The Future of Floodplains: Restoring Nature, Reducing Risk

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The Nature Conservancy

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Executive Summary

California faces increasing flood risk as climate change intensifies atmospheric rivers, alters precipitation patterns, raises sea levels, and contributes to post-wildfire watershed instability. Although flooding affects all 58 counties, and roughly one in five residents live in flood-prone areas, current flood hazard mapping and land-use planning are not keeping pace with changing hydrology. Aging flood protection infrastructure and an estimated funding gap of $50 to $115 billion further increase statewide vulnerability.

The purpose of this analysis is to examine how development patterns across California intersect with flood-related land-use policies, with a focus on six areas selected for their high projected growth or notable land-use approaches: Antelope Valley Subbasin (Los Angeles County), Whitewater River Subbasin (Riverside County), San Jacinto Subbasin (Riverside County), Sacramento County, Merced County, and Santa Clara County. The study draws on spatial development data, FEMA and climate-informed flood models, and a review of policy frameworks to understand where and why development continues to occur in flood-prone areas.

The analysis shows that while California has built a strong foundation of state flood policy, including Senate Bill 379 (Jackson, Chapter 608, Statutes of 2015), the Central Valley Flood Protection Plan, Urban Level of Protection standards, Flood-MAR, and Executive Order N-82-20, there continue to be gaps that allow exposure statewide.

Key Findings

- Flood exposure is increasing statewide despite existing policy frameworks, as development continues to shift into areas with long-term or climate-driven flood risk that are not fully addressed by current floodplain regulatory maps.
- Uneven application of state flood policies creates local gaps, allowing jurisdictions with weaker land-use controls to approve development in hazardous areas.
- Reliance on structural flood protection alone can increase long-term risk by creating a false sense of security and contributing to the “safe development paradox,” particularly where land-use policies do not also limit development in flood-prone locations.
- Jurisdictions that prioritize avoidance and nature-based approaches—such as Antelope Valley and Merced—show better outcomes, reducing exposure by steering growth away from floodplains and preserving natural flood functions.
- Improved integration of climate-informed flood data into planning decisions is essential to align future development with evolving risk conditions.
- States such as Massachusetts, New Jersey, and Washington have successfully enacted land-use policy that prioritizes avoidance of development in high-risk floodplains by combining state-level enabling legislation, local zoning, environmental overlays, and growth management policies, and can be looked to as models for California.

Strategies to Reduce High-Risk Development

Building on these findings, the analysis identifies five strategies to reduce future flood exposure while supporting resilient growth:

- Improve flood risk mapping: Updating and expanding the use of climate-informed flood maps can better reflect future conditions and guide development decisions beyond the limits of FEMA's regulatory floodplains.
- Apply land-use screens for development decisions: Standardized screening tools can help state and local agencies identify and avoid approving new development in areas subject to current or projected flood risk.
- Strengthen general plan and zoning policies: Aligning land-use designations, zoning ordinances, and housing policies with flood risk objectives can more effectively limit exposure before development occurs.
- Expand conservation agreements and incentives: Voluntary conservation easements, agricultural preservation programs, and incentive-based tools can protect flood-prone lands while supporting landowners and local economies.
- Pursue strategic land acquisition: Targeted acquisition of high-risk properties can permanently reduce exposure, enable floodplain restoration, and deliver long-term public safety and ecological benefits.

Collectively, these actions offer a path toward reducing long-term exposure, improving resilience, and aligning future growth with the realities of a changing climate.

1. Introduction

California's rapid population growth and urban expansion have significantly reshaped its landscapes over the past century. From 1950 to 2025, the state's population quadrupled from approximately 10 to 39.5 million, and is projected to reach 40.5 million by 2040.[1] While growth has slowed significantly since 2000, urban areas continue to expand outward into natural and working lands, including floodplains. This outward push of development has increasingly encroached on floodplains—areas that naturally absorb excess water during heavy precipitation or snowmelt events. These floodplains are inherently more prone to flooding than upland areas, yet continued growth has intensified pressure to build within them, creating high-risk zones for residential and commercial development. While land-use policies aim to manage sprawl and mitigate flood risk, many focus on enabling "safe" development within floodplains rather than discouraging it altogether, contributing to what researchers call the "safe development paradox"—a false sense of security that perpetuates risky development.[2] This report examines the intersection of urban expansion, floodplain development, and land-use policy in California, and explores how nature-based solutions can be integrated into planning to enhance flood resilience.

Section 1 introduces flood hazards and development risks in California.

Section 2 outlines the methodology for identifying urban areas at risk for development in floodplains.

Section 3 analyzes historical development trends inside and outside floodplains.

Section 4 connects these trends to land use and mitigation policies, including examples of successful strategies from across the United States, and the role of nature-based solutions in these areas.

> The **"Safe Development Paradox"** refers to the idea that areas either a) protected by a levee or other engineered flood control structure or b) outside of the regulatory high-risk zone (e.g., 100 year flood) create a false sense of security that encourages development to remain in or near floodplains rather than shifting growth away, ultimately increasing the community's long-term exposure and vulnerability.[2]

Finally, **Section 5** highlights effective approaches and provides recommendations for redirecting growth away from high-risk floodplain areas and improving resilience.

1.1 Flood Hazards and Development Risk in California

According to the Public Policy Institute of California, over seven million California residents, approximately one in five, live in flood-prone areas.[3] Flooding affects all 58 counties within California, whether from riverine, coastal, or inland flooding in both rural and urban communities, and the widespread extent of these damages makes flooding one of the most pervasive natural hazards in the state.[3] From 1980 to 2024, California experienced six "billion-dollar" flooding events, causing over 100 deaths and collective losses between $10–20 billion (CPI adjusted), including damages to buildings and public infrastructure, material assets, agricultural assets, and time element losses such as business interruptions or loss of living quarters, among others.[4] Climate change is amplifying these threats through intense atmospheric rivers, extreme precipitation events and precipitation events following periods of severe droughts, and sea level rise.[3, 5] Post-wildfire slope instability is an additional risk due to changes in soil composition and the loss of stabilizing vegetation.[6]

California has experienced "megaflood" atmospheric river events approximately every 200 years, most recently in the Great Flood of 1861-62.[7] In today's terms, this catastrophic event would be classified as a 100-year flood. According to U.S. Geological Survey (USGS) modeling, a major statewide flood at this scale has the potential to displace more than 1.5 million people and result in over $1 trillion in property damage and business losses.[8] This staggering potential impact underscores the vulnerability of California's aging infrastructure, much of which was built over 50 years ago and is inadequate to handle the increasing severity of storms driven by climate change.[9] As atmospheric rivers intensify, additional development and watershed changes occur, and sea levels continue to rise, the risk of catastrophic flooding continues to escalate. Despite spending approximately $2.8 billion on flood control operations and new investments annually, the state faces an estimated $50 to $115 billion gap in infrastructure needs over the next 25 years.[3] The consequences of underinvestment are especially relevant for priority populations, defined by the state in Senate Bill 535 and Assembly Bill 1550 as disadvantaged communities and low income communities and households that are disproportionately vulnerable due to higher existing environmental burdens and fewer resources to recover from flood events.[5]

Decisions concerning development in flood-prone areas have historically relied on data from the Federal Emergency Management Agency (FEMA), which has been responsible for mapping flood hazards in the United States since the 1960s. While FEMA's Flood Insurance Rate Maps (FIRMs), which indicate areas with a 1% annual chance of flooding, also known as Special Flood Hazard Areas (SFHAs), remain the standard for floodplain management throughout California, they have limitations, both in relation to integrating climate-driven uncertainty into their assessment of flood hazards and in the infrequency with which the maps are updated. Independent flood hazard and risk products, such as those produced by Fathom* are "climate-aware," including past and projected impacts of climate change on flood risk, in addition to historical hydrological data. Comparisons of FEMA and Fathom products indicate different areas of strength for each, such as greater precision around major stream and river channels in FEMA maps versus Fathom's ability to capture areas of pluvial flooding (rain-driven inundation away from major river channels).[10] The analysis in this report uses both FEMA and Fathom flood hazard and risk data for the most comprehensive understanding of where flooding could occur, and how flood hazard mapping may have informed past land use and policy decisions.

1.2 Floodplain Development Drivers

Since 1950, California's population has quadrupled from approximately 10 million to approximately 40 million, creating immense statewide pressure to meet housing demands. Driven by a combination of policy-based, cultural, and economic factors, much of this population growth has been absorbed beyond historical urban cores into suburban and exurban development, and newly urbanized areas. Of overall

* Fathom data is proprietary and not available for public use. More information on Fathom's methodology and technical documentation can be found here: https://agupubs.onlinelibrary.wiley.com/doi/10.1029/2020WR028673; https://zenodo.org/records/4740762

statewide population growth between 1950 and 2024, only 12% is attributed to the six cities that were most populous in 1950 (AECOM's calculation based on historical census data). Throughout the second half of the 20th century, federal investment in suburbanization and highway infrastructure facilitated expansion of the single-family housing model and outward growth into new suburban developments. Success of the 'slow growth' movement in established affluent urban and suburban communities further limited densification through infill development, contributing to a housing shortage and affordability crisis that continues to drive low density development outward from major cities today. The housing affordability crisis, paired with the expansion of land-intensive warehousing, logistics, aerospace, mining, agriculture, energy production, and technology industries, creates a confluence of housing demand and economic opportunity in some flood-prone areas where land is more readily available and affordable. Lower land costs in flood-prone areas also attract real estate speculators and developers willing to prioritize short-term gains over long-term sustainability if undeterred by land-use policy guardrails. These patterns ultimately result in higher long-term costs, including future flood damages, rising insurance burdens, and ongoing infrastructure maintenance, that are often shifted onto homeowners and taxpayers.

Whether due to intentional leniency or lack of flood risk awareness, local land-use and zoning policies have allowed development to expand within flood-prone areas throughout the state. Many areas historically designated as natural and working lands have been rezoned to meet demand for residential, commercial, and industrial space. Typically low-lying, flat, and located near water sources, agricultural land is attractive for residential development despite its flood-prone tendencies. Rather than regulating and limiting development in flood-prone areas, many jurisdictions have historically relied on gray infrastructure, such as levees and dams, to manage flood risks. While these engineering solutions provide a certain level of protection, they have often encouraged development in flood-prone areas under the assumption of safety, rather than promoting solutions that work with the landscape to mitigate flooding, such as nature-based solutions. Engineering solutions also introduce ongoing maintenance needs, with their success depending on the ongoing availability of funding and capacity of personnel.

The accelerating impact of climate change has also expanded and reshaped floodplains faster than flood-risk mapping, land-use planning, and adaptation measures can keep pace. Areas once deemed safe are now increasingly exposed to severe and frequent flooding, highlighting the urgency for more sustainable and adaptive approaches to development and flood management. Recognizing this need, some jurisdictions have implemented policies that prioritize flood-risk mitigation through nature-based solutions and sustainable land use.

1.3 Purpose and Objectives

As California continues to grapple with the escalating impacts of climate-driven flood hazards, the importance of land-use decisions, especially related to development in flood-prone areas, has become increasingly evident. Despite a growing awareness of flood risks and a rising adoption of nature-based solutions, residential and commercial development continues to expand in areas that are highly susceptible to flooding. This report examines how recent development trends across the state have contributed to heightened flood vulnerability, particularly in regions experiencing rapid growth. By exploring the specific drivers behind these trends and assessing their implications, we can better understand the intersection of land use and flood hazards and identify opportunities to align future development with resilience and sustainability goals.

To address these growing threats and higher-risk development trends, California must develop innovative and forward-thinking strategies to reduce risk associated with increased development in flood-prone areas. One way to do so is to rethink statewide and local land-use policies, focusing on resilience and sustainability. Integrating strategies that incorporate nature-based solutions, such as restoring wetlands, preserving floodplains, and enhancing green infrastructure implementation, into land-use planning can reduce flood risks while delivering additional co-benefits. Land-use planning that prioritizes ecological functions and climate smart growth near flood-prone areas can help mitigate future disasters and facilitate development that aligns with long-term environmental and public safety goals.

> **Nature-based solutions** are actions to protect, sustainably use, manage and restore natural or modified ecosystems, which address societal challenges, effectively and adaptively, providing human well-being and biodiversity benefits.
>
> *Source: International Union for Conservation of Nature*

This report examines flood model outputs, historical development trend data, and precedents for smart land-use policy and nature-based solutions strategies. This analysis will help identify specific opportunities and contextual considerations for The Nature Conservancy's (TNC) sustainable development and nature-based solutions efforts to reduce flood hazard risk across the state.

2. Methodology

2.1 Selection of Focus Areas

Given the scale of a statewide analysis and the diversity of California's landscape and urban development, it was necessary to identify focused areas of analysis ("focus areas") that allow for local and regional analysis of land use, development trends, and flood hazard. Focus areas include regions with high projected levels of growth, or jurisdictions that have implemented land-use approaches that have either enabled growth into flood-prone areas or successfully restrained development from expanding into flood-prone areas. Three initial focus areas were identified through TNC statewide mapping efforts: San Joaquin Valley, Pajaro River (Gilroy), and the Antelope Valley (Palmdale, Lancaster). These areas served as a starting point for further investigation and validation. These initial focus areas were refined to encompass Sacramento County, Merced County, Santa Clara County, and Antelope Valley Subbasin (Los Angeles County). Two additional focus areas of Whitewater River Subbasin (Riverside County) and San Jacinto Subbasin (Riverside County) were identified through data-driven statewide analysis of growth patterns and FEMA 100-year (1% annual chance) floodplain extents, described below.

As part of the initial screening process, FEMA-mapped repetitive loss properties and priority populations were overlayed to identify whether repetitive loss from flooding has disproportionately impacted geographies containing priority populations, and whether this relationship should inform the selection of focus areas. This assessment did not reveal a strong relationship between these two variables and therefore was not included in the final selection of focus areas. This finding does not discount that social vulnerabilities and other environmental burdens can exacerbate the impacts of flooding on priority populations, which should be considered in the planning and implementation of flood resilience measures.

To establish an initial understanding of where recent development may have occurred throughout California, an analysis of change over time in both population and number of housing units for all California census tracts was performed. This analysis used American Community Survey (ACS) 5-year Estimates for Total Population and Total Housing Units (years: 2013 and 2023).[11] Because the 2013 and 2023 ACS data use 2010 and 2020 census tract boundaries respectively, the 2023 data was standardized to the 2010 census tract boundaries using the National Historical Geographic Information Systems (NHGIS) Crosswalk table and the associated interpolation weights that NHGIS has determined for population and housing units.[12]

To understand where development is occurring within flood-prone areas, the population and housing unit change data was then overlaid with FEMA's 100-year flood hazard boundaries.[13] National Land Cover Database (NLCD) data from 2010 and 2023 was then used to map areas with an increase in fractional impervious surface area, to provide a more detailed indication of where development and sprawl has occurred—particularly on previously undeveloped land—within the 100-year floodplain.[14] This analysis resulted in GIS-based maps overlaying population and housing growth, 100-year floodplain, and impervious surface increase.

Census tracts that intersected FEMA's 100-year floodplain and fell within the top 25th percentile statewide of both population and housing unit percent increase were flagged as potential focus areas. To refine the focus area selection, impervious land cover increase data was applied as an overlay to observe the extent of greenfield development within high-growth census tracts that had occurred within the 100-year floodplain.[15]

Six focus areas were selected for analysis, representing diverse geographies, varying risk types, and a range of land uses, with the intent of producing analysis and policy considerations that are applicable to variety of development environments. Focus areas were analyzed at a high-level countywide or subbasin (HUC8 watershed) extent of similar geographic area for general context, and at one or more city or community-level extents for granular analysis of historical development drivers and policy. Focus areas are identified in Figure 1**.** Comparisons of focus areas by total area, area within the Fathom 100-year and 500-year and FEMA 100-year floodplain boundaries, and developed land area are shown in Figure 2.

1. Antelope Valley Subbasin (Los Angeles County)
2. Whitewater River Subbasin (Riverside County)
3. San Jacinto Subbasin (Riverside County)
4. Sacramento County
5. Merced County
6. Santa Clara County

Figure 1. Focus Areas

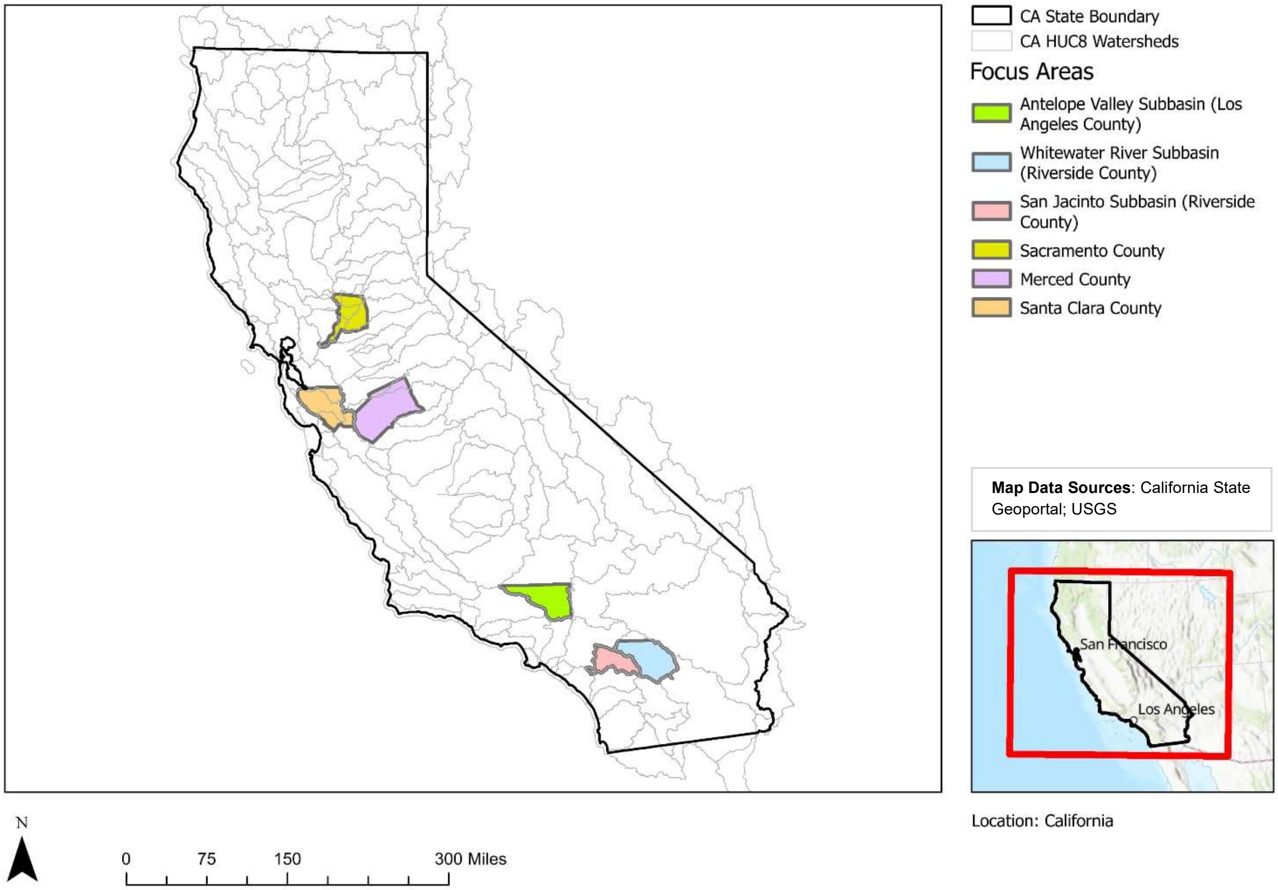
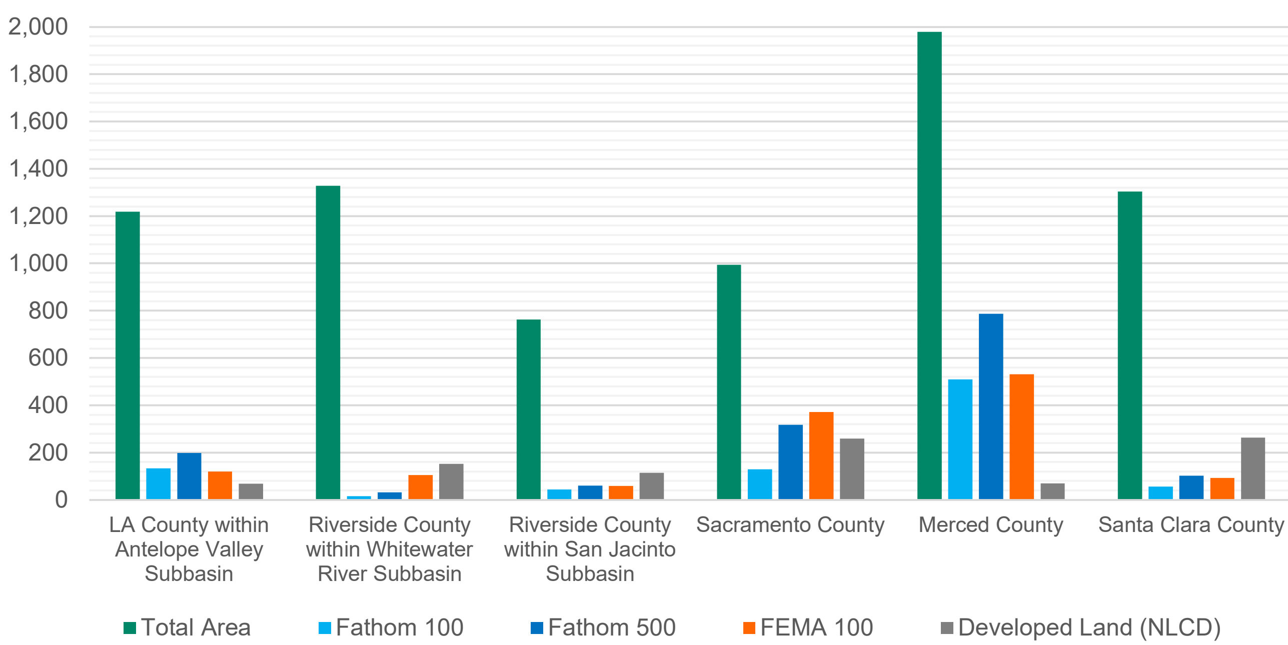


Figure 2. Focus Area Comparison: Total Area, Flood-Prone Area, and Developed Land (grouped by focus area; mi^2)



2.2 Analysis of Focus Areas

After selection of the focus areas, a more detailed analysis was performed to understand the historical trends in development overall and within the flood-prone areas. To understand areas with high-risk development, the FEMA 100-year floodplain was overlaid with developed land cover data from the NLCD and General Plan Land Use data from California's General Plan Land Use database. In addition to reviewing development as a whole, the General Plan Land Use data provided an overview of development types (residential, commercial, or industrial) that are most at risk in each focus area. Furthermore, potential areas of more extreme flood events were analyzed via adding Fathom's 500-year (0.2% annual chance) flood hazard layer, highlighting areas that may not be subject to current policies informed by FEMA-defined flood hazard data, and therefore have potentially more exposure to lower frequency flood events that are becoming more likely with climate change. The Fathom 100-year data was also included in the analysis for comparison with the FEMA flood hazard data and to assess flood hazards at a higher frequency.

A more comprehensive analysis of parcel development between 1950-2024 was conducted for focus areas, using parcel-level "year built" data from county assessors, where available. This analysis was possible for focus areas in Los Angeles County[16] (Antelope Valley), Riverside County[17] (Whitewater River and San Jacinto watersheds), and Sacramento County[18]. Parcel-based development trends over time, both overall and within flood-prone areas, informed analysis of how historical development drivers and subsequent land-use policies may have influenced where development occurred. Parcel-based "year built" data was not available for Merced County or Santa Clara County; analysis for these areas relied on qualitative research for an understanding of long-term historical development trends. Maps detailing each of the elements analyzed against flood risk are included in Appendix A.

2.3 Identification of Floodplain Development Management Approaches

Utilizing the development patterns highlighted through the analysis of the focus areas, a deep dive into the influence of land-use policies, flood mitigation plans, and risk reduction strategies on the development within flood-prone areas was performed. A custom Generative Pre-Trained Transformer (GPT), developed using OpenAI technology, was employed to automate portions of the research process. This tool accelerated the collection of relevant information, which was subsequently analyzed and reviewed for accuracy. The GPT was trained on publicly available documents related to floodplain development within and outside of California, nature-based solutions, and flood mitigation planning uploaded directly into the tool. A list of these documents is included in Appendix B. Initially built on OpenAI's GPT-4o model, the GPT was migrated to the GPT-5 Thinking architecture once this became available in August 2025. The introduction of GPT-5 allowed the development of a more robust and accurate "deep thinking" research model, with a 45% decrease in potential factual errors.[19] Following the creation of the output from the custom GPT, results were reviewed and verified using a quality assurance and quality control process. The GPT-generated reports included a full bibliography with in-text, hyperlinked citations, and all policy analysis content was reviewed by verifying these sources. Any inaccuracies were resolved through manual web searches. This process resulted in an average citation accuracy of 95%, with the initial report serving as a foundation for deeper analysis and source validation. The primary function of the GPT was to identify policies potentially influencing floodplain development, based on the temporal and spatial parameters (i.e., the periods of growth and decline within specific focus areas) defined during the development pattern analysis. These policies were assessed to determine their actual influence on floodplain development, whether they enabled or restricted sprawl, and, as a result, actionable recommendations were identified to discourage development within flood-prone areas. Outcomes of the focus area analysis and connections between these development patterns and any subsequent land-use policies, particularly as they relate to flood risk are discussed in Section 3.

3. Floodplain Development Trends and Existing Development Management Approaches

California has implemented a range of progressive flood risk reduction policies and programs designed to minimize development in high-risk flood zones and integrate climate resilience into land-use planning. Senate Bill 379 (Jackson, Chapter 608, Statutes of 2015), passed in 2015, mandates that all cities and counties in the state incorporate climate adaptation and resilience strategies into their general plans; alternatively, this requirement can be fulfilled through the adoption of a Local Hazard Mitigation Plan (LHMP).[20] Complementing this, Assembly Bill 2140 (Hancock, Chapter 739, Statutes of 2006) offers jurisdictions incentives to integrate their LHMPs into the Safety Element of their General Plans by making them eligible for additional state funding.[21]

The Central Valley Flood Protection Plan (CVFPP) stands as a cornerstone of California's regional flood management strategy. Among its provisions is the Urban Level of Protection (ULOP) standard, which requires that urban areas in designated flood hazard zones achieve a 200-year level of flood protection.[22, 23] Additionally, the CVFPP emphasizes multi-benefit flood mitigation projects that support ecosystem restoration, recreation, and agricultural viability.[24] On the coast, the California Coastal Act and the California Coastal Commission play a crucial role in reducing flood risks. These entities require new developments to minimize exposure to flooding and compel local jurisdictions to align their planning documents with the state's guidance. The state requires that all new coastal development be planned, sited, and designed to be resilient to future sea level rise, without relying on future armoring, and in a manner that protects public resources and natural shoreline processes.[25] Another innovative statewide approach is Flood-MAR (Managed Aquifer Recharge), a strategy that diverts floodwaters to agricultural and managed natural lands for groundwater recharge, enhancing both water supply and flood resilience.[26] Finally, projects like the Napa "Living River" exemplify California's commitment to integrating gray infrastructure with nature-based solutions and strategic land-use planning. These state-funded projects demonstrate how flood protection can be effectively combined with environmental restoration and community co-benefits.[27]

However, to fully assess the benefits of these, and similar policies within California across all scales of government, the connection between the introduction of flood risk reduction policies and any subsequent changes in development patterns for each focus area was analyzed. This section provides the overall context for each focus area, including land use and development patterns, flood-prone areas identified by FEMA and Fathom data, and historical parcel-based development trends where available. The analysis establishes each focus area's geography, topography, primary watershed(s), and flood hazard, followed by a broad discussion of development history, supported by data on the distribution of designated land uses, and the share of land area that is developed. Data is presented comparatively for the overall focus area and within the FEMA 100-year, Fathom 100-year, and Fathom 500-year floodplains. A closer look into the data for each focus area is included in Appendix A. This contextual analysis provides a baseline understanding of how development within each focus area occurred in relation to flood-prone areas and indicates at a high level how and where future development might occur.

To further refine the understanding of the interplay between land use and flood risk, the development trends identified within each focus area were used to analyze how land-use policies, flood mitigation plans, and risk reduction strategies have influenced increasing development within flood-prone areas. The patterns of growth and decline highlighted within each focus area were linked to the implementation of relevant land-use policies and community infrastructure plans. State-, county-, and local-level approaches to managing floodplain development were assessed to consider these impacts across all scales of government and to build a thorough understanding of successful approaches to dissuade continued high-risk development. In addition, this section explores approaches applied by other states related to reducing development in flood-prone areas and identifying successful components that may potentially be replicated within California.

3.1 Antelope Valley Subbasin (Los Angeles County)

The Antelope Valley Subbasin (Antelope-Fremont Valleys HUC8 Watershed) within Los Angeles County is a region in the western Mojave Desert, north of the San Gabriel and Sierra Pelona Mountains and Southeast of the Tehachapi Mountains. The elevated desert terrain of the valley is primarily at risk of flash flooding from intense storms and mountain runoff following undefined and meandering paths of alluvial fans along the valley floor.[28] FEMA and Fathom's 100-year floodplain maps cover 10% and 11% of the Antelope Valley within Los Angeles County, respectively, while Fathom's 500-year floodplain extends to cover 16% of land area, as detailed in Table 1 and shown in Figure 3. This focus area includes 151 FEMA FIRM panels* with effective dates of 2008 (95%), 2010 (3%), and 2021 (2%).

Table 1. Antelope Valley Subbasin (Los Angeles County): Area within Floodplain Boundaries and Developed Land

Total Area	Fathom 100		Fathom 500		FEMA 100		Developed Land (NLCD)	
(mi^2)	Area (mi^2)	%	Area (mi^2)	%	Area (mi^2)	%	Area (mi^2)	%
1,218	133	11%	198	16%	120	10%	69	6%

Land Use and Development Context

The valley contains two principal cities, Lancaster and Palmdale, and several unincorporated communities. While early development served the valley's agriculture industry, the primary industries driving economic and population growth since the mid-20th century have been aviation, aerospace, and defense.[28] More recently, Antelope Valley has seen growth in logistics operations and manufacturing industries, along with significant production of large-scale solar photovoltaic (PV) projects such as Antelope Valley Solar Ranch One and wind turbines such as Tehachapi Pass wind farm.

During the early 1980s, the region began to experience unprecedented growth, boosted by defense spending and spikes in greater Los Angeles home prices. Between the 1980 and 2010 census counts, the population of Antelope Valley grew from approximately 60,000 residents to 485,000, driven primarily by aerospace industry employment and affordable housing for Los Angeles commuters.[29] These trends are reflected in Figure 4 and Figure 5, with data indicating how much of the valley's growth during these periods occurred within the FEMA and Fathom floodplains.

As shown in Figure 6, approximately 65% percent of the Antelope Valley's land area within Los Angeles County is designated for low or medium density residential uses. Within the FEMA 100-year floodplain, 86% of land is designated for low or medium density residential uses, and another 9% for industrial uses as shown in Figure 7. Despite these land-use designations indicating a high level of potential development in the floodplain, NLCD data in Figure 8 shows only 6% of land in the watershed is considered 'developed,' and only 2% developed within the FEMA 100-year floodplain.

* FEMA FIRM panels (Flood Insurance Rate Map panels) are flood risk maps that make up a larger geographic area and are used to delineate a community's special hazard areas, flood risk zones, and base flood elevations.

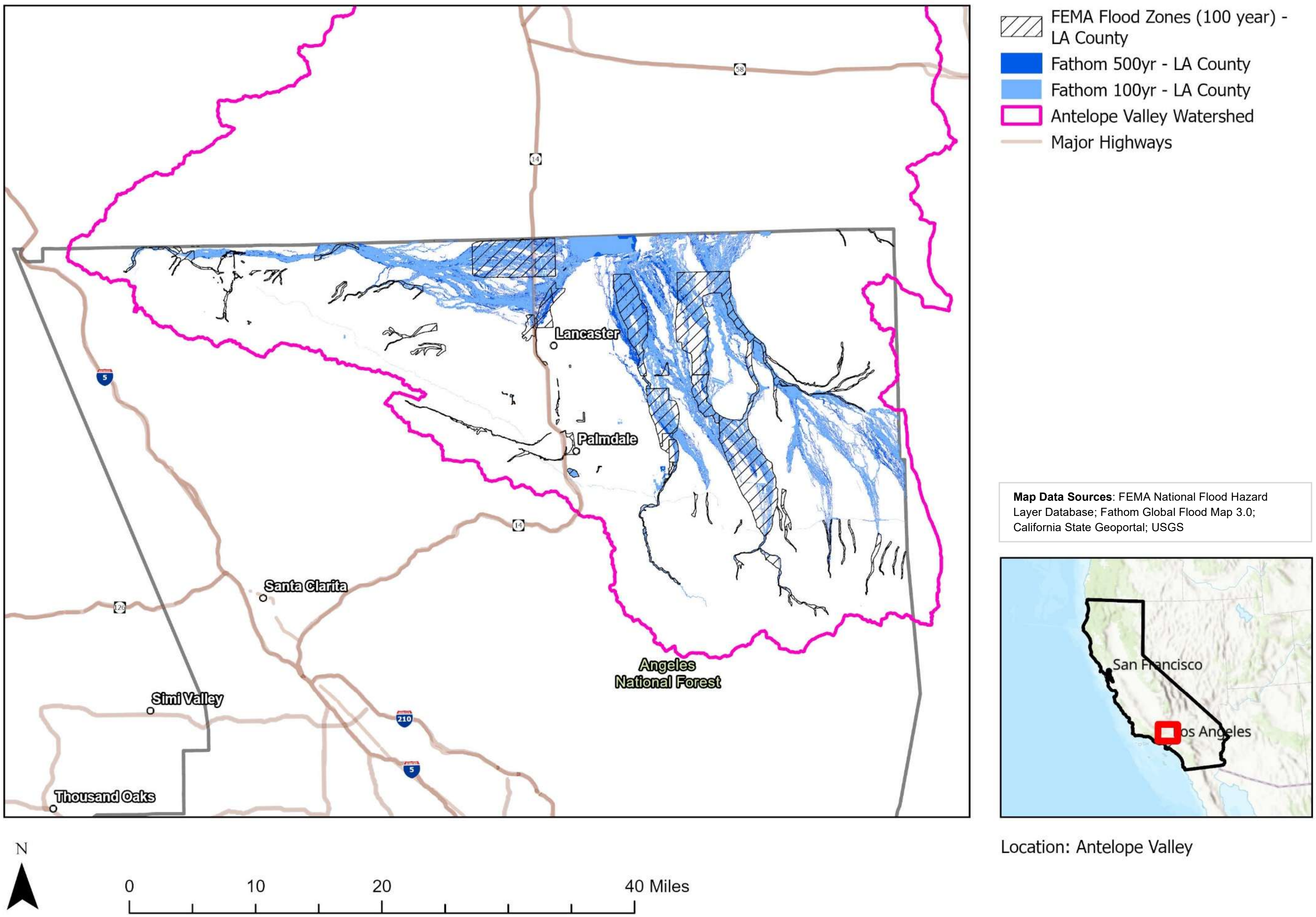
Floodplain Management Context

The Los Angeles County Department of Public Works (LACDPW) manages floodplain areas for unincorporated regions within Los Angeles County, including portions of the Antelope Valley. LACDPW enforces Title 11 of the county code, which outlines minimum development standards in flood zones such as freeboard and floodproofing requirements. This code has been maintained for decades and was updated in 2017.[30] While LACDPW oversees unincorporated areas, the incorporated cities of Palmdale and Lancaster manage their flood-related policies through their own local ordinances.

Los Angeles County has been a participant in the National Flood Insurance Program (NFIP) since 1980.[31] Title 11, also known as the Floodway Ordinance, regulates development in flood-prone areas. Titles 26 through 33 of the county's building codes establish flood resilience standards for structures. Additionally, Title 22—the Zoning Code—allows for the issuance of conditional use permits for construction in flood risk zones. The City of Palmdale regulates floodplain development through its Municipal Code Chapter 15.28, which outlines elevation and other building requirements in line with NFIP standards. Palmdale also published its LHMP in 2021. Meanwhile, the City of Lancaster generally defers to county and state building standards when managing floodplain development.

Damaging flood events in the 1970s and 1980s led to development of the Antelope Valley Comprehensive Plan of Flood Control and Water Conservation and the Palmdale Drainage Master Plan. However, both these plans emphasize the use of engineered solutions to reduce vulnerability of development in proximity to flood-prone areas, rather than land-use guidance to locate development away from flood-prone areas.

Figure 3. Floodplains within Antelope Valley Subbasin (Los Angeles County)



Map Data Sources: FEMA National Flood Hazard Layer Database; Fathom Global Flood Map 3.0; California State Geoportal; USGS

Location: Antelope Valley

Policy Analysis

The Antelope Valley's alluvial fan flooding typology did not have an associated risk analysis methodology until the 1980s, with early models first incorporated into FEMA guidelines in 1985.[32,33] Following the County's participation in the NFIP, restrictive development requirements within FEMA's newly designated flood areas appear to have contributed to a marked decline in development in FEMA flood areas. While the 1980s development boom peaked in 1990 for the focus area overall, development in FEMA flood areas began declining as early as 1985. The number of annual parcels developed in FEMA flood areas dropped from a peak of 98 parcels in 1985 to 19 parcels in 1990, further decreasing to one parcel by 1996, as shown in Figure 4. While development in FEMA flood zones rose again to 25 annual parcels during the housing boom in the early 2000s, it has remained in single digits since 2007.

