's Evacuation Management Zone Map. Each EMZ are labeled and outlined on the Evacuation Management Zone Map. Factors determining EMZ designated areas include common exposure to a given threat, availability of ingress and egress routes, population density, and likelihood of fire progression. Primary evacuation routes for each EMZ are also outlined on the Evacuation Management Zone Map. These routes

[5] The City's Evacuation Management Zone Map shown in Figure 1 is also available on the City's website: https://cityofirvine.maps.arcgis.com/apps/webappviewer/index.html?id=c452152c1a5a46129dde513d8652e81e

may not necessarily be used during an evacuation as circumstances may dictate alternate routes.

5. Evacuation proceedings are primarily reliant on "outbound" roads: roads that transport drivers away from the City. While outbound roads include both freeways and arterials, the evacuation modeling analyzes a residential area's proximity to the nearest viable freeway entrance, as this represents the fastest way out of the City. Outbound roads begin at the intersection closest to the City boundary.
6. "Proximity" is defined by the distance from a residential parcel to nearest road (for collector roads) or "nodes": the nearest intersection on the following road types: arterial, outbound, or highway/freeway.
7. All roads have a potential role in evacuations. Closer proximity to higher capacity roads and outbound roads reduces evacuation vulnerability.
8. Hazard scenarios influence the direction people evacuate (away from the hazard area).
9. Populations with limited access to automobiles (e.g., seniors or low-income residents) will be qualitatively evaluated.
10. University of California (UC), Irvine is a separate entity from the City with its own police force, EOP, and associated policies and procedures for evacuation. While there is continued coordination between the City and UC Irvine regarding emergency operations, the City is not responsible for coordinating evacuation analyses and developing policy for improving evacuation route vulnerability on campus. Therefore, student and faculty housing within the UC Irvine campus may be qualitatively discussed but is not included in the evacuation modeling.

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Section 4 Methodology

Evacuation route vulnerability scores were assigned to each residential property based on several factors, including proximity, safety, capacity, and viability. The geospatial analysis included the following steps:

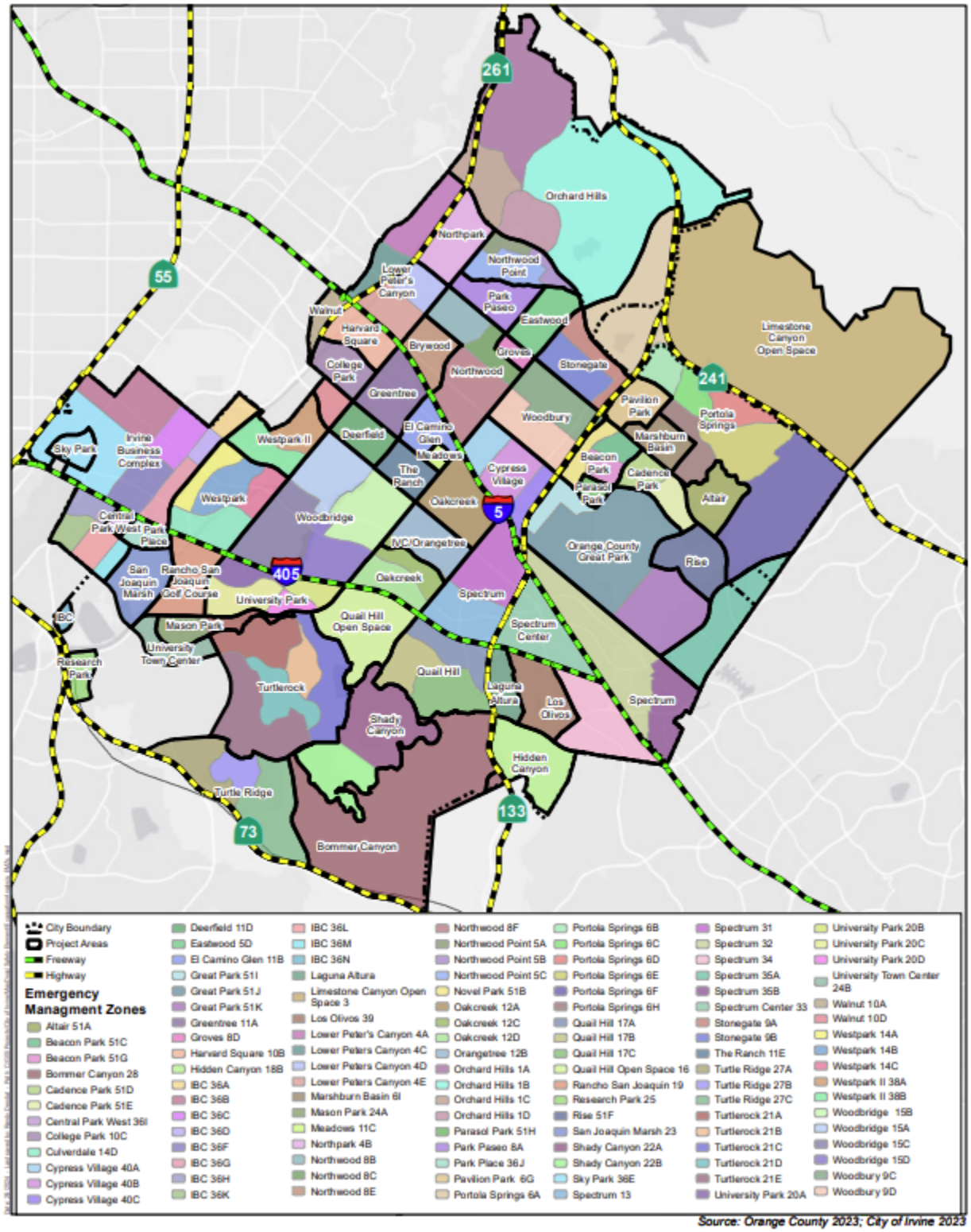
1. Map all residential parcels in Irvine and all collector, arterial and outbound roads and freeways.
2. Create nodes at the intersection of collector and local roads to arterial roads and all intersections on outbound roads, including on-ramps for highways/freeways.
3. Determine the proximity of each residential parcel to the nearest evacuation route (highway/freeway or outbound road) using the following methodology:
   a. Calculate the distance from the parcel to the nearest collector road.
   b. Calculate the distance to the nearest arterial, outbound road, or highway/freeway node.[6]
4. Each distance value calculated in Step 3 is weighted based on road type. Apply the following vulnerability weights to the road type to reflect the higher vulnerability of lower capacity roads and roads with bridges:

Road Type	Vulnerability Weight
Freeway	1
Outbound Road	2
Arterial Road	3
Collector Road	4
Road segment with bridge	10

5. Add weighted distance values for each evacuation route to calculate the evacuation route vulnerability score. Lower values indicate the evacuation route has a lower vulnerability to the hazard scenario; higher values indicate greater vulnerability.
6. For each hazard scenario, identify residential parcels whose evacuation route vulnerability has changed (increased or decreased) from the baseline, and determine if there are any residential areas with fewer than two evacuation routes. A geographic information systems (GIS) assessment that identifies potential vulnerabilities in Irvine is performed to conclude whether all residential parcels have at least two points of egress.

