# Lake Forest Park Climate Vulnerability Assessment

## CLIMATE ELEMENT

**Prepared by Cascadia Consulting Group for the City of Lake Forest Park**

**June 2025**

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The City of Lake Forest Park Climate Element is supported with funding from Washington's Climate Commitment Act. The CCA supports Washington's climate action efforts by putting cap-and-invest dollars to work reducing climate pollution, creating jobs, and improving public health. Information about the CCA is available at www.climate.wa.gov.

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# Executive Summary

The City of Lake Forest Park (City) is including a Climate Element (CE) in the 2026 Comprehensive Plan update that will integrate climate resilience goals and policies into the City's long-term planning framework. The CE will build on commitments made in the City's current Comprehensive Plan, Climate Action Plan, Multi-Jurisdictional Hazard Mitigation Plan, Stormwater Management Plan and the Shoreline Master Program, to provide consistent, clear, and actionable guidance on climate resilience and greenhouse gas (GHG) emissions reduction.

This Climate Vulnerability Assessment (CVA) supports policy development for the CE by evaluating which sectors and assets in Lake Forest Park are most vulnerable to key climate hazards, specifically extreme heat, flooding, and landslides.

## Key Findings

The overall climate vulnerability of sectors and assets in Lake Forest Park ranges from medium to high, though vulnerability can vary significantly depending on an asset's location and level of hazard exposure (Table 1). Policies in the CE and Comprehensive Plan can enhance the resilience and adaptive capacity of the most vulnerable sectors and assets. Key takeaways for each sector assessed in CVA include:

- **Critical Facilities:** The central location of Lake Forest Park's critical facilities means they are relatively equally exposed to climate hazards. These assets are most vulnerable to extreme heat.
- **Transportation and Economy:** Many assets have medium or high overall vulnerability because they intersect with flood prone areas or landslide risks zones. Assets in this sector have medium exposure to extreme heat.
- **Community Resources and Housing:** Creeks and low-income housing face the highest vulnerability of assets in this sector. Overall, assets in this sector are most exposed to landslides.
- **Water Resources:** Water resources have high vulnerability to climate hazards and face exposure to landslides and flooding.

**Table 1. Overall vulnerability scores by sector.**

| Sector | Exposure | Sensitivity | Overall Vulnerability |
|---|---|---|---|
| **Critical Facilities** | Low | High | Medium |
| **Transportation and Economy** | Medium | High | High |
| **Community Resources and Housing** | Medium | Medium | Medium |
| **Water Resources** | Medium | High | High |

# Introduction

## Legislative Background

The Washington Growth Management Act (GMA) was amended in 2023 through House Bill (HB) 1181, which updated RCW 36.70A.070(9) and RCW 36.70A.095, and requires cities and counties to integrate climate policies into comprehensive plan updates. For the City of Lake Forest Park, these required policy changes must address climate impacts and increase resilience across local sectors and reduce GHG emissions. Jurisdictions must adopt climate policies through a framework consistent with the Department of Commerce's ("Commerce") Climate Planning Guidance (Washington Department of Commerce, 2023).

## Why Assess Climate Change Vulnerability?

The City of Lake Forest Park is increasingly facing multifaceted and compounding impacts from climate change. These include rising temperatures, poor air quality due to wildfires, worsening drought conditions, and more frequent and intense precipitation events. According to the Intergovernmental Panel on Climate Change's (IPCC) Sixth Assessment Report, these impacts are projected to intensify unless meaningful mitigation efforts are implemented (IPCC, 2023). This CVA prioritizes three priority climate impacts: extreme heat, flooding, and landslides.

Extreme heat days are becoming more frequent, and the greater Seattle area has already seen an increase of 23 extreme heat days from 1970 to 2023 (Lake Forest Park, 2024). Lake Forest Park has seen flooding impacts become more prevalent as precipitation increases in frequency and intensity, leading to creak flooding and inundation throughout several parts of the City (Guzman, 2024). More intense and extreme precipitation events can loosen soil on steep slopes and have led to landslides in the areas (McNamara, 2017).

## Climate Impacts

Climate change is projected to increase the prevalence and intensity of the impacts described above and will continue to affect Lake Forest Park and the Puget Sound region.

| | |
|---|---|
| **Extreme Heat** | Since 1950, King County has experienced a 1.7°F increase in average annual temperature (NOAA, 2024). In Lake Forest Park, annual maximum temperature is projected to rise by 8.3°F by 2100 under the RCP8.5 scenario, relative to 1951–2005. Summer maximum temperature (June–August) is expected to increase from 74.5°F to 84.8°F over the same period (Hegewisch & Abatzoglou, n.d.). |
| **Precipitation** | Annual precipitation in Lake Forest Park is expected to increase 7% by the end of the century under the RCP8.5 scenario, compared to the 1950–2006 baseline with seasonal shifts expected; winter precipitation (December–February) is projected to rise by 7%, while summer precipitation (June–August) is anticipated to decrease by 21% over the same timeframe and scenario (Hegewisch & Abatzoglou, n.d.). |
| **Streamflow and inland flooding** | The City of Lake Forest Park has several creeks, including McAleer and Lyon Creek, which are historically vulnerable to flooding. Increases in winter rainfall and more frequent intense storm events are expected to raise streamflow and flood risks. |
| **Landslides** | Several factors contribute to increased erosion and landslide risk in the Puget Sound region; more frequent and intense winter and spring rain events can saturate soils, while rising temperatures can dry out soils and reduce slope stability (Mauger et al., 2015). |

# Approach and Methodology

This Climate Vulnerability Assessment (CVA) evaluates the potential impacts of climate change on the City of Lake Forest Park using spatial datasets, feedback and analysis from the client and Climate Planning Action Team (CPAT), and other supporting data sources. The analysis focused on identifying the exposure of key community assets to climate-related hazards. Where data was available, the consultant team evaluated assets for both exposure and sensitivity to flooding, extreme heat, and landslides.

## Climate Vulnerability Framework

This CVA primarily focuses on assessing the exposure and sensitivity of key city assets and sectors. The results from this assessment will help inform policies and actions that the City can implement to mitigate these impacts. The framework and key terminology used for the City of Lake Forest Park's CVA is defined as follows:

- **Climate vulnerability** is the degree that a community or system is at risk of harm from hazards or impacts driven by climate change. This is the result of the difference between climate risks (exposure + sensitivity) and the capacity to adapt to the exposure.
- **Exposure** is the degree to which a system is exposed to climate hazards. For example, low elevation coastal areas are more exposed to sea level rise and coastal flooding compared to higher elevation inland areas.
- **Sensitivity** is the degree to which that system is likely to be affected by climate change-driven hazards. For example, older adults are less able to regulate their body temperatures and are often more physically sensitive to extreme heat than younger people.
- **Community implications** are the cascading impacts of the levels of exposure and sensitivity that is felt by the surrounding community.

This climate vulnerability assessment did not consider adaptive capacity, a common element of vulnerability assessments that means the potential or ability of a system or community to adapt to the effects or impacts of climate change, independently. However, adaptive capacity was partially assessed as part of the policy audit conducted during Climate Element development, as resilience policies were catalogued and opportunities were identified to strengthen community and infrastructure resilience. This vulnerability assessment and the results of the policy audit informed Climate Element policy development.

# Assets and Sectors Assessed

The project team, client team, and the CPAT collaboratively selected sectors and assets through an iterative process. This assessment evaluates climate risk across four sectors and subsequent critical assets (Table 2).

**Table 2. Sectors and assets selected for vulnerability analysis.**

| Critical Facilities | Community Resources and Housing | Transportation and Economy | Water Resources |
|---|---|---|---|
| • Libraries<br>• Police stations<br>• Fire stations<br>• Town Hall<br>• Grocery stores<br>• Schools | • Parks<br>• Streams<br>• Urban paths<br>• Low-income housing | • Major arterials<br>• Bridges<br>• Bus routes<br>• Town center | • Wells<br>• Sewer lines<br>• Pumphouse |

## Summary of Data Sources

Cascadia used established and peer-reviewed resources relevant to Lake Forest Park to identify observed and projected climate trends that are affecting the City. When city-scale data was not available, Cascadia relied on King County-scale climate impact data, as cited throughout the report. The climate impacts summary will inform the analysis of hazard vulnerability and risk by explaining considerations for future hazard risk due to climate change. The following data sources were identified, reviewed, and directly informed the CVA.

**Table 3. Summary of data sources.**

| Map Layer | Data Source | Year |
|---|---|---|
| **Heat Severity** | Trust for Public Land - Heat Severity 2023 | 2023 |
| **Flooding** | FEMA 100- and 500-year flood maps; King County GIS | 2020 |
| **Urban Tree Canopy** | King County GIS | 2021 |
| **Landslide** | King County GIS (Critical Areas Ordinance layer) | 1990 |

# Exposure Analysis

The project team assigned each asset a low, medium, or high exposure rating based on its spatial relationship to relevant hazard layers.

### FLOOD RISK

The project team used FEMA floodplain data (FEMA, 2020) to determine flood exposure levels (Figure 1). We categorized flood exposure for each asset based on this mapping in the following ways:

- **High exposure:** Asset is located within the 100-year floodplain.
- **Medium exposure:** Asset is located within the 500-year floodplain.
- **Low exposure:** Asset is located outside of floodplains.

While FEMA floodplain data supports spatial assessment of assets that fall within designated floodplains, the CPAT noted that this dataset does not adequately represent flood risks in Lake Forest Park. Steep slopes around McAleer and Lyon Creeks increase the likelihood of both urban flooding and erosion. However, there is no comprehensive spatial dataset capturing the extent of these localized hazards. As a result, these risks were assessed qualitatively in their respective sections rather than through spatial mapping.