While subject to NFIP regulations, land-use designations allow for residential uses throughout much of the Antelope Valley subbasin focus area, facilitating low-density sprawl into some flood-prone areas. As shown in Figure 9, some larger suburban and rural communities (e.g., Sun Village and Antelope Acres [see Appendix A]) have been developed in flood-prone areas identified by Fathom flood modeling, which has not been integrated into policy guidance or decision-making.

Overall, most urban development in the focus area has grown outward from Palmdale and Lancaster, avoiding flood-prone areas. The overlay of development data, allowed land-use data, and policy context indicates the success of Los Angeles County's floodplain management ordinances in restricting and discouraging development in FEMA-designated flood areas.

Figure 4. Antelope Valley Subbasin (Los Angeles County): Number of Parcels Developed within a FEMA or Fathom Floodplain: 1950-2024

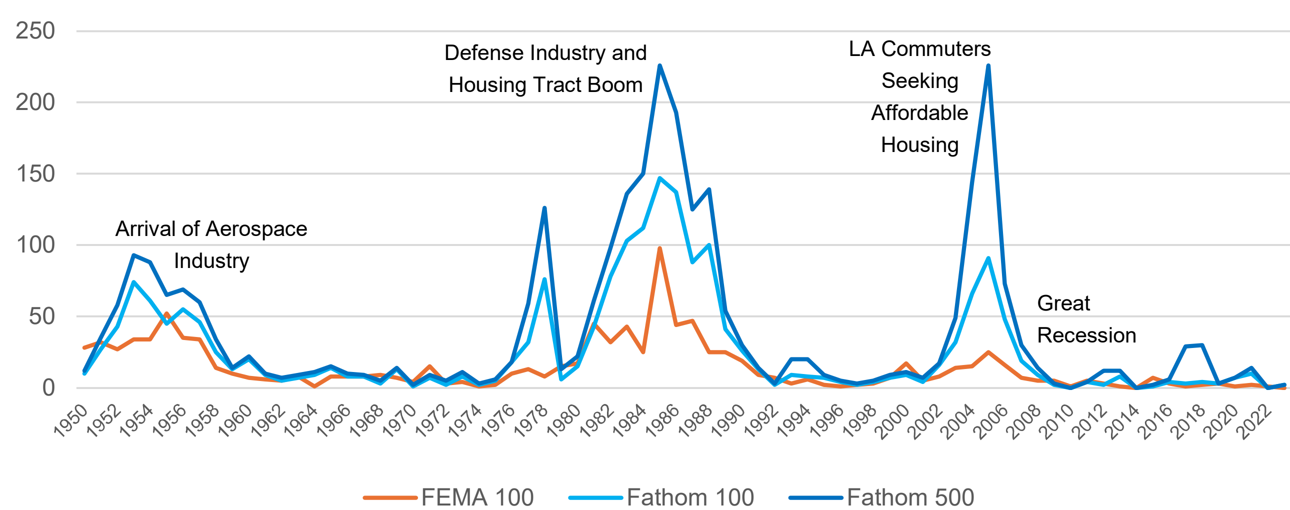


Figure 5. Antelope Valley Subbasin (Los Angeles County): Floodplain Parcel Development as Share of Overall Parcel Development by Year

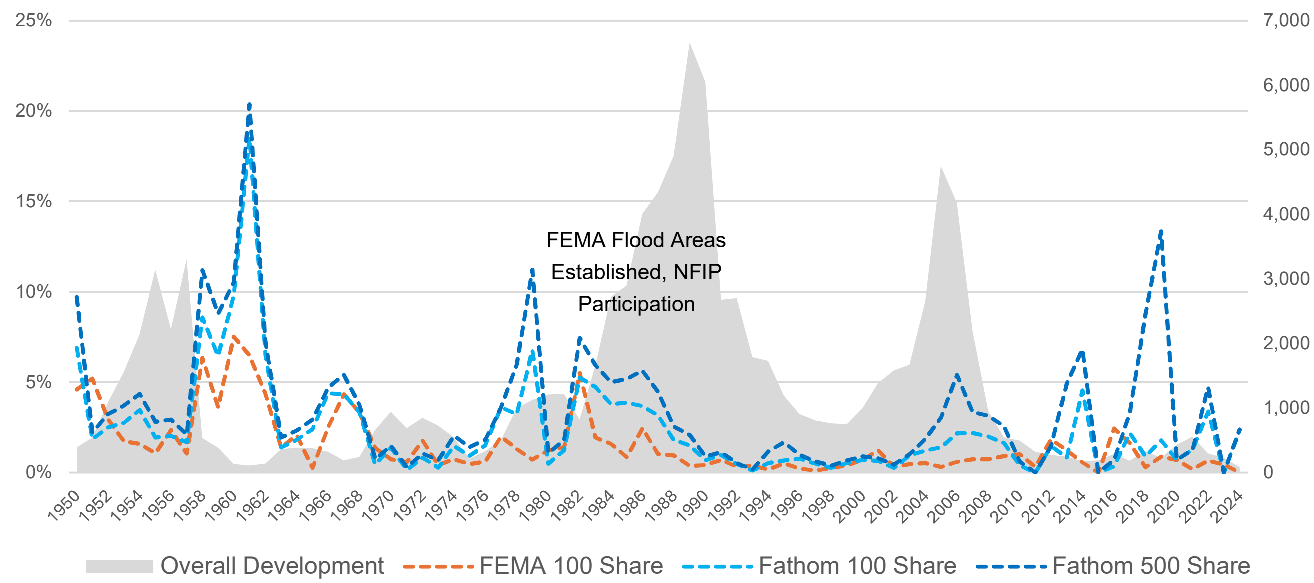


Figure 6. Antelope Valley Subbasin (Los Angeles County): General Plan Land Use as Percent of Subbasin Land Area

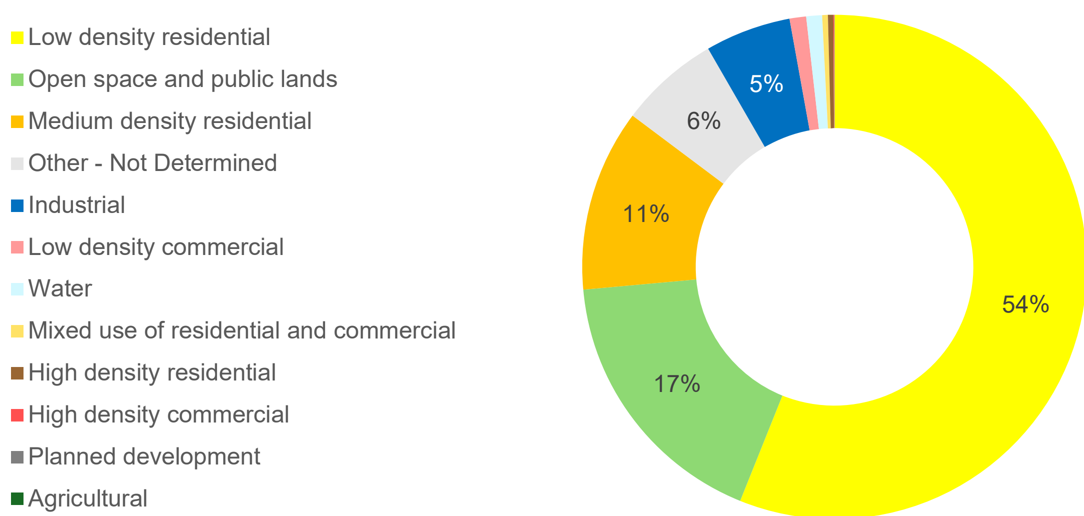


Figure 7. Antelope Valley Subbasin (Los Angeles County): General Plan Land Use as Percent of Subbasin Flood Zones

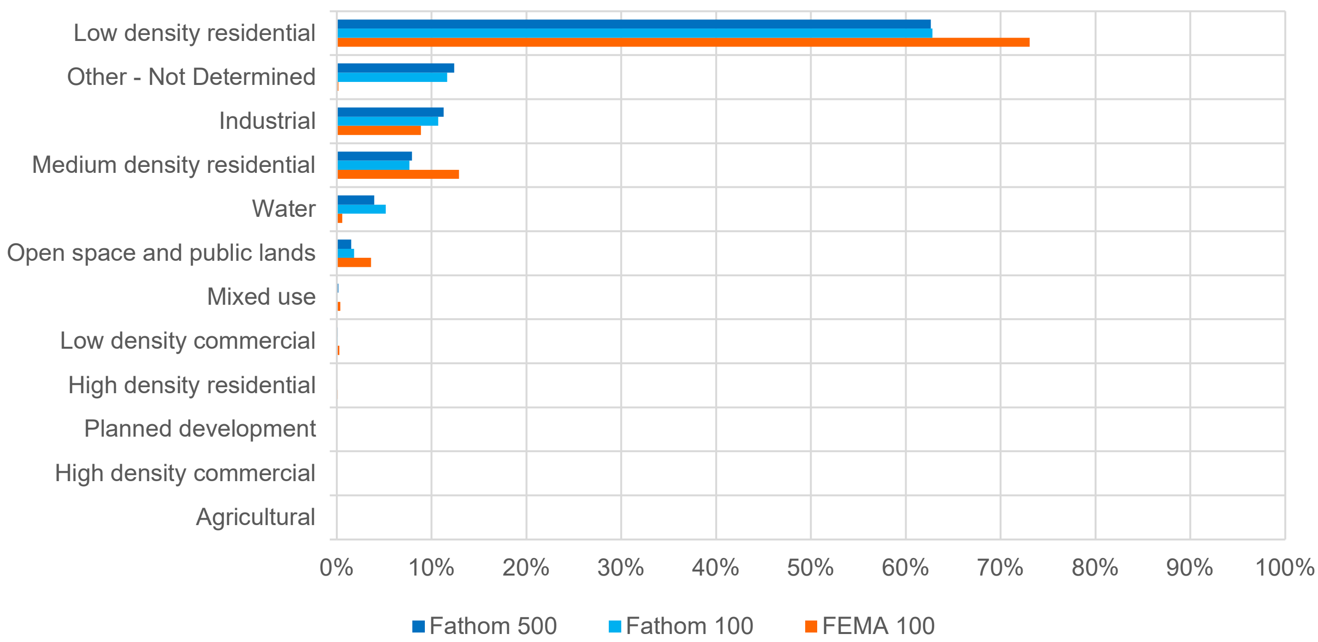


Figure 8. Antelope Valley Subbasin (Los Angeles County): NLCD Developed Land Percentages

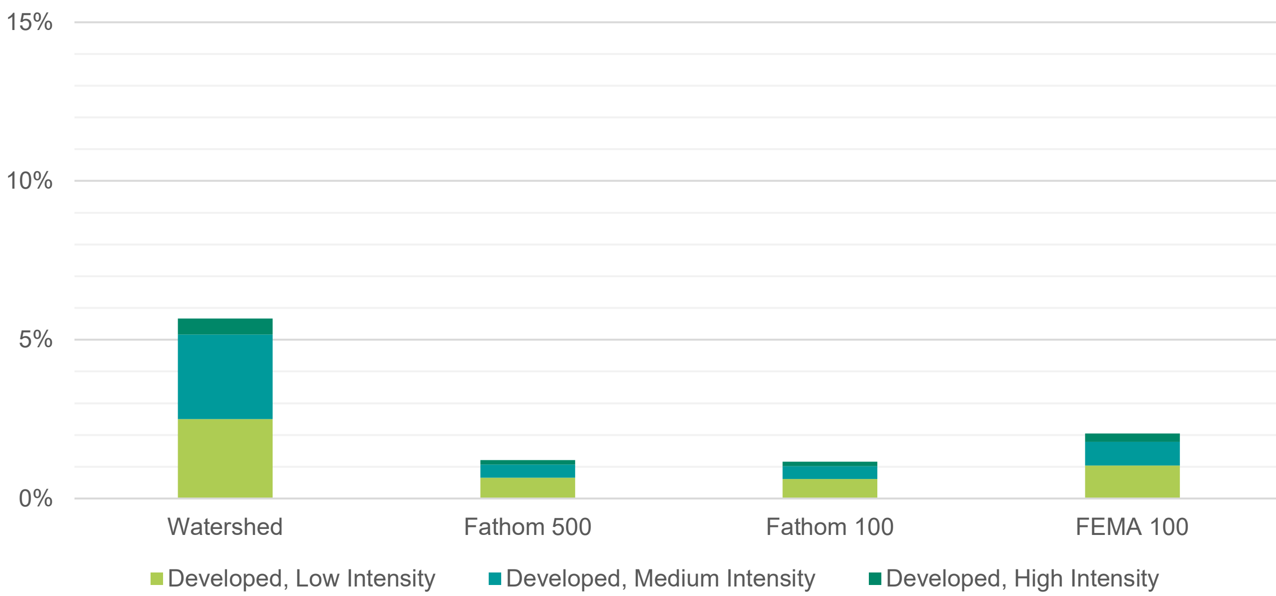
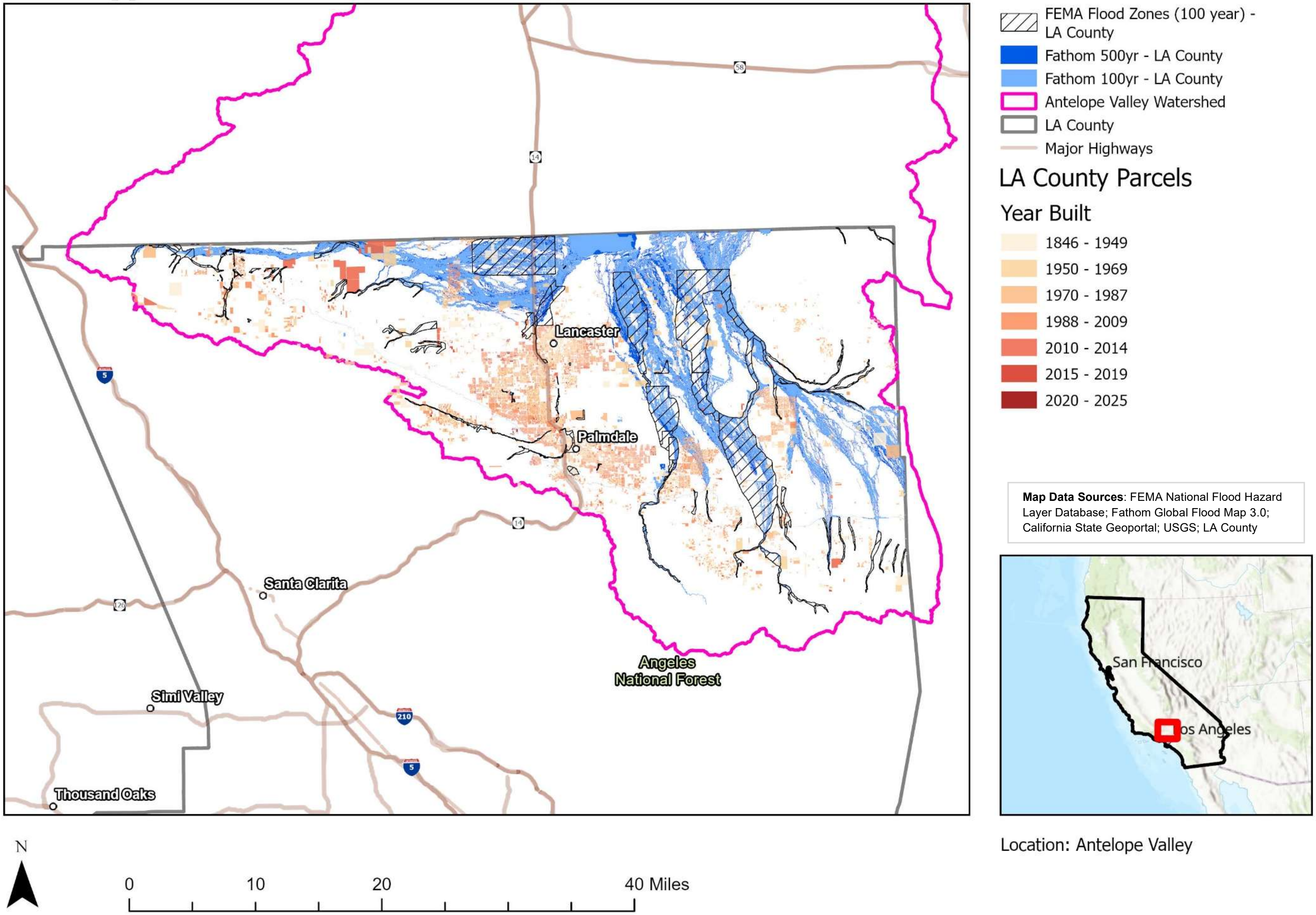


Figure 9. Assessor Parcels by Year Built within Antelope Valley Subbasin (Los Angeles County)



Map Data Sources: FEMA National Flood Hazard Layer Database; Fathom Global Flood Map 3.0; California State Geoportal; USGS; LA County

Location: Antelope Valley

3.2 Whitewater River Subbasin (Riverside County)

The Whitewater River Subbasin (Whitewater River HUC8 Watershed) encompasses the Coachella Valley, a desert basin in western Riverside County located between the Santa Rosa and San Jacinto Mountains to the south and the Little San Bernardino Mountains to the east. The valley floor is low-lying, with sea-level desert terrain at risk of flash flooding from intense desert storms and drainage from surrounding mountain peaks of over 11,000 feet.[34] Alluvial fans formed from past flooding spread across the basin, creating unpredictable flooding conditions in some developed areas. The Coachella Valley experienced extreme flooding throughout its formative years, and in recent years, with flash flooding from Tropical Strom Hilary causing extensive damage in 2023.[35,36] However, FEMA's 100-year floodplain map covers just 8% of the subbasin, and Fathom's 100-year and 500-year floodplain maps cover just 1% and 2% of the subbasin, respectively, as detailed in Table 2 and shown in Figure 10. This focus area includes 162 FEMA FIRM panels with effective dates of 2008 (76%), 2012 (1%), 2017 (11%), 2018 (10%), 2022 (1%), and 2024 (1%).

Table 2. Whitewater River Subbasin (Riverside County): Area within Floodplain Boundaries and Developed Land

Total Area	Fathom 100		Fathom 500		FEMA 100		Developed Land (NLCD)	
(mi^2)	Area (mi^2)	%	Area (mi^2)	%	Area (mi^2)	%	Area (mi^2)	%
1,328	16	1%	32	2%	105	8%	152	11%

Land Use and Development Context

The watershed contains the cities of Cathedral City, Palm Springs, Rancho Mirage, Palm Desert, Indian Wells, Indio, La Quinta, and Coachella. Early development and agriculture in the region were facilitated by construction of irrigation infrastructure, enabling settlement and establishment of date palm groves and row crop agriculture to the eastern Coachella Valley. Tourism emerged as a major economic driver in the early 1900s. Already popular as a resort destination and winter retreat, the region experienced consistent growth from the 1960s onward, driven by demand for resorts, retirement communities, golf courses, and additional housing for agricultural and hospitality workers and seasonal visitors. A major driver of more recent residential development is demand for affordable housing for low-wage farm workers, with new housing development led primarily by Coachella Valley's Housing Catalyst Fund. Beyond residential development, a substantial amount of land in the northwest valley is devoted to energy production through wind turbines in the San Gorgonio Pass Wind Farm. The region's relatively consistent development trends are reflected in Figure 11 and Figure 12, with data indicating how much of the watershed's growth during these periods occurred within the FEMA and Fathom floodplains.

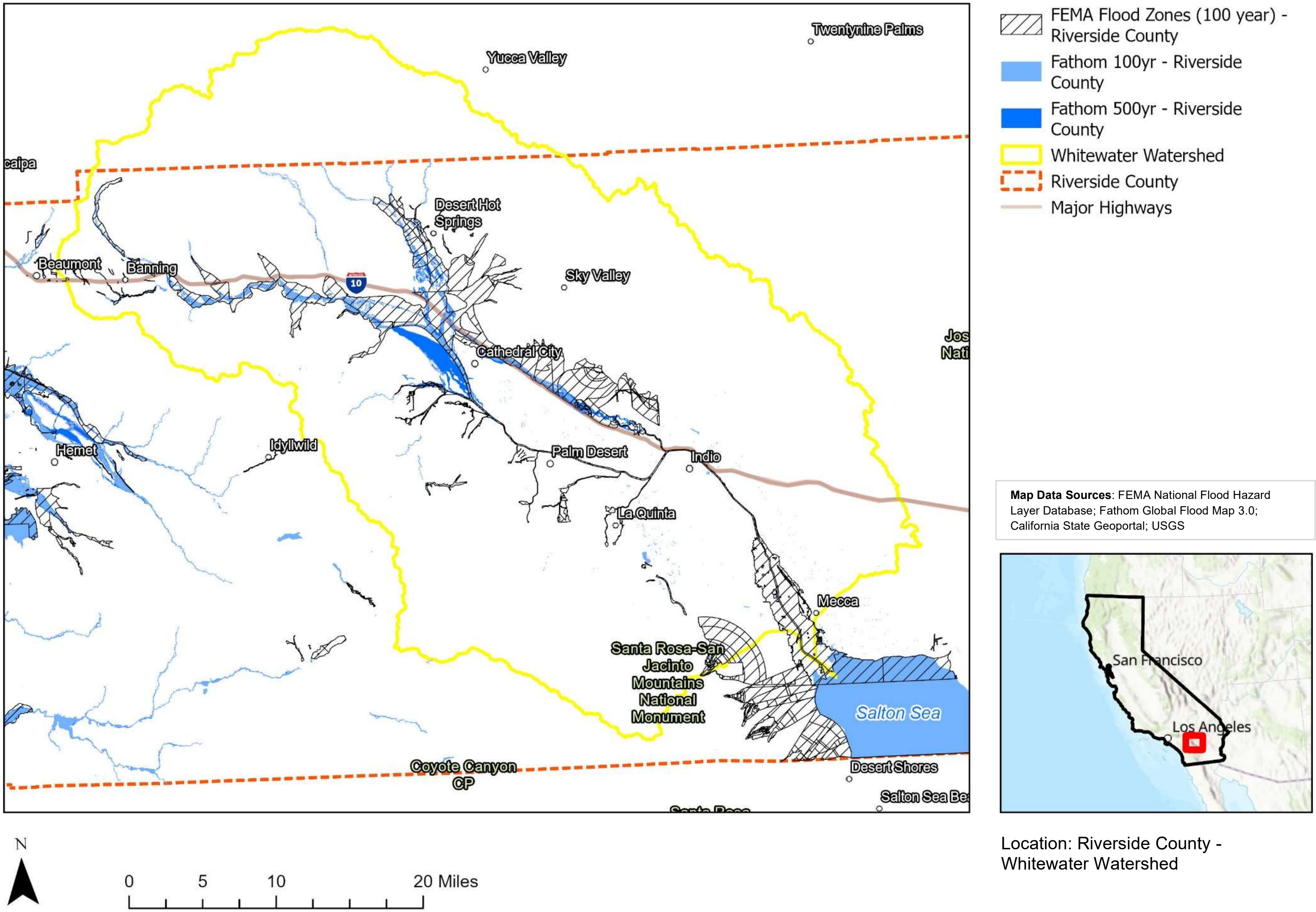
As shown in Figure 13, approximately 15% of the watershed's land area is designated for residential uses. Within the FEMA 100-year floodplain, approximately 34% of land is designated residential uses, and another 10% for commercial and industrial uses as shown in Figure 14. The share of residentially designated land is somewhat higher within the floodplains. NLCD data in Figure 15 shows that in both the watershed as a whole and the FEMA 100-year floodplain, approximately 12% of land is considered "developed," whereas nearly 30% of land in the Fathom 500-year floodplain is "developed". This indicates that Fathom modeling is capturing a substantial amount of long-term flood risk for developed areas not previously considered at risk under FEMA mapping.

Floodplain Management Context

The Whitewater River Subbasin is home to multiple jurisdictions with NFIP-compliant strategies for managing development within FEMA-designated floodplains. Countywide and municipal ordinances throughout the focus area also discourage or prohibit development in mapped floodways. In addition to utilizing FEMA-defined SFHAs and state-level flood zones as defined by the California Department of Water Resources, Riverside County maps its own flood hazard zones and enforces Ordinance 458 for new construction in unincorporated areas that fall within the SFHA or other flood hazard boundaries.[37, 38]

The Coachella Valley Water District drives much of the region's floodplain policy and operations: it runs the valley-wide stormwater system, requires developers to prepare flood control plans under Ordinance 1234.2, and enforces special permitting for development in the flood hazard areas consistent with Riverside County Ordinance 458.[39] Regional planning efforts—such as the Western Coachella Valley Area Plan and the Coachella Valley Association of Governments' Flood and Blowsand Risk Assessment and Improvement Plan—identify flood-risk areas and propose conceptual mitigation strategies.[40, 41]

Figure 10. Floodplains within Whitewater River Subbasin (Riverside County)



Map Data Sources: FEMA National Flood Hazard Layer Database; Fathom Global Flood Map 3.0; California State Geoportal; USGS

Location: Riverside County - Whitewater Watershed

Policy Analysis

Development trends in the Whitewater River subbasin indicate an overall trend of NFIP compliance through mitigation measures and engineered solutions rather than discouragement of floodplain development through land-use planning or highly restrictive development requirements. While a relatively low amount of the focus area's total development is located within FEMA-designated flood-prone areas, these areas have seen a relatively steady share of the focus area's overall development over time.

While FEMA flood areas accounted for the highest share of overall development in 1973 (15%), assessor data in Figure 11 does not indicate that the adoption of Ordinance 458 and participation in the NFIP in the late 1970s and early 1980s marked a major shift away from development in the FEMA flood areas. Rather, development in flood areas increased in the late 1980s, and again during the next major housing boom in 2007, when over 600 parcels were developed in FEMA flood areas, accounting for 11% of overall development that year.

While subject to NFIP regulations, land-use designations allow for a mix of residential, commercial, and industrial uses throughout the focus area and within flood-prone areas. As shown in Figure 16, several residential communities have been developed in FEMA-designated flood areas, including Garnet and Thousand Palms (both unincorporated areas within County jurisdiction), and a small development just east of Desert Palms (within City of Indio). A sizable residential area of Palm Springs also falls within a 500-year flood zone identified by Fathom flood modeling, which has not been integrated into policy guidance or decision-making.

The City of Desert Hot Springs provides a positive example of a jurisdiction that has largely restrained development from sprawling into surrounding FEMA flood areas through zoning, designating an Open Space - Conservation zone along much of its western boundary, interspersed with an extremely low-density "Residential Rural Desert" zone designation allowing only 1 dwelling unit per 5 acres.

Figure 11. Whitewater River Subbasin (Riverside County): Number of Parcels Developed within a FEMA or Fathom Floodplain: 1950-2024

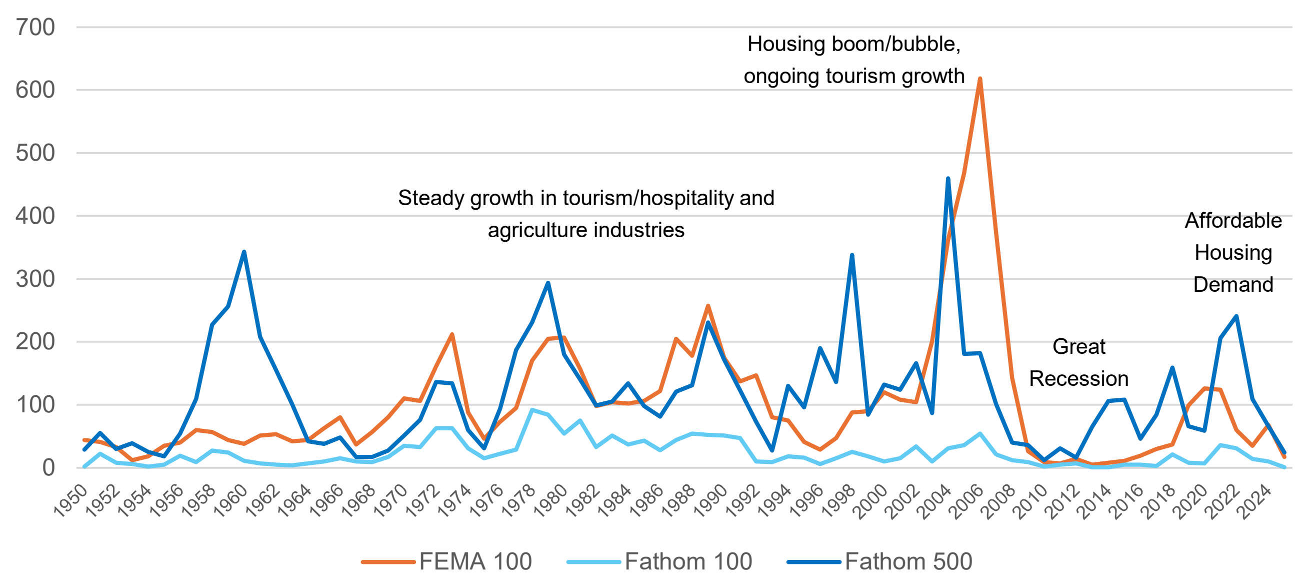


Figure 12. Whitewater River Subbasin (Riverside County): Floodplain Parcel Development as Share of Overall Parcel Development by Year

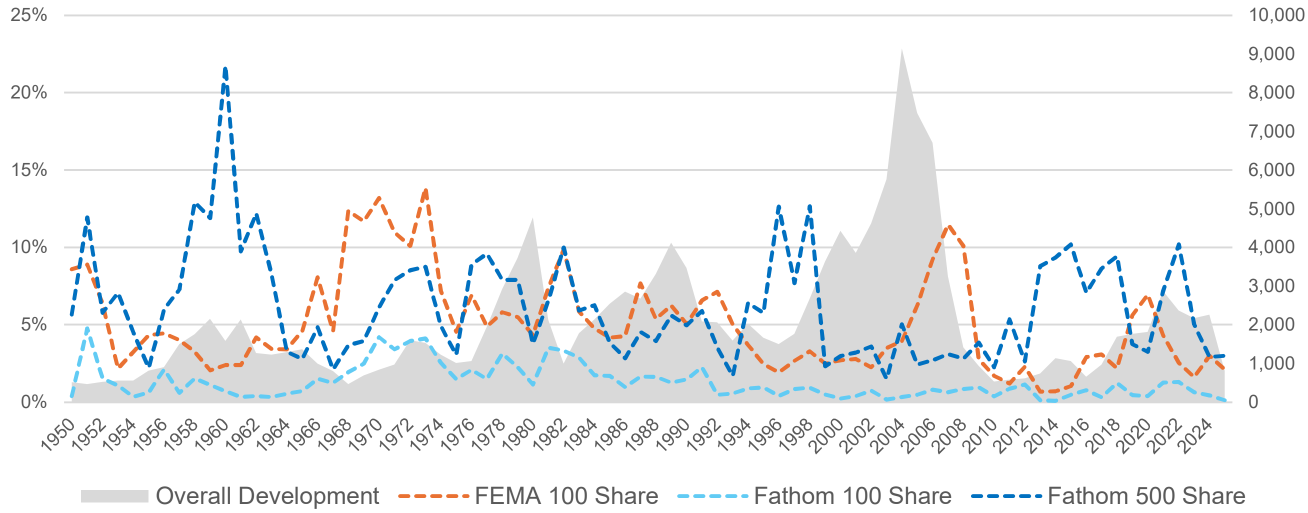


Figure 13. Whitewater River Subbasin (Riverside County): General Plan Land Use as Percent of Subbasin Land Area

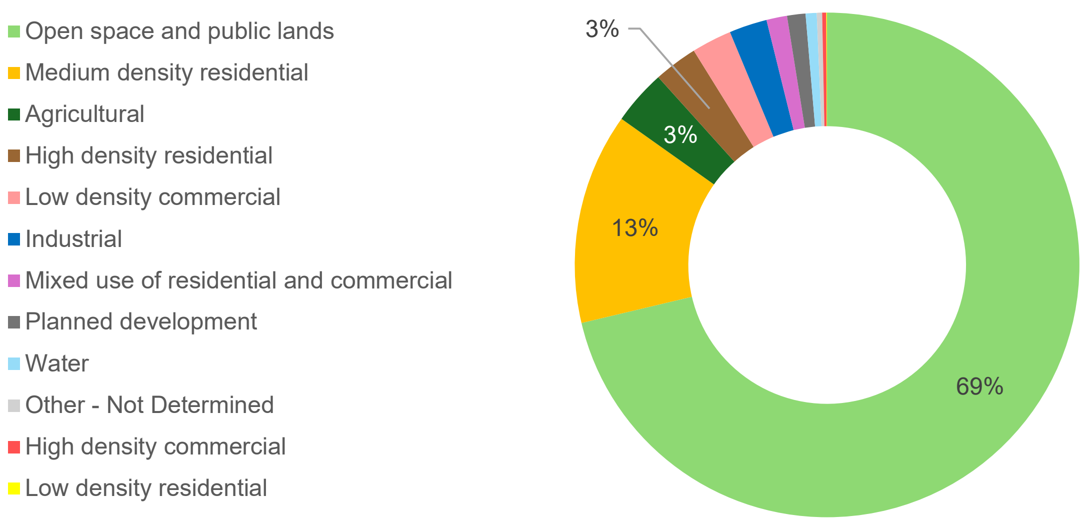


Figure 14. Whitewater River Subbasin (Riverside County): General Plan Land Use as Percent of Subbasin Flood Zones

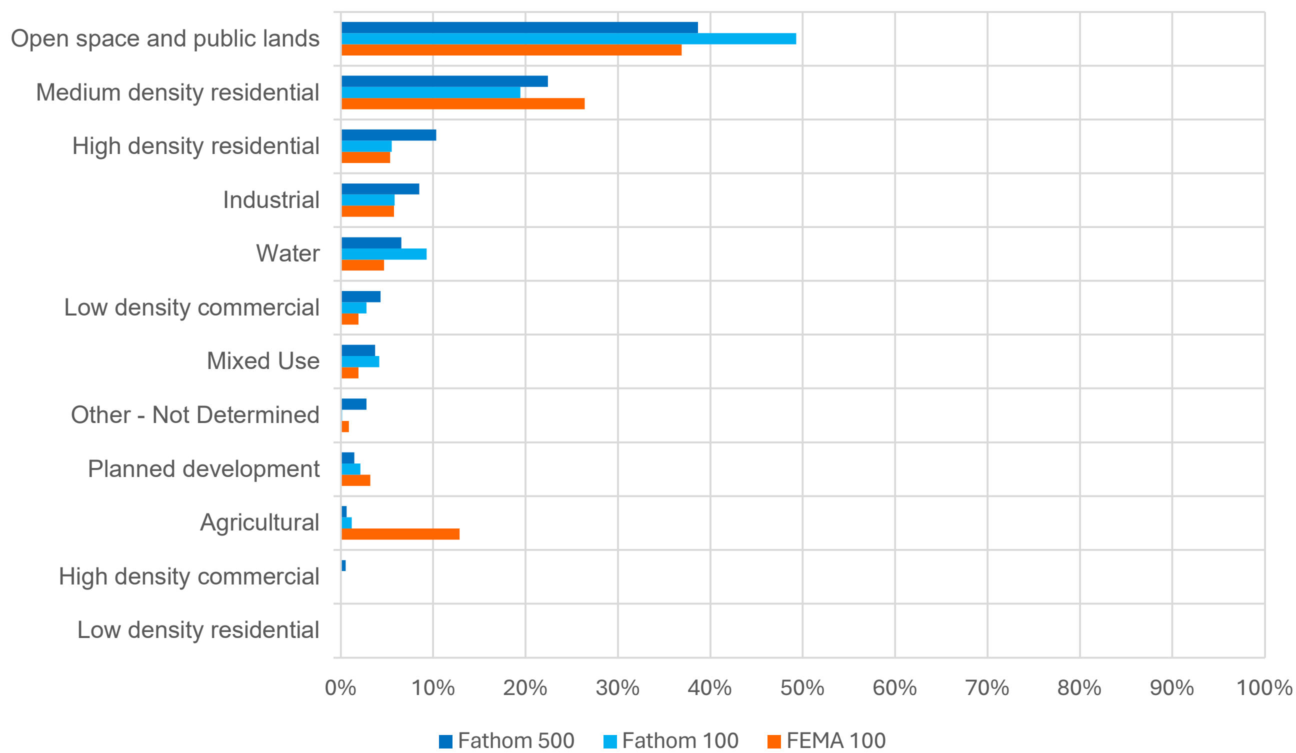


Figure 15. Whitewater River Subbasin (Riverside County): NLCD Developed Land Percentages