[6] To account for the assumption that drivers would take the route that leads them out of the City most efficiently, if the distance from a parcel to a higher capacity road is less than the distance to a lower capacity road, the distance to the lower capacity road is assigned a value of 0.

Figure 1. Evacuation Management Zone Map



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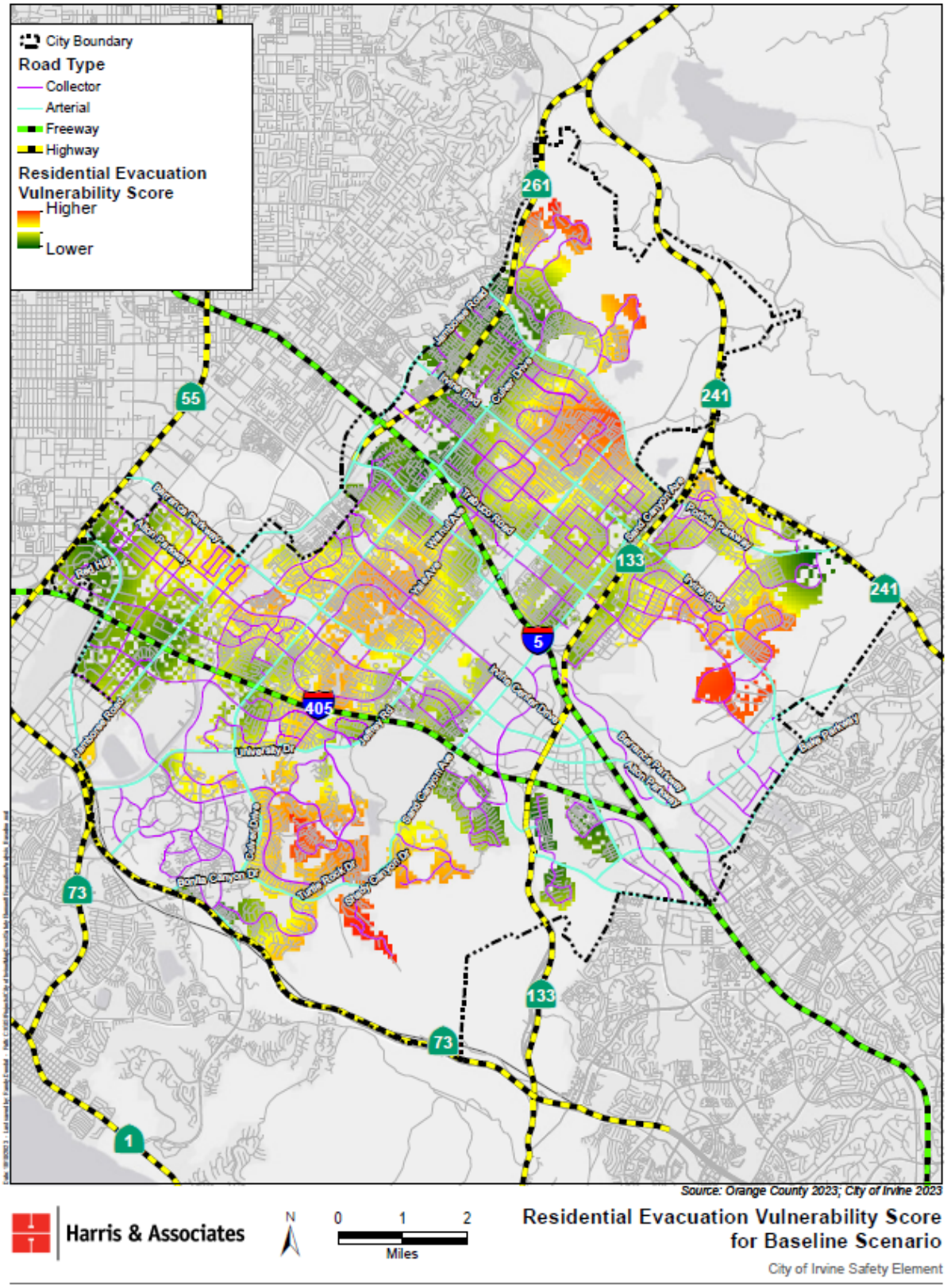
Section 5 Results

1. Baseline

The baseline scenario evaluates the evacuation route vulnerability of residential parcels absent a hazard event. In the baseline scenario, all outbound roads are available to residents for evacuation (**Figure 2, Residential Evacuation Vulnerability Score for Baseline Scenario**). Freeways have the highest capacity to evacuate residents, followed by arterials and collectors. Local roads have the lowest capacity to evacuate residents. Key intersections within the City boundary are where two arterial roads connect. Major intersections are necessary to efficiently route residents to outbound roads. Residential parcels with higher evacuation route vulnerability scores are highlighted in red, orange, or yellow. Assuming all evacuation routes are viable and safe, residents in the northeastern, central, and southern regions (EMZs 1A-1B, 5B, 5D, 8A, 9A-9B, 15A, 21B-21D, 22A-22B, 51A, 51D, and 51F) of the City have the highest evacuation route vulnerability, as they have the farthest to travel to access outbound evacuation routes (i.e., State Route [SR-] 261, SR-241, SR-133, SR-73, Interstate [I-] 405, and I-5).

In addition to considering evacuation route vulnerability, the vulnerability of residents should be considered in determining which areas may need to be prioritized by first responders during an evacuation. The areas in Irvine with a greater percentage of older adults, people with disabilities, and households that do not own a vehicle (i.e., transit-dependent populations) require greater levels of support during an evacuation. Other vulnerable groups beyond those within these demographics should be examined relative to evacuation route vulnerability.