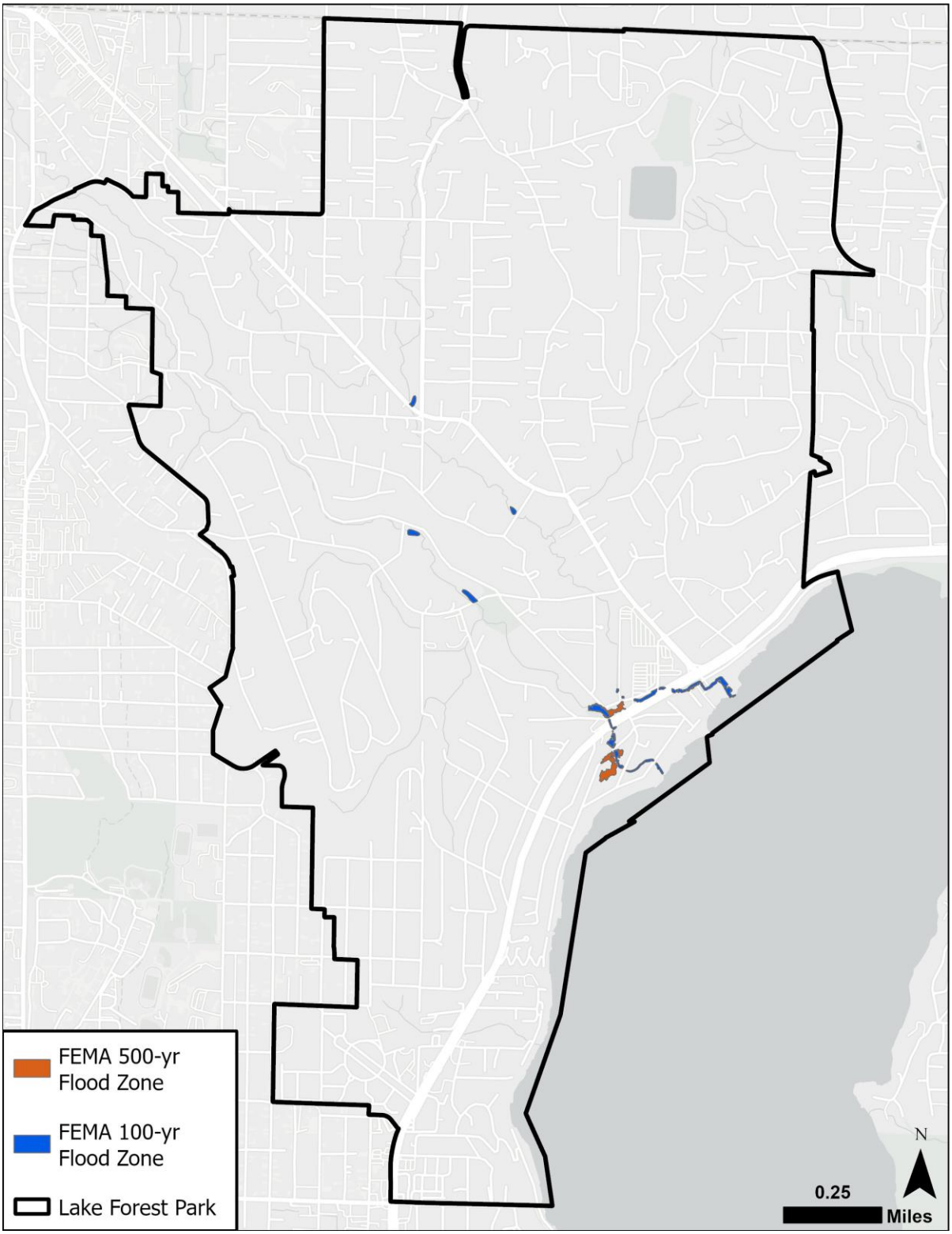


**Figure 1. FEMA 100 Year and 500 Year flood risk in Lake Forest Park. Map by Cascadia Consulting Group.**

## EXTREME HEAT

Heat severity was evaluated using temperature anomalies, comparing them to the summer months (June–August) of 2023 (Trust for Public Land, 2025). Deviations from the average land surface temperature (LST) in Lake Forest Park were used to identify areas of high, medium, and low heat exposure (Figure 2). We categorized heat exposure for each asset based on this mapping in the following ways:

- **High exposure**: The asset is located in a zone classified as moderate-to-high or severe heat, with LST up to 18°F above the city average.
- **Medium exposure:** The asset is located in a zone with LST moderately higher—within 8°F above the city average.
- **Low exposure**: The asset is located in an area where LSTs range from below the city average to slightly above it (up to approximately 2°F higher).

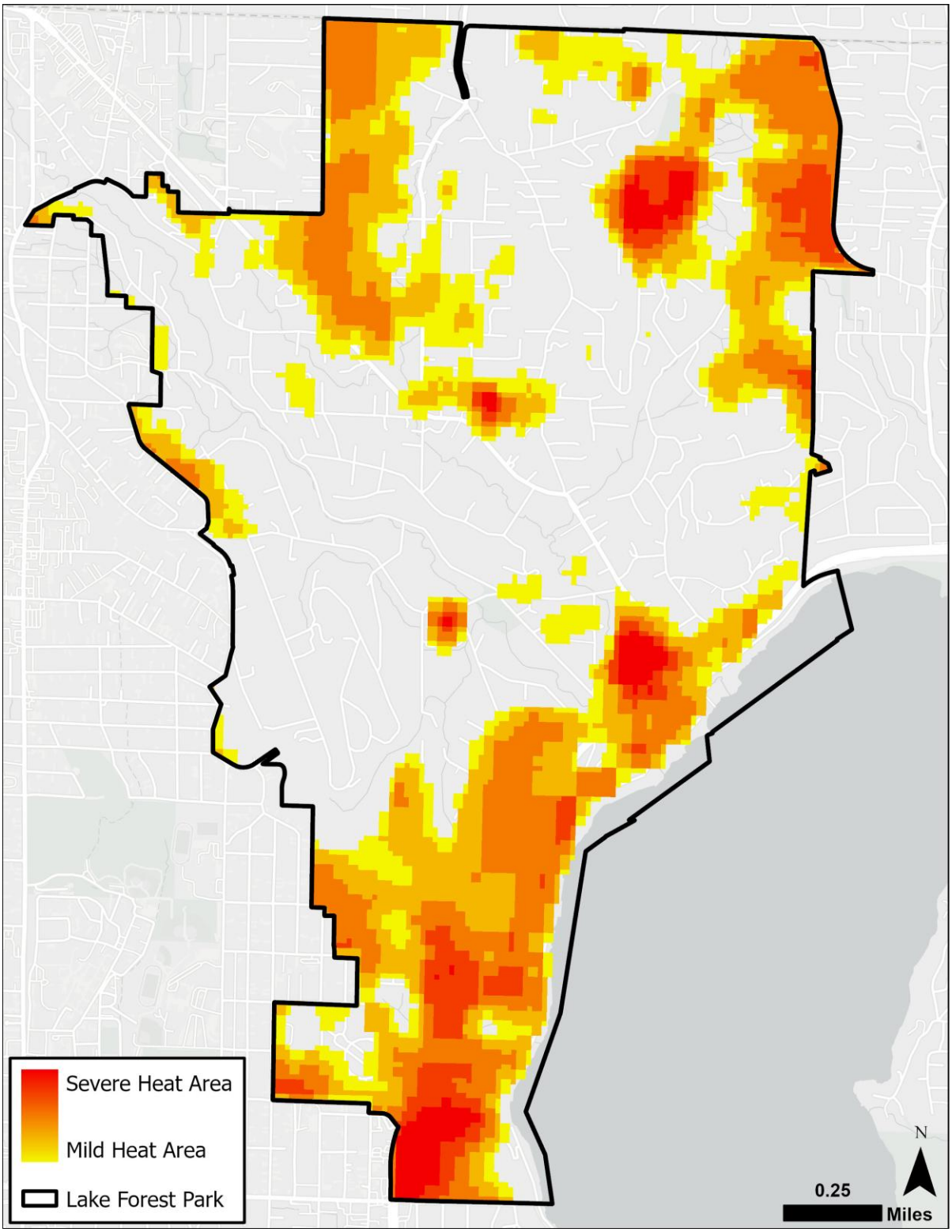


**Figure 2. 2023 Summer (June- August) heat severity in Lake Forest Park. Map by Cascadia Consulting Group.**

## LANDSLIDES

Landslide exposure classifications used landslide hazard data from the King County GIS Center (2016) (Figure 3). Asset distance from designated landslide hazard zones determined their exposure level.

- **High exposure:** Asset is located within a mapped landslide hazard zone or within 50 feet of one. The 50-foot buffer reflects the minimum protective distance required by the Lake Forest Park Municipal Code (Lake Forest Park, 2025).
- **Medium exposure:** Asset is located between 50 feet and 500 meters from a landslide hazard zone. This buffer distance is informed by landslide susceptibility research, which shows that nearby areas may share geomorphic or environmental characteristics with known landslide zones (Zhu et al., 2024).
- **Low exposure:** Asset is located more than 500 meters away from any designated landslide hazard zone.