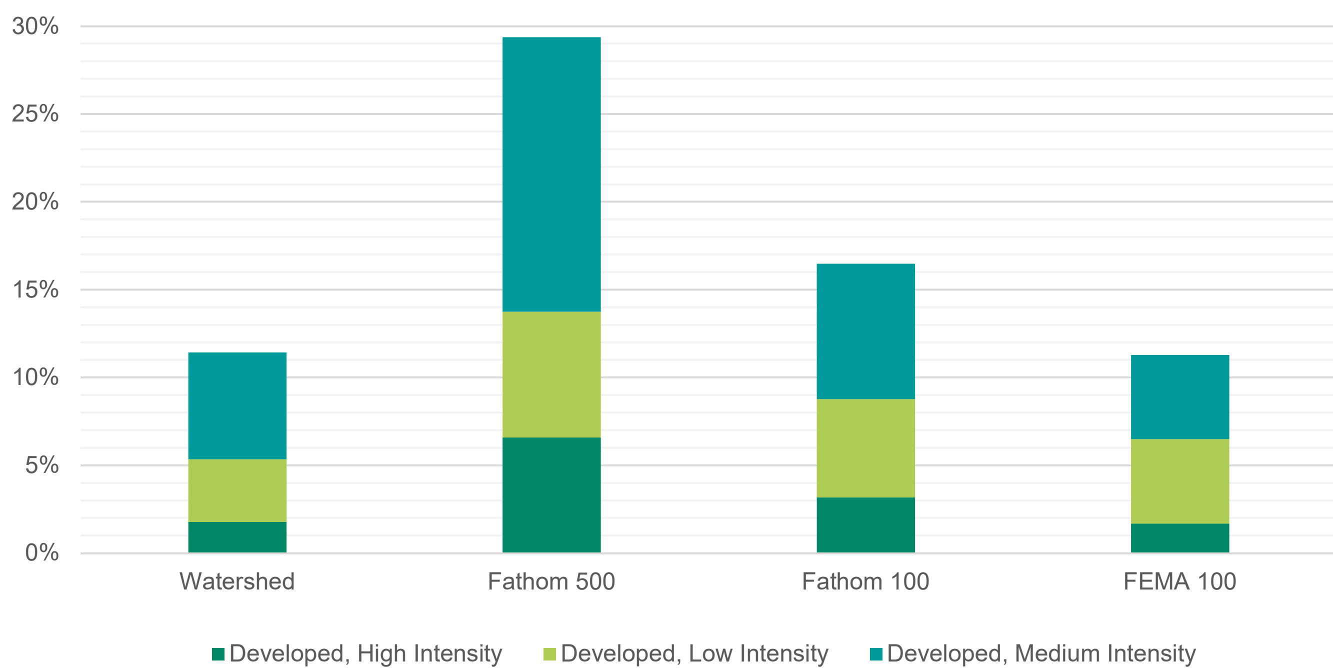
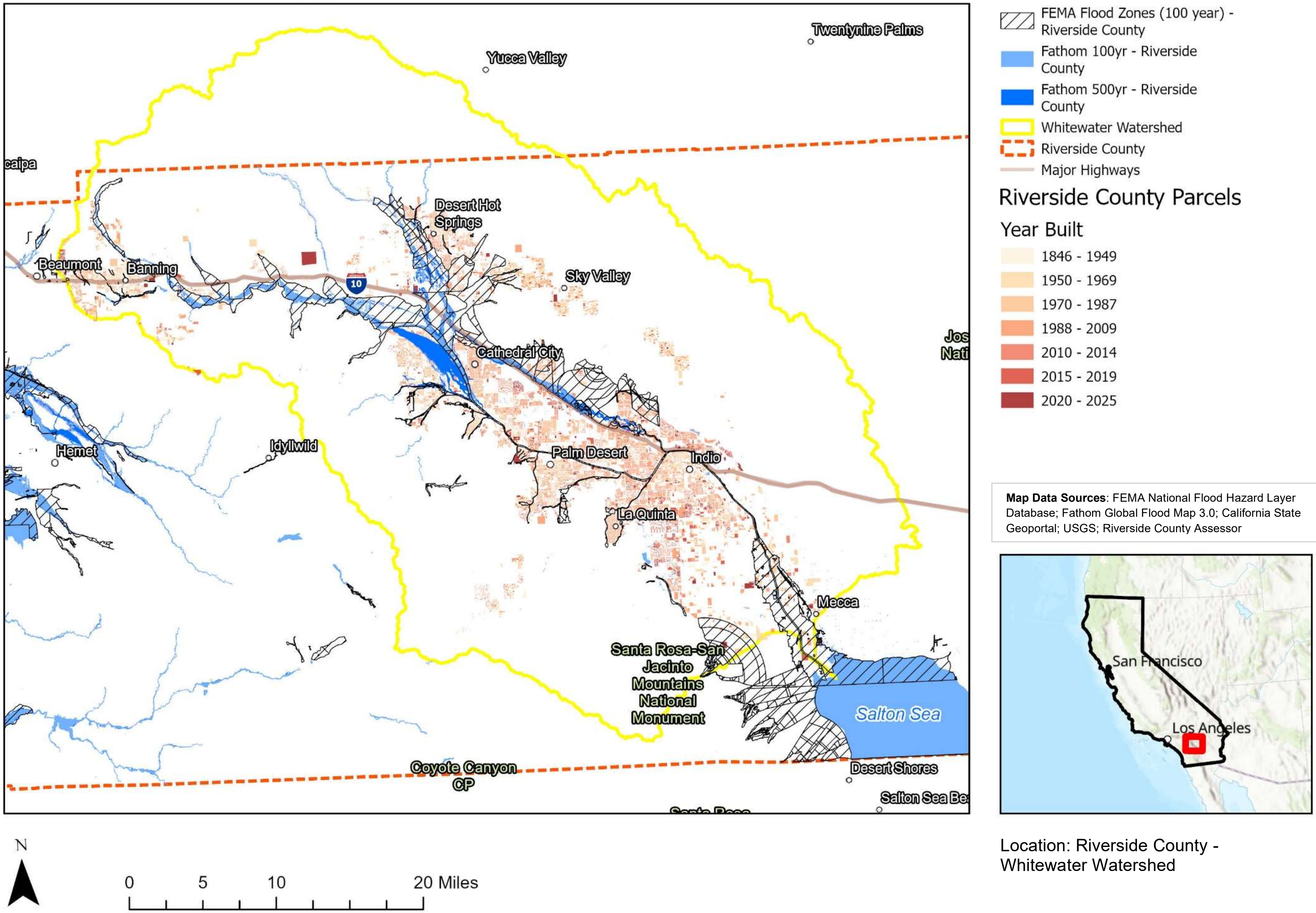


Figure 16. Assessor Parcels by Year Built within Whitewater River Subbasin (Riverside County)



3.3 San Jacinto Subbasin (Riverside County) Floodplain and Land-Use Context

The San Jacinto Subbasin (San Jacinto HUC8 Watershed) encompasses diverse terrain between the Santa Ana Mountains to the west and San Jacinto Mountains to the east, including multiple lakes, low-relief valleys, foothills, mountains, and urbanized areas. Seasonal rainfall and snowmelt from the mountains feed into streams and rivers, including the San Jacinto River, which flows into Lake Elsinore, a large, natural freshwater lake surrounded by a suburban city of the same name. During intense storm events the watershed is susceptible to flash flooding, lacustrine flooding, and riverine flooding surrounding Lake Elsinore, Canyon Lake, San Jacinto River, the Perris Valley Storm Drain, and Salt Creek.[42] The FEMA 100-year floodplain and Fathom 500-year floodplain each cover approximately 8% of the watershed's total land area, with the Fathom 100-year floodplain covering only 6%, as detailed in Table 3 and shown in Figure 17. This focus area includes 125 FEMA FIRM panels with effective dates of 2008 (72%), 2009 (6%), 2012 (6%), 2014 (9%), 2017 (5%), and 2024 (2%).

Table 3. San Jacinto Subbasin (Riverside County): Area within Floodplain Boundaries and Developed Land

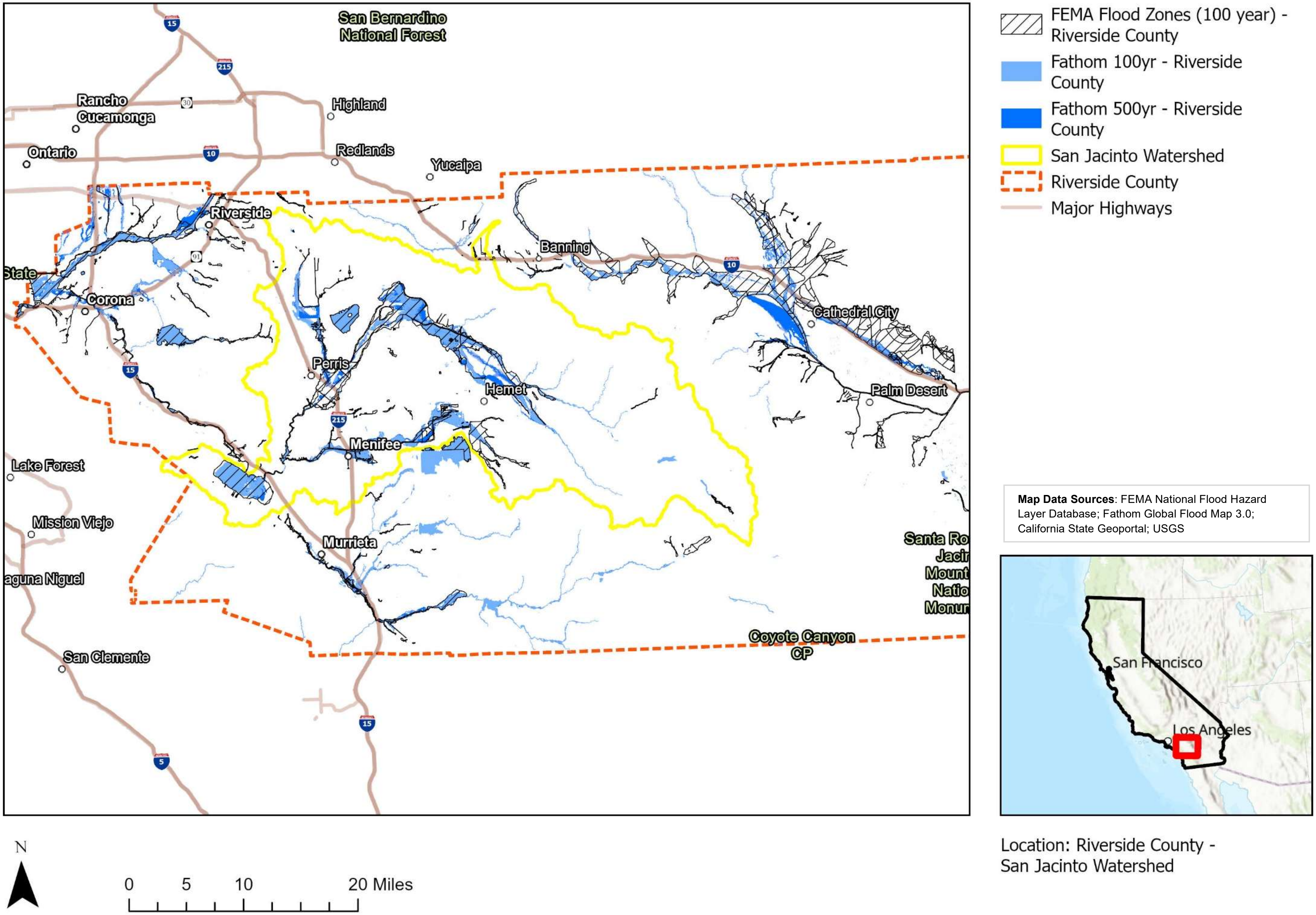
Total Area	Fathom 100		Fathom 500		FEMA 100		Developed Land (NLCD)	
(mi^2)	Area (mi^2)	%	Area (mi^2)	%	Area (mi^2)	%	Area (mi^2)	%
763	44	6%	60	8%	59	8%	114	15%

Land Use and Development Context

Major cities within the watershed include Menifee, Hemet, Perris, Lake Elsinore, and San Jacinto. Historically, the development of this region was driven by agriculture and water infrastructure, including construction of the Hemet Dam in the late 19th century to support irrigation. Over time, the introduction of railroads and highways facilitated growth in the region, as its affordable land attracted suburban development.[43] Figure 18 shows major spikes in floodplain development around 1990 and the early 2000s, reflecting establishment of master planned communities and other large-scale residential projects for retirees and commuter populations. Today, the region is characterized by a mix of suburban communities, recreational areas, and industries such as action sports tourism, logistics, retail, and light manufacturing. Planned mixed-use projects and lifestyle centers in Menifee and Lake Elsinore reflect ongoing population growth, demand for commuter communities, and trends toward diversified amenities and employment opportunities.[44,45]

Figure 19 shows that slightly under half of the land within the watershed is designated for open space/public lands, while about 33% of total land is designated for residential use. Planned Development (a designation allowing larger projects typically including a mix of residential, commercial, or industrial uses) accounts for 19% of land in the FEMA 100-year floodplain, as shown in Figure 20. The share of land designated for open space/public land and residential uses is somewhat lower within the floodplains. NLCD data in Figure 21 shows that 15% of land in the watershed is considered "developed". Compared to just 8% of land in the FEMA 100-year floodplain, roughly 22% of land in the Fathom 500-year floodplain is "developed," indicating that Fathom modeling is capturing a substantial amount of long-term flood risk for developed areas not previously considered at risk under FEMA mapping. Supporting this assumption, Figure 18 and Figure 22 indicate that a relatively small share of development occurred in the FEMA 100-year floodplain until approximately 2010, while the Fathom 100-year and 500-year floodplains saw major spikes in line with regional trends. Since 2010, development in all three floodplains has increased, with a consistently higher share of development in the FEMA Floodplain than at any previous point.

Figure 17. Floodplains within San Jacinto Subbasin (Riverside County)



Location: Riverside County - San Jacinto Watershed

Floodplain Management Context

Floodplain management in the San Jacinto Subbasin involves coordination among Riverside County, multiple incorporated jurisdictions, and regional flood agencies. City of Lake Elsinore provides a representative example of how development in flood-prone areas is managed. The City's Flood Damage Prevention Code (Chapter 15.64), first adopted in 2001 and updated in 2017, aligns with NFIP requirements and mandates special permits for development within mapped FEMA flood zones. Although development is not categorically prohibited in these areas, the code requires elevation, floodproofing, and site-specific mitigation measures for proposed projects. These mapped flood zones are also referenced within the General Plan Safety Element.[46]

Lake Elsinore's 2017 LHMP outlines priority flood risk mitigation strategies, including drainage improvements, flood hazard identification, and emergency preparedness measures. Participation in the NFIP and Community Rating System (CRS) provides additional incentives for incorporating flood risk reduction into planning decisions. However, differences between Riverside County's Ordinance No. 458 (especially regarding freeboard requirements) and the City's permitting standards introduce inconsistencies that may affect floodplain development outcomes.[45,46]

Policy Analysis

Development patterns in the San Jacinto Subbasin illustrate how housing demand and regional growth pressures can outpace the constraints of existing floodplain policy frameworks. Parcel level analyses in Figure 18 and Figure 22 show that before 2010, development was more heavily concentrated within the Fathom 500-year floodplain than the FEMA 100-year floodplain, indicating success of FEMA-based policy to discourage development. After 2010, however, development increased across all flood zones, including a significant rise within FEMA designated areas, indicating increased exposure despite existing regulatory tools.[17]

Existing floodplain policies (including Lake Elsinore's Flood Damage Prevention Code, requirements for special permits within flood hazard areas, the city's LHMP, and Riverside County's Ordinance No. 458) create a baseline regulatory framework but do not explicitly discourage development in higher risk areas identified through long-term flood models, as long as they meet Flood Damage Prevention Criteria. In comparison, areas like Antelope Valley may require flood-control infrastructure to be built prior to consideration for development. As a result, growth continues along the I15 corridor and within cities such as Menifee, Hemet, Perris, and Lake Elsinore including in areas adjacent to waterways and drainage systems that have historically flooded (Figure 23). Planned mixed-use developments and lifestyle centers further reflect the region's continuing development trajectory.[15,43,44]

Looking ahead, long-term resilience will depend on stronger integration of state and federal flood risk standards into local land-use controls. This may include expanding nature-based flood management strategies such as riparian restoration and groundwater recharge focused floodplain projects, strengthening subdivision review requirements, and improving regional coordination to support consistent standards across city and county jurisdictions. As population growth continues, especially in high demand communities surrounding Lake Elsinore, proactive measures will be needed to prevent further encroachment into areas with both current and future flood vulnerability.[36,43,44,45,46]

Figure 18. San Jacinto Subbasin (Riverside County): Number of Parcels Developed within a FEMA or Fathom Floodplain: 1950-2024

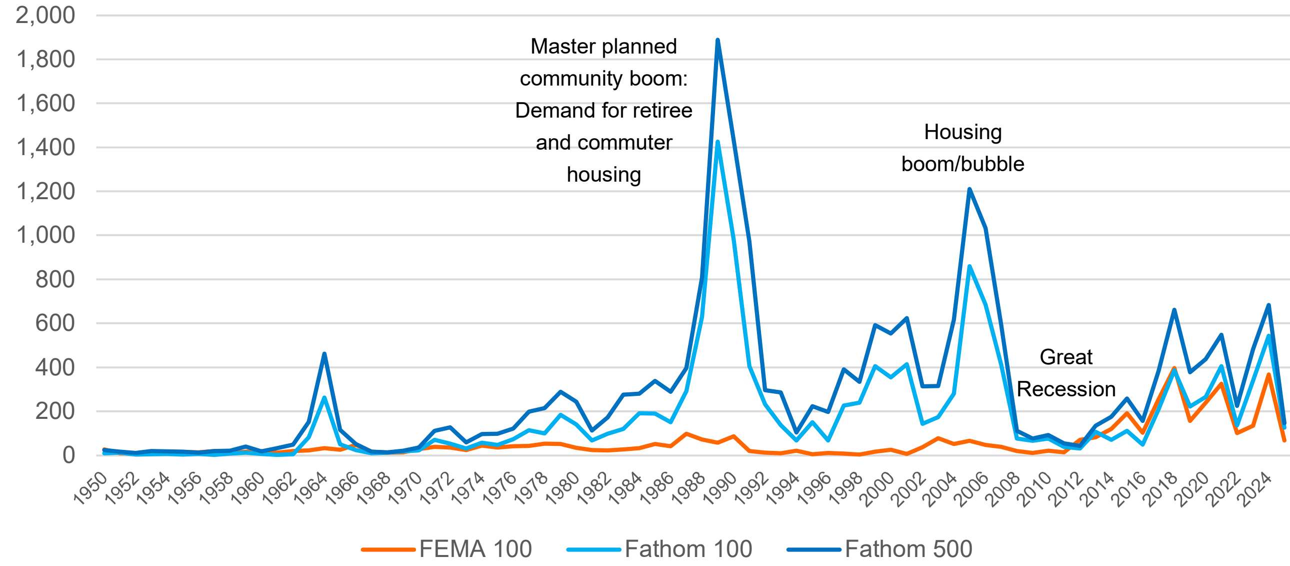


Figure 19. San Jacinto Subbasin (Riverside County): General Plan Land Use as Percent of Subbasin Land Area

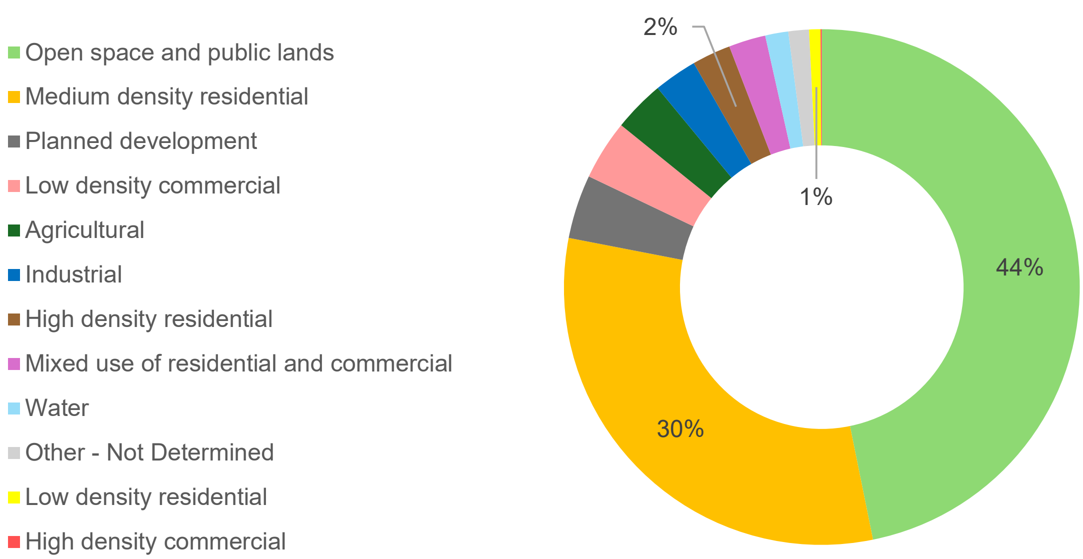


Figure 20. San Jacinto Subbasin (Riverside County): General Plan Land Use as Percent of Subbasin Flood Zones

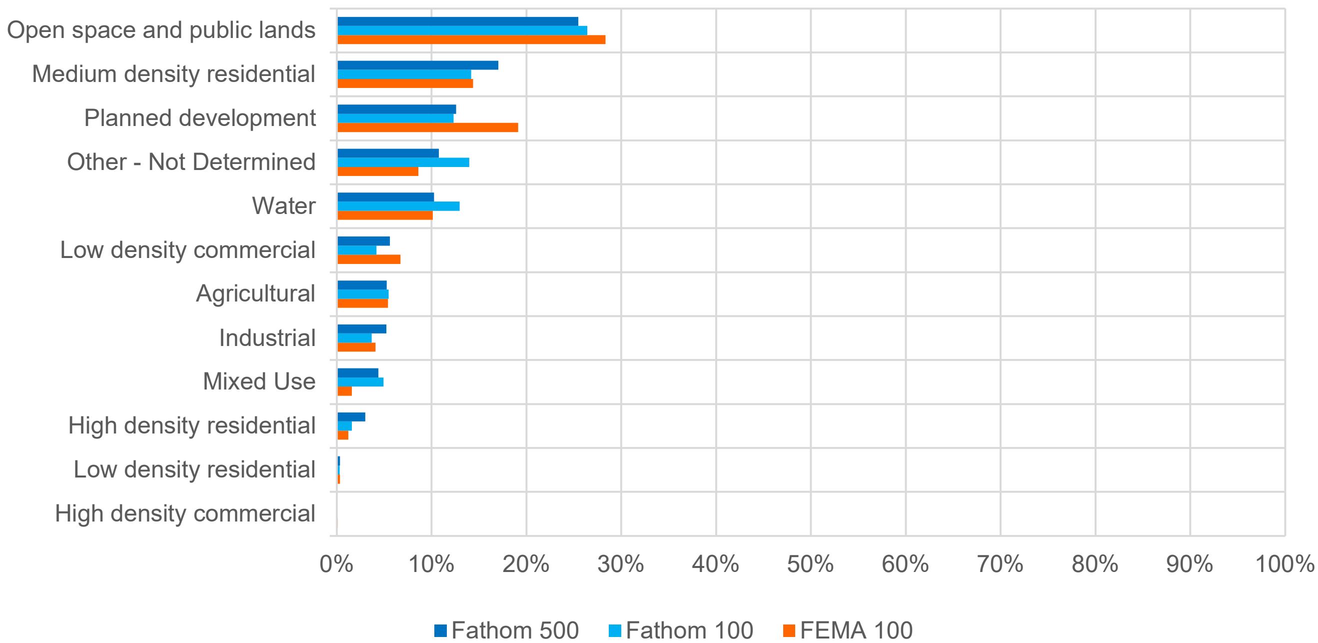


Figure 21. San Jacinto Subbasin (Riverside County): NLCD Developed Land Percentages

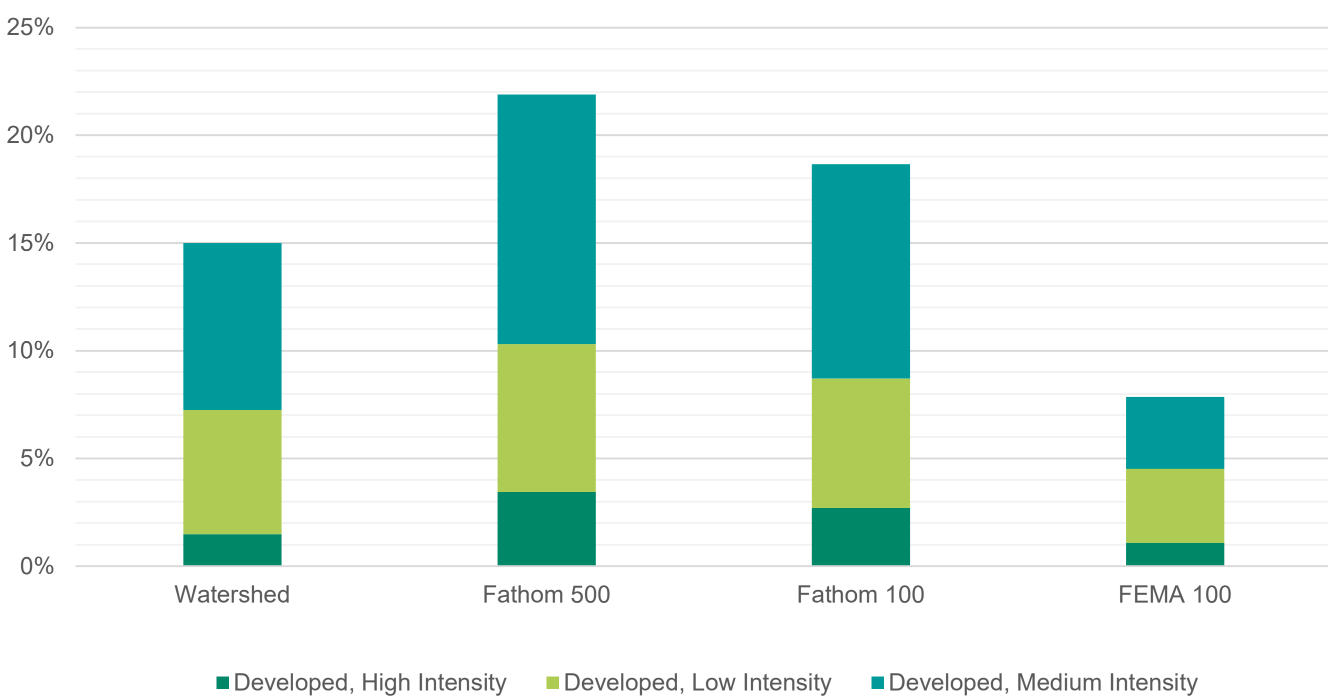


Figure 22. San Jacinto Subbasin (Riverside County): Floodplain Parcel Development as Share of Overall Parcel Development by Year

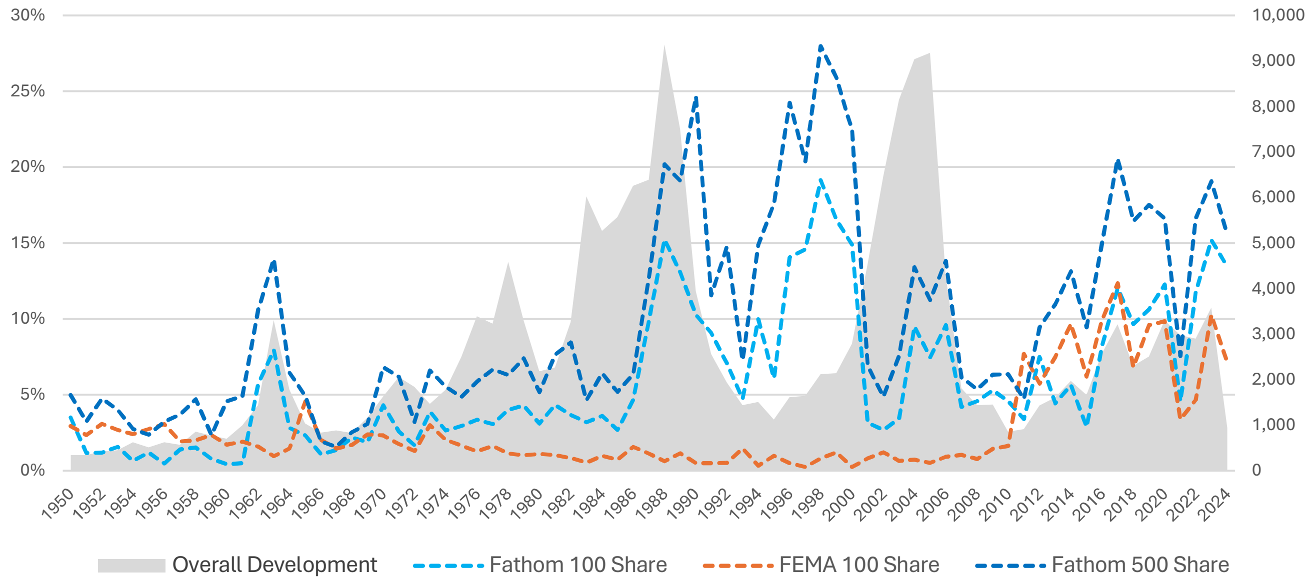
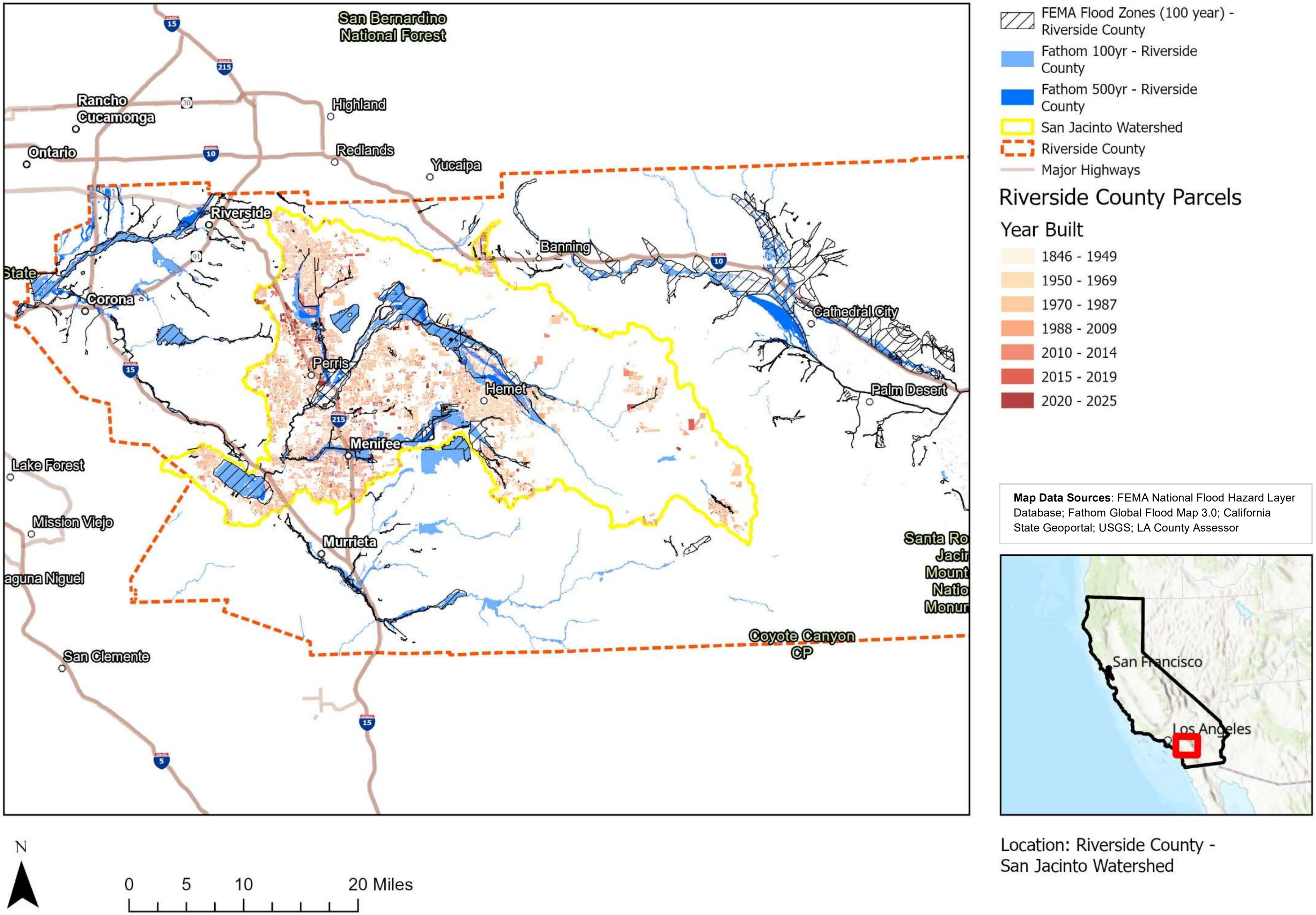


Figure 23. Assessor Parcels by Year Built within San Jacinto Subbasin (Riverside County)



3.4 Sacramento County Floodplain and Land-Use Context

Sacramento County occupies one of the most flood-prone geographies in the northern Central Valley, sitting at the confluence of the Sacramento, American, and Cosumnes rivers, which together generate significant riverine flood risk for the region. The landscape consists of expansive agricultural lowlands, basin floor urban development, and the Sacramento-San Joaquin Delta system, all intersected by a complex network of levees. As detailed in Table 4 and shown in Figure 24, approximately 37% of the county lies within FEMA's 100-year floodplain, while the Fathom 500-year floodplain accounts for 32% of land area and the Fathom 100-year floodplain accounts for 13%, demonstrating widespread exposure across both frequent and infrequent flood scenarios.[13,47] This focus area encompasses 563 FEMA FIRM panels with effective dates of 2008 (7%), 2009 (12%), 2010 (7%), 2012 (31%), 2015 (9%), 2016 (16%), 2017 (1%), 2018 (11%), and 2024 (6%).