Figure 2. Residential Evacuation Vulnerability Score for Baseline Scenario

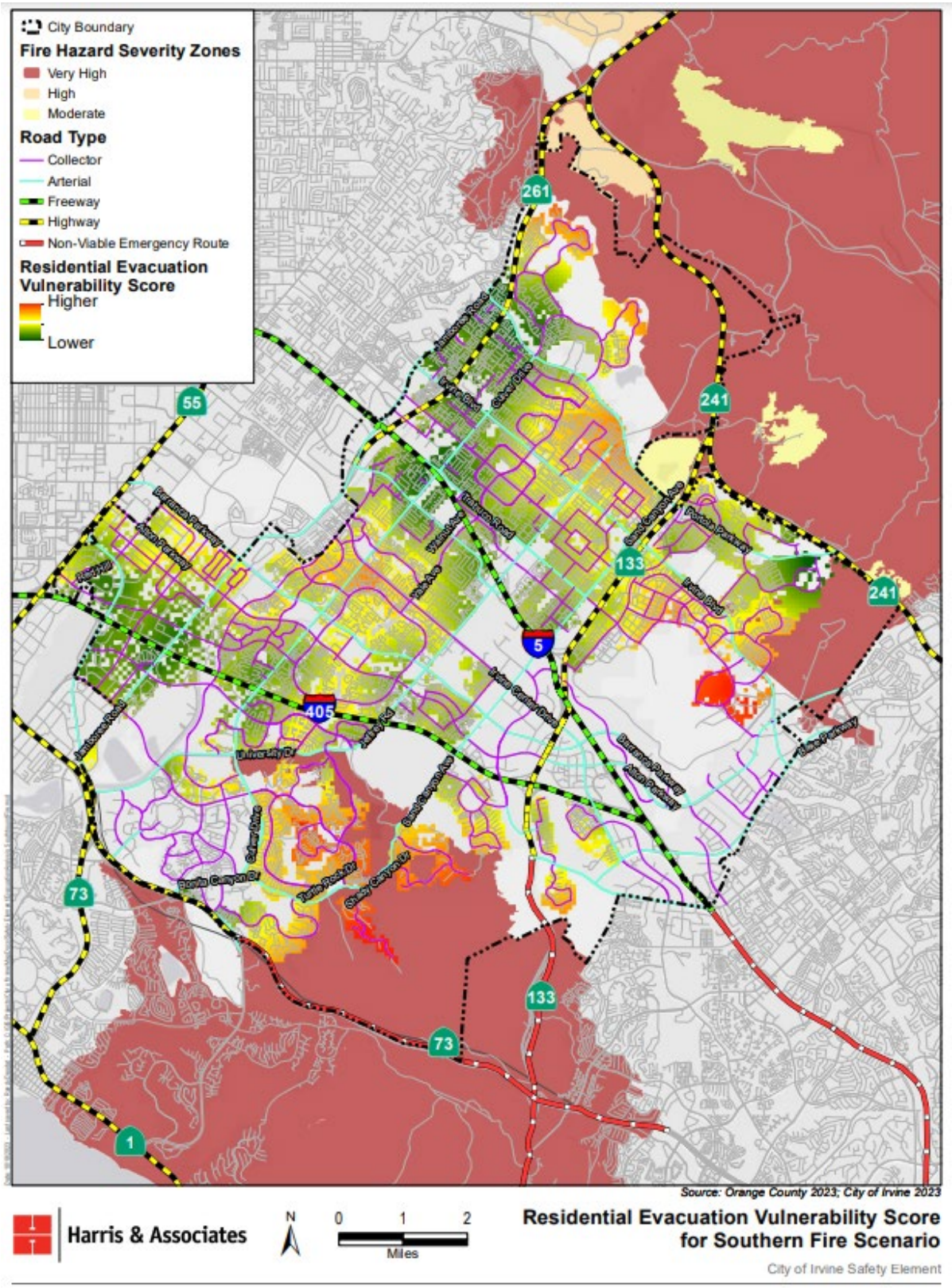


2. Wildfire (South)

This scenario assumes a mandatory residential evacuation due to a wildfire originating south of the City. Outbound roads leading south, such as SR-73 South, SR-133 South, and I-5 South, are assumed to be not safe or viable due to the wildfire hazard. The north- and west-bound freeways are the most viable evacuation routes in Irvine in this scenario; however, SR-241 South is assumed to be viable under this scenario given that it is located well outside of the high FHSZs south of the City. Evacuation vulnerability scores are re-calculated from the baseline scenario to account for the increased distance to the next closest, viable outbound road. **Figure 3, Residential Evacuation Vulnerability Score for Southern Fire Scenario**, highlights residential parcels with evacuation route vulnerability scores that increased as a result of the southbound SR-73, SR-133, and I-5 evacuation routes being closed. Residents in the southern portion of the City (EMZs 21B-21D and 22A-22B) are most vulnerable to a fire originating from the very high FHSZs south of the City. Additionally, residents in the southern portion of the City are more vulnerable to unsafe road conditions related to the fire, such as poor visibility and air quality due to smoke and ash, falling embers, etc. However, residents in the northern and eastern portions of the City (e.g., EMZ 51F) are still shown to have high or moderately high vulnerability scores given their proximity to a viable outbound freeway entrance relative to other residential areas of the City.

I-405 and northbound I-5, SR-133, SR-241, SR-261, and SR-73 are the outbound roads most likely to be used in this scenario. Residents are able to travel along a number of arterial roadways in Irvine in order to access the viable north-, east-, and west-bound freeways including, but not limited to, the following: Jamboree Road, Culver Drive, Irvine Boulevard, Portola Parkway, and Barranca Parkway. The viable north-, east-, and west-bound freeways under this scenario increase overall evacuation capacity in Irvine. However, the City's internal roadways (arterial, collector, and local roads) are subject to congestion as residents attempt to access the outbound freeways. Emergency responders should consider activating evacuation traffic management along arterial roads to allow for easier access to the freeways.