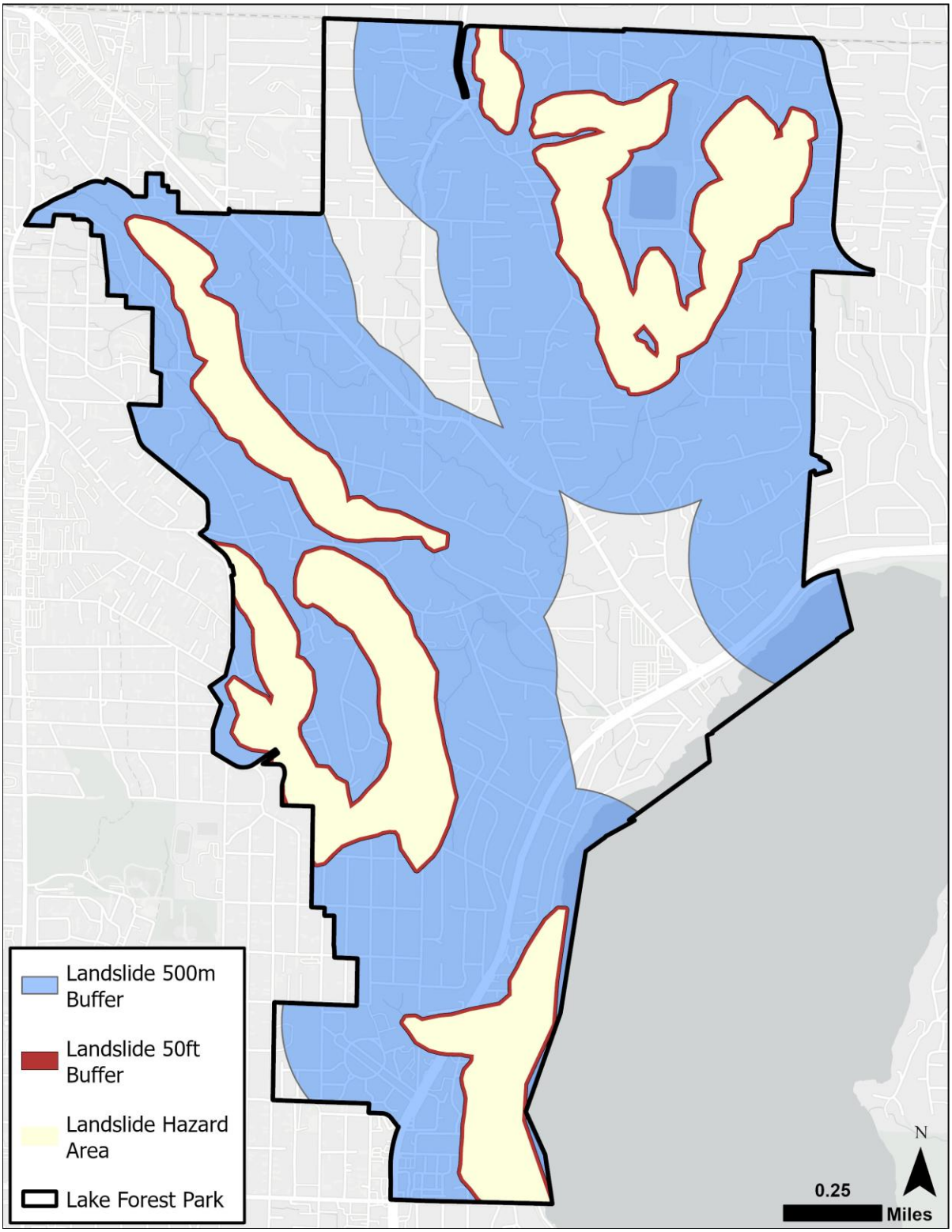


**Figure 3. King County Critical Ordinance Landslide Hazard Zones, and respective buffers. Map by Cascadia Consulting Group.**

For asset types composed of multiple individual assets, the overall exposure rating was determined by assessing the distribution of exposure designations across those assets and selecting the more conservative rating. For example, if one school is located in a high-risk flood zone and another in a medium-risk zone, the overall flood exposure for the "schools" asset type would be classified as high to reflect the full range of risk within the group.

To determine an overall exposure rating, each individual hazard exposure was assigned a numerical score: low (1), medium (2), and high (3). These scores were then averaged across all hazards for each asset. The resulting average was rounded to the nearest whole number (1, 2, or 3) to determine the overall exposure classification of low, medium, or high.

## Sensitivity Analysis

Criteria such as criticality, redundancy, and ease of use or access determined asset sensitivity to each climate hazard. Sensitivity levels were assigned based on how essential the asset is, whether alternatives exist, and how easily the asset can be used or restored after a disruption. Assets were categorized into three sensitivity levels:

- **High sensitivity:** The asset is critical and has no redundant or alternate sources. Access or use of the asset is delayed after the hazard ends, and re-establishment requires significant time or financial resources.
- **Medum sensitivity**: Asset is critical but there are some redundant or alternate sources. Use/access to asset can resume after climate hazard ends or soon after. Reestablishment of access requires minimal time or money investment.
- **Low sensitivity:** The asset is not critical, or alternative or redundant sources exist. Access or use of the asset can resume immediately after the climate hazard ends.

Overall sensitivity was determined using the same method as overall exposure, by assigning numerical scores to individual sensitivity ratings (low = 1, medium = 2, high = 3), averaging them, and rounding to the nearest whole number to classify the overall sensitivity as low, medium, or high.

## Overall Vulnerability and Community Implications

Vulnerability ratings were a product of each asset or sectors' exposure and sensitivity ratings to each climate hazard. These composite scores can help give a sense of which assets are most vulnerable to climate hazards, which can inform subsequent policy development.

The community implications section builds on this analysis by evaluating how the combined effects of climate hazards, especially when they interact or compound with each other, may impact the broader Lake Forest Park community. It highlights potential cascading or compounding effects and provides additional insight into the City's overall vulnerability and resilience, capturing dimensions of risk that are not conveyed through spatial analysis alone.

# Sector-Based Climate Vulnerability Analysis

## Critical Facilities

Critical facilities, such as libraries, police and fire stations, schools, grocery stores, and city hall, provide essential services. In addition to their primary functions, these facilities can serve as emergency shelters, gathering spaces, or cooling centers, offering residents a safe refuge and access to necessary resources during extreme weather events.

Lake Forest Park has seven critical facilities (Figure 4) – one library (Lake Forest Park Library), one police station, one fire station, two schools (Brookside Elementary and Lake Forest Park Elementary School), one grocery store (Safeway), and city hall. All critical facilities, except the schools, are in Lake Forest Park's downtown area near Lake Washington. The library, police station, city hall, and grocery store are even in the same plaza, while the fire station is located southwest of the plaza between two small parks.

Depending on the severity, certain climate hazards can directly damage critical facilities or block access to the facilities through obstructed roads. Either scenario would hinder the critical facilities' ability to provide their primary and emergency services.

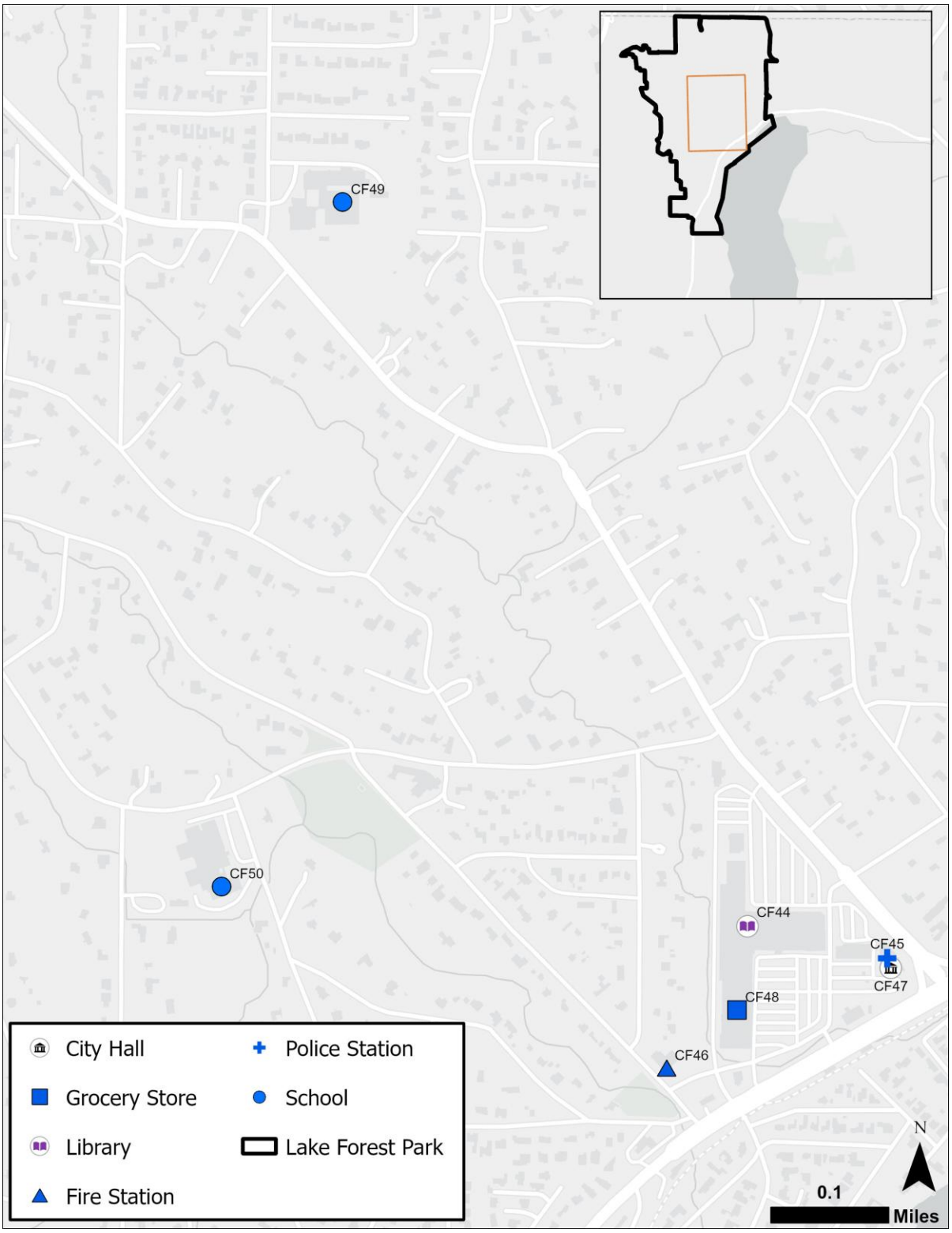


**Figure 4. Map of critical facilities in Lake Forest Park. Map by Cascadia Consulting Group.**

# Exposure

**Table 4. Critical facilities and climate hazard exposure rankings.**

| Asset | Extreme Heat | Flooding | Landslide |
|---|---|---|---|
| **Library** | High | Low | Low |
| **Police Station** | High | Low | Low |
| **Fire Station** | Medium | Low | Low |
| **City Hall** | High | Low | Low |
| **Schools** | High | Low | Medium |
| **Grocery Store** | High | Low | Low |
| **Overall Exposure** | **High** | **Low** | **Low** |