Table 4. Sacramento County: Area within Floodplain Boundaries and Developed Land

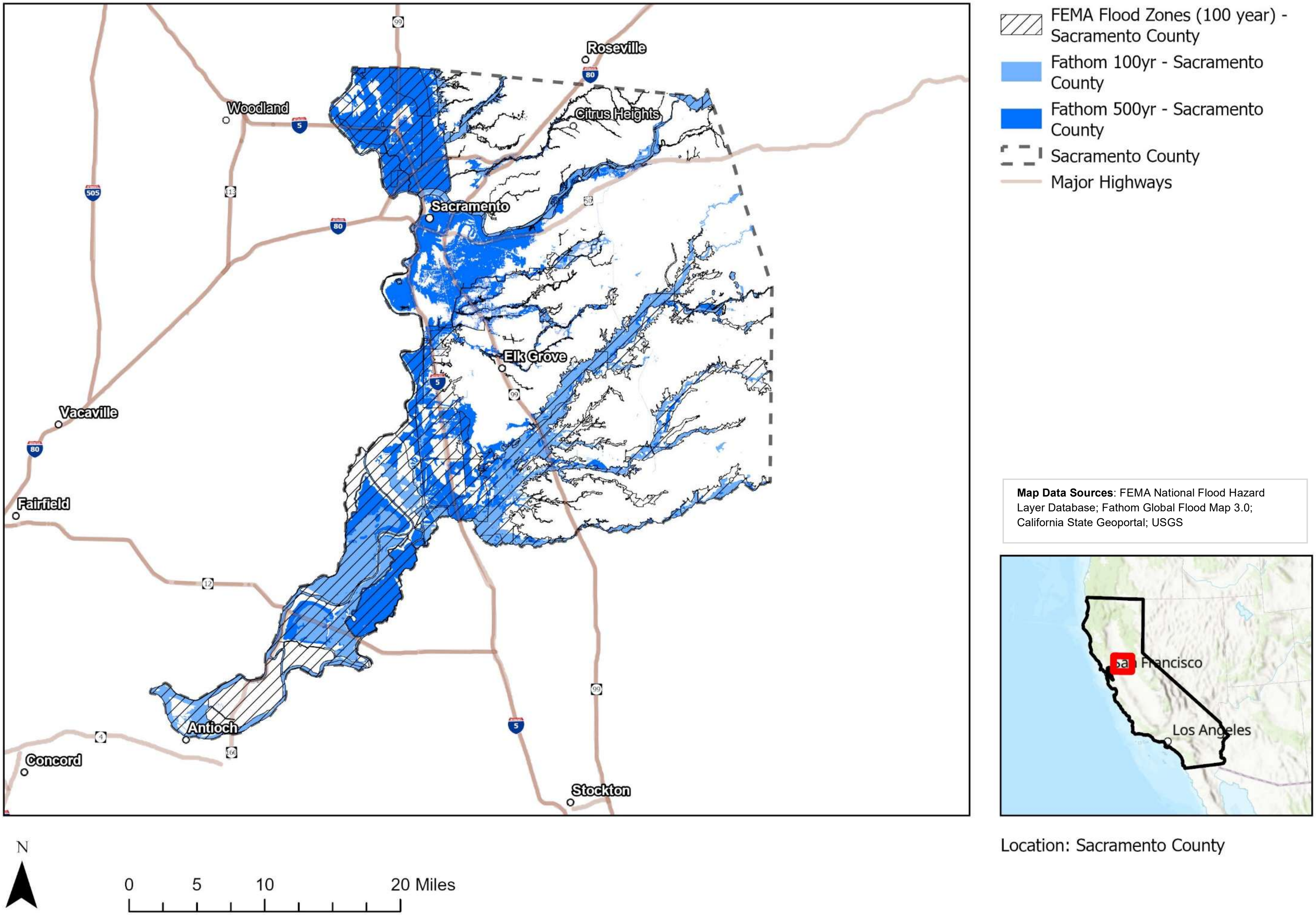
Total Area	Fathom 100		Fathom 500		FEMA 100		Developed Land (NLCD)	
(mi^2)	Area (mi^2)	%	Area (mi^2)	%	Area (mi^2)	%	Area (mi^2)	%
994	130	13%	317	32%	371	37%	260	26%

Land Use and Development Context

The county's long-term development trajectory reflects its role as California's state capital and a major employment hub. Government services, healthcare, logistics, and more recently technology sectors have driven sustained economic growth, contributing to steady immigration and suburban expansion following World War II. As interstate and state highway systems (including I-80, Highway 50, and Highway 99) connected the region to broader markets, outward suburban growth extended into areas with substantial flood exposure. Residential communities expanded into fringe locations such as North Sacramento, Elk Grove, and Rancho Cordova, despite persistent vulnerability tied to the basin's hydrology and flood management constraints.[48]

Countywide land-use patterns displayed in Figure 25 show that approximately 47% of Sacramento County is designated for agricultural use, with residential uses comprising roughly 25%. Within FEMA's 100-year floodplain, agricultural and open space designations together cover nearly 85% of the area, while residential uses constitute only about 5%, as shown in Figure 26. Developed land patterns documented in Figure 27 indicate that although roughly 26% of the county is developed overall, only 8% of the FEMA 100-year floodplain is developed, compared with 22% of the Fathom 500-year floodplain. Parcel level development trends illustrated in Figure 28 and Figure 29 show that from 1950 through at least the early 2000s, the Fathom 500-year floodplain consistently absorbed more development than FEMA designated areas, indicating long term reliance on levee based protection rather than avoidance of high-risk flood zones.[14,15,18]

Figure 24. Floodplains within Sacramento County



Floodplain Management Context

Sacramento County's floodplain management framework is shaped heavily by its position within the CVFPP planning area and by the ULOP requirement mandating 200-year flood protection for development in urban and urbanizing areas. The Natomas Basin serves as the county's most prominent example of evolving flood risk oversight. In 2006, significant deficiencies in the Natomas levee system were identified, prompting the U.S. Army Corps of Engineers to withdraw levee certification. In 2008, FEMA redesignated the basin as Zone AE, placing it within the 100-year floodplain and triggering a mandatory building moratorium that halted nearly all new construction and required flood insurance for existing development.[49,50]

The Natomas Levee Improvement Program, initiated in 2007 and advanced by the U.S. Army Corps of Engineers' 2010 Post Authorization Change Report, led to major structural upgrades to increase flood protection. Subsequent congressional authorization in 2014 accelerated these improvements, enabling FEMA to reclassify the basin as Zone A99, a transitional designation indicating substantial progress toward meeting required flood protection standards. While development was allowed to resume under the A99 designation, it did so only under strict conditions, including levee setbacks, elevated finished floor requirements, mandatory flood insurance, and the imposition of annual building permit caps until full certification is achieved.[50,51,52,53,54,23]

Outside Natomas, Sacramento County enforces additional flood risk restrictions through the American River Parkway Floodplain Zone, which prohibits structural development along the American River corridor. Local jurisdictions also integrate ULOP requirements into their general plan safety elements, mandating that major subdivisions demonstrate 200-year flood protection prior to approval. Together, these federal, state, and local controls create a multilayered regulatory framework that tightly links land-use decisions with flood risk conditions and evolving infrastructure performance.[49,54]

Policy Analysis

Development patterns within Sacramento County illustrate the safe development paradox: as structural flood protection improves, development continues to expand into areas that remain hazard prone. Parcel level analyses in Figure 28 and Figure 29 show that prior to FEMA's 2008 remapping of the Natomas Basin, development was disproportionately concentrated within the Fathom 500-year floodplain rather than within the mapped FEMA 100-year floodplain. Following FEMA's redesignation of Natomas as Zone AE, development increased, demonstrating the strong influence of federal flood hazard boundaries on local land-use decisions (Figure 30).[18,50]

When FEMA redesignated Natomas as Zone A99, development resumed but under stricter mitigation requirements, illustrating how policy changes can shape both the pace and pattern of growth. Despite strong tools such as ULOP compliance, the American River Parkway floodway restrictions, and development caps tied to flood protection progress, Sacramento County lacks comprehensive policies discouraging new construction within the broader 500-year floodplain, where historic development has been substantial. Additionally, although agricultural lands dominate the floodplain, these designations do not establish long term protection from conversion, leaving them vulnerable to future development pressure.[15,18]

Reducing exposure to high-risk development will require complementary strategies that pair structural flood protection efforts with stronger land-use controls, including agricultural conservation easements, expanded open space zoning, floodplain restoration, and multi-benefit landscape management. While the Natomas Basin demonstrates that significant policy intervention can occur in response to acute risk, proactive planning will be essential as climate change intensifies flood hazards, increases hydrologic variability, and broadens areas of exposure across Sacramento County.[49,50,51,52,53,54,23]

Figure 25. Sacramento County: General Plan Land Use as Percent of Countywide Land Area

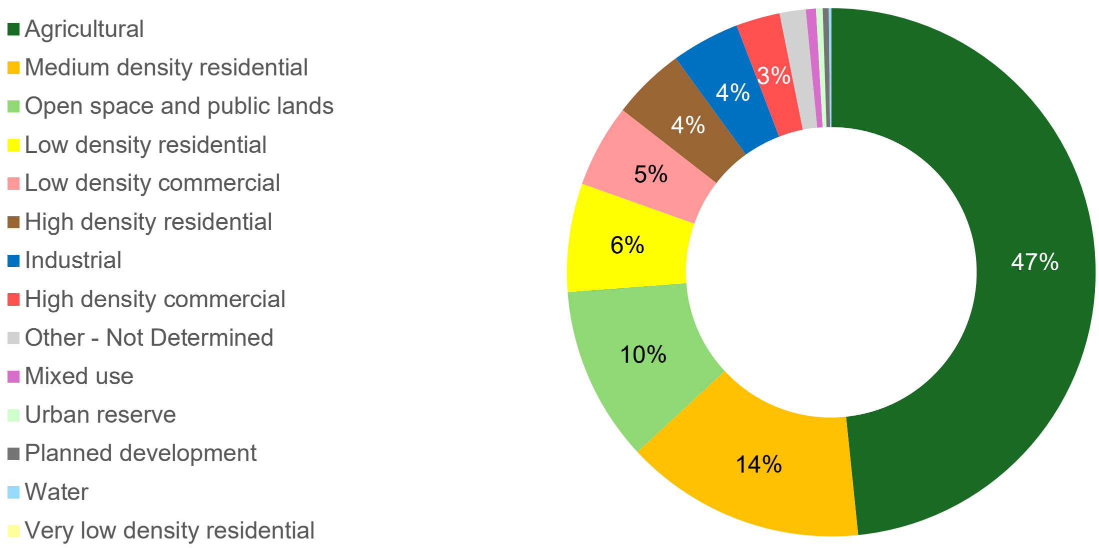


Figure 26. Sacramento County: General Plan Land Use as Percent of Countywide Flood Zones

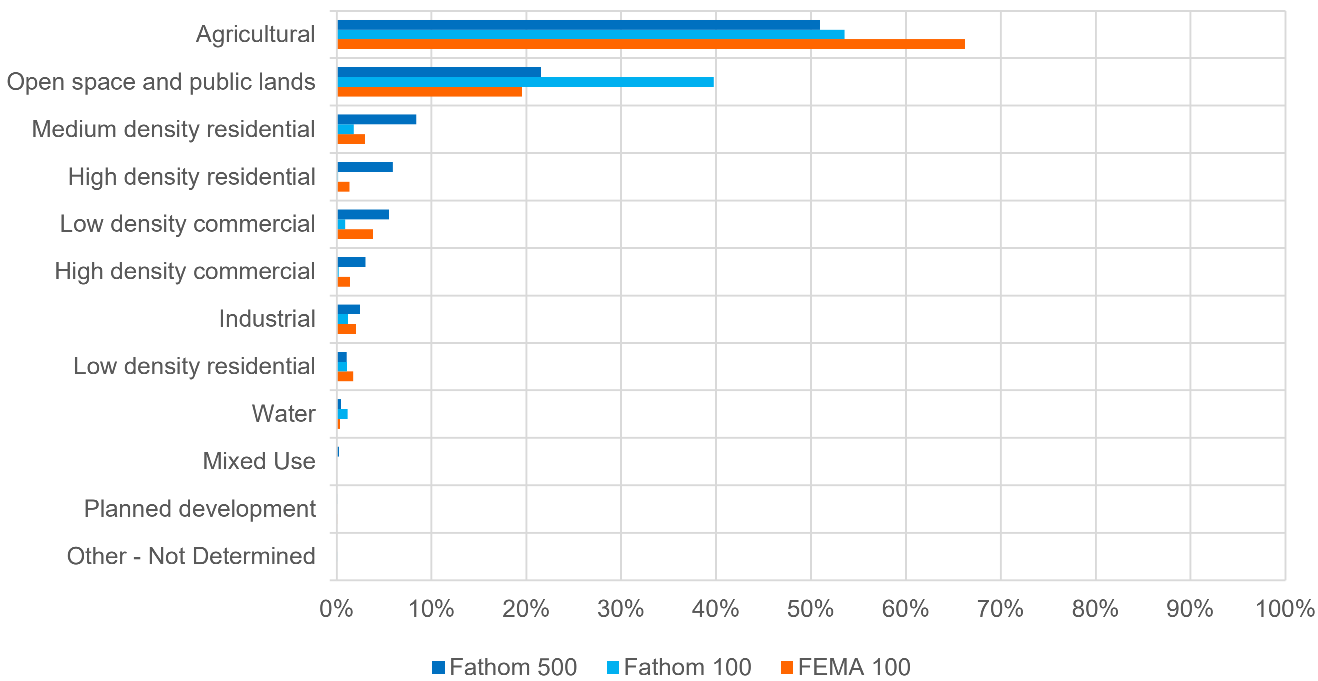


Figure 27. Sacramento County: NLCD Developed Land Percentages

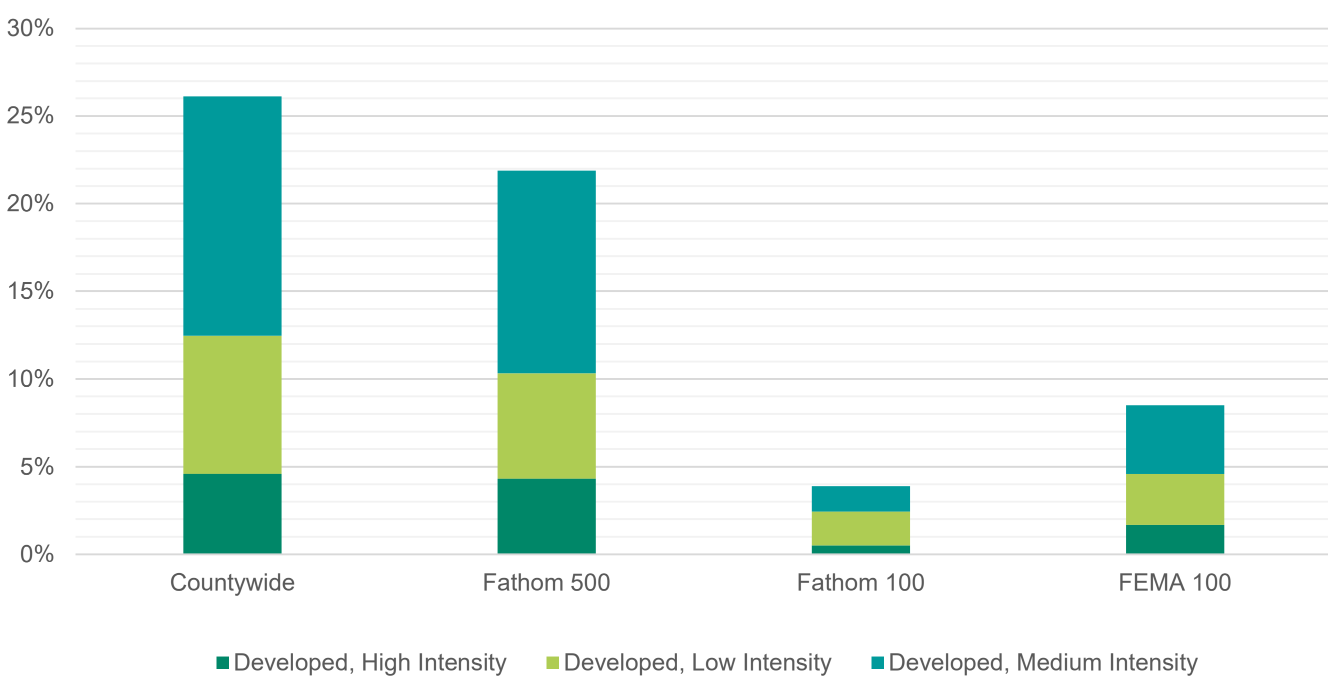


Figure 28. Sacramento County: Number of Parcels Developed within a FEMA or Fathom Floodplain: 1950-2024

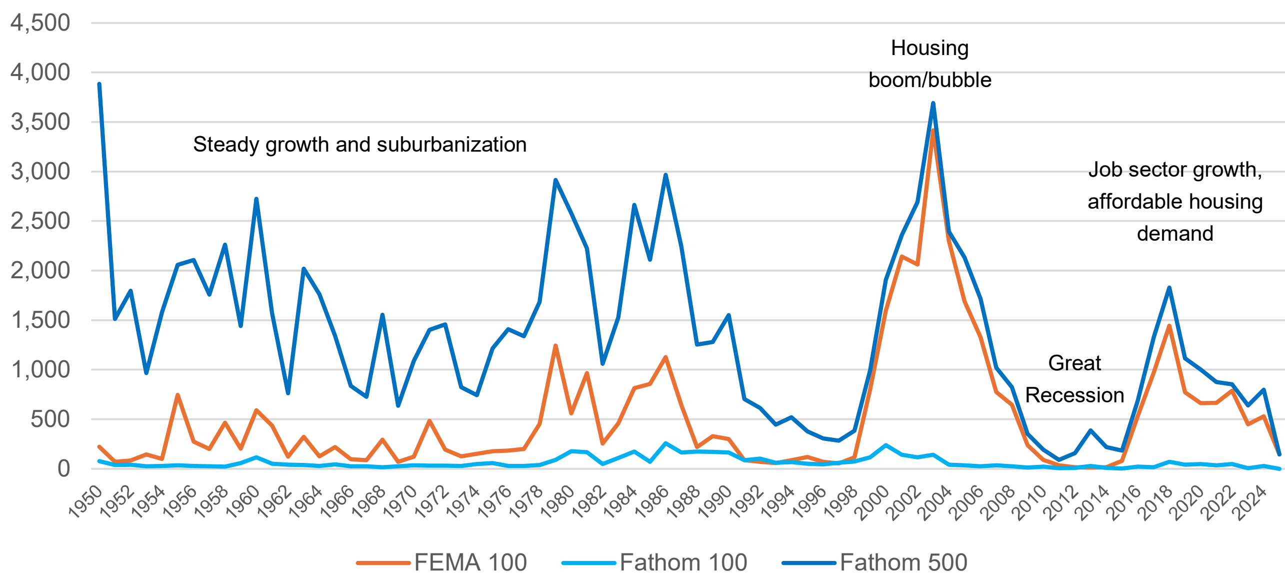


Figure 29. Sacramento County: Floodplain Parcel Development as Share of Overall Parcel Development by Year

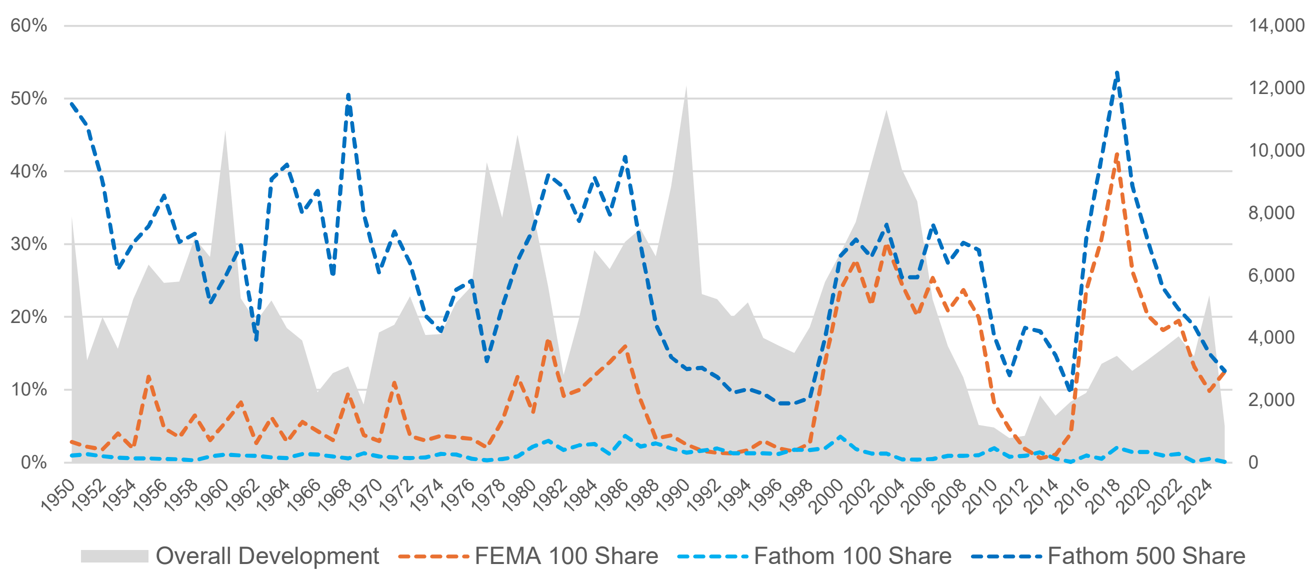
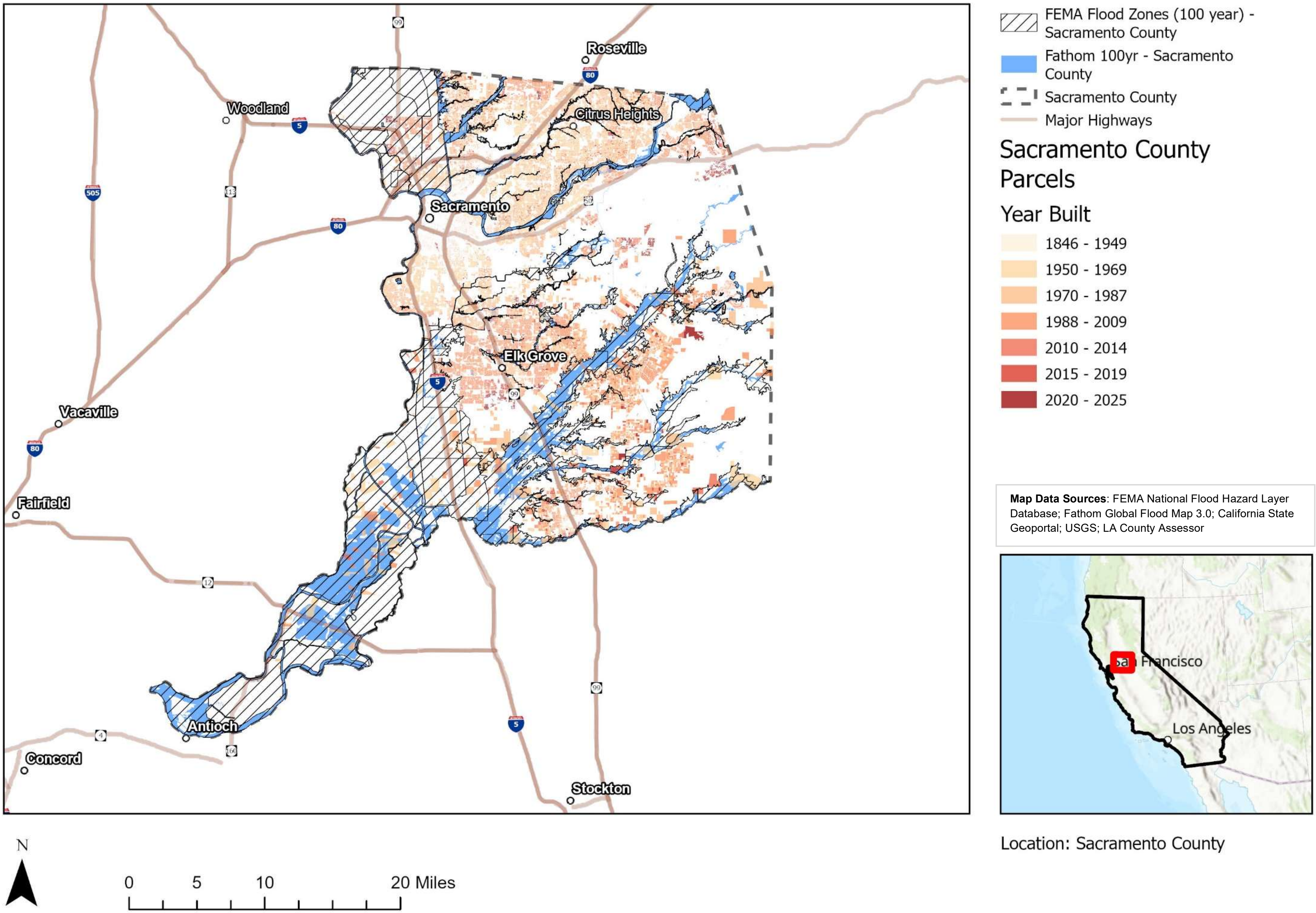


Figure 30. Assessor Parcels by Year Built within Sacramento County



3.5 Merced County Floodplain and Land-Use Context

Merced County is part of the Upper San Joaquin River Basin within the San Joaquin Valley, a flat basin located between the Sierra Nevada mountains to the east and Coast Ranges to the west. The county contains the Merced River Watershed, which spans from the Sierra Nevada foothills to the valley floor. The region's relatively flat topography contributes to its susceptibility to riverine flooding from the Merced River and its tributaries, such as Bear Creek and Black Rascal Creek, which are prone to overflowing, especially during high precipitation events or rapid snowmelt.[55] In 2023, multiple atmospheric rivers caused flooding of homes, businesses, and agricultural lands throughout the San Joaquin Valley, highlighting its vulnerability to flooding.[56] As detailed in Table 5 and shown in Figure 31, the Fathom 500-year floodplain covers 40% of Merced County's total land area, while the FEMA and Fathom 100-year floodplains cover 27% and 26% of total land area, respectively. This focus area encompasses 271 FEMA FIRM panels with effective dates of 2008 (69%), 2009 (28%), and 2021 (3%).

Table 5. Merced County: Area within Floodplain Boundaries and Developed Land

Total Area	Fathom 100		Fathom 500		FEMA 100		Developed Land (NLCD)	
(mi^2)	Area (mi^2)	%	Area (mi^2)	%	Area (mi^2)	%	Area (mi^2)	%
1,979	510	26%	787	40%	531	27%	70	4%

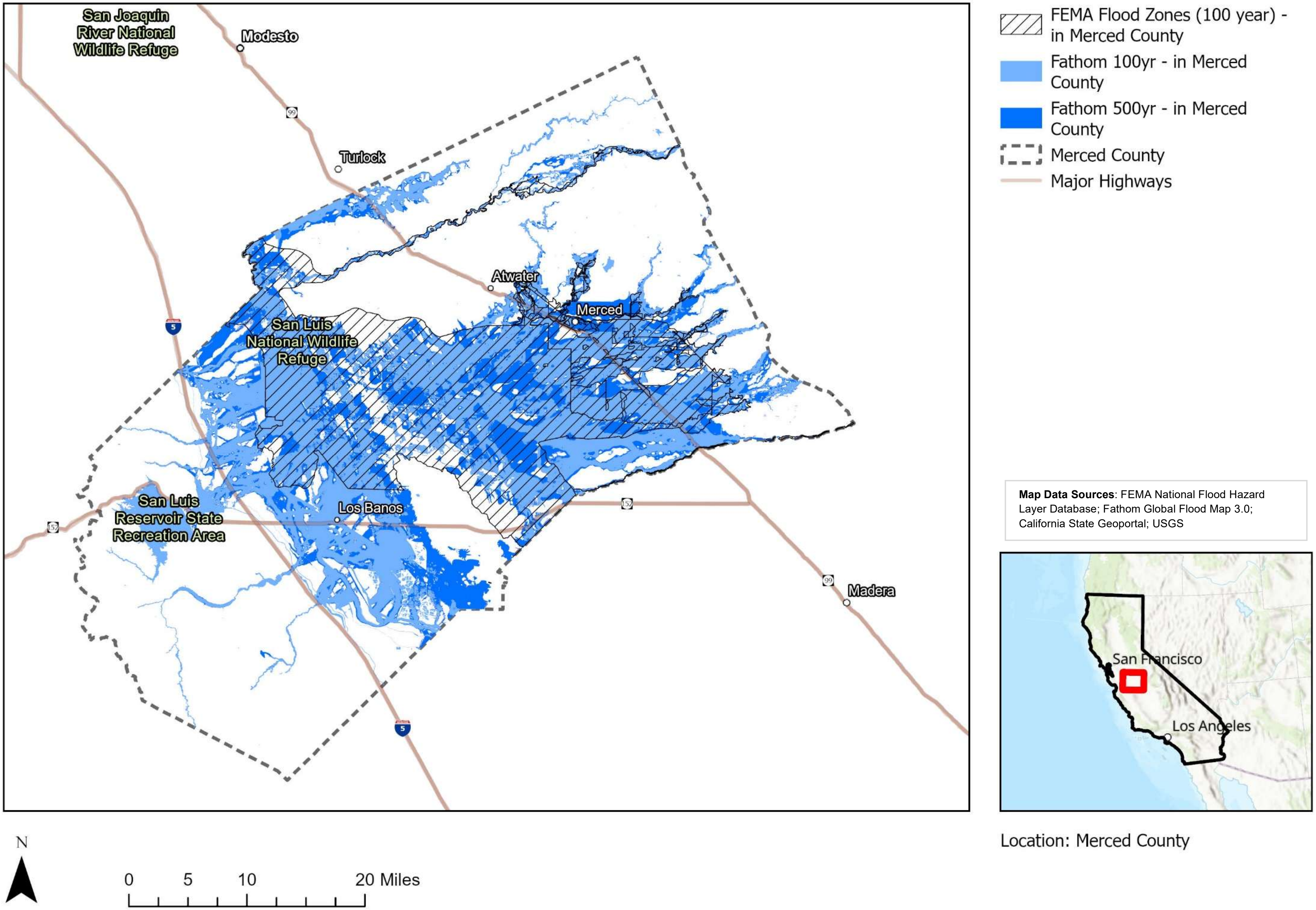
Land Use and Development Context

Merced's agricultural and urban development has historically been driven by its proximity to fertile land and strategic location along the Central Pacific Railroad, which facilitated trade and migration. In the 20th century, the establishment of the Merced Irrigation District and the construction of Exchequer Dam enabled large-scale irrigation, transforming the region's capacity for agricultural production.[57] The county's economy, while still rooted in agriculture, is diversifying with the expansion of education, healthcare, and logistics sectors. The opening of the University of California, Merced in 2005 has spurred a new wave of urban growth, attracting students, faculty, and related industries. The region's relative affordability compared to the San Francisco Bay Area has also contributed to increased residential demand. The City of Merced's Vision 2030 General Plan reflects a shift toward accommodating this growth through planned urban expansion, often into previously agricultural lands.[58]

Figure 32 shows that the vast majority (95%) of Merced County's land is designated for agricultural use, while only 3% of total land is designated for residential use. Similarly, approximately 95% of land is designated for Agricultural use within each of the FEMA and Fathom floodplains, as shown in Figure 33.

NLCD data in Table 5 and Figure 34 shows that under 4% of land in the County is considered 'developed,' with similarly low proportions of land in each of the FEMA and Fathom floodplains (between 3-5% for all). This data reflects that the County is still largely agricultural and undeveloped, despite recent and planned urban expansion within and surrounding the City of Merced.

Figure 31. Floodplains within Merced County



Floodplain Management Context

Historically, floodplain management in the City of Merced was primarily focused on structural and regulatory compliance tools, including adherence to NFIP standards, elevation of finish floors above base flood elevation, and freeboard requirements. These tools, codified locally through the city's Flood Damage Prevention Ordinance (Merced Municipal Code Title 17.48), allowed development to proceed within SFHAs as long as minimum construction standards were met.[59] Beginning in the late 2000's and accelerating after the adoption of the Central Valley Flood Protection Act (Senate Bill 5) and the establishment of the ULOP standard, Merced's floodplain management strategy began shifting toward integrating flood risk consideration into broader land-use planning decisions. Both of these policies required local governments to evaluate whether proposed land-use designations, densities, and subdivision patterns could feasibly achieve a 200-year level of flood protection, as established in ULOP standard, rather than relying solely on elevation or floodproofing at the parcel level.[22]

This shift became more apparent in the city's Vision 2030 General Plan, which highlighted the intent to deter future development from high-risk flood areas by incorporating state flood mandates, updated flood hazard mapping, and stronger policy direction to avoid increased development in areas that are not able to meet long-term flood protection standards.[58] More recently, the city's update to their LHMP explicitly calls for mitigation actions that link land-use planning and flood risk reduction and emphasizes reducing exposure by discouraging new development in high-risk flood zones and prioritizing open space and floodplain preservation.[60]

This paradigm shift in management strategies was supported in practice by the development of the Black Rascal Creek Flood Control Project in 2017. Designed to attenuate peak flows associated with up to 200-year storm events by storing water on the landscape via a detention basin and wetland complex, rather than conveying the water downstream. This innovative approach converted high risk land previously zoned for development into vital flood risk infrastructure, effectively reducing downstream flood impacts and reinforcing the importance of floodplains as essential components of flood resilience.[61,62]

Policy Analysis

For Merced County, parcel-based "year built" data was not available, and an in-depth development-based analysis of development within the Fathom 500-year floodplain was not possible at the time of this report. However, qualitative research provided an overview of historical development trends in the City of Merced in relation to the FEMA 100-year and 500-year floodplains.

The city was incorporated in the late 1880's, and as population began to increase in part due to the gold rush, residential developments began to localize around the Central Pacific Railroad line and along the banks of Bear Creek. Over the next century, the City of Merced saw steady growth and development of commercial properties and additional residential lots between the creek and railroad system. By this point, a majority of the City of Merced had been developed in the floodplain of Bear Creek and in the 1950's, a major flood event inundated much of the city. As flood risk is driven mostly by riverine influence from Bear Creek during excessive rainfall and extreme weather events, including its tributaries Black Rascal Creek and Fahrens Creek, the city established an urban growth boundary in 1980, directing growth away from high-risk flood zones and encouraging new developments towards the north and south.[63]

Following this, the General Plan continued to promote the north-south growth pattern, establishing future development patterns around Lake Yosemite and areas around the University of California, Merced to limit expansion in flood-prone areas and unincorporated lands subject to repeated inundation.[58] This strategic growth pattern was further reinforced through the city's LHMP, which identified extensive portions of the City of Merced within FEMA's 100-year floodplain and prioritized actions that would reduce future exposure, including the preservation of open space for multi-purpose regional flood detention (such as the Black Rascal Creek project) and natural floodwater storage.[60] Integrating flood risk into long-range land-use planning and encouraging growth towards safer corridors, the City of Merced has progressively shifted development away from high risk areas while also using designated open space to accommodate flood flows and protect existing and future development.

Figure 32. Merced County: General Plan Land Use as Percent of Countywide Land Area

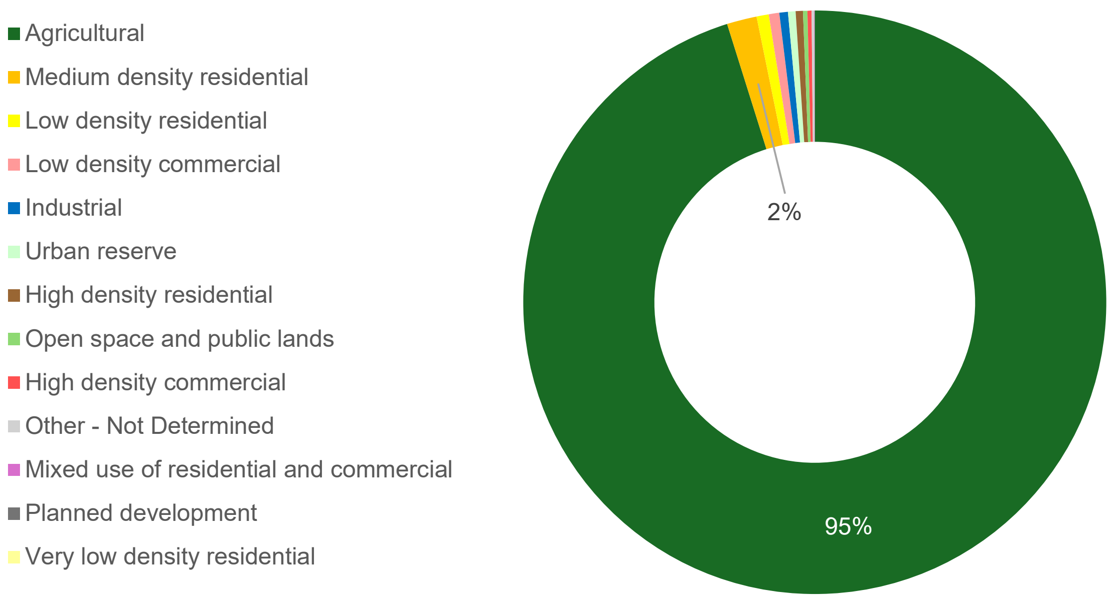


Figure 33. Merced County: General Plan Land Use as Percent of Countywide Flood Zones

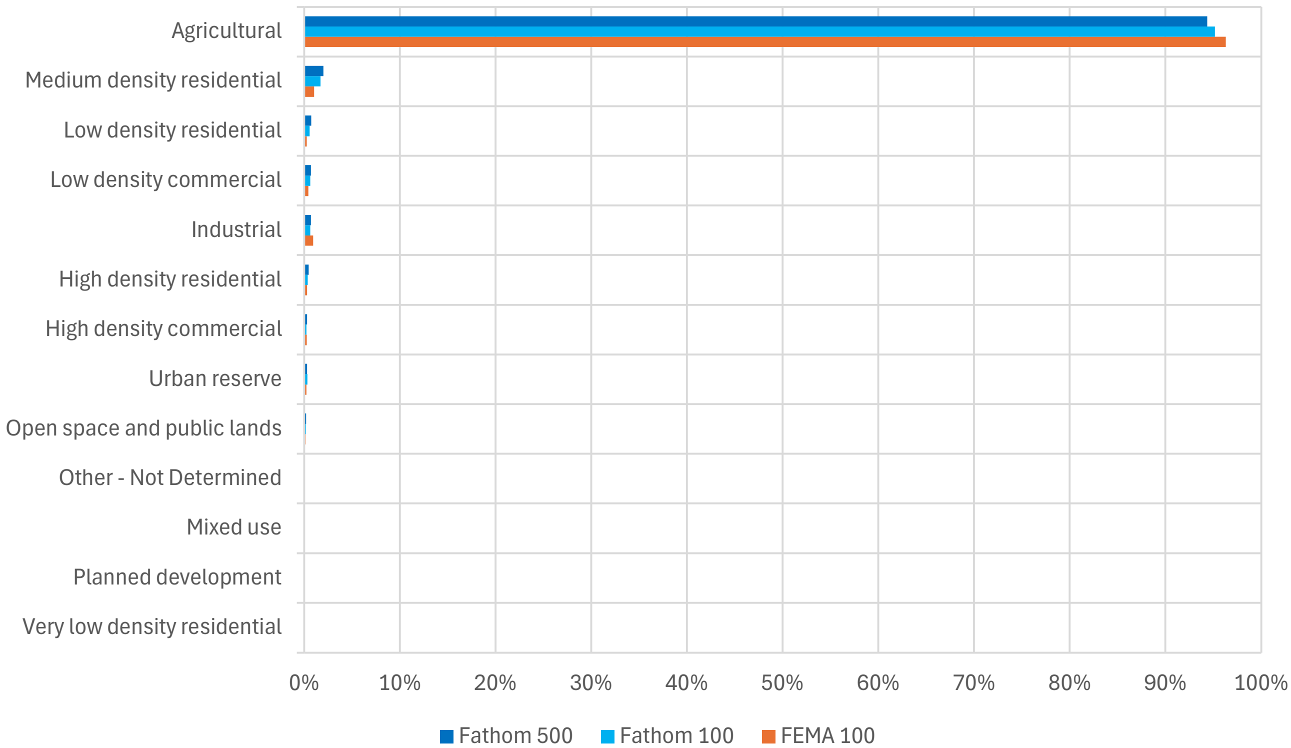
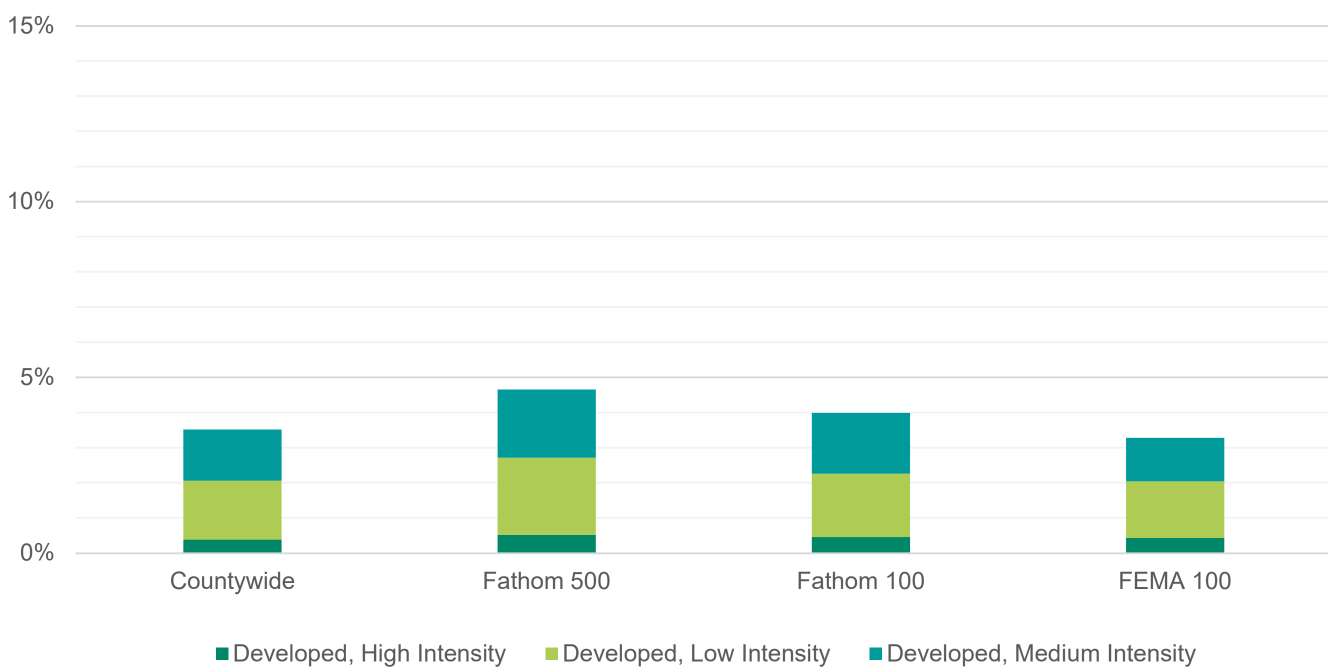