Figure 3. Residential Evacuation Vulnerability Score for Southern Fire Scenario



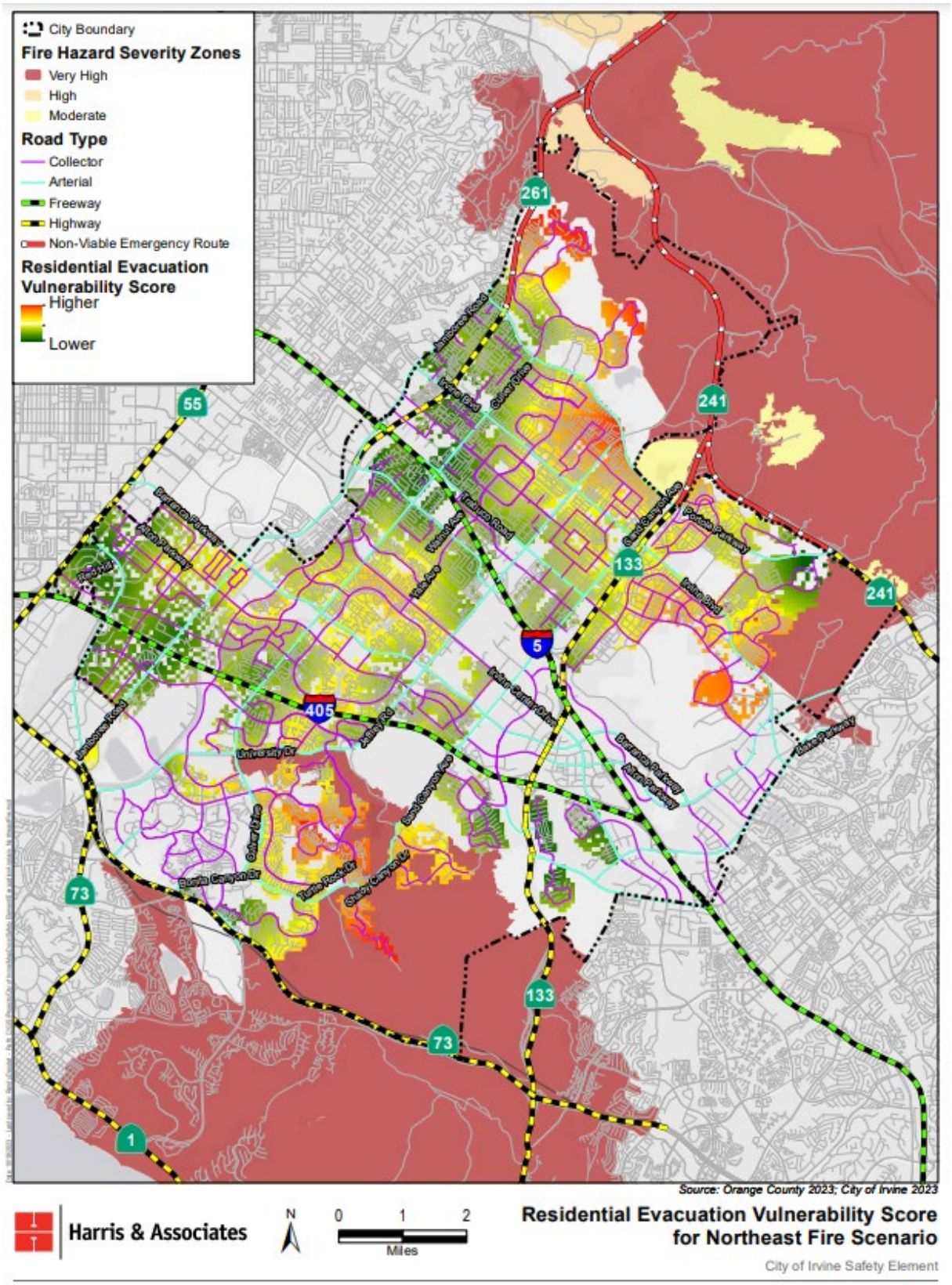
3. Wildfire (Northeast)

This scenario assumes a mandatory residential evacuation due to a wildfire originating northeast of the City. Outbound roads leading north/east, such as SR-261 North and SR-241 North are assumed to be not safe or viable due to the wildfire hazard.[7] The northwest-, west-, and south-bound freeways are the most viable evacuation routes in Irvine in this scenario. Evacuation vulnerability scores are re-calculated from the baseline scenario to account for the increased distance to the next closest, viable outbound road. **Figure 4, Residential Evacuation Vulnerability Score for Northeast Fire Scenario**, highlights residential parcels with evacuation route vulnerability scores that increased as a result of the SR-261 North and SR-241 North evacuation routes being closed. Residents in the northern portion of the City (EMZs 1A-1B, 5B, 5D, 8A, and 9A-9B) are most vulnerable to a fire originating from the very high FHSZs northeast of the City. Additionally, residents in the northeastern portion of the City are more vulnerable to unsafe road conditions related to the fire, such as poor visibility and air quality due to smoke and ash, falling embers, etc. However, some residents in the northeastern portion of the City (e.g., EMZ 6E) still have low vulnerability scores under this scenario given their close proximity to the SR-241 southbound entrance at Portola Parkway, which could quickly evacuate residents southbound out of the City. Conversely, the southern residential areas of the City (e.g., EMZs 21C-21D, 22B) are still shown to have high vulnerability scores given their proximity to an outbound freeway entrance in relation to other residential areas of the City.

SR-55, SR-73, SR-133 South, I-405, and I-5 are the outbound roads most likely to be used in this scenario. Additionally, residents are able to travel along a number of arterial roadways in Irvine in order to access the viable northwest-, west-, and south-bound freeways including, but not limited to, the following: Jamboree Road, Culver Drive, University Drive, San Canyon Avenue, Portola Parkway, and Barranca Parkway. The viable northwest-, west-, and south-bound freeways under this scenario increase overall evacuation capacity in Irvine. However, the City's internal roadways (arterial, collector, and local roads) are subject to congestion as residents attempt to access the outbound freeways. Emergency responders should consider activating evacuation traffic management along arterial roads to allow for easier access to the freeways.

[7] The very high FHSZ area north of the City and west of SR-261 is included under this scenario, as a fire in this area would make SR-261 North a non-viable route.