## EXTREME HEAT EXPOSURE

Critical facilities face medium or high exposure to extreme heat (Figure 5). Their location and the existence of tree canopy explain the variation in extreme heat exposures. The library, police station, city hall, and grocery store are highly exposed to extreme heat because they are located within the plaza, which has very few trees to provide shade and lots of asphalt and concrete surfaces to absorb the heat. While the fire station is also near the plaza, it has two small parks nearby that provide more tree cover that provide a cooling effect. Brookside Elementary School, which is also next to a park that provides more tree cover, faces a medium exposure to extreme heat. Lake Forest Park Elementary School, which is situated near a state highway that absorbs more heat, faces high exposure to extreme heat.

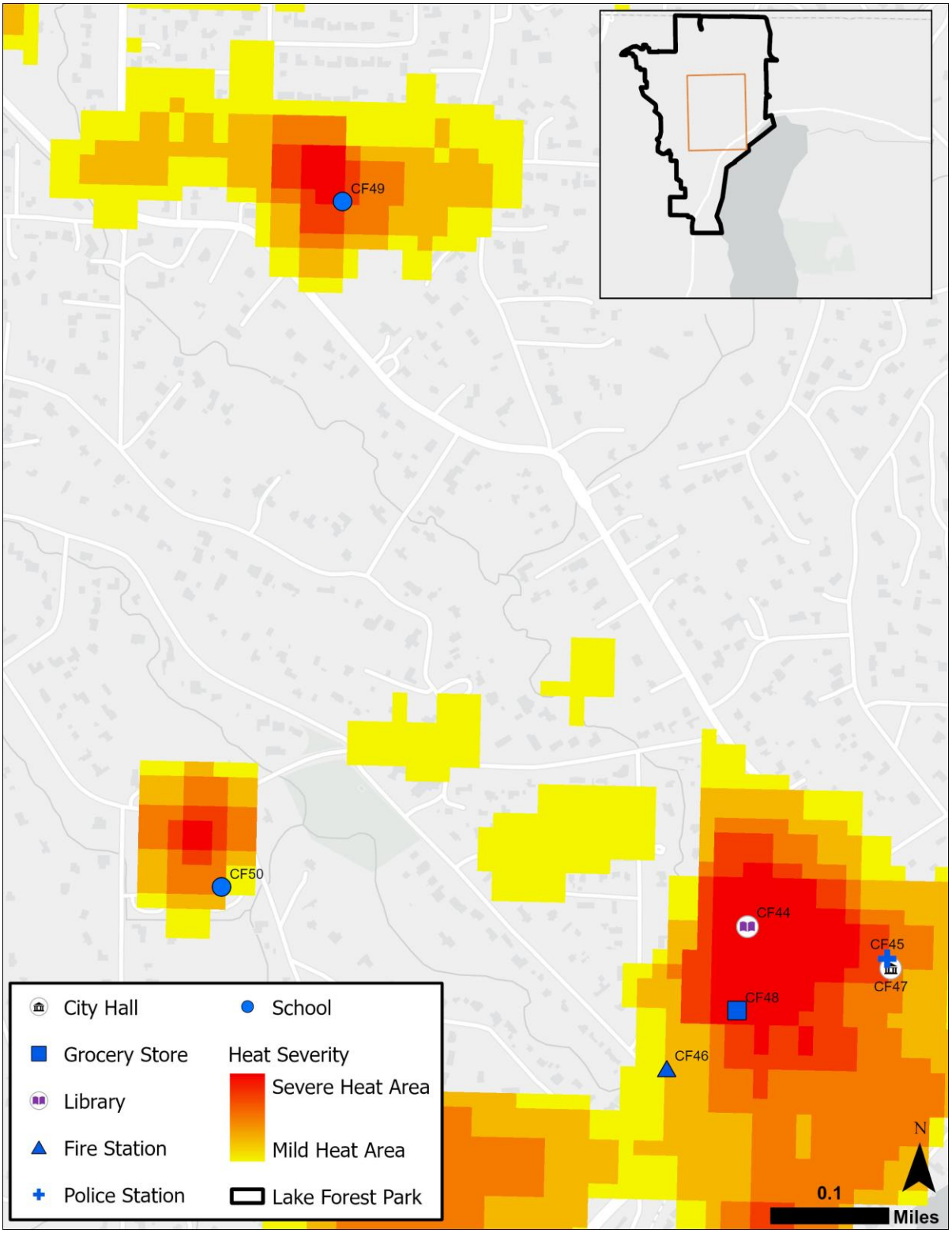


**Figure 5. Locations of critical facilities relative to heat severity areas. Map by Cascadia Consulting Group.**

### FLOODING EXPOSURE

All critical facilities face low flooding exposure, as none are located within the 100-year or 500-year FEMA floodplains. However, it is worth noting that several assets in the general Lake Forest Park area, including the Lake Forest Park Fire Station, have experienced flooding in the past. However, the completion of the Lyon Creek Flood Mitigation Project in 2016 has significantly reduced flooding in this area, and much of the surrounding area has since been removed from the FEMA-designated flood risk zone (APWA, 2016).

### LANDSLIDE EXPOSURE

All critical facilities, except schools, are outside landslide buffer zones and face low exposure. Schools are within 500 meters of a hazard area and in hillier terrain, putting them at medium exposure for landslides (Washington State Department of Natural Resources, 2017).

## Sensitivity

**Table 5. Critical facilities climate hazard sensitivity rankings.**

| Asset | Extreme Heat | Flooding | Landslide |
|---|---|---|---|
| **Library** | Low | High | High |
| **Police Station** | Low | High | High |
| **Fire Station** | Low | High | High |
| **City Hall** | Low | High | High |
| **Schools** | Low | High | High |
| **Grocery Store** | Low | High | High |
| **Overall Sensitivity** | **Low** | **High** | **High** |

### EXTREME HEAT SENSITIVITY

All critical facilities have low extreme heat sensitivity because extreme heat is unlikely to prevent access to critical facilities or significantly impede their ability to provide services. Critical facilities can experience power outages or interruptions if the energy demand from air conditioning use exceeds energy supply. Lake Forest Park's electricity provider, Seattle City Light, reported that during the 2021 Heat Dome event, the energy demand was 50% above its normal summertime demand levels (Seattle City Light, 2024). However, critical facilities in King County are usually equipped with back-up generators (King County, 2025).

### FLOODING SENSITIVITY

All critical facilities have high flooding sensitivity because flooding damage can lead to temporary closures and impact services during the recovery period. If a severe flood were to hit Lake Forest Park's critical facilities, they would need a safety inspection to check for potential sewage or chemical contamination and gas leaks before resuming operations (U.S. National Weather Service, 2025). The grocery store will need to inspect not only damages to the property but also to their products. Federal guidelines discourage grocery stores from selling foods affected by a flood due to food safety concerns (U.S. Food and Drug Administration, 2022). Even if a critical facility can stay open, flood-related power outages or interruptions, road obstructions, and damage to resources can impede its provision of primary and emergency services.

### LANDSLIDE SENSITIVITY

All critical facilities have high landslide sensitivity because a landslide that directly hits a critical facility could have immediate and longer-term impacts on services. Immediately after the landslide, all personnel and visitors would need to evacuate because landslides could affect the foundational structure of a building. In the longer term, critical facilities will have to temporarily close, until safety inspections and necessary restoration and repair work are conducted (CDC, 2024).

## Overall Vulnerability and Community Implications

Due to their central location, distance from steep slopes, and recent floodplain improvements, critical facilities received a low exposure rating. However, given their essential role and the City's reliance on them, they are considered highly sensitive, resulting in a medium overall vulnerability (Table 6).

**Table 6. Overall vulnerability (exposure + sensitivity) of critical facility assets.**

| Asset type | Exposure Score | Sensitivity Score | Overall Vulnerability Score |
|---|---|---|---|
| **Library** | Low | High | **Medium** |
| **Police Station** | Low | High | **Medium** |
| **Fire Station** | Low | High | **Medium** |
| **City Hall** | Low | High | **Medium** |
| **Schools** | Low | High | **Medium** |
| **Grocery Store** | Low | High | **Medium** |

**Community Implications**

Critical facilities provide essential services for residents of Lake Forest Park, but as climate hazards become more intense and frequent, these services will face increasing strain.

Extreme heat can heighten demand for emergency medical services, with heat waves leading to more ambulance call-outs, emergency department visits, and hospitalizations (Sapari et al., 2023; Wettstein et al., 2024). Heat-sensitive populations include the elderly, children, pregnant individuals, people with chronic conditions, those experiencing homelessness, residents living in heat islands or without effective cooling systems, outdoor workers, and low-income community members (LaCivita, 2024).