Figure 34. Merced County: NLCD Developed Land Percentages



3.6 Santa Clara County Floodplain and Land-Use Context

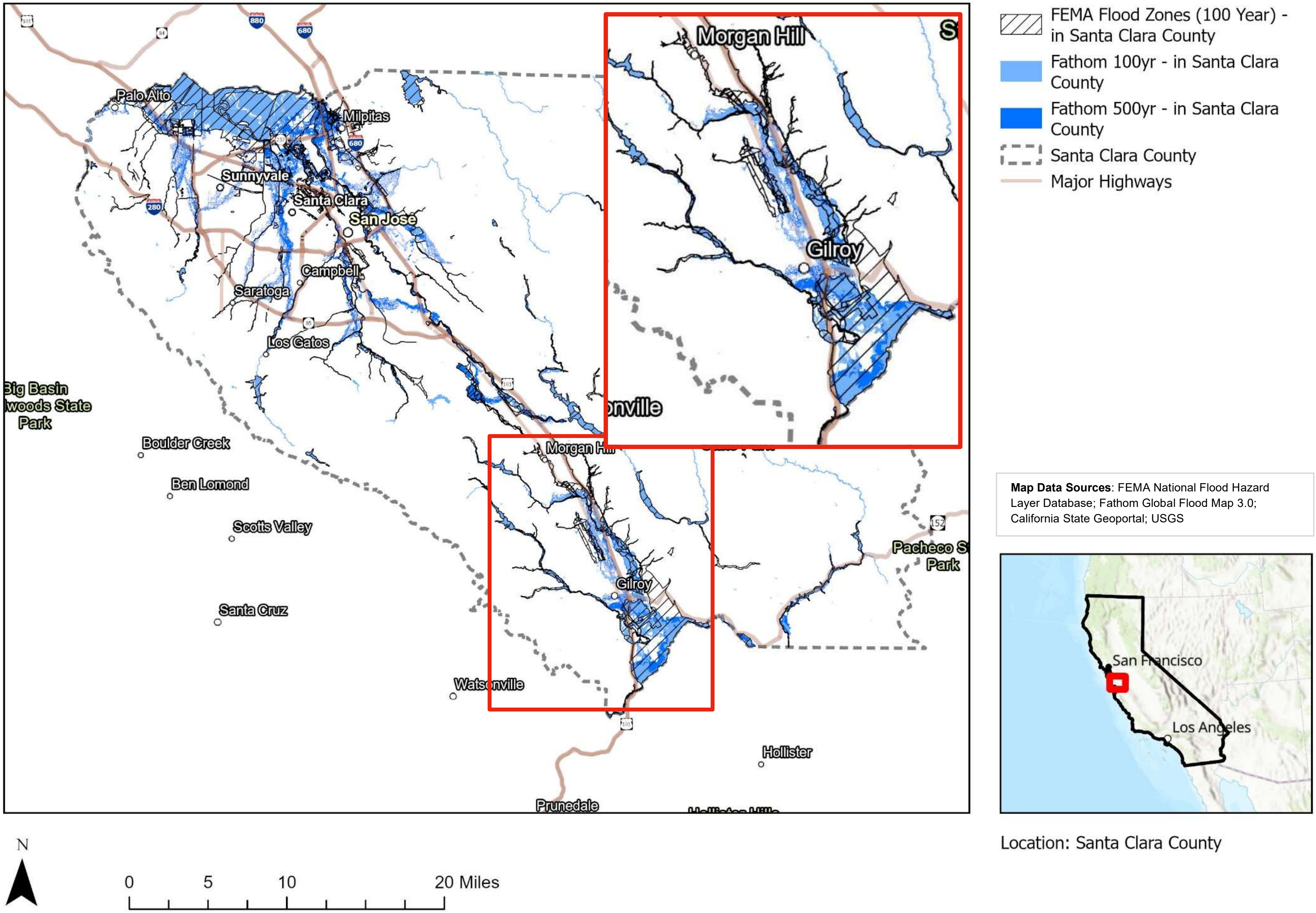
Santa Clara County encompasses a diverse land use and floodplain context shaped by its varied topography and watershed systems. The northern portion of the county, including San José and other Silicon Valley cities, drains into the San Francisco Bay via the Guadalupe and Coyote watersheds, while the southern portion, including Gilroy and Morgan Hill, drains southward into the Pajaro River watershed. This analysis focuses on floodplain development trends in the southern portion of the County, particularly Gilroy, which is located within the Uvas-Llagas sub-watershed of the larger Pajaro River Watershed. Gilroy is situated on a valley floor between the Santa Cruz Mountains to the west and the Diablo Range to the east. This topography contributes to localized flood risks, particularly during periods of heavy rainfall when runoff from the surrounding hills overwhelms creeks like Uvas and Llagas.[64, 65, 66, 67]

As detailed in Table 6 and shown in Figure 35, a relatively small share of Santa Clara County falls within floodplains, with just 7% and 8% of total land area covered by the FEMA 100-year and Fathom 500-year floodplains, respectively. This focus area includes 398 FEMA FIRM panels with effective dates of 2008 (8%), 2009 (68%), 2012 (20%), 2014 (3%), and 2019 (1%).

Table 6. Santa Clara County: Area within Floodplain Boundaries and Developed Land

Total Area	Fathom 100		Fathom 500		FEMA 100		Developed Land (NLCD)	
(mi²)	Area (mi²)	%	Area (mi²)	%	Area (mi²)	%	Area (mi²)	%
1,304	56	4%	102	8%	93	7%	263	20%

Figure 35. Floodplains within Santa Clara County



Land Use and Development Context

Gilroy's development history is rooted in agriculture, with large-scale cultivation beginning in the late 19th century. Over time, the city evolved from a rural farming hub into a suburban community, with residential and commercial development expanding onto former agricultural lands. Today, Gilroy and the broader South County region are experiencing steady population growth and economic diversification, with freeway access to Silicon Valley attracting commuters seeking more affordable housing options. Industry has also expanded from agriculture to include light manufacturing, retail, and tourism, adding to commercial, industrial, and residential development pressure. As a planned stop on the proposed California High Speed Rail line, demand for further development is likely to increase in the coming decades.[68, 69]

Figure 36 shows that 77% of land in the County is designated for Agricultural and Open Space/Public Land uses, while roughly 12% of total land is designated for residential use. Within the FEMA 100-year floodplain, Agriculture and Open Space make up 70% of land area, compared to 85% in the Fathom 100-year floodplain. Residential, commercial, and industrial land uses make up the highest share of land in the Fathom 500-year floodplain, as shown in Figure 37.

NLCD data in Figure 38 shows that 20% of land in the County is considered 'developed,' while nearly double that percentage (38%) of land in the Fathom 500-year floodplain is 'developed'. While less than 10% of land in the Fathom 100-year floodplain is 'developed', 28% is 'developed' within the FEMA 100-year floodplain.

Floodplain Management Context

Historically, floodplain management for the city has been fragmented across multiple jurisdictions. At a regional level, the Santa Clara Valley Water District (Valley Water) manages broader flood risk across Santa Clara County. Taking a watershed-scale approach, Valley Water is responsible for planning, constructing, and maintaining major flood control infrastructure, such as channel improvements, reservoirs, levees, and conveyance capacity, along Uvas Creek, Llagas Creek, and associated tributaries, the primary drivers of flood risk in the City of Gilroy.70 As flood risk is managed beyond the authority of Gilroy, the scope of projects are often unable to capture localized flood hazards, leaving mitigation of these risks up to municipal ordinances.

Locally, the City of Gilroy enforces NFIP criteria through the 1998 Floodplain Ordinance (Ordinance No. 98-17) until the adoption of the Floodplain Management Ordinance (Chapter 27E) in 2017. While both policies recognize the risk of inundation when developing in a floodplain, they do not explicitly restrict development from occurring, as long as the floodproofing and freeboard requirements are satisfied.[71,72] In addition, the city also authorizes and plans for land use in their General Plan, originally adopted in 1968 and most recently amended in 2020 as the 2040 General Plan. The evolution of this land-use plan has shifted from viewing flood risk as a technical constraint to recognizing its role in maintaining growth potential. The 2040 General Plan designates open space, which includes floodways, as areas where development is undesirable and encourages leaving current agricultural and recreational lands undeveloped, but does not necessarily aim to increase open space designations to reduce flood risk to new development. In addition, the General Plan incorporates the Urban Growth Boundary voted in by residents in 2016, which does constrain regional sprawl, but does not explicitly exclude flood-prone areas. While flood risk is integrated into land-use policies, these policies emphasize mitigation through structural upgrades, elevation, and floodproofing rather than avoiding the risk altogether.[73,74]

This de-coupling of land-use regulations with flood risk reduction strategies has limited the adoption of land-use policies targeted at reducing the exposure of development to flood hazards. In addition, with the perceived protection provided by regional flood control infrastructure, the City of Gilroy has focused more on engineered solutions rather than land use avoidance.

Policy Analysis

Similar to Merced, parcel-based “year built” data was not available for Santa Clara County, and an in-depth review of development within both the FEMA and Fathom floodplains was not possible at the time of this report. Qualitative research provided an overview of historical development trends in relation to flood-focused land-use policies.

While the land-use policies that shape development in Gilroy do not prohibit development in mapped floodplains, they have indirectly influenced development towards designated urbanized areas and away from large tracts of existing agricultural land along Uvas Creek and Llagas Creek. The 2040 General Plan, in support of the Urban Growth Boundary, prioritizes high-density growth within the existing city footprint and planned growth areas that reinforces an inward growth model reducing pressure on existing open space areas. Furthermore, the designation of agricultural lands and floodplains as open space has helped preserve their ability to effectively convey floodwaters, even though these designations are framed more as land use compatibility measures as opposed to flood risk avoidance policies. However, the absence of explicit flood-risk-based land-use policies focusing on avoidance of flood-prone areas means that development trends remain closely tied to the assumption of protection from regional flood control infrastructure and compliance-based mitigation, contributing to patterns where land-use policy manages exposure indirectly rather than deliberately avoiding flood-prone areas.

Figure 36. Santa Clara County: Zoned Land Use as Percent of Countywide Land Area

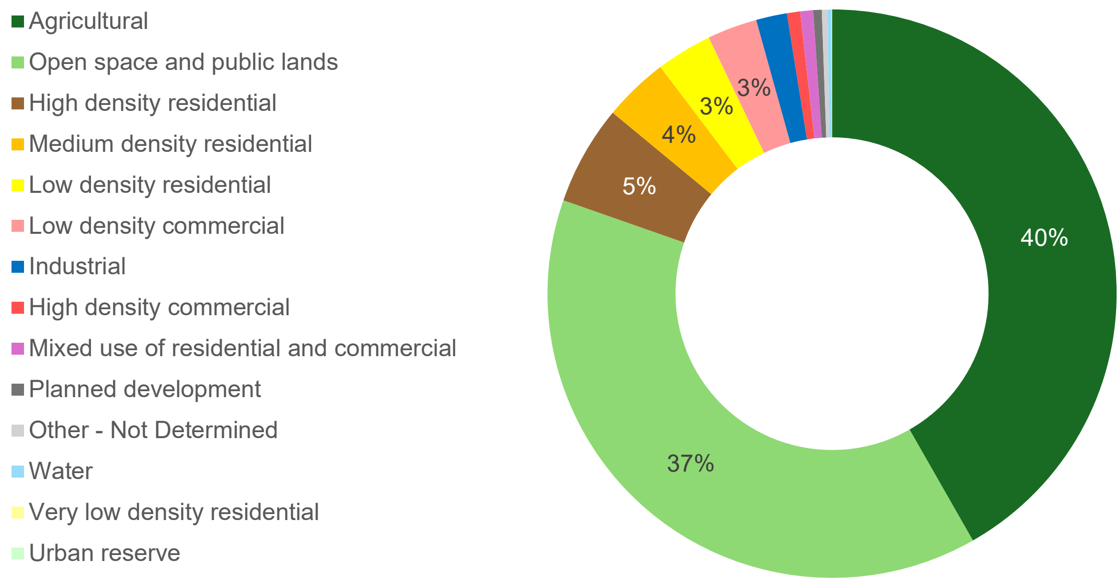


Figure 37. Santa Clara County: Zoned Land Use as Percent of Countywide Flood Zones

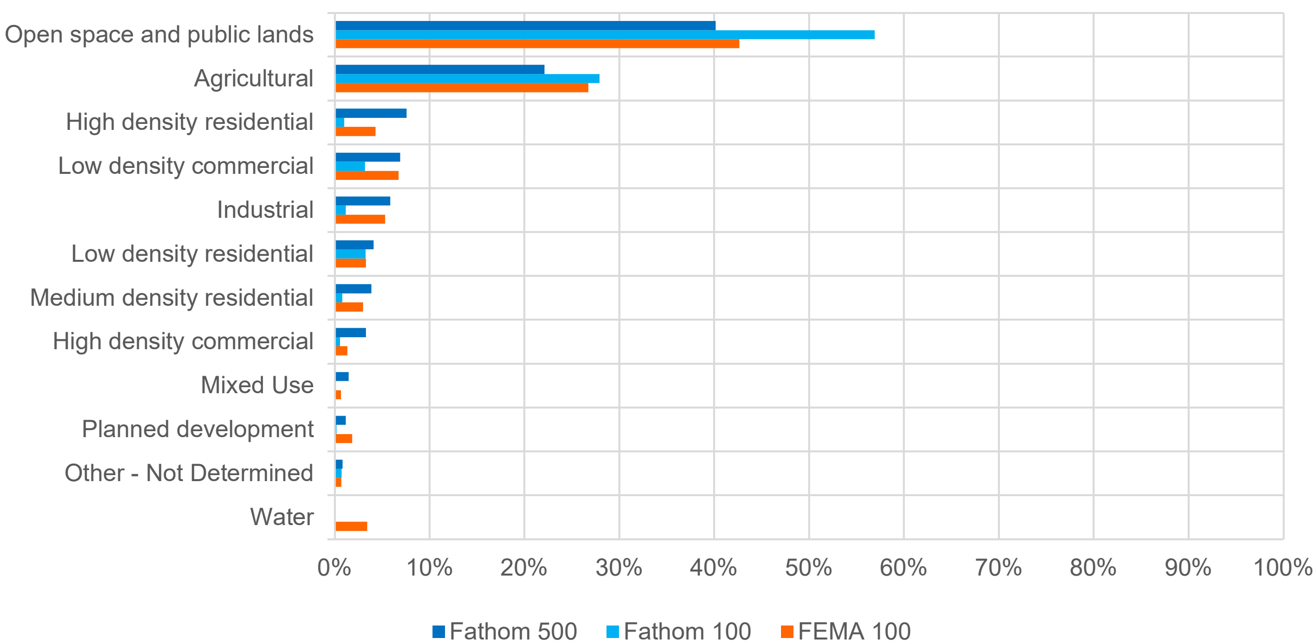
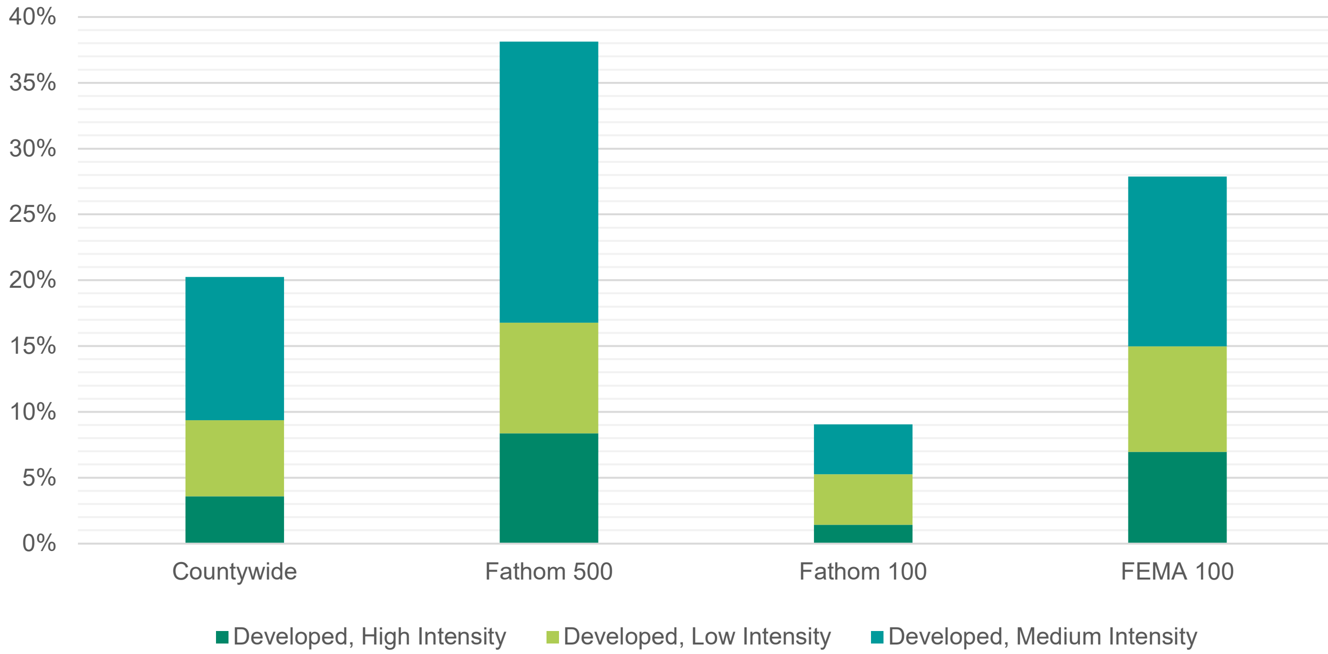


Figure 38. Santa Clara County: NLCD Developed Land Percentages



4. Nature Forward Sustainable Development Strategies

nature-based solutions will be central to California's long-term flood resilience strategy. While they can be designed and implemented to manage floodwaters to reduce risk, they provide multiple additional benefits, including habitat restoration, groundwater recharge, and climate adaptation, benefits that have increasingly opened the door to state and federal funding opportunities. Still, nature-based projects face hurdles. Their performance can be difficult to model, they often require ongoing upkeep to function as intended, and their wide range of ecological and social benefits remain challenging to quantify within standard cost-benefit frameworks. [75,76,77]

California's rising flood risks, whether along the river systems of the Central Valley, the tidal and storm-driven hazards of the Bay Area and outer coast, or the flash-flooding that affects inland urban corridors, underscore the need for approaches that work with, rather than against, natural processes. Utilizing nature-based solutions to restore or enhance existing landscapes to absorb, slow, or redirect floodwaters can reduce impacts on people and infrastructure. In doing so, they offer co-benefits: improved water quality and capture potential, carbon sequestration, expanded recreational access, job creation, and healthier surrounding communities, often paired with lower long-term maintenance costs.[77,78 79,80]

The diversity of California's landscapes shapes the form these strategies take. In riverine systems, reconnecting rivers to their natural floodplains and restoring riparian corridors allows high flows to spill safely into designated flood zones, relieving pressure on levees and reducing risks to upstream and downstream communities. Along the coast, wetland and marsh restoration creates a natural buffer that absorbs storm surge and rising sea levels, limits erosion, and provides storage that protects nearby neighborhoods from rising tides. In densely built inland areas, green infrastructure, such as permeable pavement, bioswales, and expanded tree canopy, helps manage stormwater where it falls, reducing the severity of flash-flood events. Rural and agricultural regions introduce another set of opportunities, using land management and rangeland conservation practices to retain water, improve soil health, and slow runoff across broad landscapes.[78,79,81]

nature-based solutions already play an important role in reducing flood risks across California, and their relevance will only grow as climate pressures intensify. While initiatives such as the state's Natural and Working Lands Climate Smart Strategy, 30x30 conservation goal, and nature-based solutions climate targets signal a growing commitment, much more progress is needed to match the pace of changing conditions.[75,82,83] Integrating nature-based approaches more deeply into statewide, regional, and local policy frameworks and addressing the underlying drivers of escalating flood risk will be essential to expanding their use. Doing so will help position California to weather the mounting challenges of a warming climate and reduce exposure to the severe flood hazards facing communities today and in the decades ahead.

4.1 Nature-Based Flood Risk Reduction Strategies

California's land use and flood management framework offers a strong foundation for integrating nature-based solutions into strategies that reduce flood risk while avoiding new development in high-hazard areas. Rather than relying primarily on structural defenses, the state has increasingly emphasized land-use planning, floodplain protection, and landscape-scale restoration as complementary risk-reduction tools. Executive Order N-82-20 formalized this approach by directing state agencies to align land use, infrastructure investment, and natural resource management to reduce climate risk, explicitly prioritizing natural and working lands as protective assets.[84] By framing resilience as a cross-sector responsibility, the order enables local governments to embed floodplain protection and ecosystem restoration into general plans, zoning, and capital planning without treating nature-based solutions as discretionary or secondary measures.

At the state level, guidance from the Office of Land Use and Climate Innovation encourages local governments to use general plans, conservation elements, and hazard mitigation policies to steer growth away from flood-prone areas while preserving floodplains as multifunctional landscapes that provide storage, conveyance, and ecological benefits. Research shows that communities can effectively limit floodplain development through the consistent application of routine land-use tools, such as zoning, subdivision controls, and infrastructure siting, rather than relying on novel or extraordinary regulations.[85] FEMA guidance for local communities explicitly identifies land-use planning, open space preservation, and hazard mitigation planning as key pathways for implementing nature-based solutions that reduce flood risk while avoiding new exposure.[86] California's flood management institutions, particularly in the Central Valley, reinforce this linkage by promoting agricultural land conservation, setback levees, and floodplain restoration as strategies that simultaneously expand flood capacity and discourage urban expansion into high-risk areas.[23]

These policy frameworks are reflected in regional and local land-use strategies across the state, as seen in the focus area discussions in Section 3. In Sacramento County, the requirement that new development achieve 200-year flood protection has functioned as a growth-management tool, steering development away from high-risk flood zones while supporting large-scale habitat restoration and agricultural land transitions that buffer flood flows. Similar patterns appear in the San Joaquin Valley and the City of Merced, where floodplain restoration and agricultural land preservation support flood risk reduction, groundwater recharge, and limits on development into hazard zones. In Southern California, floodplain preservation and natural channel management along systems such as the Whitewater River and the San Jacinto watershed rely on land-use controls that maintain open space in active flood corridors, allowing natural processes to dissipate floodwaters rather than concentrating risk downstream.

Across these diverse landscapes, the effectiveness of nature-based solutions depends on sustained coordination across land-use planning, flood management, conservation, and funding programs. State and federal funding mechanisms increasingly recognize nature-based projects as eligible investments, helping overcome historic biases toward gray infrastructure.[87] Nonetheless, challenges remain, including governance complexity, fragmented land ownership, limited local capacity, and the lack of standardized performance metrics for nature-based solutions. Even so, California's experience demonstrates that embedding floodplain avoidance and nature-based solutions into land-use policy can meaningfully reduce flood risk while delivering ecological and social co-benefits. Treating floodplains, wetlands, and working lands as essential infrastructure and aligning development decisions accordingly will be critical to managing flood risk as climate pressures intensify.[88]

4.2 Strategies Across the United States Applicable to California

Several U.S. states have demonstrated that land-use-based avoidance of development within FEMA-mapped floodplains is an effective strategy for reducing flood risk. The following examples highlight how state enabling legislation and locally implemented zoning, environmental overlays, and growth management policies have been used to limit or redirect development away from high-risk floodplain areas.

Massachusetts employs a layered land-use framework that effectively limits development within FEMA-designated floodplains by combining state-level environmental regulation with locally enforced zoning controls. Central to this approach is the Massachusetts Wetlands Protection Act, which restricts development in riverfront areas, bordering vegetated wetlands, and floodplains by requiring avoidance and minimization of impacts as a condition of permitting, often rendering new development in FEMA SFHAs infeasible.[89] This statutory baseline is reinforced by widespread municipal adoption of Floodplain Overlay Districts based on the state's Model Floodplain Bylaw, which frequently prohibits new residential development in floodways and imposes elevation, density, and use limitations in the 100-year floodplain that exceed NFIP minimum standards.[89] Together, these tools shift local land-use decisions toward avoidance rather than accommodation by constraining developable land supply in flood-prone areas while maintaining NFIP eligibility.

New Jersey demonstrates how consistent application of routine municipal land-use tools can substantially reduce floodplain development without relying on novel regulatory mechanisms. A recent study shows that the majority of New Jersey municipalities placed little to no new housing in FEMA-mapped floodplains between 2001 and 2019, largely through zoning ordinances, subdivision controls, environmental overlays, and redevelopment standards that restrict density or prohibit development in flood hazard areas.[85] These local actions are supported by strong state coordination through the New Jersey Department of Environmental Protection, Executive Order 89, and the Statewide Climate Change Resilience Strategy, which emphasize climate-informed land-use planning and explicitly discourage expansion of development in high-risk floodplain areas.[90] Rather than promoting engineered flood protection, New Jersey's approach relies on regulatory consistency, administrative capacity, and alignment between floodplain management and local planning frameworks.

Washington State limits floodplain development through a combination of state-mandated growth management, shoreline regulation, and locally implemented critical areas ordinances that prioritize avoidance over structural mitigation. Under the Growth Management Act, counties and cities are required to designate frequently flooded areas as critical areas and adopt development regulations that reduce exposure to flood hazards, often prohibiting or severely limiting new residential development within FEMA-mapped floodplains.[91] These regulatory requirements are reinforced by the Shoreline Management Act, which restricts new development along rivers and coastal areas and prioritizes ecological protection and hazard reduction, resulting in conservative land-use designations in flood-prone zones.[92] In parallel, Washington's Floodplains by Design program provides a complementary incentive-based approach by funding large-scale, multi-benefit floodplain projects that restore floodplain function, reconnect rivers to floodplains, and reduce flood risk while explicitly discouraging new development in high-risk areas. By coupling land-use restrictions with state investment in floodplain restoration and agricultural land protection, Floodplains by Design helps shift local planning away from floodplain urbanization and toward long-term risk reduction and resilience.[93]

Across Massachusetts, New Jersey, and Washington, a consistent lesson emerges: flood risk reduction is most effective when land-use policy prioritizes avoidance of development in FEMA floodplains rather than reliance on floodproofing or engineered protection. These states demonstrate that avoidance can be achieved using existing land use tools, such as floodplain overlay zones, critical areas ordinances, environmental permitting, and growth management requirements, when those tools are implemented consistently and supported by state-level guidance and coordination.[94,85] For California, these examples underscore the limitations of approaches that enable continued development within or adjacent to mapped floodplains, contributing to the "safe development paradox" identified in national analyses.[95,2] California could leverage these lessons by strengthening alignment between General Plans, zoning codes, housing elements, and flood hazard data to more explicitly discourage urban expansion in FEMA SFHAs, while pairing avoidance policies with incentives for infill development, strategic retreat, and nature-based floodplain restoration.

5. Recommendations to Reduce High-Risk Development in California

The following recommendations are informed by the successes and limitations of policies analyzed for the six focus areas, lessons from strategies adopted elsewhere in California and the United States, and industry best practices in land-use planning and preservation. These recommendations are intended to help jurisdictions across California manage and redirect growth to appropriate areas, balancing state requirements for housing production and local economic development priorities with the human, environmental, and economic risks of expanding development into floodplains. The recommendations fall into five primary categories:

- Improving Maps
- Land-use Screens
- General Plan Policy and Zoning Regulations
- Conservation Agreements and Policy Incentives
- Strategic Land Acquisition

5.1 Improving Maps

FEMA flood maps remain the standard for evaluating flood risk at the policy level as they remain one of the only publicly available sources for assessing flood risk. Although FEMA is required to assess and revise flood maps every 5 years, regulatory and bureaucratic hurdles mean that new maps take an average of 7 years to complete and are dependent on support from the current executive administration. As a result, 75% of FEMA flood maps are older than five years and less than 50% accurately reflect flood risk.[96] Additionally, FEMA maps only consider riverine and coastal flooding, whereas pluvial and sea level rise flooding increasingly put communities at risk. Existing maps also do not accurately reflect changing flood dynamics, as climate change brings more frequent and severe extreme precipitation events. Municipalities relying on outdated or inaccurate information are likely to make land-use decisions without a comprehensive understanding of flood risk, which can lead to unexpected losses. For example, 40% of claims to the National Flood Insurance Program between 2017 and 2019 were outside official 1-in-100-year flood hazard zones or occurred in areas that FEMA had not yet mapped. There is a critical need to develop forward looking, comprehensive flood maps that can be regularly updated to ensure that municipalities are using the best available data to determine flood risk. California's Department of Water Resources is currently developing the Best Available Maps (BAM)[97] – flood maps that are more comprehensive and forward-looking and are explicitly intended for land-use planning and risk awareness. Beginning in 2024–2025, they have also begun piloting Climate Risk-Informed Flood Mapping [98] that incorporates future climate scenarios. While these do not replace FEMA maps for regulatory or insurance purposes, they could—in partnership with the California Governor's Office of Emergency Services (CalOES)—inform eligibility for FEMA hazard mitigation funding through inclusion in guidelines for both the State Hazard Mitigation Plan and Local Hazard Mitigation Plans.

Key Benefits:

- Enables jurisdictions to integrate accurate flood risk projections into land-use planning, keeping people out of harm's way and creating opportunities for open space and nature-based solutions.
- Decreases unexpected losses from multiple types of flooding and from more frequent and severe flooding events associated with climate change.

Key Considerations and Limitations:

- Updating flood maps can be time and resource intensive. However, these costs would likely be offset by avoided damages.
- Changes to existing flood zones are likely to receive political pushback due to mandatory flood insurance requirements for homeowners with federally backed mortgages, as well as reduced property values and opportunities for development.

5.2 Land-use Screens

Land-use screens are a data-driven way to guide development to safer, more sustainable places. By using the best available models and maps to identify high risk flood hazard areas, land-use screens are able to exclude these areas from consideration for new development, thereby reducing community exposure to future disasters, lowering long term public safety and infrastructure costs, and avoiding placing households in locations that may become uninsurable or repeatedly damaged.

Many high-risk climate flood zones overlap with biologically rich lands, meaning that protecting people from hazards often simultaneously protects ecosystems and wildlife habitat. By flagging natural and working lands, wildlife movement corridors, wetlands, and high-value agricultural soils, screens help avoid development in landscapes essential for biodiversity, food production, and carbon sequestration. By mapping these constrained lands, land-use screens can help planners steer growth toward areas that are safer for people and more compatible with long-term community resilience and sustainability.

Regions like Fresno have already successfully applied land-use screens to distribute housing allocations more safely and sustainably. In their Regional Housing Needs Assessment methodology, the Fresno Council of Governments identified vacant sites in 100-year flood zones and other hazard areas that were then removed from housing capacity, ensuring new development would not increase the number of residents exposed to future harm.

Key Benefits:

- Allows jurisdictions to integrate flood risk considerations into housing allocation methodologies, ensuring that local jurisdictions meet housing needs without increasing hazard exposure.
- Decreases long-term infrastructure maintenance and emergency response costs by steering development away from areas that will require expensive future protection, repair, or disaster response.
- Supports ecological conservation and climate resilience by flagging high hazard floodplains that overlap with biologically rich or environmentally sensitive areas.

Key Considerations and Limitations:

- Effective land-use screens rely on the quality and resolution of flood maps, hazard models, and ecological datasets which, if incomplete or outdated, may result in ineffective screens.
- Jurisdictions may worry about meeting state housing mandates, especially if a region faces housing shortages or affordability pressures, which could result in tension about where growth should be redirected.

5.3 General Plan Policy and Zoning Regulations

General Plan policy and zoning regulations are effective tools for proactively directing long-term growth in safe and sustainable ways, focusing development in areas of low flood risk while preserving natural floodplains. In addition to designating areas at high risk of flooding for open space, agriculture, and other low-intensity land uses, planners should also ensure that their zoning code facilitates infill development in areas with low exposure to flooding, allowing densities that are sufficient to meet the area's housing demand and fulfill state-allocated regional housing targets.

For California jurisdictions, the zoning code implements the vision and policy guidance set forth in the General Plan. In addition to the designation of broad land-use categories or "place types" in the Land Use Element, the General Plan's Safety, Housing, Open Space, and Conservation Elements contribute to jurisdictions' documentation of climate hazards, establishment of a long-term growth strategy, and identification of sites for housing, conservation areas, recreational open space, and urban growth boundaries. Flood risk should be factored into the process of updating each of these Elements, including the inventory of suitable sites for housing development (as required for the Housing Element), and inclusion of policies to preserve and expand parkland, open space, and natural resources, and discourage conversion of agricultural land for other uses.

Zoning for flood-prone areas should also account for local context by considering specific allowed uses and development standards that may manage appropriate forms of development. For example, Rural Residential Zones can allow for very low-density development associated with livestock farming or other land uses requiring on-site residence, while establishing development standards to reduce vulnerability of structures in those areas.

Key Benefits:

- Allows jurisdictions to integrate floodplain avoidance into an overall growth strategy that redirects development to safer areas and integrates climate resilience with regional housing, transportation, and economic development goals.
- Allows jurisdictions to apply regulations broadly across areas with similar typologies, while tailoring regulations for local context.
- Zoning can incorporate complementary incentives such as density bonuses or streamlined permitting to encourage development in low-risk areas appropriate for growth.

Key Considerations and Limitations:

- Updates to General Plans and Zoning codes can be time-intensive, resource-intensive, and politically contentious processes, delaying the implementation of floodplain protection measures.
- 'Top-down' policy changes restricting allowed land uses and development potential for privately owned land are often met with pushback and political pressure from landowners and developers.
- Long-range planning processes are required to address a multitude of issues, and the significance of flood risk may be underestimated among competing priorities.
- Zoning regulations can be amended or overturned, meaning they do not guarantee long-term protection of floodplains.

5.4 Conservation Agreements and Incentives

For flood-prone private lands that would contribute to broader conservation networks, but may otherwise be considered desirable for future development, jurisdictions should consider conservation agreements as a strategy to restrict development while allowing owners to retain ownership and use of their property. Conservation agreements, such as conservation easements, are voluntary legal agreements that are a cost-effective alternative to land acquisition, enabling jurisdictions to protect floodplains without purchasing land outright. Easements can also be applied to targeted portions of properties, such as buffer zones along rivers that allow for periodic flooding.

Conservation agreements can be facilitated or complemented by other policy incentives and tools, such as tax benefits, grants, zoning bonuses, and transfer of development rights to encourage landowners to participate in floodplain preservation and management efforts while allowing them to successfully pursue worthwhile development opportunities in low-risk areas. Jurisdictions can collaborate with conservation organizations and land trusts to help facilitate and fund agreements and maximize the benefits of land protected under conservation agreements. Conservation easement programs such as TNC's Natural Floodplain Protection Program (NFPP) along the Santa Clara River prioritize preventing future structural flood control projects by preserving floodplain capacity through agricultural conservation easements in the 500-year floodplain. Lands targeted for voluntary easements in this program is based on hydrologic modeling of downstream flood reduction benefits, not just habitat value, addressing the safe development paradox head-on.

Key Benefits:

- Conservation agreements are less expensive than fee simple acquisitions.
- Conservation easements provide long-term or perpetual restrictions on development in floodplains.
- Easements can provide highly targeted conservation approaches to larger properties with variations in flood risk.
- Landowners retain ownership and use of their land, reducing resistance to participation.

Key Considerations and Limitations:

- Conservation agreements rely on landowner willingness, which may limit the areas that can be protected.
- These agreements are typically applied on a parcel-by-parcel basis, which may not address regional floodplain management needs.
- Protected lands require long-term monitoring and enforcement to ensure compliance with easement terms.

5.5 Strategic Land Acquisition

Jurisdictions should consider strategic land acquisition for flood-prone private lands with similar characteristics to those suitable for conservation agreements, that are most critical for integration within broader floodplain management strategies and conservation networks under management by public agencies or land trusts. Acquisition ensures that flood-prone areas remain undeveloped, preserving their natural flood control functions and reducing flood risk to downstream communities. Acquired lands can be maintained or repurposed for open space, recreation, agriculture, or habitat restoration, contributing to sustainable land use and climate resilience. While costly, acquisitions can be funded by state or federal matching grants, state bond measures, local dedicated sales taxes, development fees, or land trusts.

Key Benefits:

- Acquired land is permanently removed from development consideration, guaranteeing long-term floodplain preservation and natural flood control functions.
- Ownership and management by public agencies or land trusts can enable coordinated large-scale floodplain conservation efforts.
- Acquired lands can be repurposed for multi-benefit uses.