Figure 4. Residential Evacuation Vulnerability Score for Northeast Fire Scenario

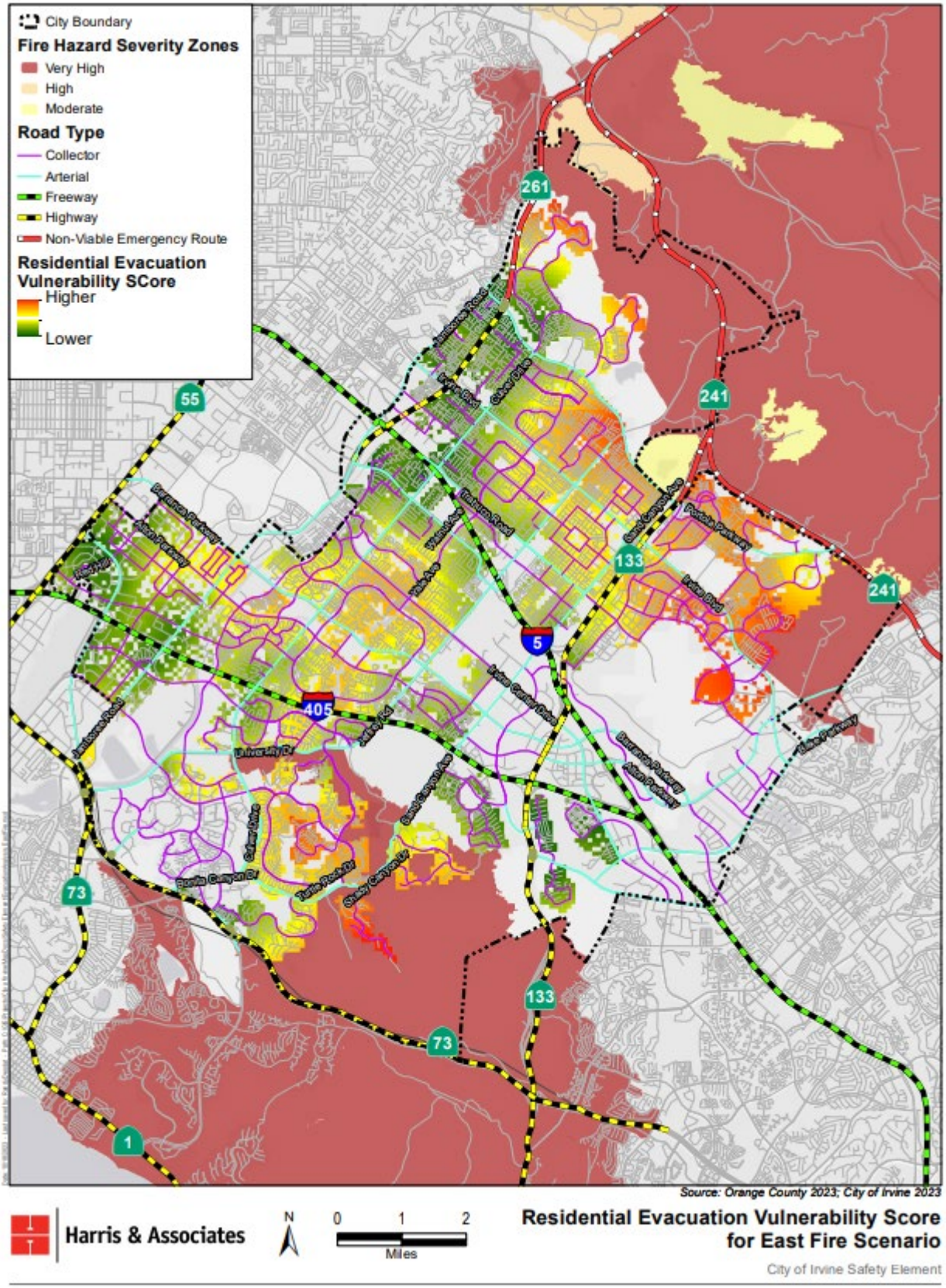


4. Wildfire (East)

This scenario assumes a mandatory residential evacuation due to a wildfire originating east of the City. Outbound roads leading east/northeast, including SR-261 and SR-241, are assumed to be not safe or viable. The south- and northwest-bound freeways are the most viable evacuation routes in Irvine in this scenario. Evacuation scores are re-calculated from the baseline scenario to account for the increased distance to the next closest, viable outbound road. **Figure 5, Residential Evacuation Vulnerability Score for East Fire Scenario**, highlights residential parcels with evacuation route vulnerability scores that increased as a result of the SR-261 and SR-241 evacuation routes being closed. Residents in the northern and eastern portions of the City (EMZs 1A-1B, 5D, 9A-9B, 6B-6D, 6H, 51A, 51D-51E, and 51H) are most vulnerable to a fire originating from the very high FHSZs east of the City. Additionally, residents in the eastern portion of the City are more vulnerable to unsafe road conditions related to the fire, such as poor visibility and air quality due to smoke and ash, falling embers, etc. The southern residential areas of the City (e.g., EMZs 21C-21D, 22B) are still shown to have high vulnerability scores given their proximity to an outbound freeway entrance in relation to other residential areas of the City. SR-133 South, SR-73, I-5, and I-405 are the outbound roads most likely to be used in this scenario.

The viable south- and northwest-bound freeways under this scenario increase overall evacuation capacity in Irvine. However, the City's internal roadways (arterial, collector, and local roads) are subject to congestion as residents attempt to access the freeways. Emergency responders should consider activating evacuation traffic management along arterial roads to allow for easier access to the freeways.

Figure 5. Residential Evacuation Vulnerability Score for East Fire Scenario



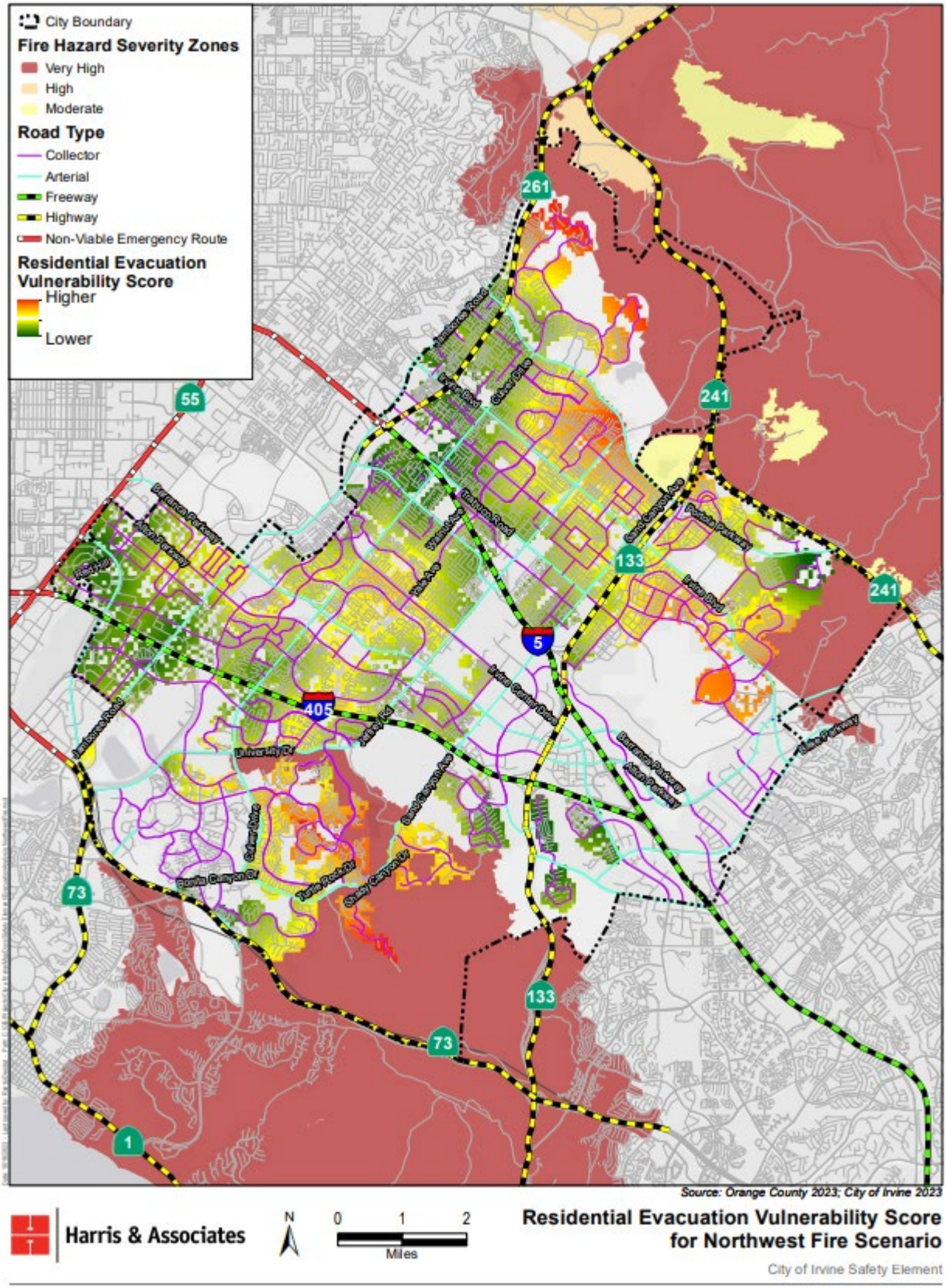
5. Wildfire (Northwest)