Flooding and landslides can disrupt the operations of critical facilities while also increasing the need for emergency response. Those most affected include facility personnel and students impacted by closures, residents with property damage, and the general public experiencing delays in essential services and utility disruptions (USGS Landslide Hazards Program, n.d.).

# Transportation and Economy

Reliable access to transportation can support work commutes, regional commerce, utility service delivery, and access to services (e.g., school, emergency response, healthcare). Extreme heat, flooding and landslides may cause disruptions by damaging or blocking access to roads. Beyond short term damage and disruptions caused by climate hazards, transportation infrastructure may not be adequately designed for future climate impacts and may require increased maintenance. Damage could have serious impacts for local economies and human life as commutes are disrupted, travel becomes unsafe, businesses are affected, and key service routes may be cut off.

The assets considered in the spatial analysis of vulnerability for this sector are bus routes 331 and 322, SR 104, SR 522, seven bridges, the town center, and Third Place Commons (a multi-functional community gathering space**Error! Reference source not found.**) (Figure 6). Lake Forest Park's transportation system is reliant on two state routes, SR 104 (Ballinger Way) and SR 522 (Bothell Way), which connect to winding arterials and local residential streets. SR 104 provides access to transit, schools, trails, the town center, and homes. SR 522, categorized as a "highway of statewide significance," connects Seattle to the Eastside, serves as a freight corridor between US 2 and I-5, and is a key travel route for residents and regional commuters (City of Lake Forest Park, 2016; Fehr & Peers, 2018). Bus service, primarily along SR 522, is provided by King County Metro and Sound Transit, with limited routes along SR 104 and to the Horizon View neighborhood (City of Lake Forest Park, 2016). The Town Center is the main commercial and transportation hub, home to the Town Center, Third Place Commons, and several small businesses (King County Department of Assessments, 2024). The majority of transportation and economic assets are within a 0.5 square mile area at the intersection of SR 104 and SR 522.

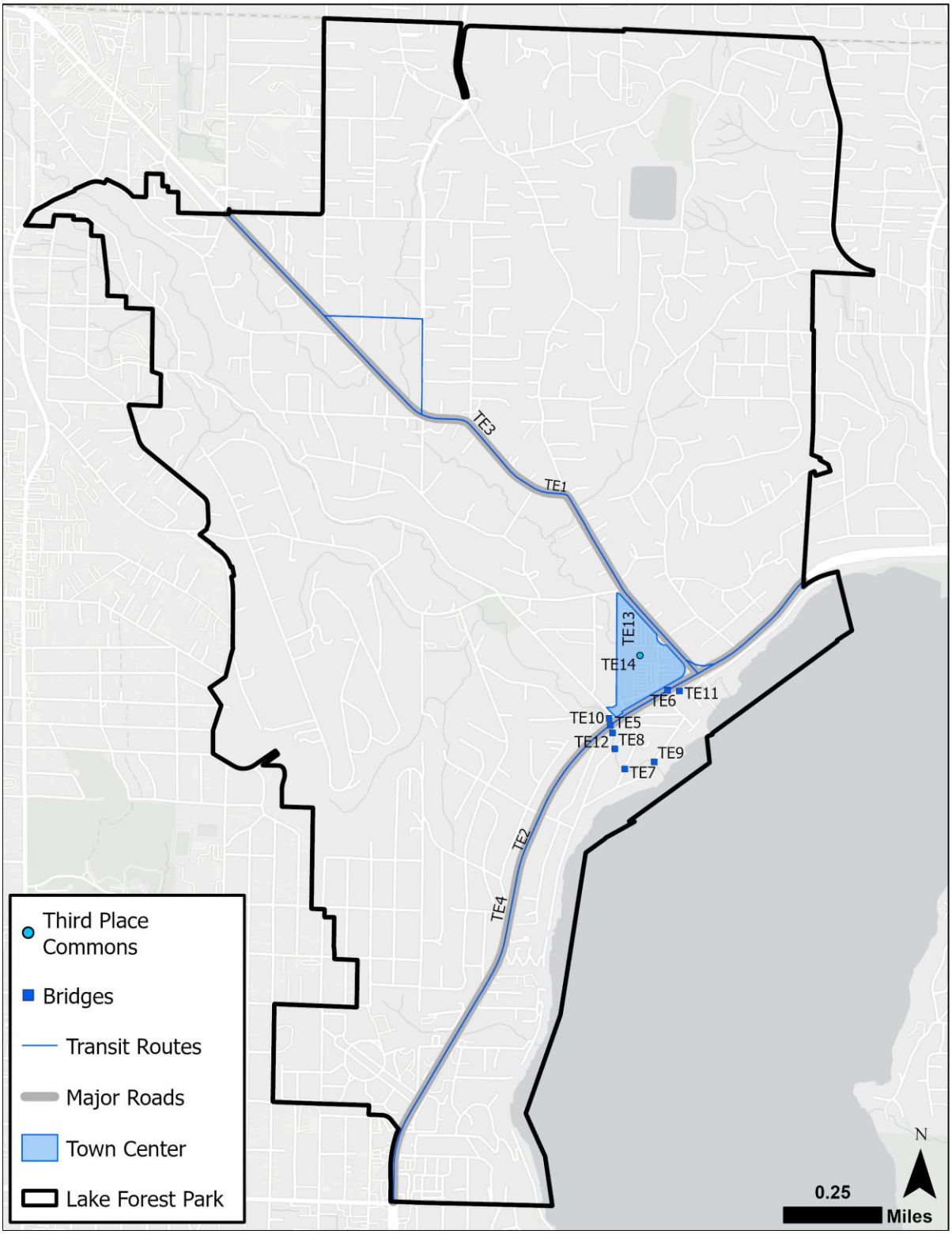


**Figure 6. Location of transportation assets in Lake Forest Park. Map by Cascadia Consulting Group.**

# Exposure

**Table 7. Transportation and economy climate hazard exposure rankings.**

| Asset | Extreme Heat | Flooding | Landslide |
|---|---|---|---|
| **Bus Routes** | Medium | High | High |
| **Major Arterials** | Medium | High | High |
| **Bridges** | Medium | Medium | Low |
| **Town Center** | High | Medium | Low |
| **Third Place Commons** | High | Low | Low |
| **Overall Exposure** | **High** | **Medium** | **Medium** |

## EXTREME HEAT EXPOSURE

Overall, the transportation and economy sectors face high exposure to extreme heat (Figure 7). Extreme heat events can cause pavement to buckle or crack, which can cause disruptions and delays. In the long term, rising temperatures and more frequent heat waves will likely lead to premature deterioration of roads resulting in higher costs to maintain infrastructure (United States Environmental Protection Agency, 2025).

Bus routes and major arterials, which largely overlap, experience medium exposure to extreme heat. SR 522 faces higher exposure than SR 104, likely due to a more pronounced urban heat island effect. Bridges experience medium exposure to extreme heat. The Town Center and Third Place Commons both experience high exposure to extreme heat due to the lack of tree canopy around the Town Center.