Key Considerations and Limitations:

- Land acquisition requires significant upfront investment.
- Acquisitions are typically made on a parcel-by-parcel basis, which may not address regional floodplain management needs.
- Acquisitions also rely on landowner willingness, and acquisition processes can be complex, slow, and resource intensive.
- Long-term stewardship costs can be expensive, covering everything from Operations and Maintenance to Resource Management and Legal and Liability issues.

References

1. California's Population – Public Policy Institute of California, 2025 (ppic.org)
2. How the 'Safe Development Paradox' Shapes Risky Floodplain Growth – Association of State Floodplain Managers, 2025 (floods.org)
3. Floods in California – Public Policy Institute of California, 2023 (ppic.org)
4. Billion-Dollar Weather and Climate Disasters: California Summary – NOAA National Centers for Environmental Information, 2023 (ncei.noaa.gov)
5. What does California's flooding (and drought) have to do with climate change? – Environmental Defense Fund, 2023 (vitalsigns.edf.org)
6. Perspective: Post-fire Slope Stability in the Wake of the Palisades and Eaton Fires – Samueli School of Engineering University of California, Los Angeles, 2025 (samueli.ucla.edu)
7. The Coming Megafloods – Scientific American, 2012 (atmosedu.com via web.archive.org)
8. ARkStorm Scenario – USGS Science Application for Risk Reduction (usgs.gov)
9. 2025 Report Card for California's Infrastructure – American Society of Civil Engineers, 2025 (infrastructurereportcard.org)
10. Not all flood maps are created equal – PreventionWeb, 2024 (preventionweb.net)
11. American Community Survey 5-Year Estimates – U.S. Census Bureau, 2023
12. Geographic Crosswalks – National Historic Geographic Information System (nhgis.org/geographic-crosswalks)
13. FEMA's 100-Year Floodplain Data – Federal Emergency Management Agency, 2023
14. National Land Cover Database – U.S. Geological Survey, 2024 (usgs.gov)
15. California General Plan Land Use – California Governor's Office of Land Use and Climate Innovation, 2023 (gis.data.ca.gov)
16. Parcels, Year Built – Los Angeles County Assessor, 2025 (data.lacounty.gov)
17. Parcels, Year Built – Riverside County Assessor, 2025 (gis.rivco.org)
18. Parcels, Year Built – Sacramento County Assessor, 2025 (data provided via email)
19. Introducing GPT-5 – Open AI (openai.com)
20. Senate Bill 379 Climate Adaptation & Resiliency Guidebook – Southern California Association of Governments (SCAG), 2017 (scag.ca.gov)

21. Assembly Bill 2140 Fact Sheet – California Governor's Office of Emergency Services (Cal OES), 2024 (caloes.ca.gov)

22. Urban Level of Flood Protection (ULOP) Criteria – California Department of Water Resources, 2013 (cawaterlibrary.net)

23. Ordinance Amending Titles 15, 17, and 18 of the Sacramento City Code Relating to Floodplain Management Findings for an Urban Level of Flood Protection – City of Sacramento, 2016

24. Central Valley Flood Protection Plan – California Department of Water Resources, November 2025 (water.ca.gov)

25. California Coastal Act (Public Resources Code §30000 et seq.) – California Coastal Commission, November 2025 (coastal.ca.gov)

26. Flood-MAR (Managed Aquifer Recharge) – California Department of Water Resources, November 2025 (floodmar.org)

27. Napa River/Napa Creek Flood Protection Project – County of Napa, November 2025 (napacounty.gov)

28. Antelope Valley Areawide General Plan – Los Angeles County Department of Regional Planning, 1986 (planning.lacounty.gov)

29. The Shifting Demographics of Antelope Valley - And Development's Consequences – PBS SoCal, 2017 (pbssocal.org)

30. Los Angeles County Code of Ordinances – Municode Library, accessed November 2025 (library.municode.com)

31. What to Know About Flood Risk – Los Angeles County Department of Public Works, October 2024

32. Alluvial Fan Flooding – National Academies, 1996 (nationalacademies.org)

33. Alluvial Fan Studies – FEMA, 1985 (fema.gov)

34. The Story of the Whitewater River Watershed – Riverside County Watershed Protection, 2020 (rcwatershed.org)

35. Flooding from Hilary Leaves Palm Springs, Coachella Valley Reeling – Los Angeles Times, August 2023 (latimes.com)

36. District History – Riverside County Flood Control & Water Conservation District (rcflood.org)

37. Ordinance No. 458 (as amended through 458.17) – County of Riverside, 2022 (rcflood.org)

38. Riverside County Floodplain Map – Riverside County Flood Control, 2025 (rcflood.org)

39. Guideline K-7 – Coachella Valley Water District Ordinance No. 1234.2, 2020 (cvwd.org)

40. Coachella Valley Flood & Blowsand Management Report – Coachella Valley Association of Governments (CVAG), 2020 (kesq.b-cdn.net)

41. Western Coachella Valley Area Plan – County of Riverside General Plan, 2017 (planning.rctlma.org)

42. Lake Elsinore & San Jacinto Watersheds Authority (mywatersheds.com)

43. History – City of Menifee (cityofmenifee.us)

44. Industry Profiles – Riverside County Economic Development (rivcoed.org)

45. Climate Resiliency Vulnerability Assessment – Lake Elsinore General Plan Update, 2024 (lake-elsinore.org)

46. City of Lake Elsinore – Draft Safety Element (Public Review Draft), accessed November 2025 (cdnverify.bof.fire.ca.gov)

47. Sacramento Valley Subregion – Sacramento River Watershed Program, 2025 (sacriver.org)

48. Economic Development Strategic Plan – Sacramento County, 2025 (economic.saccounty.gov)

49. Natomas Basin – U.S. Army Corps of Engineers, Sacramento District, 2025 (www.spk.usace.army.mil/natomas/)

50. American River Common Features Project, Natomas Basin: Post-Authorization Change Report and Interim General Reevaluation Report – U.S. Army Corps of Engineers, Sacramento District, 2010

51. Proposed Responsible Development Program for the Natomas Basin during the Remaining Years of the Natomas Levee Improvement Project – City of Sacramento, 2015

52. Proposed Development Program for the Natomas Basin under A99 Flood Zone Designation – City of Sacramento, 2015

53. Ordinance No. 2008-034 (Interim ordinance on assumption of flood-risk for Natomas construction) – City of Sacramento, 2008

54. Article IV. ARP-F Zone—American River Parkway–Floodplain Zone – City of Sacramento, 2025

55. Merced Stormwater Resources Plan – Merced Integrated Regional Water Management Authority, 2019 (mercedirwmp.org)

56. Flood Waters in the San Joaquin Valley Threaten Homes and Residents' Incomes – NPR, March 2023 (npr.org)

57. History of the District – Merced Irrigation District, 2024 (mercedid.org)

58. Vision 2030 General Plan – City of Merced, 2012 (cityofmerced.gov)

59. Merced, California – Code of Ordinances, Title 17, Chapter 17.48 – Flood Damage Prevention – City of Merced, 2025 (library.municode.com)

60. Local Hazard Mitigation Plan – City of Merced, 2015 (cityofmerced.gov)

61. Final Environmental Impact Report, Black Rascal Creek Flood Control Project – Merced County, 2017 (web2.co.merced.ca.us)

62. Black Rascal Creek Watershed Plan and Environmental Assessment Black Rascal Creek Watershed, California – Merced County, 2023 (web2.co.merced.ca.us)

63. Merced County Hazard Mitigation Plan, City of Merced – Merced County, 2021 (web2.co.merced.ca.us)

64. Santa Clara Stormwater Resource Plan – Santa Clara Valley Urban Runoff Pollution Prevention Program, 2018 (scvurppp.org)

65. Watersheds of Santa Clara Valley – Valley Water, 2025 (valleywater.org)

66. Local waterbodies – County of Santa Clara Watershed Protection Division, 2025 (watershed.santaclaracounty.gov)

67. Flood Management – City of Gilroy, 2025 (cityofgilroy.org)

68. A Brief History of Gilroy – City of Gilroy, 2025 (cityofgilroy.org)

69. South Santa Clara County Valley Historical Ecology Study: Land Use History – San Francisco Estuary Institute, 2008 (sfei.org)

70. Safe Clean Water and Natural Flood Protection Program, Priority E – Valley Water, 2025 (valleywater.org)

71. Floodplain Management Ordinance – City of Gilroy, September, 1998 (cityofgilroy.org)

72. Chapter 27E, Floodplain Management Ordinance – City of Gilroy, 2017 (cityofgilroy.org)

73. Gilroy General Plan Chapter Two – City of Gilroy, 2002 (cityofgilroy.org)

74. 2040 General Plan: Chapter 9 – Potential Hazards – City of Gilroy, November 2020 (cityofgilroy.org)

75. Expanding Nature-based solutions Initiative – California Natural Resources Agency, 2023 (resources.ca.gov)

76. Natural Climate Solutions Roadmap – Science for Conservation, 2023 (scienceforconservation.org)

77. Nature-Based Climate Solutions in California – U.S. Nature4Climate, 2023 (usnature4climate.org)

78. Restoring California's Depleted Groundwater – River Partners, 2024 (riverpartners.org)

79. Climate Solutions in California – The Nature Conservancy, 2023 (nature.org)

80. Nature-based solutions Toolkit – Nature-based solutions Community, 2023 (nrcsolutions.org)

81. Nature-Based Climate Solutions – The Nature Conservancy, 2020 (storymaps.arcgis.com)

82. 30x30 California – California Natural Resources Agency, 2023 (californianature.ca.gov)

83. California's Nature-based solutions Climate Targets – California Natural Resources Agency, 2024 (resources.ca.gov)

84. Executive Order N-82-20 – Executive Department State of California, 2020 (gov.ca.gov)

85. How local governments avoid floodplain development through consistent implementation of routine municipal ordinances, plans, and programs – A R Siders, Jennifer Niemann-Morris, Miyuki Hino, Elizabeth Shields, Lidia Cano Pecharroman, Tess Doeffinger, Logan Gerber-Chavez, Ju-Ching Huang, Alexandra Lafferty, Salvesila Tamima, Caroline Williams, Armen Agopian, Christopher Samoray, Katharine J Mach, 2024 (academic.oup.com)

86. Building Community Resilience with Nature-based solutions – FEMA, 2020 (fema.gov)

87. Expanding the Role of Nature-based solutions in FEMA's Hazard Mitigation Assistance Programs, 2021 (scienceforconservation.org)

88. Restoring rivers and floodplains for habitat and flood risk reduction: Experiences in multi-benefit floodplain management from California and Germany – Serra-Llobet A, Jähnig SC, Geist J, Kondolf GM, Damm C, Scholz M, Lund J, Opperman JJ, Yarnell SM, Pawley A, Shader E, Cain J, Zingraff-Hamed A, Grantham TE, Eisenstein W and Schmitt R, 2022 (frontiersin.org)

89. Model Floodplain Bylaw and Floodplain Management Guidance – Massachusetts Department of Conservation and Recreation & Metropolitan Area Planning, 2020 (mass.gov)

90. New Jersey Interagency Council on Climate Resilience 2024 Annual Report – New Jersey Department of Environmental Protection, 2025 (dep.nj.gov)

91. Floodplain Management, Growth Management, and Critical Areas Protections in Washington State – Washington State Department of Commerce, 2023 (commerce.wa.gov)

92. Shoreline Management Act – Department of Ecology State of Washington, 1972 (ecology.wa.gov)

93. Floodplains by Design – Department of Ecology State of Washington, 2013 (ecology.wa.gov)

94. A Nationwide Analysis of Community-Level Floodplain Development Outcomes and Key Influences – Agopian, A., Hino, M., Siders, A. R., Samoray, C., & Mach, K. J., 2024 (agupubs.onlinelibrary.wiley.com)

95. The Safe Development Paradox of the United States Regulatory Floodplain – Sanchez, G. M., Lawrimore, M. A., Petrasova, A., Vogler, J. B., Collins, E. L., & Meentemeyer, R. K., 2024 (journals.plos.org)

96. Understanding FEMA Flood Maps and Limitations – First Street, 2019 (firststreet.org)

97. Best Available Maps, California Department of Water Resources (gis.bam.water.ca.gov/bam)

98. DWR Advances Groundbreaking Climate-Resilient Flood Mapping Through FEMA Partnership – California Department of Water Resources, 2025 (water.ca.gov)

AECOM

The Nature Conservancy

Appendix A

Custom GPT Knowledge Base

Custom GPT Knowledge Base

Agopian, A., M. Hino, A. R. Siders, C. Samoray, and K. J. Mach. 2024. “A Nationwide Analysis of Community-Level Floodplain Development Outcomes and Key Influences.” Earth’s Future, 12.

Chamberlin, S. J., M. Passero, A. Conrad-Saydah, T. Biswas, C. K. Stanley, et al. 2023. Nature-Based Climate Solutions: A Roadmap to Accelerate Action in California. The Nature Conservancy, Sacramento, CA.

NJ Interagency Council on Climate Resilience. 2025. 2024 Annual Report. New Jersey Department of Environmental Protection, Trenton, NJ.

iParametrics. 2021. Washington Mapping the Impact Report: Climate Disaster Declarations, Funding, and Social Vulnerability. Prepared for American Society of Civil Engineers (ASCE).

San Joaquin River Flood Control Project Agency. 2023. Climate Resilience Perspectives in the Upper San Joaquin River Region: Regional Flood Management Planning White Paper. Draft, April 2023.

Sanchez, G. M., M. A. Lawrimore, A. Petrasova, J. B. Vogler, E. L. Collins, V. Petras, T. Harper, E. J. Butzler, and R. K. Meentemeyer. 2024. “The Safe Development Paradox of the United States Regulatory Floodplain.” PLOS ONE, 19(12): e0311718.

Serra-Llobet, A., S. C. Jähnig, J. Geist, G. M. Kondolf, C. Damm, M. Scholz, J. Lund, J. J. Opperman, S. M. Yarnell, A. Pawley, E. Shader, J. Cain, A. Zingraff-Hamed, T. E. Grantham, W. Eisenstein, and R. Schmitt. 2022. Restoring Rivers and Floodplains for Habitat and Flood Risk Reduction: Experiences in Multi-Benefit Floodplain Management from California and Germany. Frontiers in Environmental Science, 9(778568).

Shi, L., A. Fisher, R. M. Brenner, A. Greiner-Safi, C. Shepard, and J. Vanucchi. 2022. “Equitable Buyouts? Learning from State, County, and Local Floodplain Management Programs.” Climatic Change, 174: 29.

Siders, A. R., J. Niemann-Morris, M. Hino, E. Shields, L. Cano Pecharroman, T. Doeffinger, L. Gerber-Chavez, J.-C. Huang, A. Lafferty, S. Tamima, C. Williams, A. Agopian, C. Samoray, and K. J. Mach. 2024. “How Local Governments Avoid Floodplain Development through Consistent Implementation of Routine Municipal Ordinances, Plans, and Programs.” Oxford Open Infrastructure and Environment, Paper OP-OXFL240018.

The Nature Conservancy (TNC). 2018. Valuing the Flood Reduction Benefits of Marsh Restoration in the San Francisco Bay. The Nature Conservancy and Coastal Resilience Lab, UC Santa Cruz.

The Nature Conservancy (TNC). 2022. Expanding the Role of Nature-Based Solutions in FEMA’s Hazard Mitigation Assistance Programs: Lessons and Recommendations. The Nature Conservancy, Arlington, VA.

US Water Alliance. 2020. Water Rising: Equitable Approaches to Urban Flooding. US Water Alliance, Washington, DC.

White House Council on Environmental Quality (CEQ) and Office of Science and Technology Policy (OSTP). 2023. Nature-Based Solutions Resource Guide 2.0. Executive Office of the President, Washington, DC.

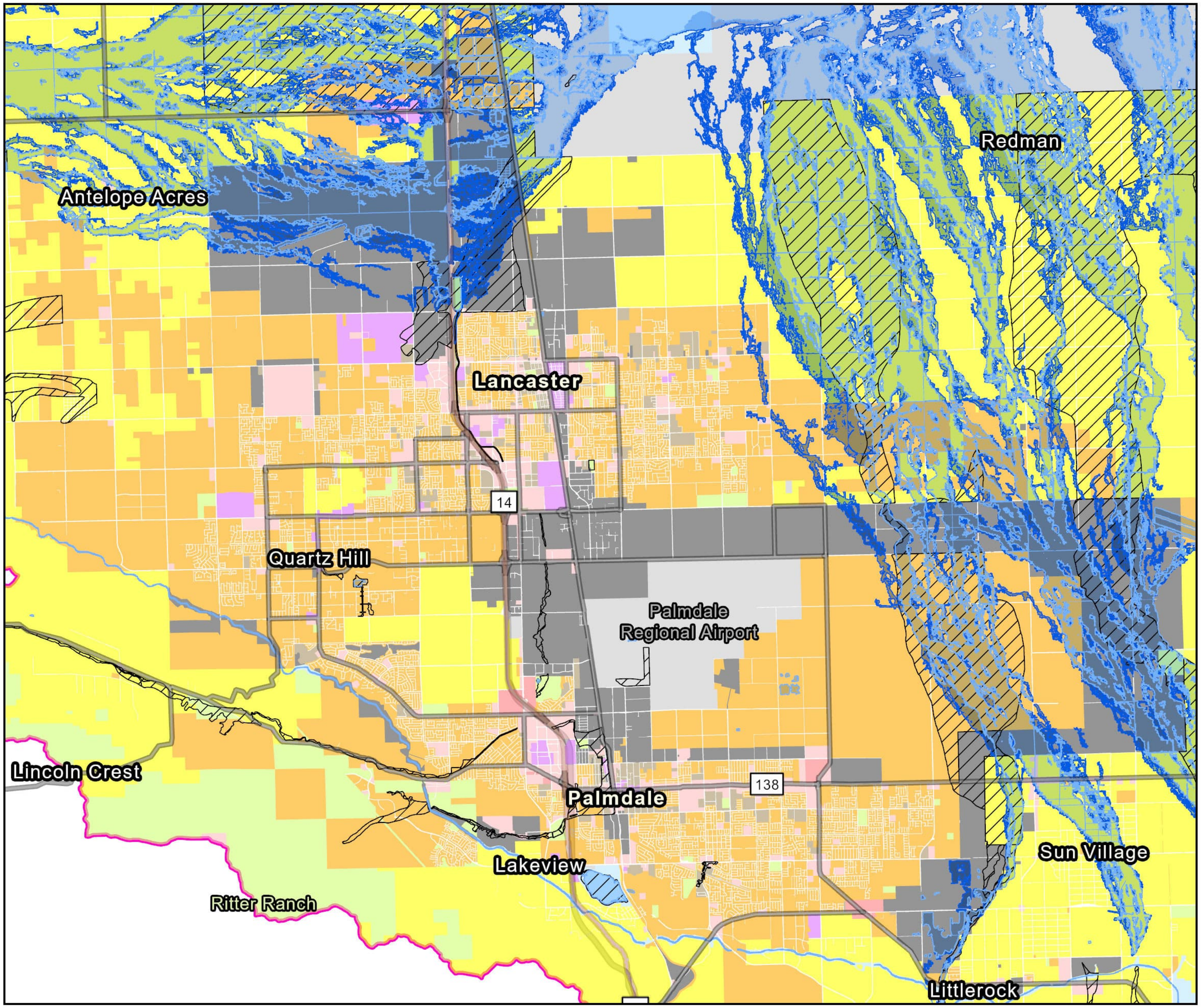
Appendix B

Detailed Development Trends Analysis Maps

AECOM

Antelope Valley Subbasin
(Los Angeles County)

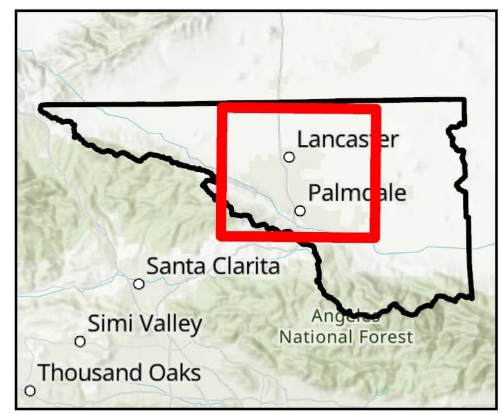
General Plan Land Use - Antelope Valley Watershed in LA County



- FEMA Flood Zones (100 year) - LA County
- Fathom 100yr - LA County
- Fathom 500yr - LA County
- Antelope Valley Watershed
- LA County
- Roads

General Plan Land Use

- 8+ Dwelling Units/Acre
- 0.5 to 7 Dwelling Units/Acre
- 2 to 20 Acres/Dwelling Unit
- 20+ Acres/Dwelling Unit
- High density commercial
- Low density commercial
- Mixed use of residential and commercial
- Industrial
- Agricultural
- Open space and public lands
- Urban reserve
- Planned development
- Water
- Other - Not Determined



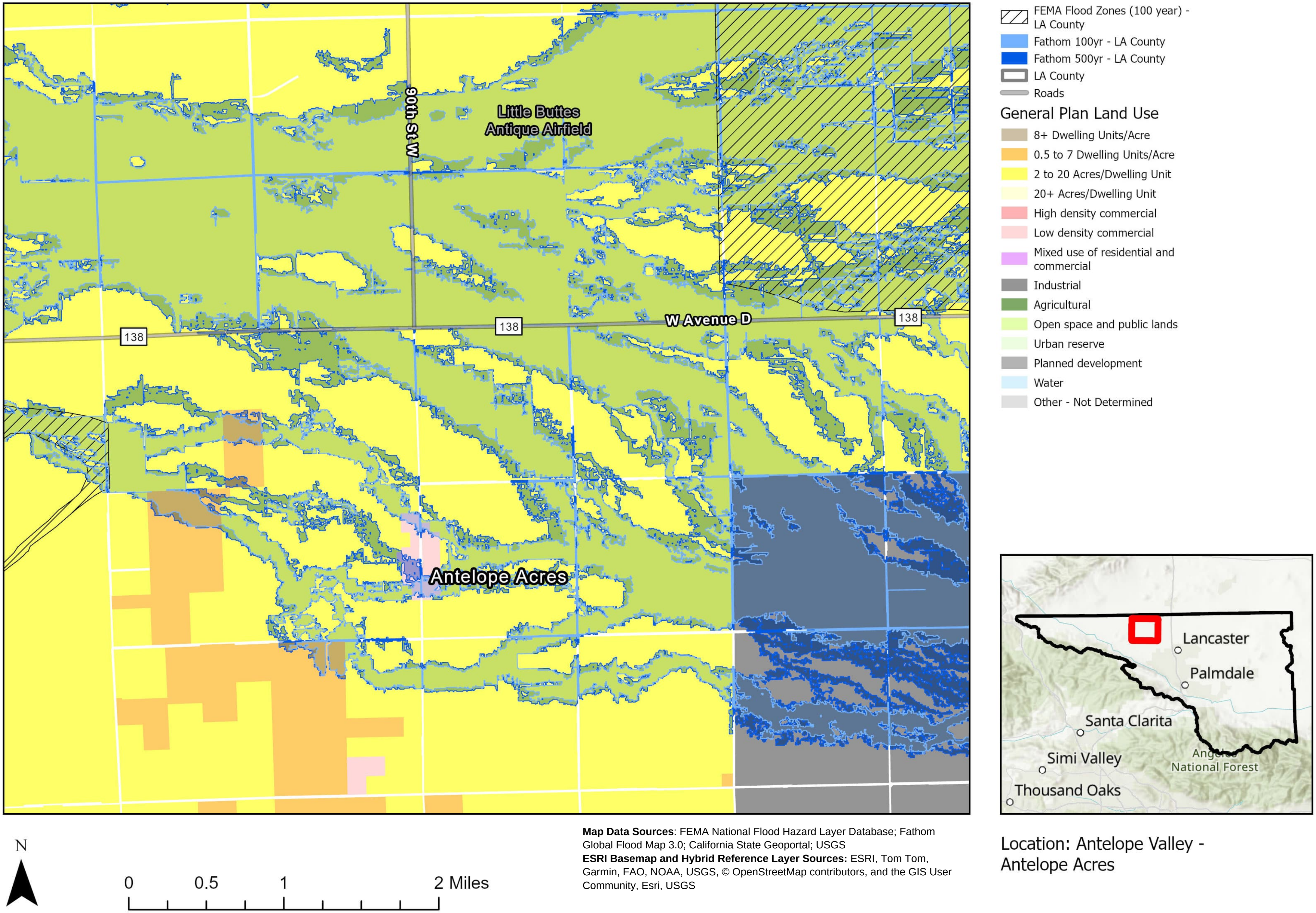
N

0 2 4 8 Miles

Map Data Sources: FEMA National Flood Hazard Layer Database; Fathom Global Flood Map 3.0; California State Geoportal; USGS
ESRI Basemap and Hybrid Reference Layer Sources: ESRI, Tom Tom, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community, Esri, USGS

Location: Antelope Valley - Greater Palmdale and Lancaster

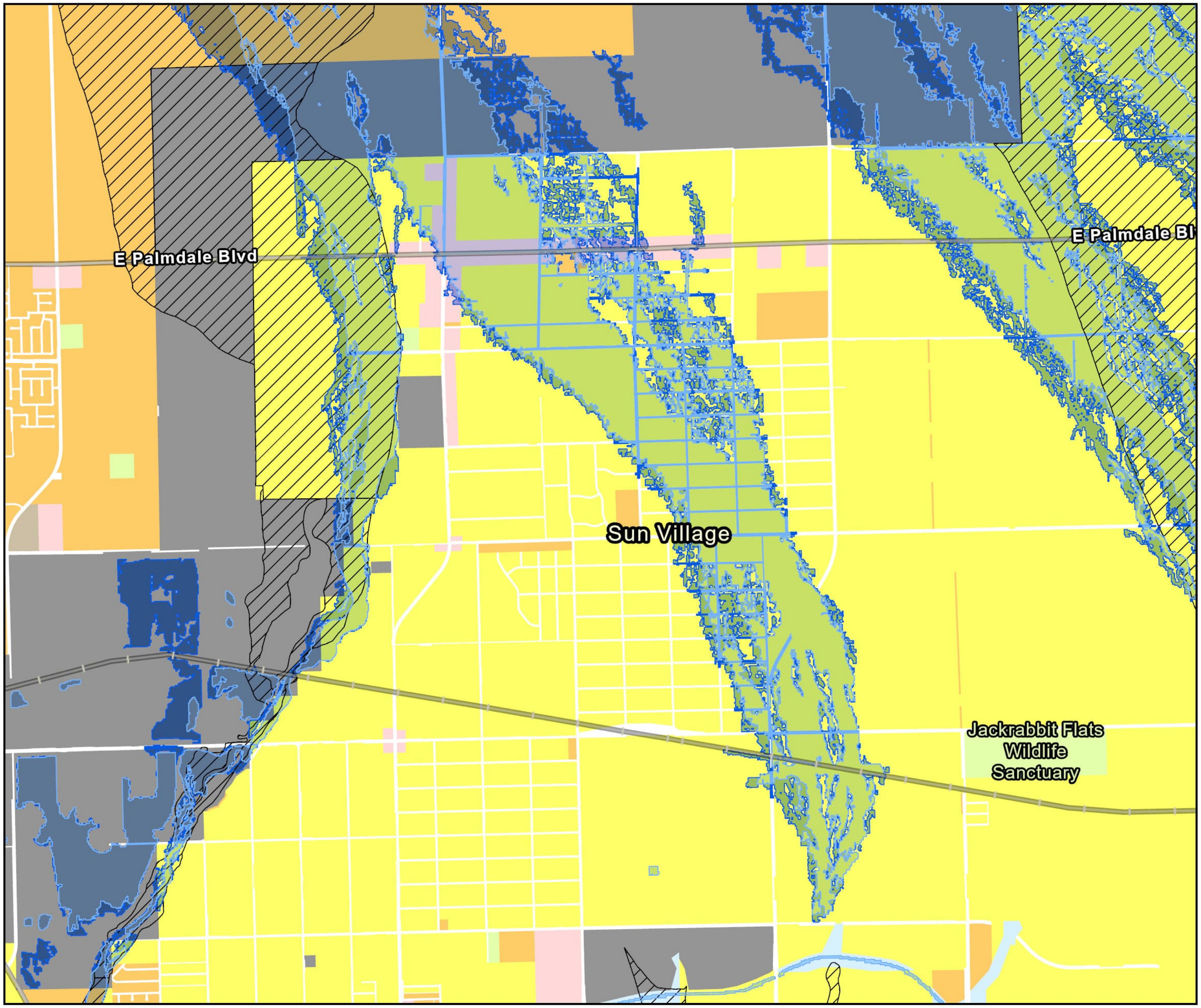
General Plan Land Use - Antelope Valley Watershed in LA County



Map Data Sources: FEMA National Flood Hazard Layer Database; Fathom Global Flood Map 3.0; California State Geoportal; USGS
ESRI Basemap and Hybrid Reference Layer Sources: ESRI, Tom Tom, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community, Esri, USGS

Location: Antelope Valley - Antelope Acres

General Plan Land Use - Antelope Valley Watershed in LA County



FEMA Flood Zones (100 year) - LA County
Fathom 100yr - LA County
Fathom 500yr - LA County
LA County
Roads

General Plan Land Use
8+ Dwelling Units/Acre
0.5 to 7 Dwelling Units/Acre
2 to 20 Acres/Dwelling Unit
20+ Acres/Dwelling Unit
High density commercial
Low density commercial
Mixed use of residential and commercial
Industrial
Agricultural
Open space and public lands
Urban reserve
Planned development
Water
Other - Not Determined

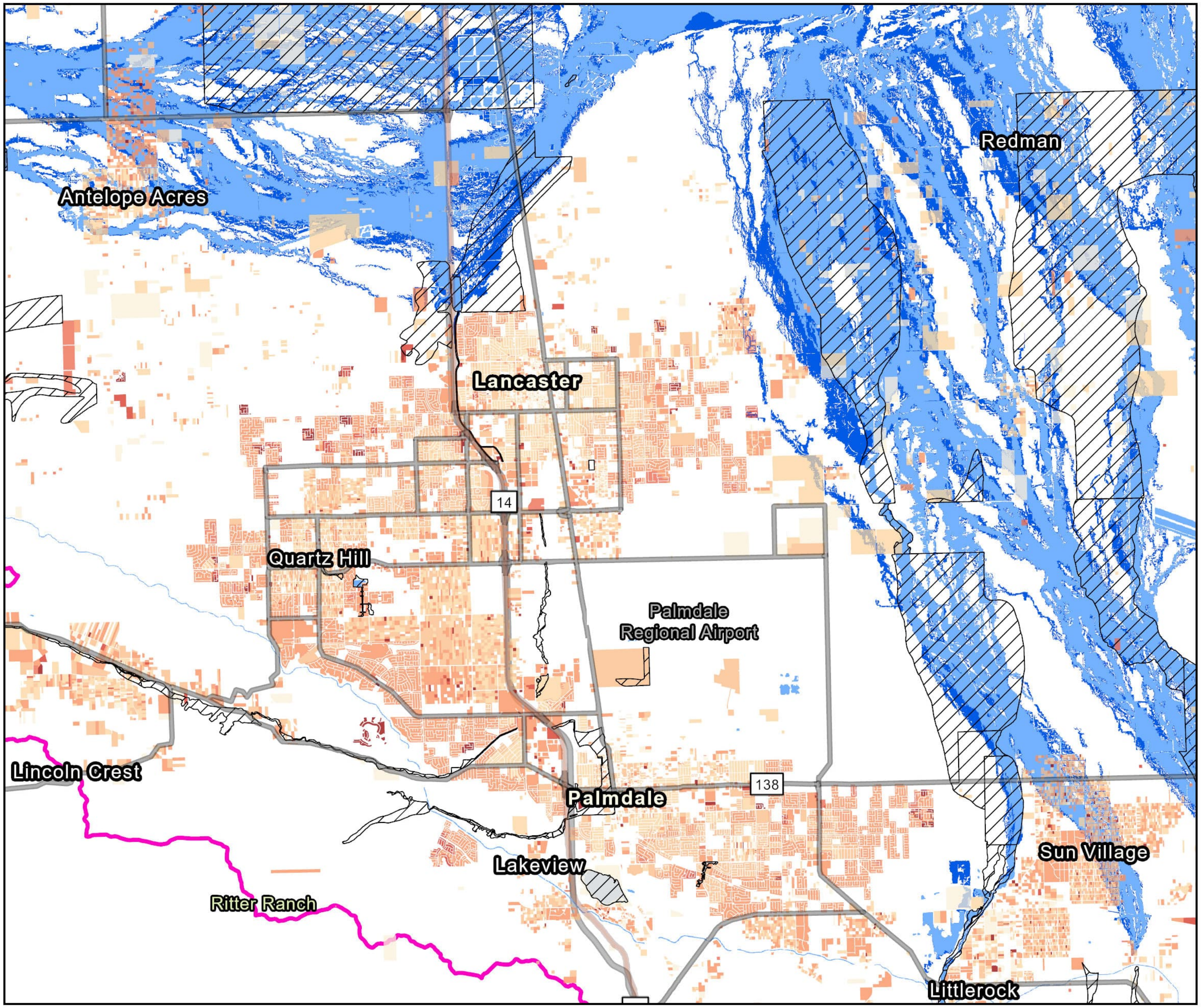
Location: Antelope Valley - Sun Village

N

0 0.5 1 2 Miles

Map Data Sources: FEMA National Flood Hazard Layer Database; Fathom Global Flood Map 3.0; California State Geoportal; USGS
ESRI Basemap and Hybrid Reference Layer Sources: ESRI, Tom Tom, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community, Esri, USGS

LA County Parcels Within Antelope Valley Watershed

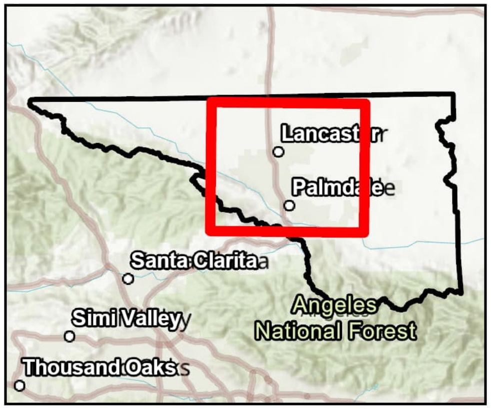


FEMA Flood Zones (100 year) - LA County
Fathom 100yr - LA County
Fathom 500yr - LA County
Antelope Valley Watershed
LA County
Roads

LA County Parcels

Year Built

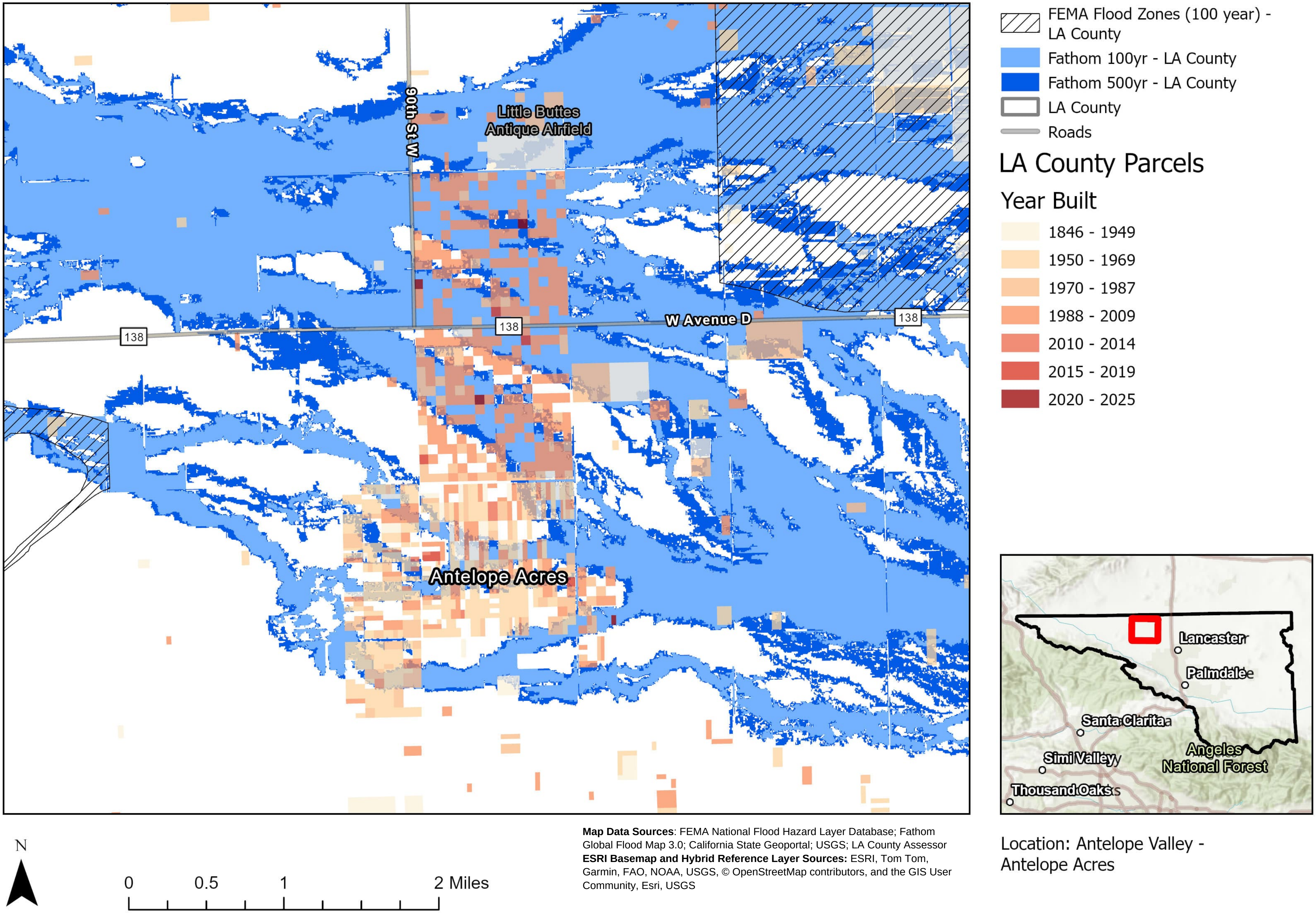
1846 - 1949
1950 - 1969
1970 - 1987
1988 - 2009
2010 - 2014
2015 - 2019
2020 - 2025