This scenario assumes a mandatory residential evacuation due to a wildfire originating northwest of the City. It should be noted that this scenario is less like to occur given that there are no high or very high FHSZs in the urban land northwest of the City.[8] Outbound roads leading northwest/west, including SR-73 North, SR-55 South, I-405 West, and I-5 West, are assumed to be not safe or viable. The south-, north-, and east-bound freeways are the most viable evacuation routes in Irvine in this scenario. Evacuation scores are re-calculated from the baseline scenario to account for the increased distance to the next closest, viable outbound road. **Figure 6, Residential Evacuation Vulnerability Score for Northwest Fire Scenario**, highlights residential parcels with evacuation route vulnerability scores that increased as a result of the SR-73 North, SR-55 South, I-405 West, and I-5 West evacuation routes being closed. Residents in the northern portion of the City (EMZs 1A-1B, 5B, 5D, and 9B) are most vulnerable to a fire originating from the very high FHSZs northwest of the City. Additionally, residents in the northwestern portion of the City are more vulnerable to unsafe road conditions related to the fire, such as poor visibility and air quality due to smoke and ash, falling embers, etc. Although residents in the eastern and southern portions of the City (e.g., EMZs 21C-21D, 22B) are further away from the hazard, these areas are still shown to have high vulnerability scores given their proximity to an outbound freeway entrance in relation to other residential areas of the City.

SR-261, SR-241, SR-133, SR-73 South, I-5 South, and I-405 East/South are the outbound roads most likely to be used in this scenario. Residents are able to travel along viable arterial roadways in Irvine to access the viable south-, north-, and east-bound freeways, including, but not limited to, the following: Irvine Boulevard, Culver Drive, and Jeffrey Road. The viable north- and east-bound freeways under this scenario increase overall evacuation capacity in Irvine. However, the evacuation of residents without life-saving resources or residents with reduced mobility, such as those who do not have access to a vehicle of their own, may be more challenging.

[8] The very high FHSZ area north of the City and west of SR-261 is included under the Northeast Fire scenario, as a fire in that area would make SR-261 North a non-viable route. The Northwest Fire scenario assumes a fire originating from the urban land northwest/west of the City.