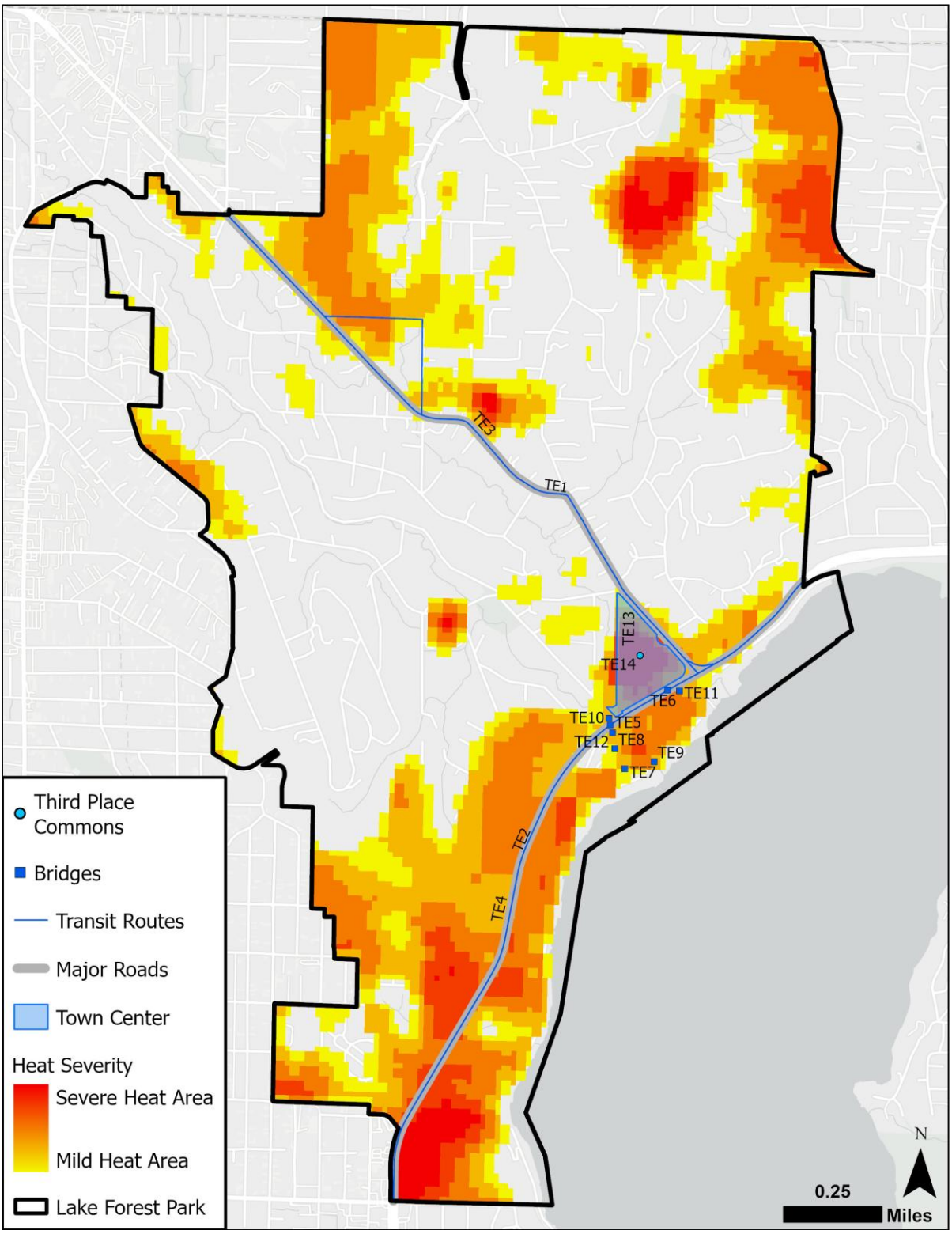


**Figure 7. Transportation assets and heat severity. Map by Cascadia Consulting Group.**

### FLOODING EXPOSURE

The transportation and economy sector faces medium exposure to flooding. Floods cover sections of road with water, wash out sections of road, scour and wash away bridges, and block or damage roads with debris (United States Environmental Protection Agency, 2025). Lake Forest Park's major arterials and bus routes face high exposure to flooding, while bridge exposure to flooding is lower, with a medium-level ranking. The Town Center faces medium exposure to flooding and Third Commons faces low exposure to flooding.

### LANDSLIDE EXPOSURE

The transportation and economy sectors face medium exposure to landslides. Landslides may block, undercut, and damage transportation infrastructure (United States Environmental Protection Agency, 2025). Lake Forest Park's major arterials and bus routes, which largely overlap with each other face high exposure to landslides. Bridges, the Town Center, and Third Place Commons are considered to have low exposure to landslides.

## Sensitivity

**Table 8. Transportation and economy climate hazard sensitivity rankings.**

| Asset | Extreme Heat | Flooding | Landslide |
|---|---|---|---|
| **Bus Routes** | Medium | Medium | Medium |
| **Major Arterials** | Medium | Medium | High |
| **Bridges** | Medum | High | High |
| **Town Center** | Low | High | High |
| **Third Place Commons** | Low | Medium | Medium |
| **Overall Sensitivity** | **Medium** | **Medium** | **High** |

### EXTREME HEAT SENSITIVITY

Transportation infrastructure, including bus routes, major arterials, and bridges, has medium sensitivity to extreme heat because extreme heat is expected to increase wear and tear and maintenance needs for SR 104, SR 522, and Lake Forest Park's bridges. There will not likely be additional damage to buses or bus stops, but passenger experience on bus routes could be unpleasant during heat events.

The Town Center has low sensitivity to extreme heat, as does Third Place Commons. Use of and access to the Town Center and Third Place Commons is unlikely to be significantly affected by individual heat events, but power outages due to regional extreme heat are possible. Small businesses are more sensitive than larger businesses to impacts from extreme events.

### FLOODING SENSITIVITY

Overall sensitivity to flooding within this sector is medium. Bus routes have medium sensitivity to flooding because flooding and any downed trees may interrupt usage, but damage is not likely to be lasting. Furthermore, buses can generally be re-routed to neighboring streets.

State routes have medium sensitivity to flooding; SR 104 and SR 522 are critical for access to the Town Center, transit, and urban areas such as Seattle, Bellevue, or Redmond. Flooding and any downed trees may interrupt usage, but damage is likely not lasting.

The Town Center has high sensitivity to flooding, while Third Place Commons has medium sensitivity due to its relatively lower criticality. Flooding would interrupt access to and usage of Town Center and Third Place Commons and would require time and money to repair.

### LANDSLIDE SENSITIVITY

The sensitivity of bridges and the two state routes is high; depending on the size and extent of a landslide, use of bridges, SR 104 and 522 will be interrupted and damage may be costly and time intensive to repair. The sensitivity of bus routes is medium, as buses will likely be able to be rerouted around a landslide.

The sensitivity of Town Center to landslides is high and that of Third Place Commons is medium. Damage from landslide could be expensive and catastrophic, with few alternatives available for relocation.

## Overall Vulnerability and Community Implications

Many transportation and economic assets have medium or high overall vulnerability because they are located in similar areas (Table 9) and rely on shared infrastructure, such as major arterials and bus routes. These common dependencies increase the likelihood of similar hazard impacts and can limit access, contributing to higher sensitivity scores.

**Table 9. Overall vulnerability (exposure + sensitivity) of transportation and economic assets.**

| Asset type | Exposure Score | Sensitivity Score | Overall Vulnerability Score |
|---|---|---|---|
| **Bus Routes** | High | Medium | **High** |
| **Major Arterials** | High | Medium | **High** |
| **Bridges** | Low | High | **Medium** |
| **Town Center** | Medium | Medium | **Medium** |
| **Third Place Commons** | Medium | Medium | **Medium** |

**Community Implications**

Disruptions along SR 522 and, to a lesser extent, SR 104, are likely to increase commute times. Nearly all (98%) of the workforce living in Lake Forest Park works for employers located outside of the City; while 21% of the workforce works from home, over half (61%) commutes by car (U.S. Census, 2022). At least 50,000 vehicles per weekday travel through Lake Forest Park via SR 522 (Fehr & Peers, 2018). During extreme events, such as heatwaves or flash flooding, acute damage can happen which can make some road conditions unsafe.

The Town Center is an important commercial activity hub in Lake Forest Park and several small businesses are located there (City of Lake Forest Park, 2016). Some businesses may be damaged or forced to close during extreme weather events or will suffer reduced foot traffic due to disruption of transit and walking routes. Extreme heat events will result in lost labor hours, affecting business revenues and workers' wages. Storms, heat, and flooding may disrupt supply chains or increase business costs due to scarce materials, rising insurance costs, or higher energy demand for cooling. Small businesses are generally less resilient than larger businesses to climate-related economic shocks (Calvin et al., 2023).

Furthermore, there can be cascading consequences across communities and systems. A road closure can cause disruptions for communities—for example, there may be significant back-ups for residents to reach Seattle if SR 522 is blocked, particularly due to the high traffic volume on that road. In addition, the impacts from extreme weather may simultaneously affect transportation and other infrastructure or emergency management systems. In 2024, flooding shut down both directions of State Route 104 at 35th Avenue and forced school closures and delays for many districts (Guzman, 2024).

# Community Resources and Housing

Community resources include the trails, parks, and streams that provide opportunities for recreation, community gathering, and time outside. As a residential community, housing is important in Lake Forest Park. Woodland North, a low- and moderate- income housing option in Lake Forest Park, is included in this analysis. Lake Forest Park has three urban trails and six parks. The trails travel mostly alongside the major roads in Lake Forest Park. Parks are distributed primarily through the southwest half of the City, except for Horizon View Park in the northeast. Low-income housing is in the southwest corner of the City along SR-522. Lyon and McAleer creeks bisect the City and empty into Lake Washington (Figure 8).

Community resources may be impacted by climate impacts but may also help residents and the City cope with climate impacts. For example, parks can help residents manage extreme heat events by providing a cooling effect for itself and adjacent areas, which could be important for households that do not have sufficient cooling systems. Flooding and landslides can block resident access to parks and trails. Additionally, these hazards can disrupt wildlife and habitat corridors that are important for fish, birds, and other wildlife in Lake Forest Park. Climate hazards can also damage low-income housing.