Location: Antelope Valley - Greater Palmdale and Lancaster

Map Data Sources: FEMA National Flood Hazard Layer Database; Fathom Global Flood Map 3.0; California State Geoportal; USGS; LA County Assessor
ESRI Basemap and Hybrid Reference Layer Sources: ESRI, Tom Tom, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community, Esri, USGS

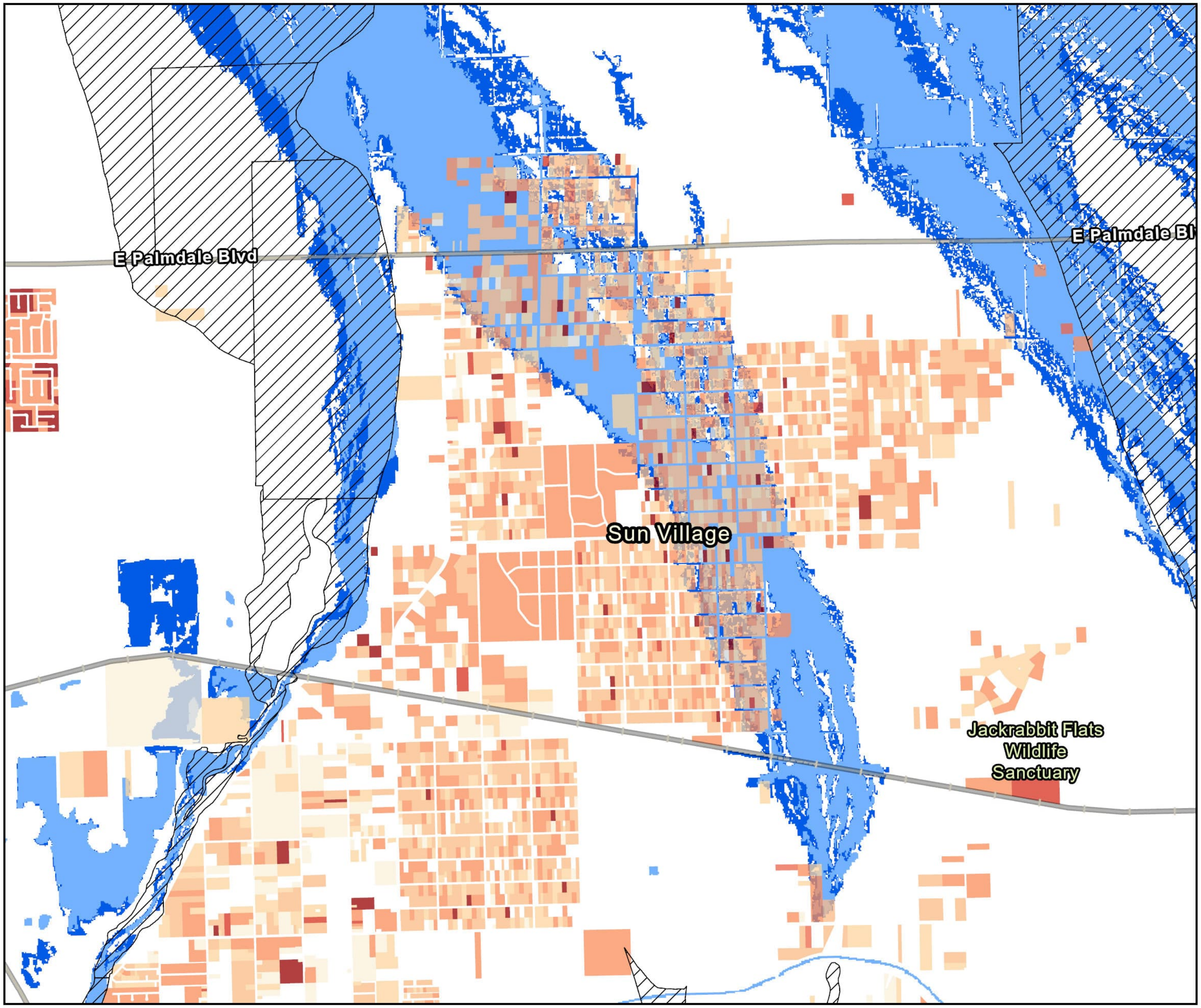
LA County Parcels Within Antelope Valley Watershed



Map Data Sources: FEMA National Flood Hazard Layer Database; Fathom Global Flood Map 3.0; California State Geoportal; USGS; LA County Assessor
ESRI Basemap and Hybrid Reference Layer Sources: ESRI, Tom Tom, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community, Esri, USGS

Location: Antelope Valley - Antelope Acres

LA County Parcels Within Antelope Valley Watershed

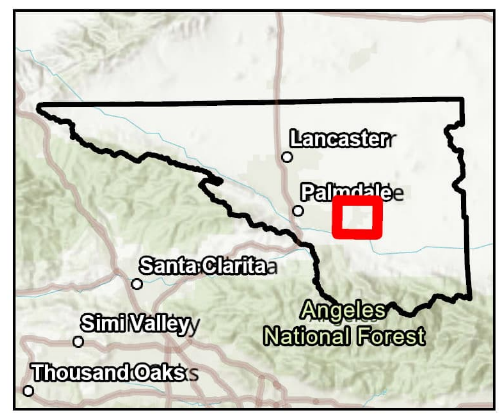


FEMA Flood Zones (100 year) - LA County
Fathom 100yr - LA County
Fathom 500yr - LA County
LA County
Roads

LA County Parcels

Year Built

1846 - 1949
1950 - 1969
1970 - 1987
1988 - 2009
2010 - 2014
2015 - 2019
2020 - 2025



N

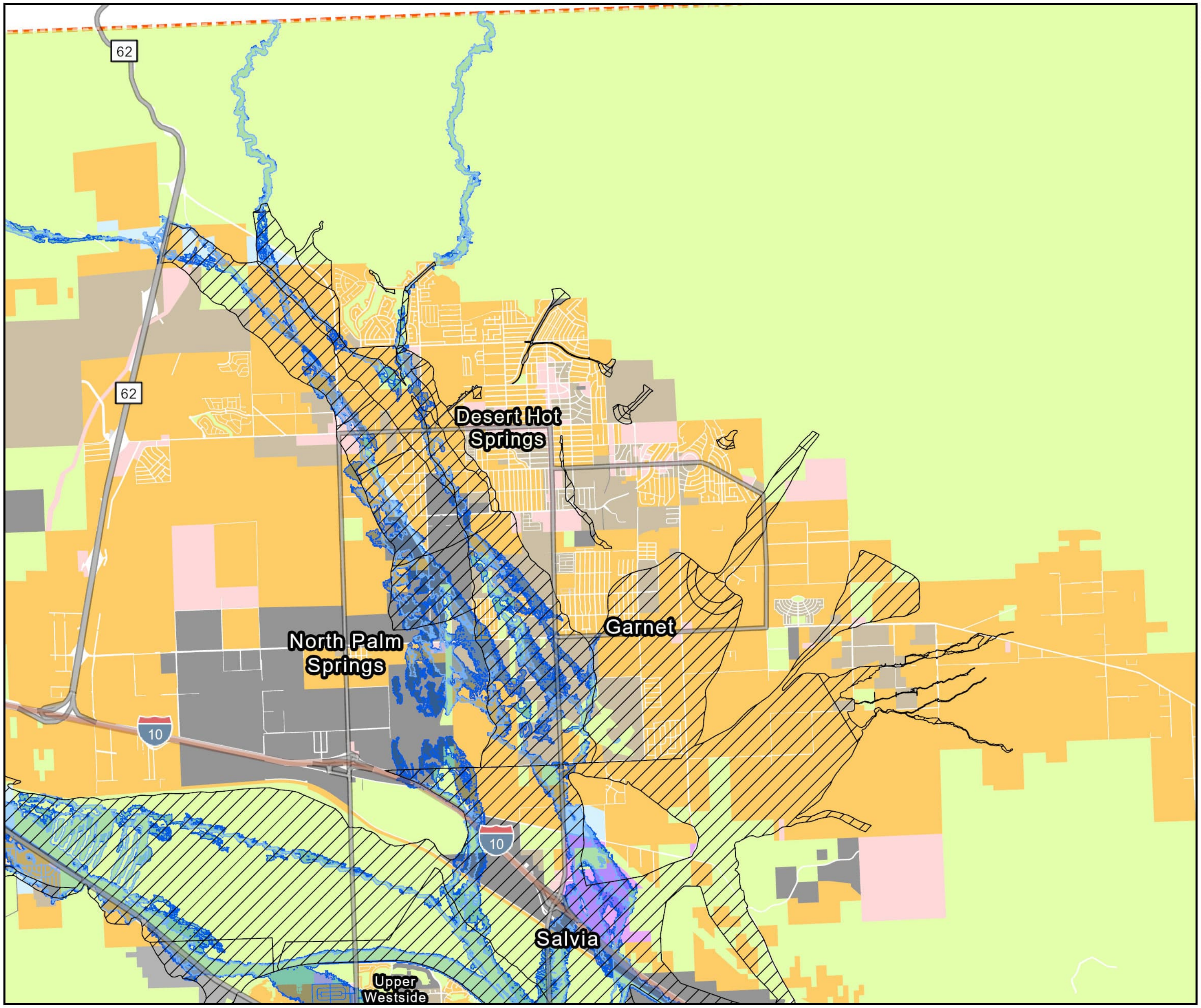
0 0.5 1 2 Miles

Map Data Sources: FEMA National Flood Hazard Layer Database; Fathom Global Flood Map 3.0; California State Geoportal; USGS; LA County Assessor
ESRI Basemap and Hybrid Reference Layer Sources: ESRI, Tom Tom, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community, Esri, USGS

Location: Antelope Valley - Sun Village

Whitewater River Subbasin
(Riverside County)

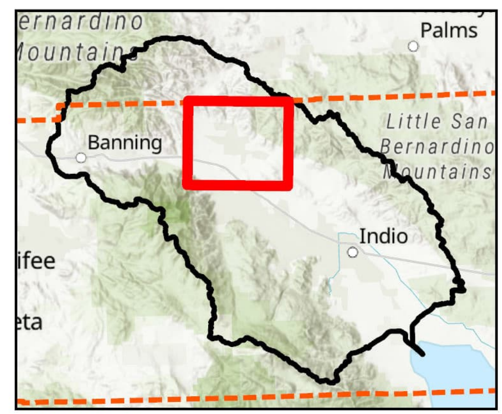
General Plan Land Use - Whitewater River Watershed in Riverside County

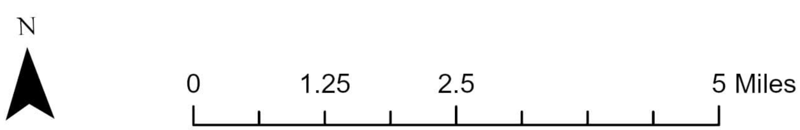


FEMA Flood Zones (100 year) - Riverside County
Fathom 100yr - Riverside County
Fathom 500yr - Riverside County
Riverside County
Major Highways

General Plan Land Use

8+ Dwelling Units/Acre
0.5 to 7 Dwelling Units/Acre
2 to 20 Acres/Dwelling Unit
20+ Acres/Dwelling Unit
High density commercial
Low density commercial
Mixed use of residential and commercial
Industrial
Agricultural
Open space and public lands
Urban reserve
Planned development
Water
Other - Not Determined

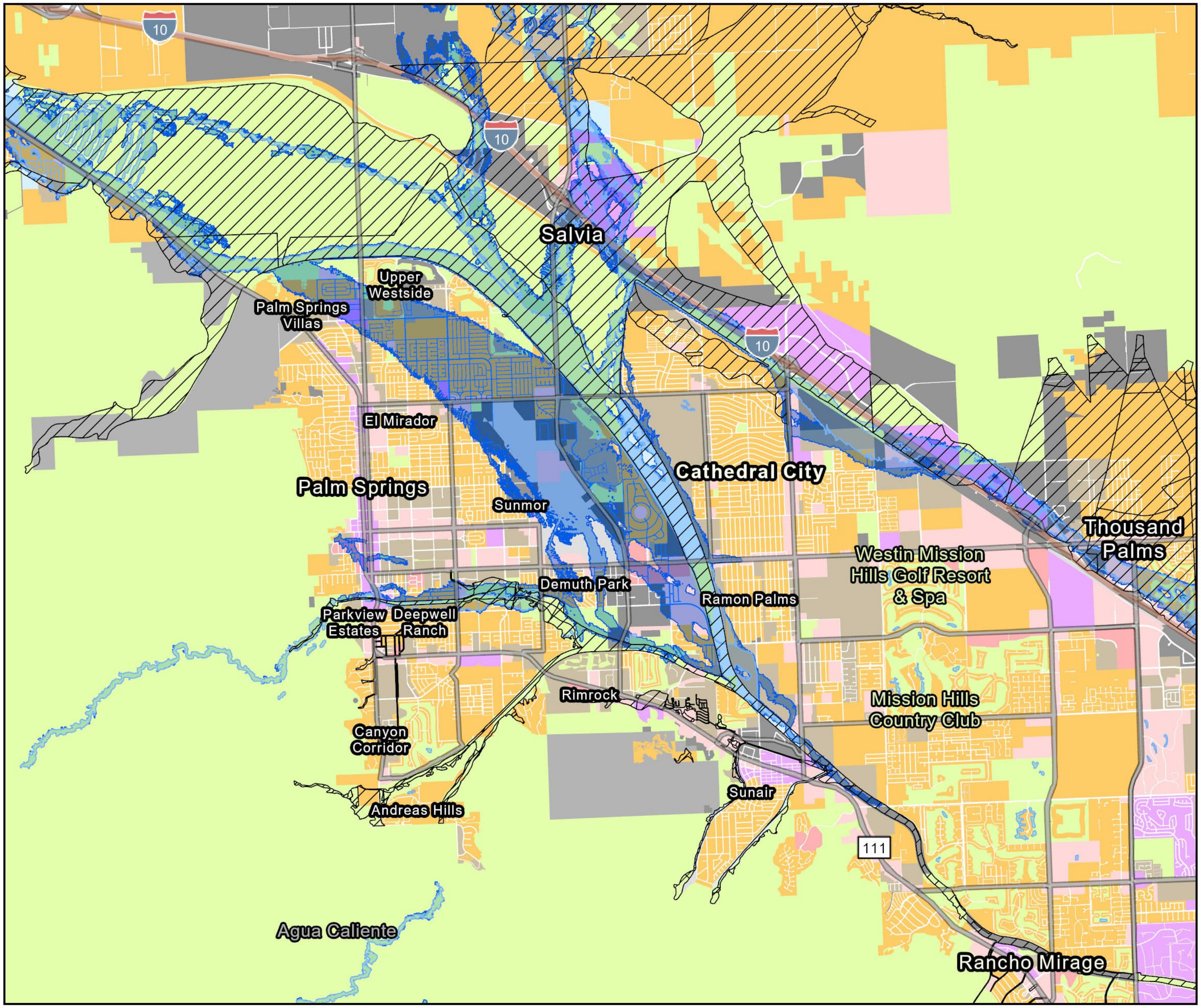




Map Data Sources: FEMA National Flood Hazard Layer Database; Fathom Global Flood Map 3.0; California State Geoportal; USGS
ESRI Basemap and Hybrid Reference Layer Sources: ESRI, Tom Tom, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community, Esri, USGS

Location: Riverside County - Whitewater River Watershed - Desert Hot Springs

General Plan Land Use - Whitewater River Watershed in Riverside County



- FEMA Flood Zones (100 year) - Riverside County
- Fathom 100yr - Riverside County
- Fathom 500yr - Riverside County
- Riverside County
- Major Highways

General Plan Land Use

- 8+ Dwelling Units/Acre
- 0.5 to 7 Dwelling Units/Acre
- 2 to 20 Acres/Dwelling Unit
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- High density commercial
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- Industrial
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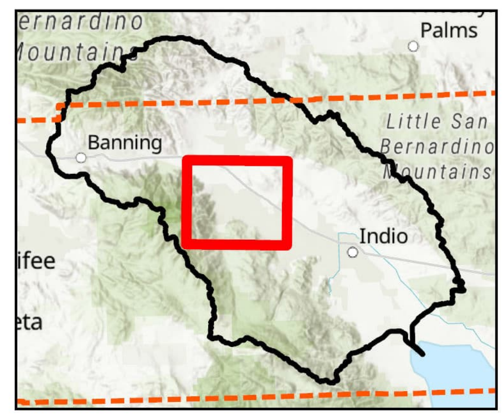


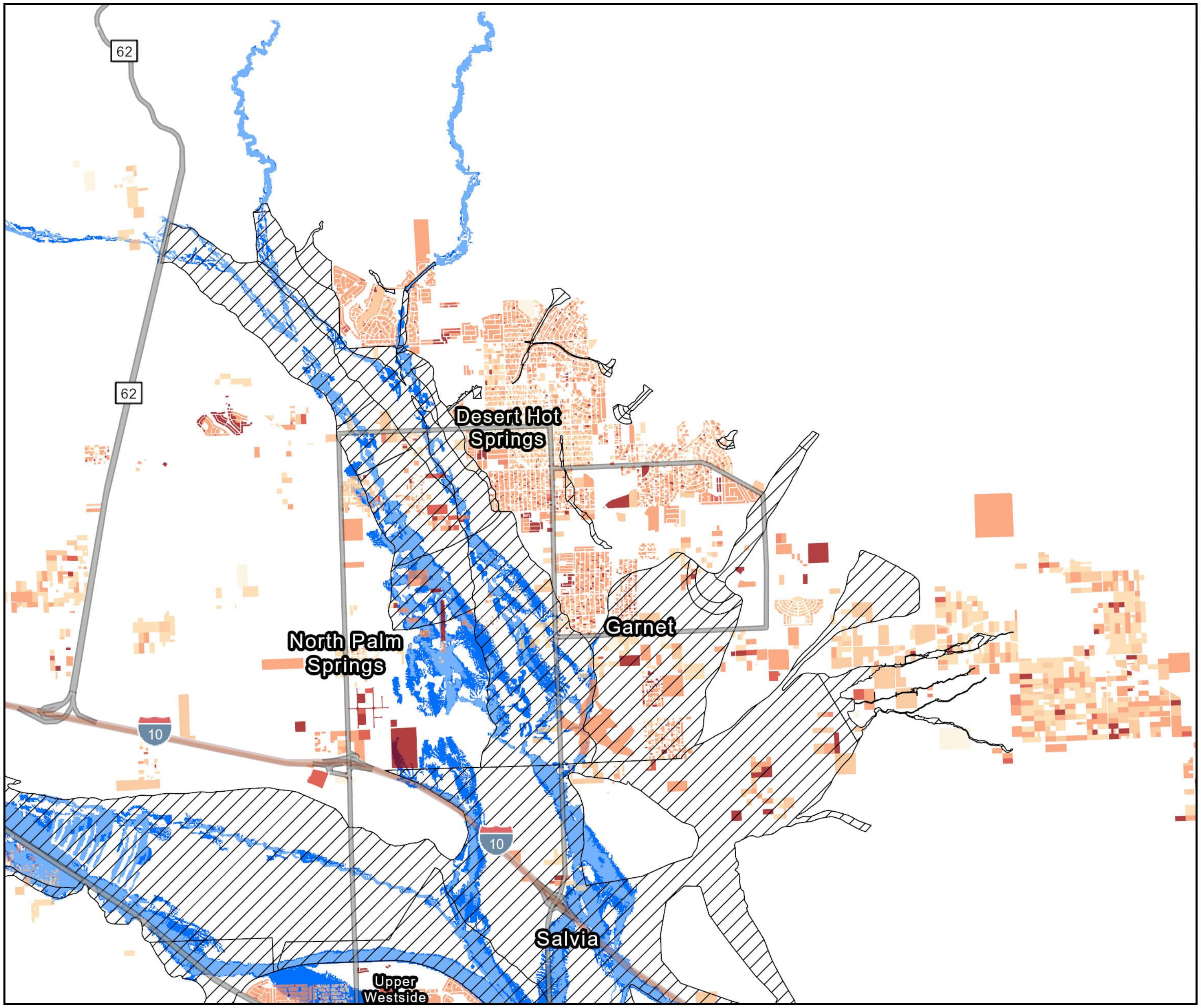
N

0 1.25 2.5 5 Miles

Map Data Sources: FEMA National Flood Hazard Layer Database; Fathom Global Flood Map 3.0; California State Geoportal; USGS
ESRI Basemap and Hybrid Reference Layer Sources: ESRI, Tom Tom, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community, Esri, USGS

Location: Riverside County - Whitewater River Watershed - Palm Springs

Parcels Within Whitewater River Watershed in Riverside County

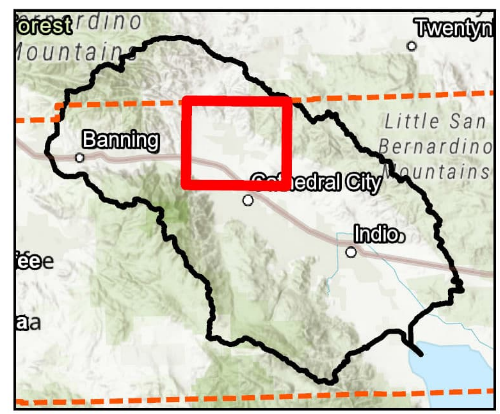


FEMA Flood Zones (100 year) - Riverside County
Fathom 100yr - Riverside County
Fathom 500yr - Riverside County
Major Highways

Riverside County Parcels

Year Built

- 1846 - 1949
- 1950 - 1969
- 1970 - 1987
- 1988 - 2009
- 2010 - 2014
- 2015 - 2019
- 2020 - 2025



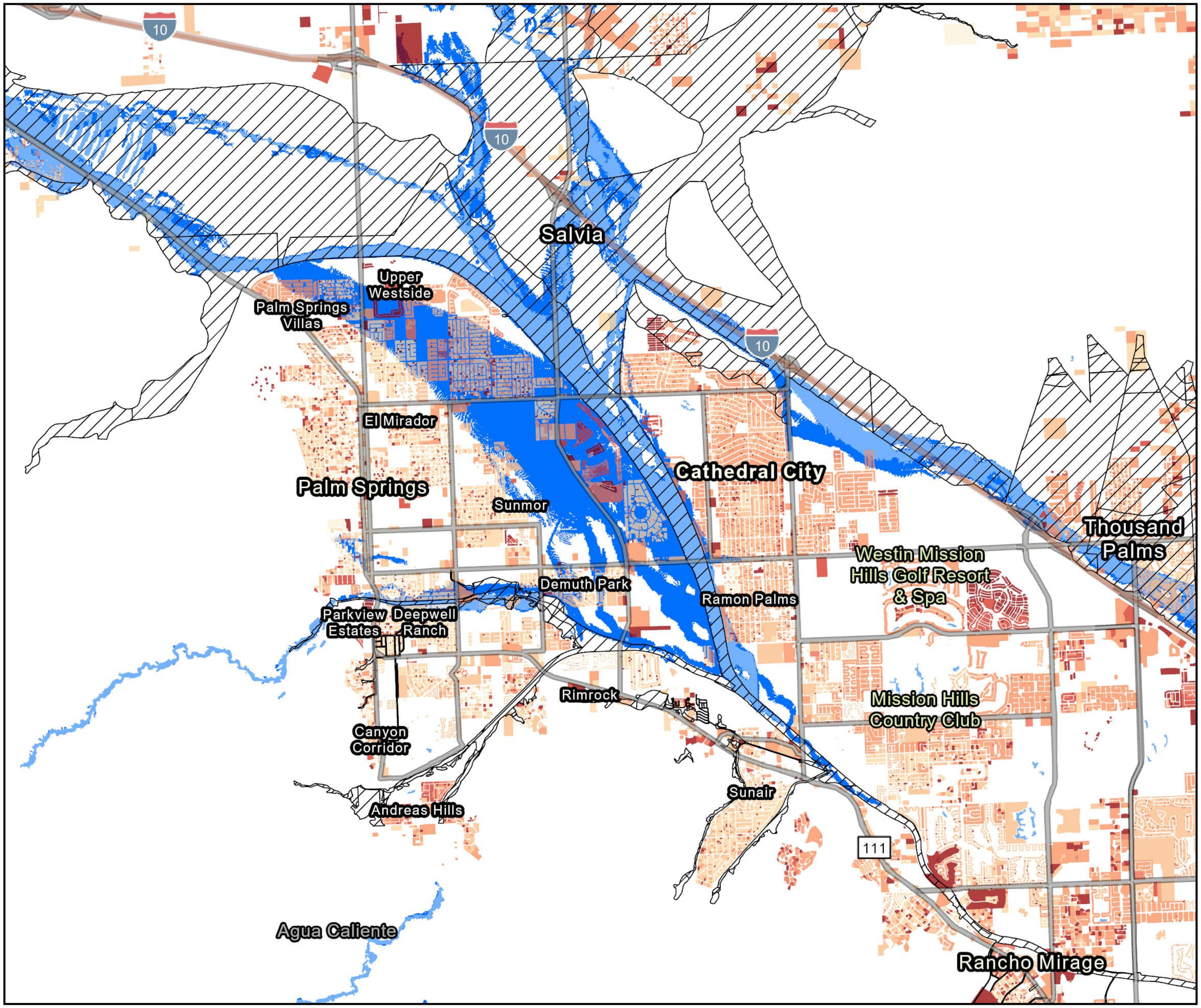
N

0 1.25 2.5 5 Miles

Map Data Sources: FEMA National Flood Hazard Layer Database; Fathom Global Flood Map 3.0; California State Geoportal; USGS; Riverside County Assessor
ESRI Basemap and Hybrid Reference Layer Sources: ESRI, Tom Tom, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community, Esri, USGS

Location: Riverside County - Whitewater River Watershed - Desert Hot Springs

Parcels Within Whitewater River Watershed in Riverside County

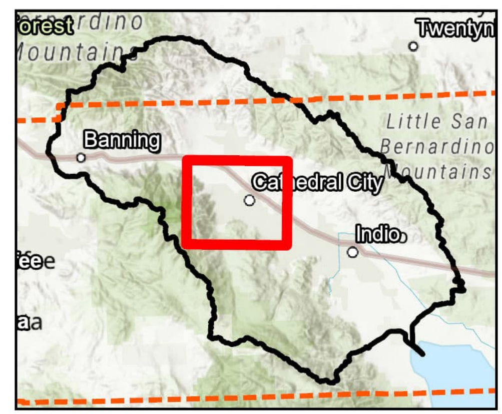


FEMA Flood Zones (100 year) - Riverside County
Fathom 100yr - Riverside County
Fathom 500yr - Riverside County
Major Highways

Riverside County Parcels

Year Built

- 1846 - 1949
- 1950 - 1969
- 1970 - 1987
- 1988 - 2009
- 2010 - 2014
- 2015 - 2019
- 2020 - 2025



N

0 1.25 2.5 5 Miles

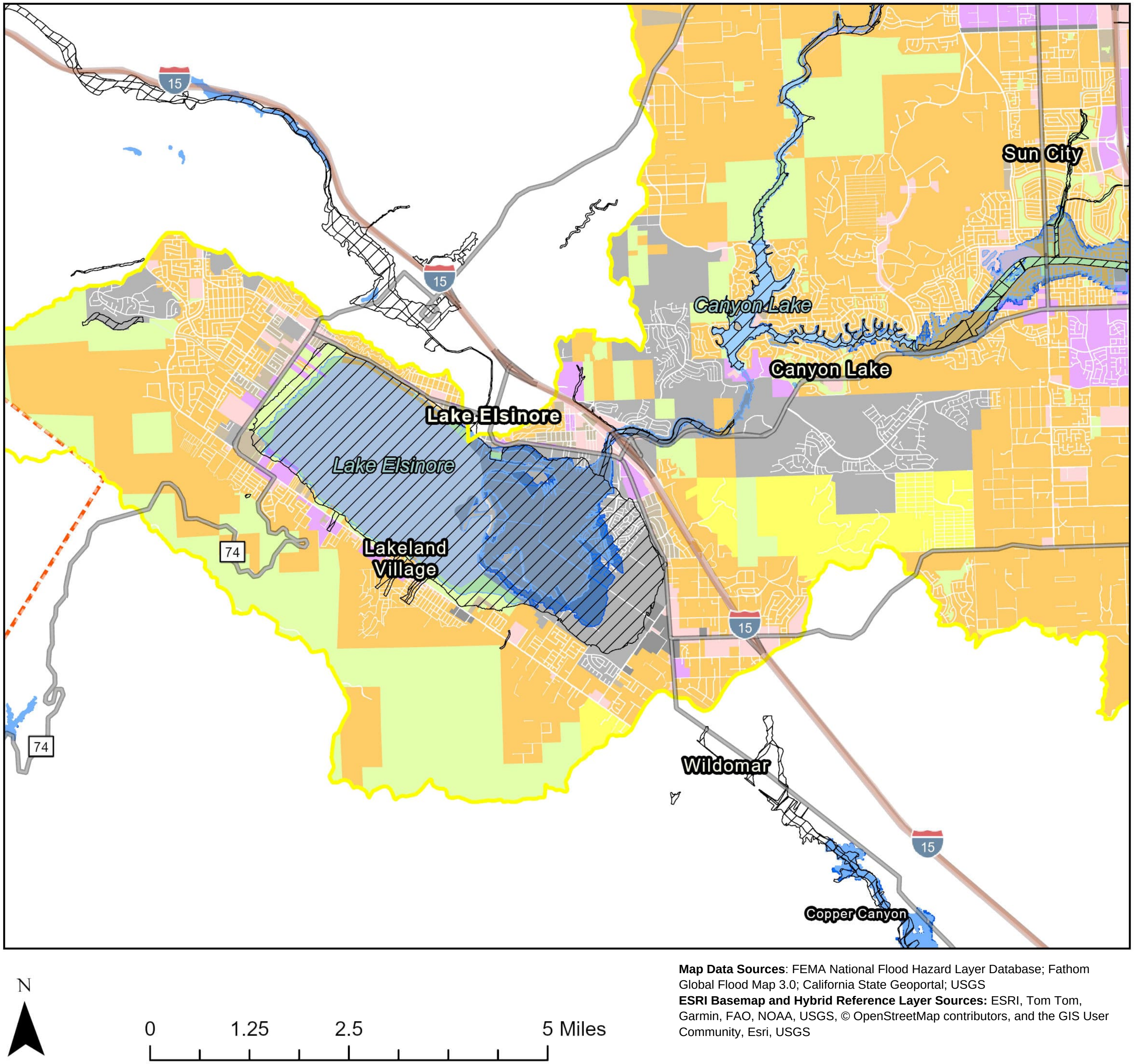
Map Data Sources: FEMA National Flood Hazard Layer Database; Fathom Global Flood Map 3.0; California State Geoportal; USGS; Riverside County Assessor
ESRI Basemap and Hybrid Reference Layer Sources: ESRI, Tom Tom, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community, Esri, USGS

Location: Riverside County - Whitewater River Watershed - Palm Springs

AECOM

San Jacinto Subbasin
(Riverside County)

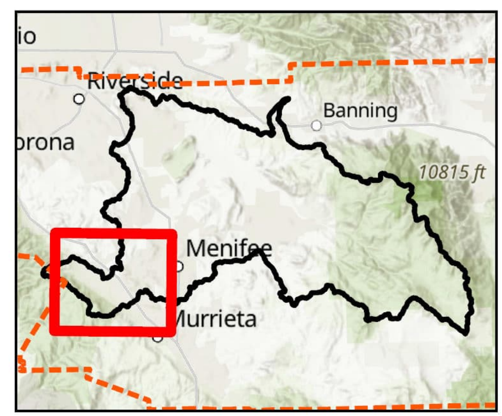
General Plan Land Use - San Jacinto Watershed in Riverside County



FEMA Flood Zones (100 year) - Riverside County
Fathom 100yr - Riverside County
Fathom 500yr - Riverside County
San Jacinto Watershed
Riverside County
Major Highways

General Plan Land Use

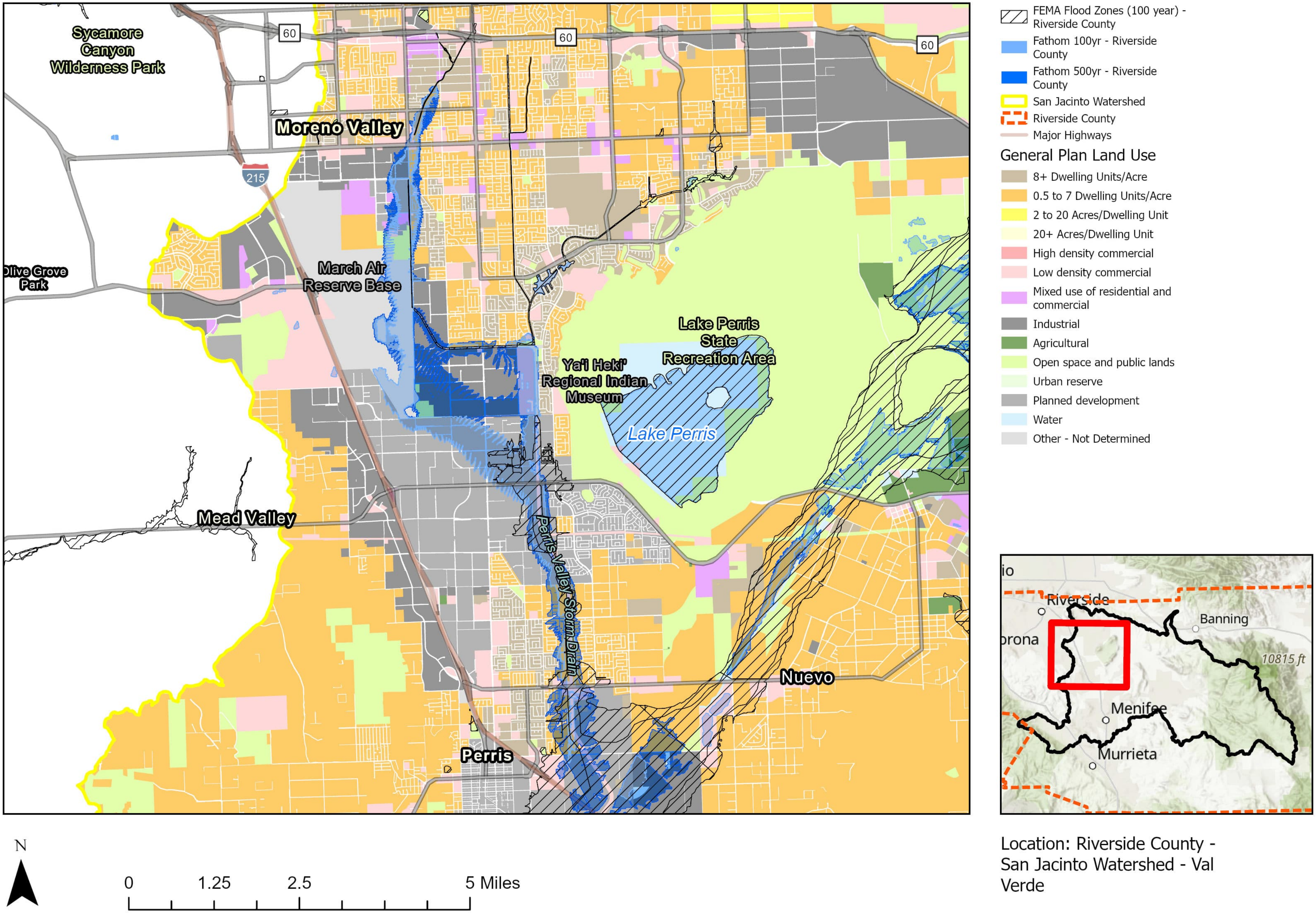
8+ Dwelling Units/Acre
0.5 to 7 Dwelling Units/Acre
2 to 20 Acres/Dwelling Unit
20+ Acres/Dwelling Unit
High density commercial
Low density commercial
Mixed use of residential and commercial
Industrial
Agricultural
Open space and public lands
Urban reserve
Planned development
Water
Other - Not Determined



Map Data Sources: FEMA National Flood Hazard Layer Database; Fathom Global Flood Map 3.0; California State Geoportal; USGS
ESRI Basemap and Hybrid Reference Layer Sources: ESRI, Tom Tom, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community, Esri, USGS