Figure 6. Residential Evacuation Vulnerability Score for Northwest Fire Scenario

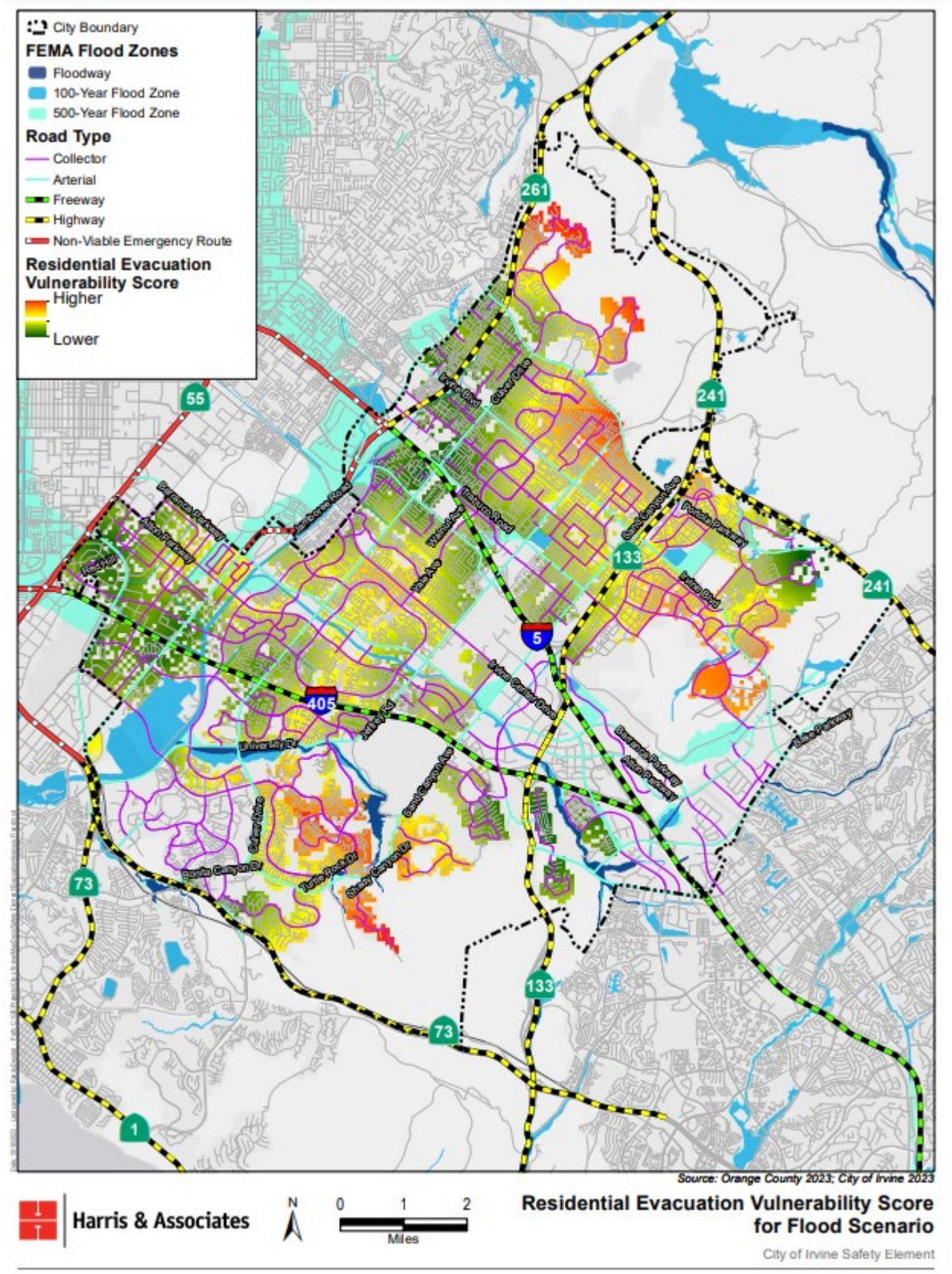


6. Flood (Extreme Precipitation)

The flood scenario assumes that all City residents will need to evacuate away from the flood zone. The roadways located within the floodways (i.e., portions of Jamboree Road, I-5 North, and SR-55 South) are assumed to be non-viable routes due to unsafe road conditions. Evacuation scores are re-calculated from the baseline to account for the increased distance to the next closest, viable outbound road (**Figure 7, Residential Evacuation Vulnerability Score for Flood Scenario**). Figure 7 highlights residential parcels with evacuation route vulnerability scores that increased as a result of the evacuation routes being closed. Given that all City residents are assumed to need to evacuate, residents furthest from a viable freeway entrance are shown to have the highest vulnerability, although some of these areas (e.g., EMZs 1A-1B, 5D, and 9A) are much less likely to be affected by a flood. Generally, the northernmost and southernmost portions of the City have a higher evacuation route vulnerability. Residents closest to the flood zones (the central portions of the City) are at highest risk of being affected by a flood hazards, although some of these residents (e.g., EMZs 10B-10C, 19, and 36L) have more options for viable routes to evacuate the City. Assuming the flood occurs due to extreme precipitation, unsafe road conditions could occur not only from route inundation, but also due to reduced visibility from heavy rain.

The roadways (arterial and collector) that flow in directions away from the floodway are the outbound roads most likely to be utilized in this scenario (e.g., Bonita Canyon Drive, Barranca Parkway, Irvine Center Drive, Yale Avenue, Bryan Avenue). However, the floodway includes sections of several of the arterial roads in Irvine (e.g., Culver Drive, University Avenue, Jeffrey Road, Sand Canyon Avenue, and Shady Canyon Drive, where they cross the floodplain). Roadways that connect residents to evacuation routes (arterial, collector, and local roads) may be inundated, limiting the ability of residents to evacuate. Also, first responders may have more difficulty accessing vulnerable populations that need to be evacuated once the water inundates the area. For example, people with mobility restrictions (e.g., wheelchairs) would not be able to cross a ladder and would be more difficult to access in a flooded area. Therefore, vulnerable populations may need to be prioritized by first responders during an evacuation due to flooding. It should be noted, the time it takes to evacuate is not as critical during a flooding event as compared to a wildfire because a flood is generally a slower-onset hazard.

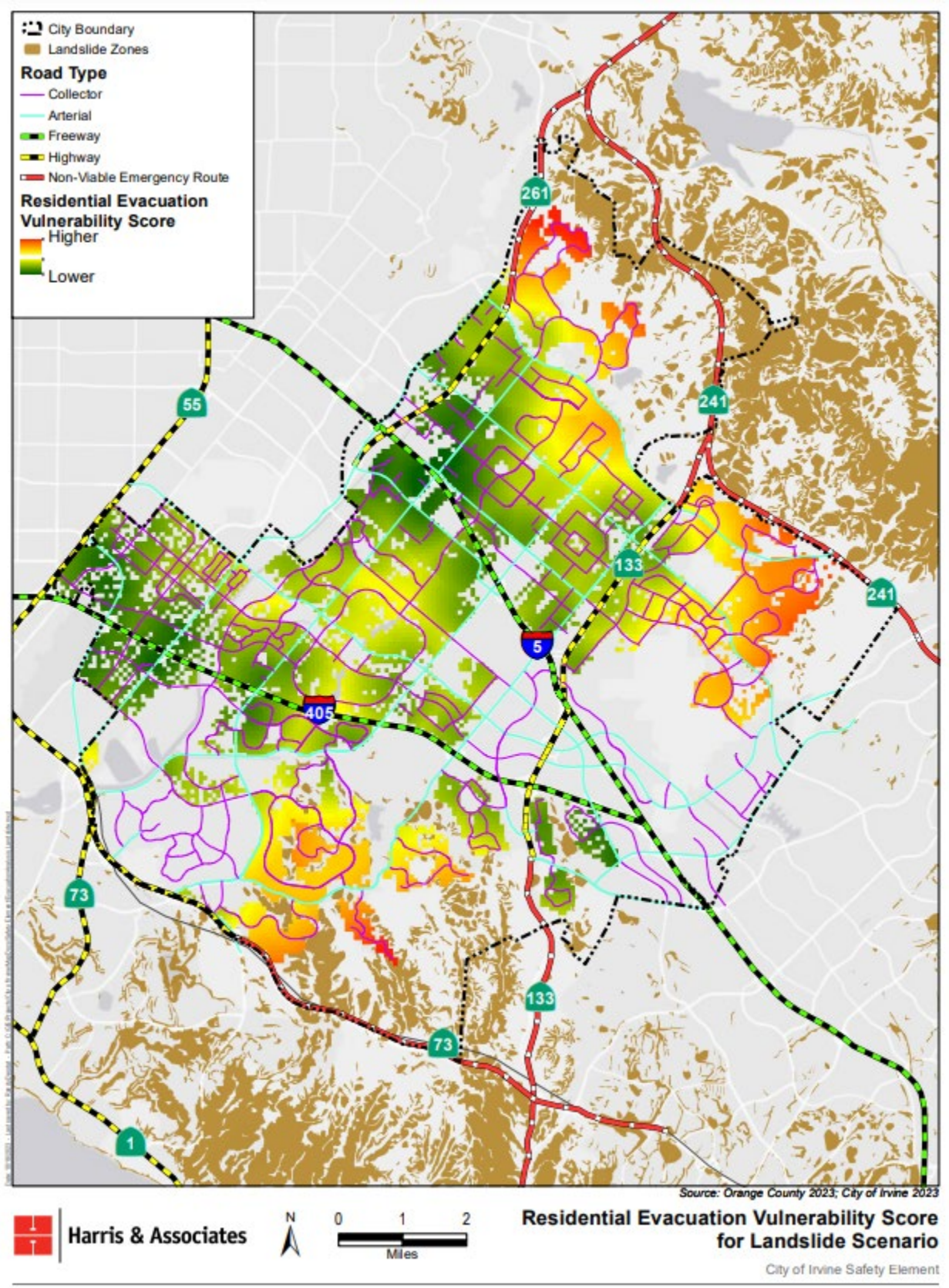
Figure 7. Residential Evacuation Vulnerability Score for Flood Scenario