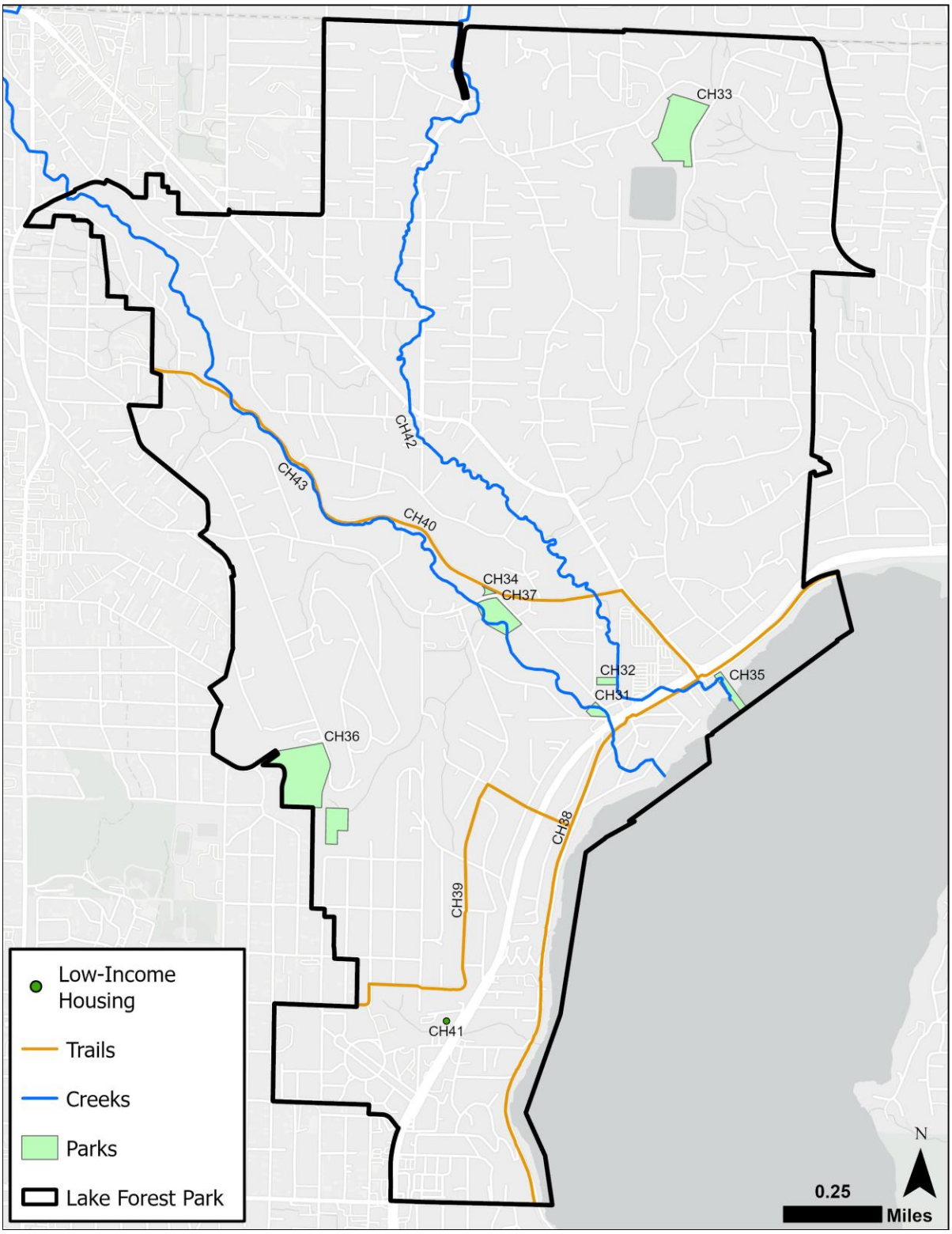


**Figure 8. Locations of key community resources in Lake Forest Park. Map by Cascadia Consulting Group.**

# Exposure

**Table 10. Community resources and housing climate hazards exposure rankings.**

| Asset type | Extreme Heat | Flooding | Landslide |
|---|---|---|---|
| **Parks** | Medium | Medium | Medium |
| **Urban Trails and Paths** | Low | Medium | High |
| **Creeks** | Medium | High | High |
| **Low-Income Housing** | Low | Low | High |
| **Overall Exposure Ranking** | **Medium** | **Medium** | **High** |

## EXTREME HEAT EXPOSURE

Low-income housing and urban trails and paths in Lake Forest Park have low exposure to extreme heat. However, segments of the Burke-Gilman Trail and Shoreline Interurban Connector briefly intersect medium heat exposure zones.

Lake Forest Park's parks and creeks face medium exposure to extreme heat. The City's parks are in medium heat exposure areas. The parks with higher heat exposure include Horizon View Park and Lyon Creek Waterfront Preserve. Lyon Creek and McAleer Creek have higher extreme heat exposure.

### FLOODING EXPOSURE

Parks, urban trails, and paths have medium exposure to flooding, while low-income housing has low exposure. McAleer and Lyon Creeks, located between Lake Washington and WA 522, intersect with both the 100-year and 500-year floodplains, indicating high exposure. Additional inland areas such as the intersection of 35th Avenue NE and WA 104, NE 180th Street near Pfingst Animal Acres Park and Eagle Scout Park, and 33rd Avenue NE are also located within the 100-year floodplain.

### LANDSLIDE EXPOSURE

Overall, parks have medium exposure to landslides. Some parks, like Lyon Creek Waterfront Preserve, have low exposure, while others such as Grace Cole Nature Reserve and Horizons View Park, are highly exposed to landslides. Creeks, low-income housing, and urban trails also have high exposure, as all are located within or intersect landslide hazard areas (Figure 9).

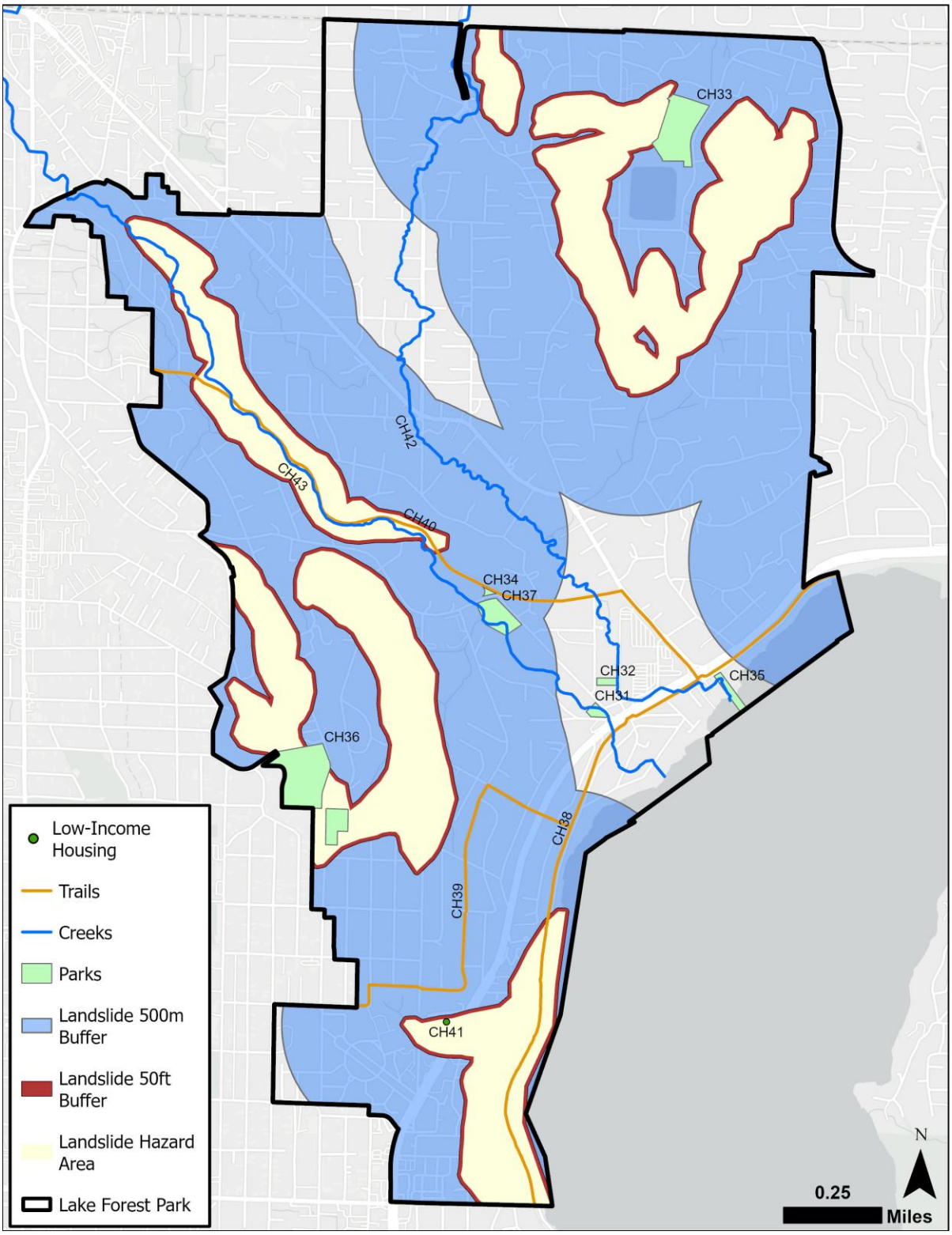


**Figure 9. Map of community resources and landslide exposure. Map by Cascadia Consulting Group.**

### Urban Tree Canopy

Urban trees are vulnerable to climate impacts, but they also play a key role in mitigating climate impacts. Lake Forest Park's urban tree canopy provides essential benefits, including cooling, air and water quality improvements, soil stability, and support for public health. Trees also aid in stormwater management and groundwater recharge.

About 80 percent of the City's trees are in areas with low exposure to extreme heat, but nearly 18 percent are in zones moderately above average temperatures (**Error! Reference source not found.**). Prolonged heat can outpace a tree's ability to absorb water, leading to desiccation, injury, or death, and reducing the canopy's cooling benefits (PennState Extension, 2024).

Tree loss can destabilize soils, increasing landslide risks, especially on steep slopes, and degrade creek ecosystems. Over 50 percent of the canopy is within 500 meters of a landslide hazard zone, placing it at medium risk. Although most trees lie outside flood-prone areas, flooding can still trigger landslides in unstable soils, uprooting trees. Conversely, healthy trees help mitigate flooding by improving soil water retention and reducing runoff.

**Table 11. Percent of tree canopy exposed to climate hazards**

| Exposure Zones | Flood Risk | Landslide Risk | Heat Risk |
|---|---|---|---|
| **Low** | 100% | 46% | 80% |
| **Medium** | 0.1% | 51.4% | 17.8% |
| **High** | 0.2% | 2.6% | 1.7% |

# Sensitivity

**Table 12. Community resources and housing climate hazards sensitivity rankings.**

| Asset type | Extreme Heat | Flooding | Landslide |
|---|---|---|---|
| **Parks** | Low | Low | Medium |
| **Urban Trails and Paths** | Low | Low | Medium |
| **Creeks** | Medium | Low | Medium |
| **Low-Income Housing** | Medium | High | High |
| **Overall Sensitivity** | **Medium** | **Medium** | **Medium** |

### EXTREME HEAT SENSITIVITY

Parks, open spaces, and urban trails are expected to be largely unaffected by rising temperatures and may experience increased use by residents during heat waves, as they can offer cooler environments. As a result, they are considered to have low sensitivity to extreme heat.

Low-income housing is moderately sensitive to extreme heat, as these buildings are often older and poorly insulated, contributing to lower building performance to extreme heat (Ouma, 2022).