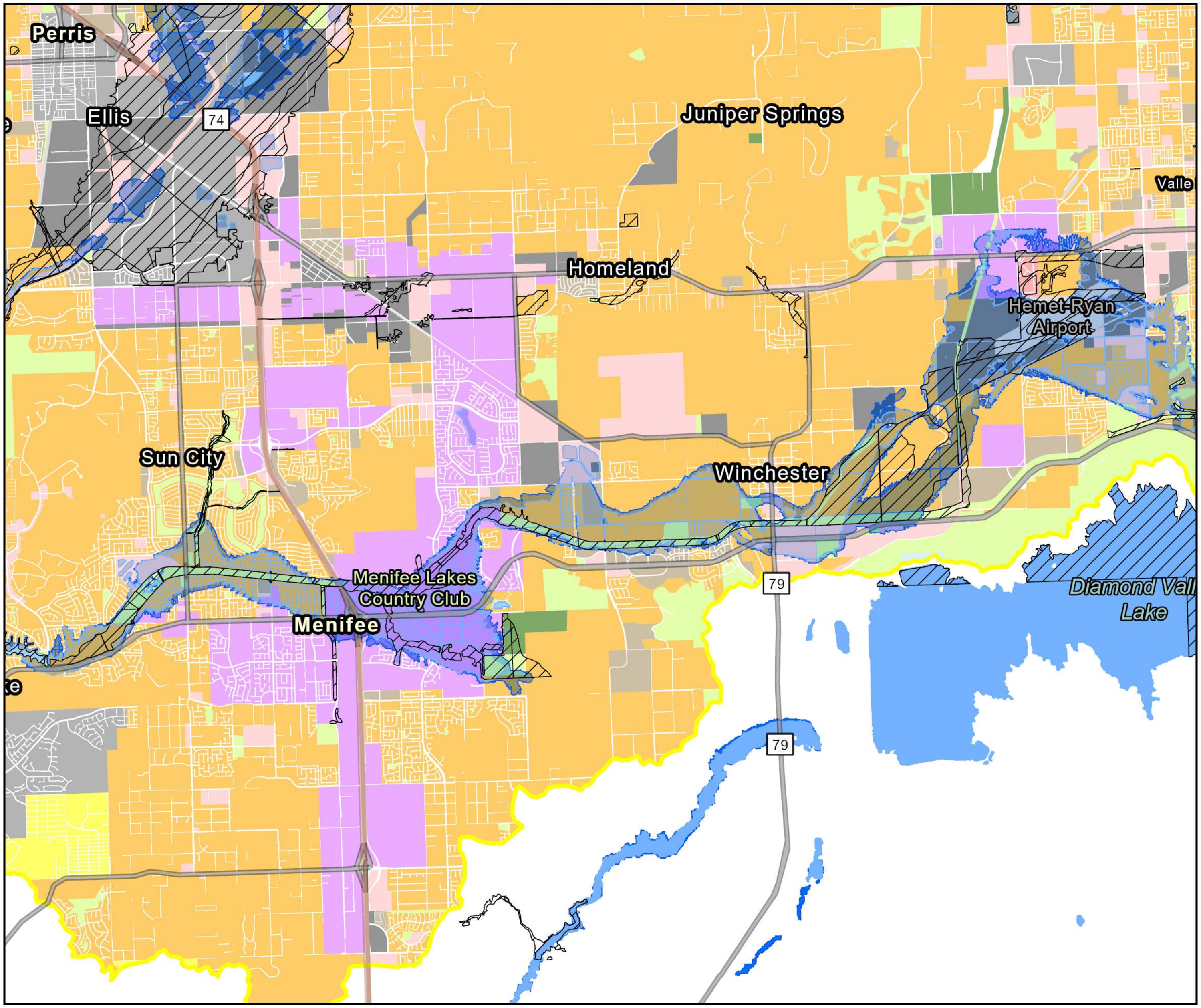
Location: Riverside County - San Jacinto Watershed - Lake Elsinore

General Plan Land Use - San Jacinto Watershed in Riverside County



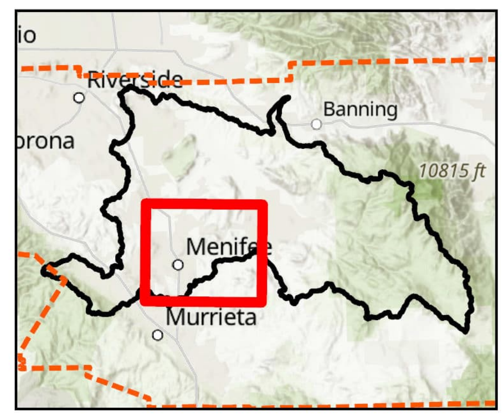
Location: Riverside County - San Jacinto Watershed - Val Verde

General Plan Land Use - San Jacinto Watershed in Riverside County



FEMA Flood Zones (100 year) - Riverside County
Fathom 100yr - Riverside County
Fathom 500yr - Riverside County
San Jacinto Watershed
Riverside County
Major Highways

General Plan Land Use
8+ Dwelling Units/Acre
0.5 to 7 Dwelling Units/Acre
2 to 20 Acres/Dwelling Unit
20+ Acres/Dwelling Unit
High density commercial
Low density commercial
Mixed use of residential and commercial
Industrial
Agricultural
Open space and public lands
Urban reserve
Planned development
Water
Other - Not Determined



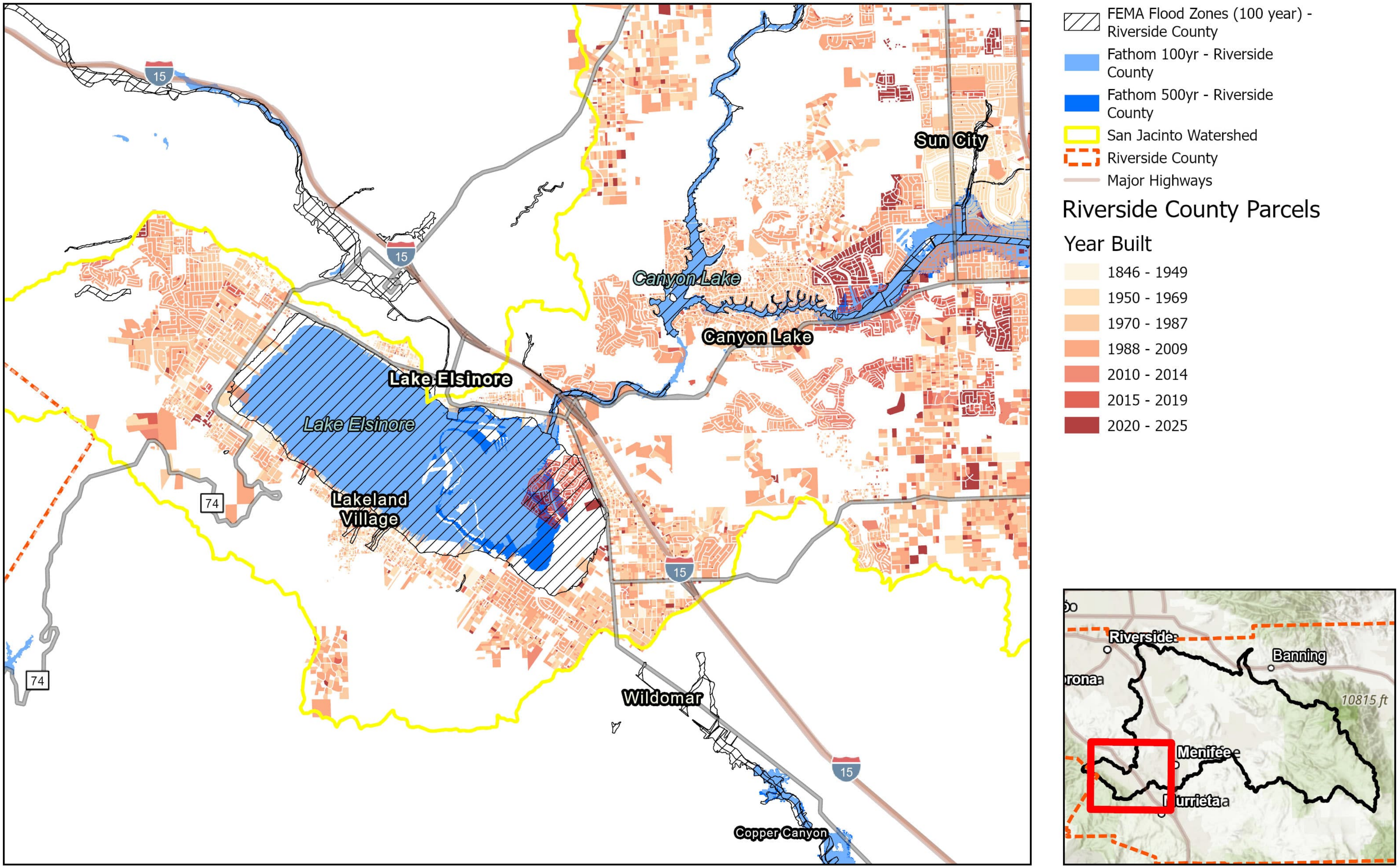
N

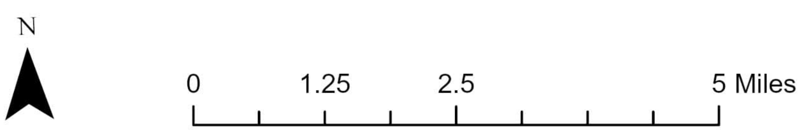
0 1.25 2.5 5 Miles

Map Data Sources: FEMA National Flood Hazard Layer Database; Fathom Global Flood Map 3.0; California State Geoportal; USGS
ESRI Basemap and Hybrid Reference Layer Sources: ESRI, Tom Tom, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community, Esri, USGS

Location: Riverside County - San Jacinto Watershed - Winchester

Parcels Within San Jacinto Watershed in Riverside County

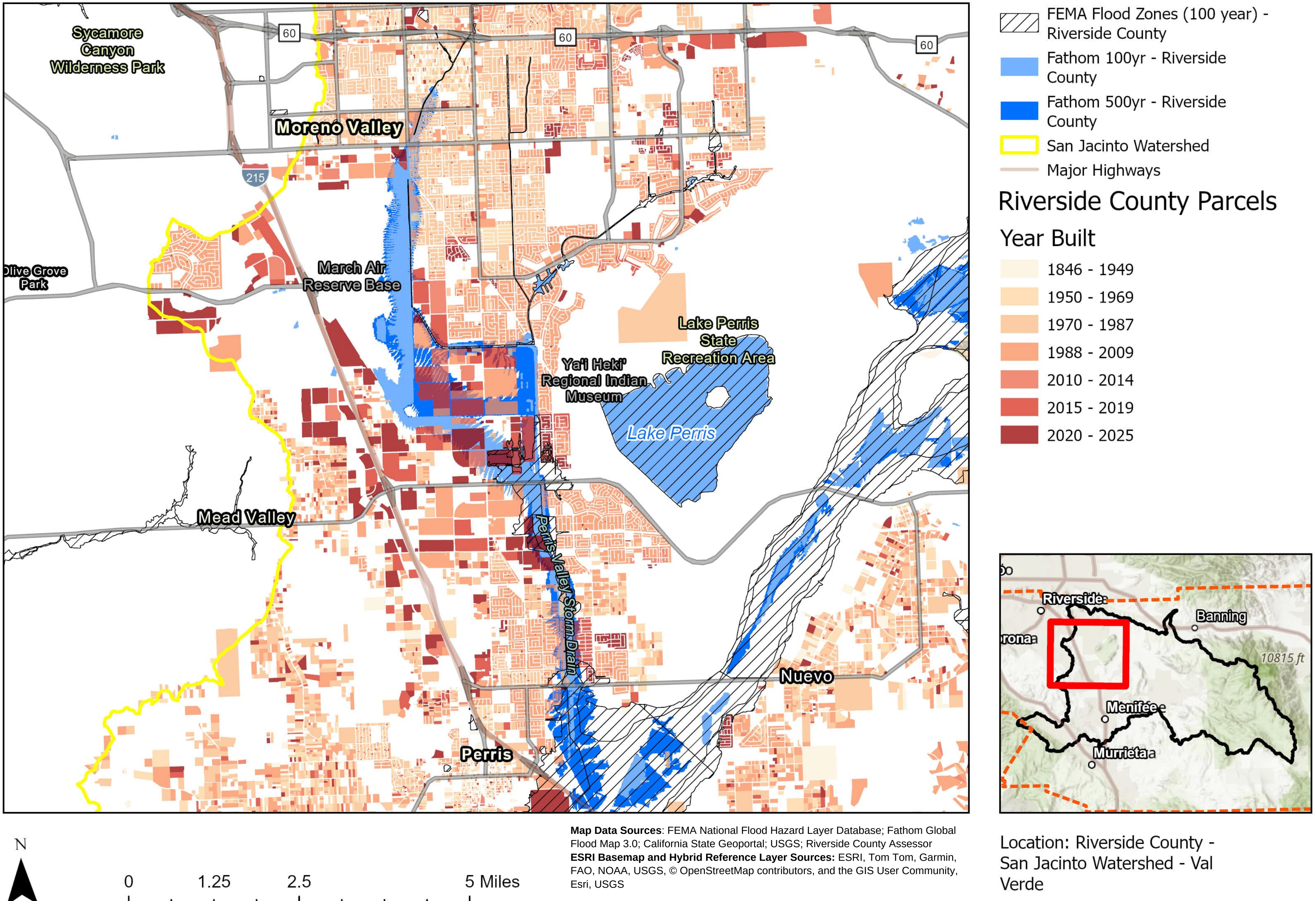




Map Data Sources: FEMA National Flood Hazard Layer Database; Fathom Global Flood Map 3.0; California State Geoportal; USGS; Riverside County Assessor
ESRI Basemap and Hybrid Reference Layer Sources: ESRI, Tom Tom, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community, Esri, USGS

Location: Riverside County - San Jacinto Watershed - Lake Elsinore

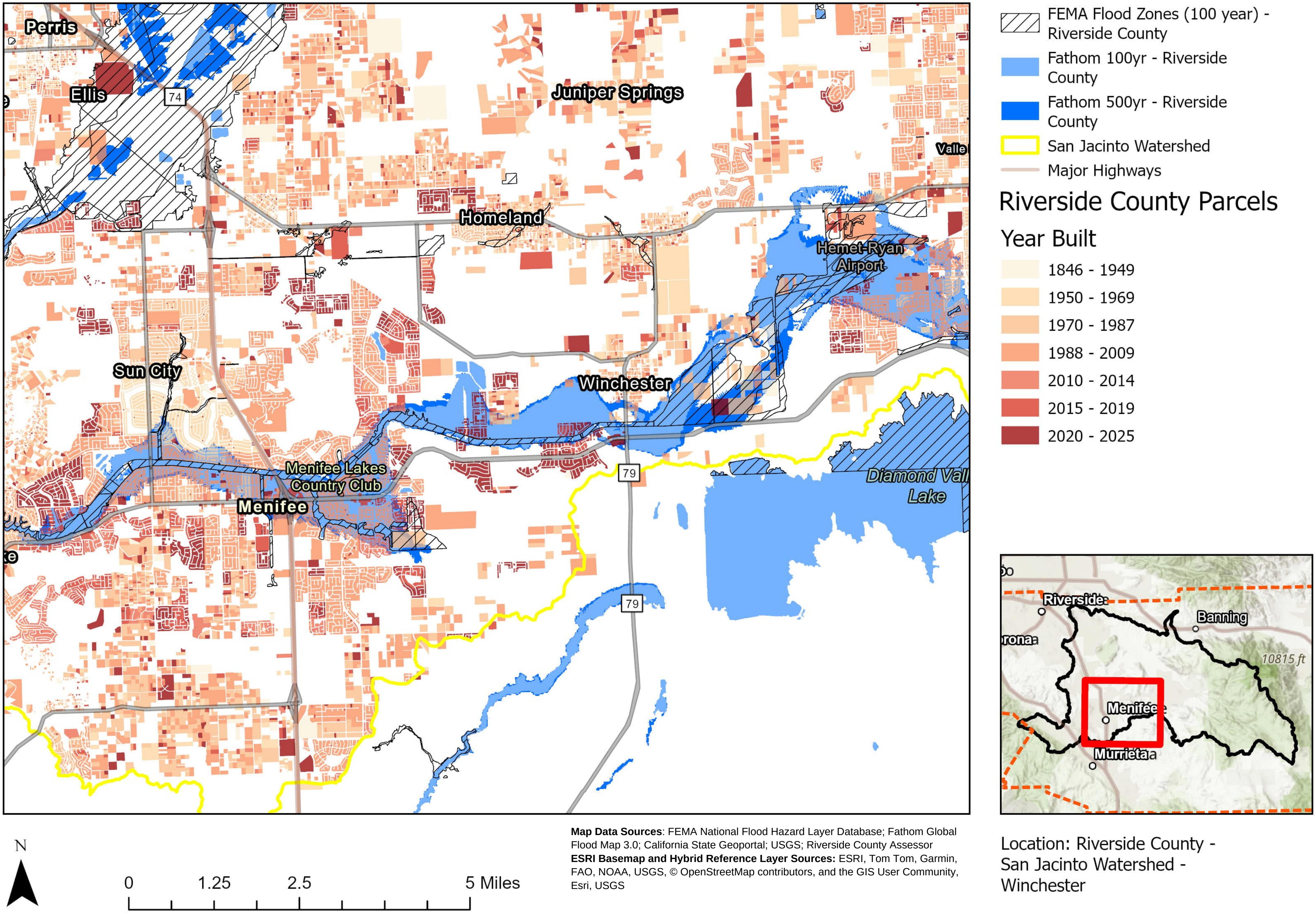
Parcels Within San Jacinto Watershed in Riverside County



Map Data Sources: FEMA National Flood Hazard Layer Database; Fathom Global Flood Map 3.0; California State Geoportal; USGS; Riverside County Assessor
ESRI Basemap and Hybrid Reference Layer Sources: ESRI, Tom Tom, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community, Esri, USGS

Location: Riverside County - San Jacinto Watershed - Val Verde

Parcels Within San Jacinto Watershed in Riverside County



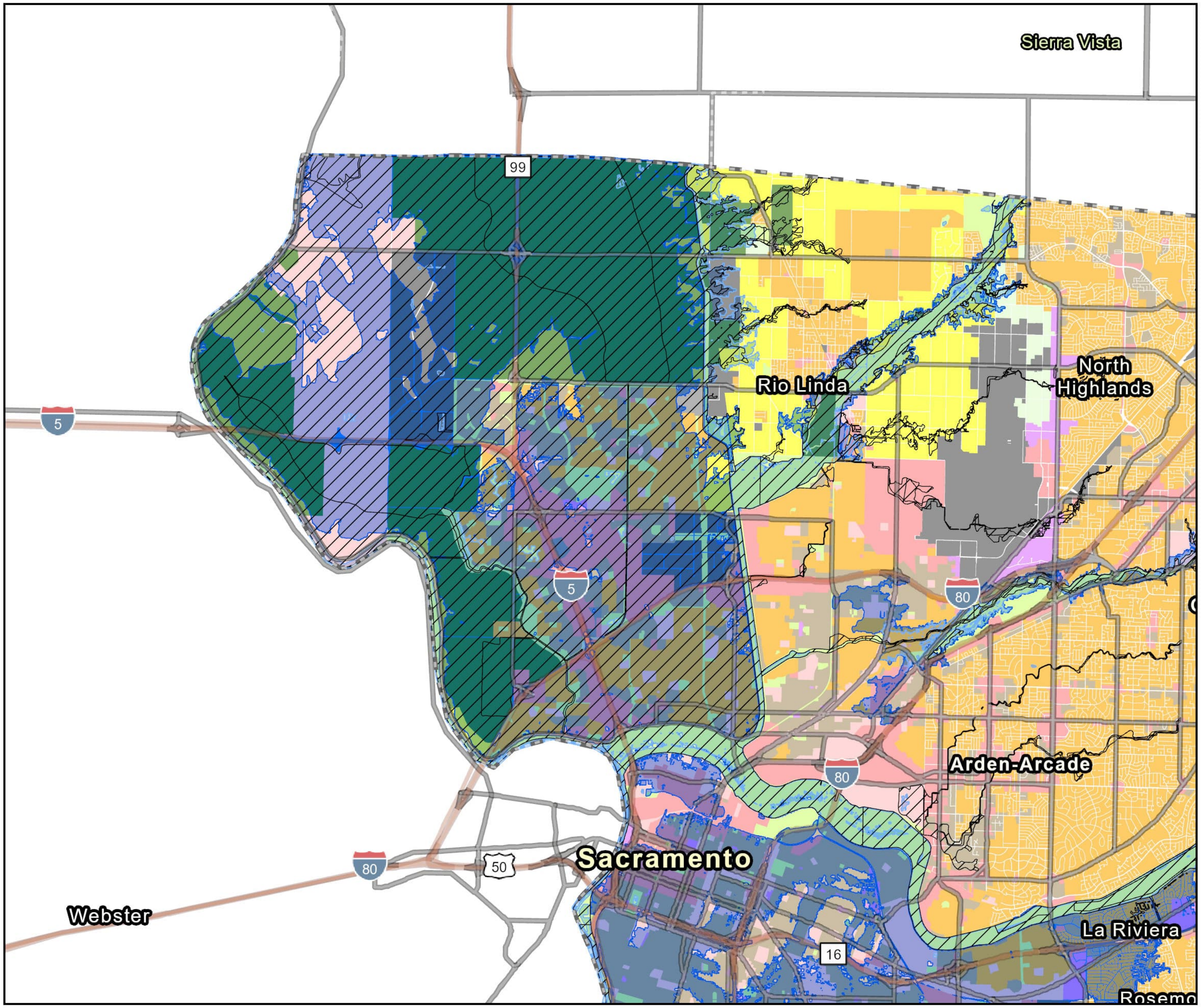
Map Data Sources: FEMA National Flood Hazard Layer Database; Fathom Global Flood Map 3.0; California State Geoportal; USGS; Riverside County Assessor
ESRI Basemap and Hybrid Reference Layer Sources: ESRI, Tom Tom, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community, Esri, USGS

Location: Riverside County - San Jacinto Watershed - Winchester

AECOM

Sacramento County

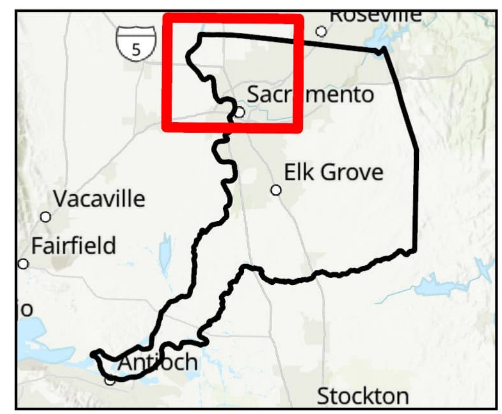
General Plan Land Use in Sacramento County



- FEMA Flood Zones (100 year) - Sacramento County
- Fathom 100yr - Sacramento County
- Fathom 500yr - Sacramento County
- Sacramento County
- Major Highways

General Plan Land Use

- 8+ Dwelling Units/Acre
- 0.5 to 7 Dwelling Units/Acre
- 2 to 20 Acres/Dwelling Unit
- 20+ Acres/Dwelling Unit
- High density commercial
- Low density commercial
- Mixed use of residential and commercial
- Industrial
- Agricultural
- Open space and public lands
- Urban reserve
- Planned development
- Water
- Other - Not Determined



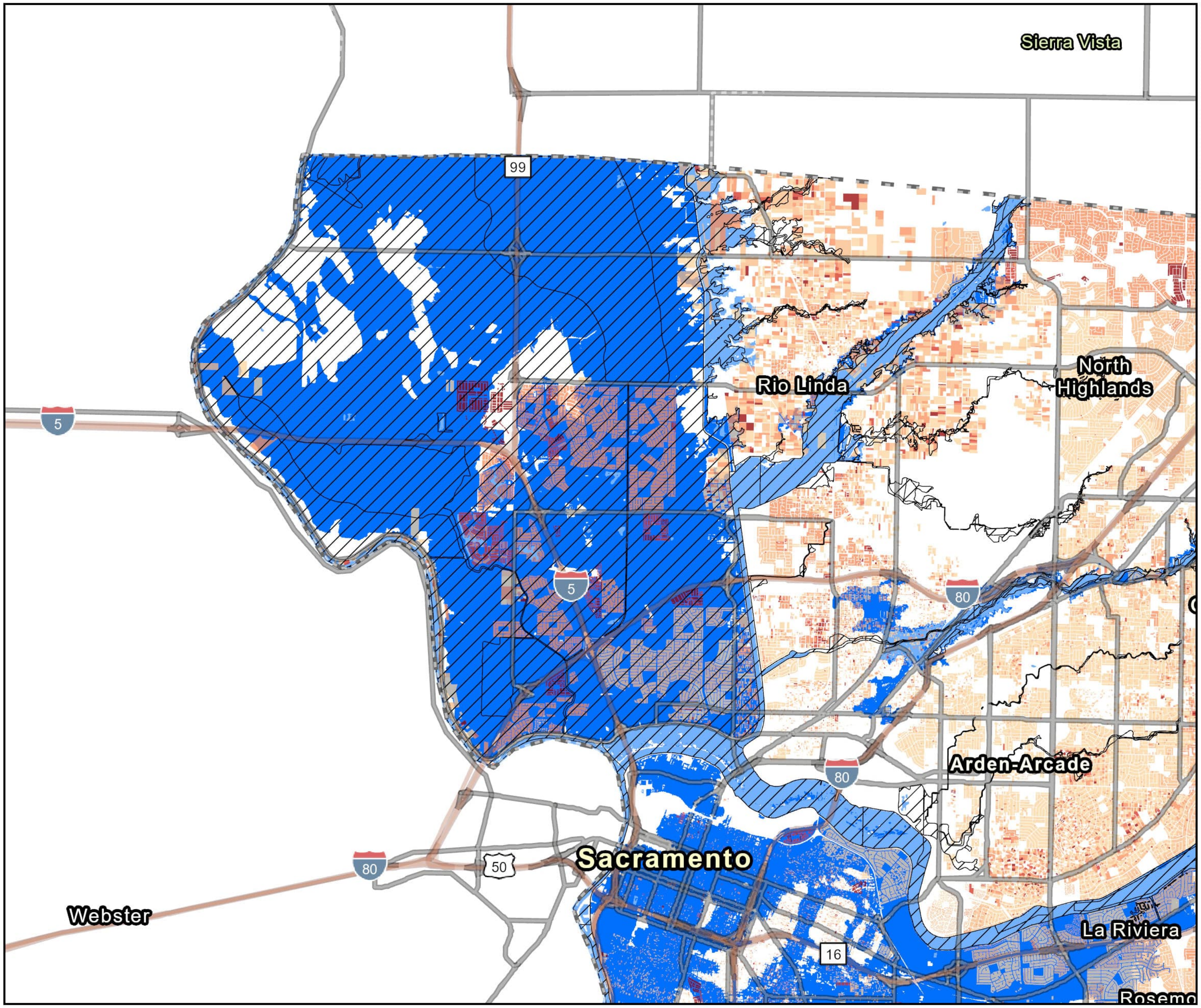
Location: Sacramento County - North Sacramento

N

0 1.25 2.5 5 Miles

Map Data Sources: FEMA National Flood Hazard Layer Database; Fathom Global Flood Map 3.0; California State Geoportal; USGS
ESRI Basemap and Hybrid Reference Layer Sources: ESRI, Tom Tom, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community, Esri, USGS

Parcels in Sacramento County

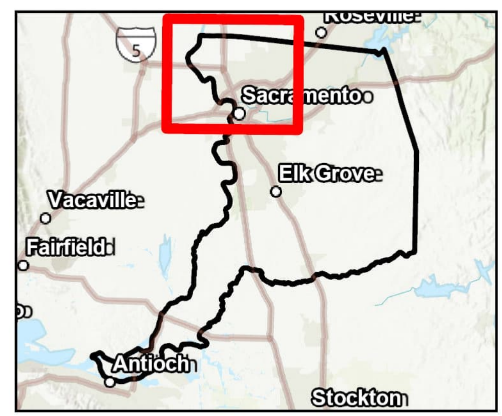


FEMA Flood Zones (100 year) - Sacramento County
Fathom 100yr - Sacramento County
Fathom 500yr - Sacramento County
Sacramento County
Major Highways

Sacramento County Parcels

Year Built

1846 - 1949
1950 - 1969
1970 - 1987
1988 - 2009
2010 - 2014
2015 - 2019
2020 - 2025



Location: Sacramento County - North Sacramento

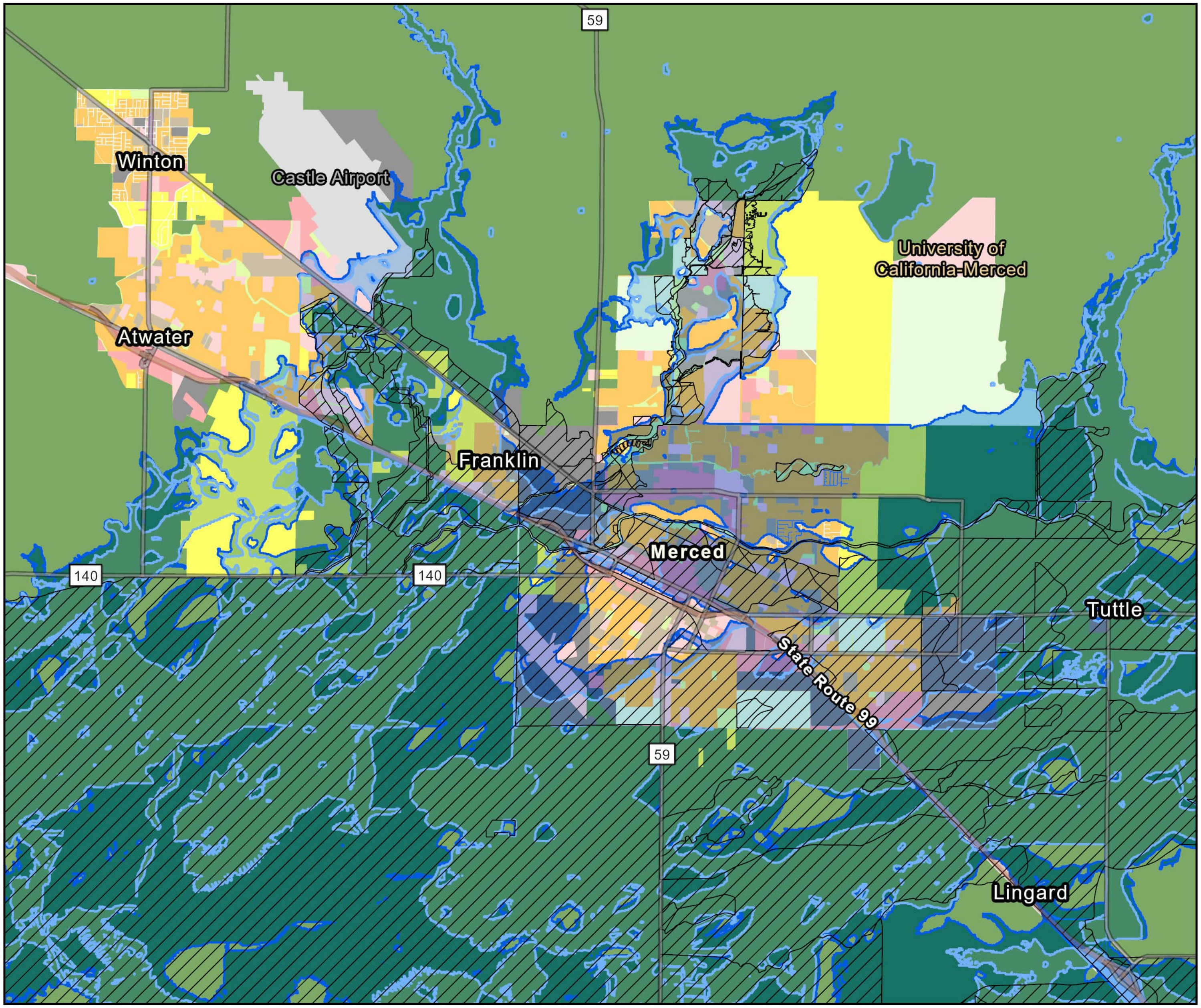
N

0 1.25 2.5 5 Miles

Map Data Sources: FEMA National Flood Hazard Layer Database; Fathom Global Flood Map 3.0; California State Geoportal; USGS; Sacramento County Assessor
ESRI Basemap and Hybrid Reference Layer Sources: ESRI, Tom Tom, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community, Esri, USGS

Merced County

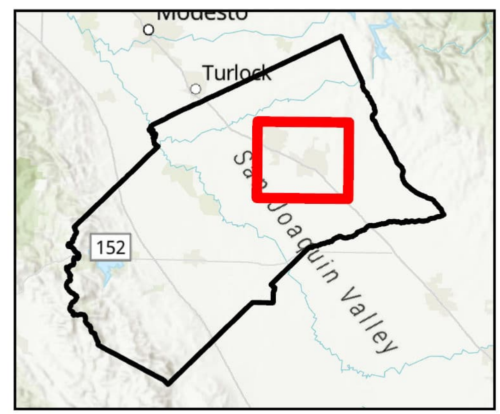
General Plan Land Use in Merced County



FEMA Flood Zones (100 year) - in Merced County
Fathom 100yr - in Merced County
Fathom 500yr - in Merced County
Major Highways

General Plan Land Use

- 8+ Dwelling Units/Acre
- 0.5 to 7 Dwelling Units/Acre
- 2 to 20 Acres/Dwelling Unit
- 20+ Acres/Dwelling Unit
- High density commercial
- Low density commercial
- Mixed use of residential and commercial
- Industrial
- Agricultural
- Open space and public lands
- Urban reserve
- Planned development
- Water
- Other - Not Determined



Location: Merced County - Merced

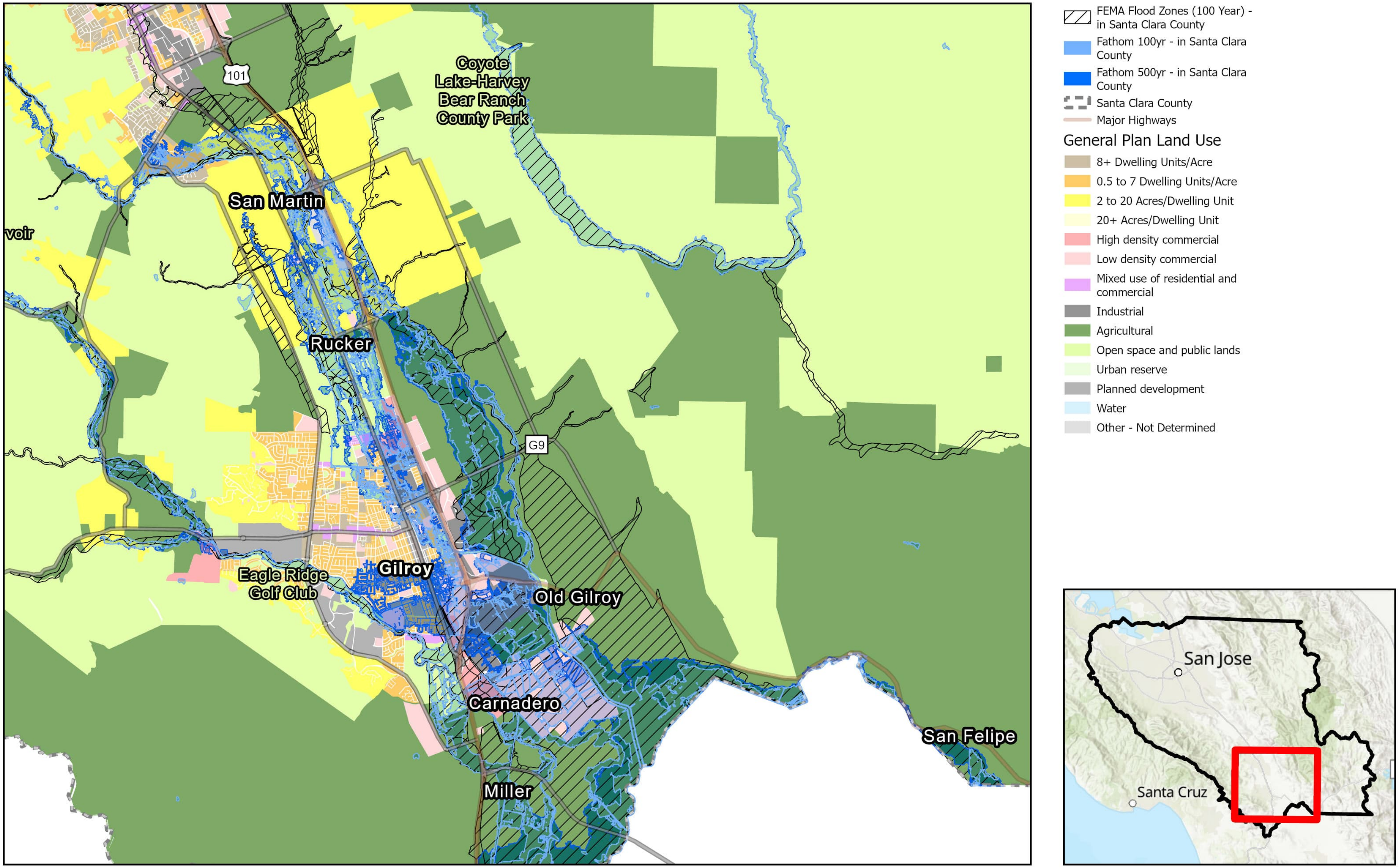
N

0 1.25 2.5 5 Miles

Map Data Sources: FEMA National Flood Hazard Layer Database; Fathom Global Flood Map 3.0; California State Geoportal; USGS
ESRI Basemap and Hybrid Reference Layer Sources: ESRI, Tom Tom, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community, Esri, USGS

Santa Clara County

General Plan Land Use in Santa Clara County



N

0 1 2 4 Miles

Map Data Sources: FEMA National Flood Hazard Layer Database; Fathom Global Flood Map 3.0; California State Geoportal; USGS
ESRI Basemap and Hybrid Reference Layer Sources: ESRI, Tom Tom, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community, Esri, USGS

Location: Santa Clara County - Gilroy