7. Landslide

This scenario assumes a mandatory residential evacuation due to landslides in all areas of the City determined to have a high landslide susceptibility. Outbound roads leading into these areas, such as SR-261, SR-241, and SR-73 South, are assumed to be unsafe or non-viable due to the landslide hazard. Many collector and local roads (and some arterials) could also be non-viable or have limited capacity due to landslide debris, reducing the overall evacuation capacity of Irvine. I-5 and I-405 are the most viable evacuation routes in Irvine in this scenario. Evacuation vulnerability scores are re-calculated from the baseline scenario to account for the increased distance to the next closest, viable outbound road. **Figure 8, Residential Evacuation Vulnerability Score for Landslide Scenario**, highlights residential parcels with evacuation route vulnerability scores that increased as a result of the SR-261, SR-241, and SR-73 South evacuation routes being closed. Residents in the southern (EMZ 22B), eastern (EMZs 6E and 51A), and northern (EMZs 1A and 1B) portions of the City are most vulnerable to landslide hazards and evacuation during landslide events.

Figure 8. Residential Evacuation Vulnerability Score for Landslide Scenario



Section 6 Evacuation Locations

In accordance with AB 1409, this Evacuation Route Analysis is required to identify evacuation locations for the City. Evacuation locations for City residents would be dependent on the type and location of hazardous event affecting the City and would be determined by first responders on site during emergency situations. For example, if a wildfire occurs northeast of the City, residents would be directed to evacuate to community centers and City buildings in the southern and western portions of the City, such as the City of Irvine Civic Center or to areas west of the City, such as Huntington Beach and Long Beach. Evacuation locations would consist of places in Irvine that residents are familiar with, such as parks, community centers, schools, libraries, City department buildings, or churches.

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Section 7 Conclusion

The results of the Evacuation Route Analysis were as expected for each of the hazard scenarios. Residential parcels near outbound roads that were assumed to be non-viable under the hazard scenario saw an increase in their Evacuation Route Vulnerability Score compared to the baseline scenario, reflecting the greater distance residents would need to travel to access the next nearest outbound evacuation route:

- The baseline scenario suggests that residents in the northernmost, eastern, and southernmost areas of the City are most vulnerable given the distance they would need to travel to access an outbound freeway.

The Evacuation Route Analysis identified potential vulnerabilities in the City according to a GIS assessment that concludes whether all residential parcels have at least two points of egress. The analysis shows that residents closest to the southern, northern, and eastern extents of the City are most vulnerable given the distance and number of roads would need to traverse to access an outbound road:

- The residential parcels in the southern region of the City are the most vulnerable in the event of a wildfire from the south; however, these residents have more than two viable evacuation routes in this scenario.
- The residential parcels in the northern and eastern regions of the City are the most vulnerable in the event of a wildfire from the northeast; however, these residents have more than two viable evacuation routes in this scenario.
- The residential parcels in the northern and eastern regions of the City are the most vulnerable in the event of a wildfire from the east; however, these residents have more than two viable evacuation routes in this scenario.
- The residential parcels in the northern region of the City are the most vulnerable in the event of a wildfire from the northwest; however, these residents have more than two viable evacuation routes in this scenario.
- The residential parcels in the southern region of the City (EMZ 22B) only have one viable evacuation route in the event of a flood (Sunnyhill Road to Turtle Rock Drive) given that Shady Canyon Drive would be inundated to the west and east of Copper Creek (road).
- The residential parcels in the northernmost, eastern, and southernmost extents of the City are the most vulnerable in the event of a landslide; however, these residents have more than two viable evacuation routes in this scenario.

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Section 8 Recommendations

The Evacuation Route Analysis suggests that emergency responders should be flexible in emergency scenarios since the location and extent of a hazard may disrupt established evacuation routes. Given the potential for congestion when certain evacuation routes are closed, emergency responders should consider contraflow lane reversal (i.e., the reversal of lanes in order to temporarily increase the capacity of congested roads) as one strategy to efficiently evacuate residents during all hazard scenarios. In the event of a flood hazard, residences near the San Diego Creek may be inundated with floodwaters before first responders can access the area. Given that flood hazards are generally more slow moving, first responders should focus first on evacuating areas closest to the flood zone. Additionally, first responders may have more difficulty accessing vulnerable populations that need to be evacuated. For example, people with mobility restrictions (e.g., wheelchairs) would not be able to cross a ladder and would be more difficult to access in a flooded or fire area. Special consideration should be made for accessing people with mobility restrictions (e.g., at hospitals, senior centers) during flood and fire hazards.

Evacuation in the City was not analyzed under an earthquake scenario given that orders would typically be to shelter in place during and after an earthquake event. Nevertheless, it should be noted that the majority of the outbound evacuation routes rely on a bridge or several bridges associated with roadway, freeway, and railroad overcrossings, which are vulnerable to earthquakes and seismic hazards. Parcels that require access to bridges to evacuate should be prioritized as areas of concern in the event of an earthquake.

Social vulnerability indicators, including age, disability, and other mobility factors, should be further examined to determine other potential barriers to evacuation besides distance to and capacity of evacuation routes. The City, in coordination with the County of Orange, continues to plan for the needs of individuals with disabilities and access and functional needs, including but not limited to, providing accessible transportation during evacuations and providing public information in multiple languages. The City's EOP details the measures to ensure that preparedness and response strategies serve the needs of the entire population within the City, including vulnerable populations, such as people with disability, access, and functional needs; persons in institutional or care facilities; those with chronic conditions or with limited or no English; children; the elderly; and persons who may require specialized transportation assistance before, during, and after an incident.

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