Salmon and other fish species in Lyon and McAleer Creeks are sensitive to rising air temperatures, which can increase stream temperatures, particularly during low-flow periods (Phair, 20214). Therefore, creeks have medium sensitive to extreme heat.

### FLOODING SENSITIVITY

Parks and trails have low sensitivity, though flooding in some areas may limit access and require detours. Streams have low sensitivity, as flooding is a natural fluvial process that supports the health of rivers and creeks, and their surrounding ecosystems (LOOS, 2016). Low-income housing is highly sensitive due to the potential for costly flood-related damage and a lack of redundancy.

### LANDSLIDE SENSITIVITY

Landslides can make Lake Forest Park's parks and trails inaccessible for extended periods, with costly and time-consuming cleanup. These assets have medium sensitivity to landslides. Streams have medium sensitivity, as landslides contribute to erosion, turbidity, and sedimentation, hindering species movement with no alternate routes. Low-income housing is highly sensitive due to the potential for severe structural damage.

## Overall Vulnerability and Community Implications

Community resources in Lake Forest Park generally exhibit medium to high overall vulnerability. Parks, trails, and the tree canopy tend to have medium exposure and sensitivity, resulting in medium vulnerability. In contrast, creeks and low-income housing are more sensitive to climate hazards, resulting in high overall vulnerability scores (Table 13).

**Table 13. Overall vulnerability (exposure + sensitivity) of community resources.**

| Asset type | Exposure | Sensitivity | Overall Vulnerability |
|---|---|---|---|
| **Parks** | Medium | Low | **Medium** |
| **Urban Trails and Paths** | Medium | Low | **Medium** |
| **Creeks** | High | Medium | **High** |
| **Low-Income Housing** | Low | High | **Medium** |

**Community Implications**

There is on average at least 50% tree canopy coverage across Lake Forest Park, which can provide shade, stormwater filtration, and wildlife habitat throughout the city. Lake Forest Park has a tree equity composite score of 94, indicating the city has relatively more tree canopy in areas with more residents who may be disproportionately impacted by extreme heat.

The floodplain in Lake Forest Park is small and may not represent all potential areas of flooding, pooling, or standing water following heavy rain events. Impervious surfaces like parking lots and roads can prevent water from being absorbed into the ground. Lake Forest Park has 33% of impervious surfaces, with higher proportions in census tracts with more vulnerable populations. In addition, 4% of properties in the city are at risk of flooding .

The current location of low-income housing is outside of the floodplain. However, if new units are developed within the floodplain or flooding occurs beyond the floodplain, housing damage can be expensive. A flood may force residents to relocate out of the area if costs to rebuild or renovate are too high, or if sufficient alternate housing is unavailable. There is a limited supply of low- and moderate- income housing in Lake Forest Park which could be further limited if a flood damaged Woodland North.

Lyon Creek is a priority catchment area through the Stormwater Management Action Plan to reduce flooding risk, improve water quality, and protect habitat and natural environments ( (City of Lake Forest Park, n.d.). In December 2024, Lyon Creek at Ballinger Way flooded following heavy rains, closing the road for several hours (Shoreline Area News, 2024). The Stormwater Management Action Plan plans to adjust the creek passage will improve salmon runs and may alleviate some flooding.

# Water Resources

Water resources—such as drinking water systems, stormwater conveyance, and sewer systems—can ensure that residents have clean water. As climate change drives longer and more intense drought conditions and heatwaves, water systems could see reductions in water storage as well as increases in demand. More intense precipitation events could lead to increased stormwater runoff that can overwhelm stormwater and wastewater systems.

The City of Lake Forest Park's drinking water is supplied and processed by multiple providers, including the Lake Forest Park Water District (LFPWD), Northshore Utility District, Seattle Public Utilities, and North City Water District. LFPWD is the only provider that does not purchase water directly from Seattle Public Utilities; instead, it sources its supply from wells located within Lake Forest Park. Stormwater and wastewater services are managed by King County. This analysis focuses on critical water-related assets exposed to climate change impacts, including the McAleer and Lyon stormwater mains, the McKinnon Creek Pump House, and several deep and shallow wells (Figure 10).**Error! Reference source not found.**

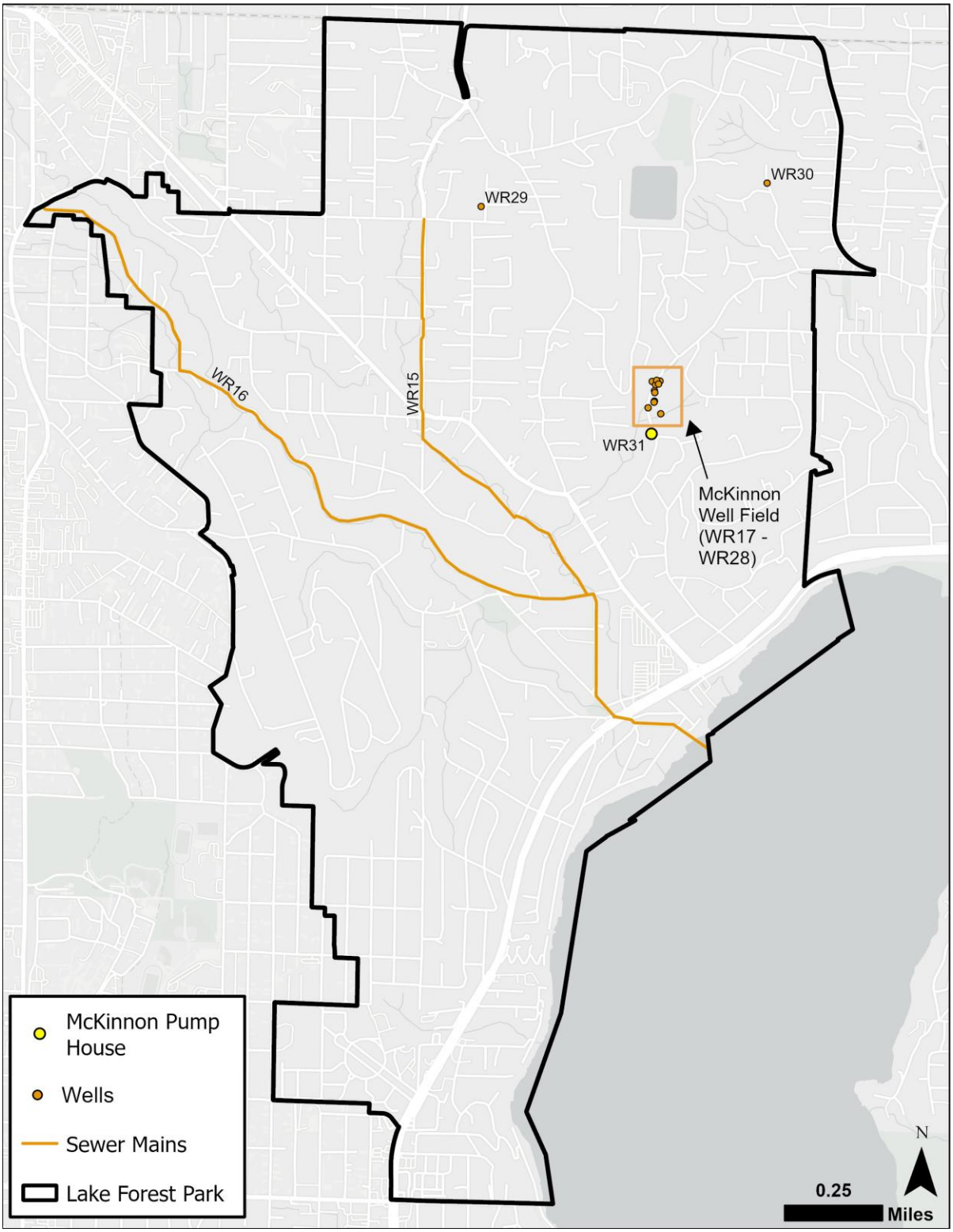


**Figure 10. Location of key water resource assets within the city, including stormwater mains, wells, and the McKinnon Pump House. Map by Cascadia Consulting Group.**

Lake Forest Park has two major stormwater mains, the Lyon Main (WR16) in the north and the McAleer Main (WR15) further south, which merge before reaching Lake Washington. The McKinnon Wellfield (WR17–WR28), located in the northern part of the City, consists of several shallow artesian wells and three deep wells, and it also contains the McKinnon Pump House (WR31). The Horizon View Wellfield, situated near Horizon View Park, contains two deep wells (WR29 and WR30). Both wellfields source water from the Lake Forest Park Water District Aquifer. Additionally, the City has three reservoirs for water storage, however, their locations could not be shared. Thus, their impacts are assessed on a more general level.

## Exposure

**Table 14. Water resources climate hazard exposure rankings.**

| Asset type | Extreme Heat | Flooding | Landslide |
|---|---|---|---|
| **McKinnon Pump House** | Low | Low | Medium |
| **Wells** | Low | Low | High |
| **Stormwater Mains** | Medium | Medium | High |
| **Overall Exposure** | **Low** | **Low** | **High** |

### EXTREME HEAT EXPOSURE

The McKinnon Pump House and all 13 wells have low exposure scores due to their location in areas with low heat exposure. The Lyon stormwater main also has low heat exposure. In contrast, the McAleer stormwater main passes through several hotspots with land surface temperatures moderately above the city average, resulting in a medium heat exposure score.

### FLOODING EXPOSURE

The McKinnon Pump House and all wells are outside flood hazard zones and face low exposure. The McKinnon and Lyon Mains converge near the Town Center, where they pass through the 500-year floodplain. Thus, we ranked them to have moderate flood exposure.

## LANDSLIDE EXPOSURE

All water resource assets are located within at least 500 meters of a landslide hazard zone (

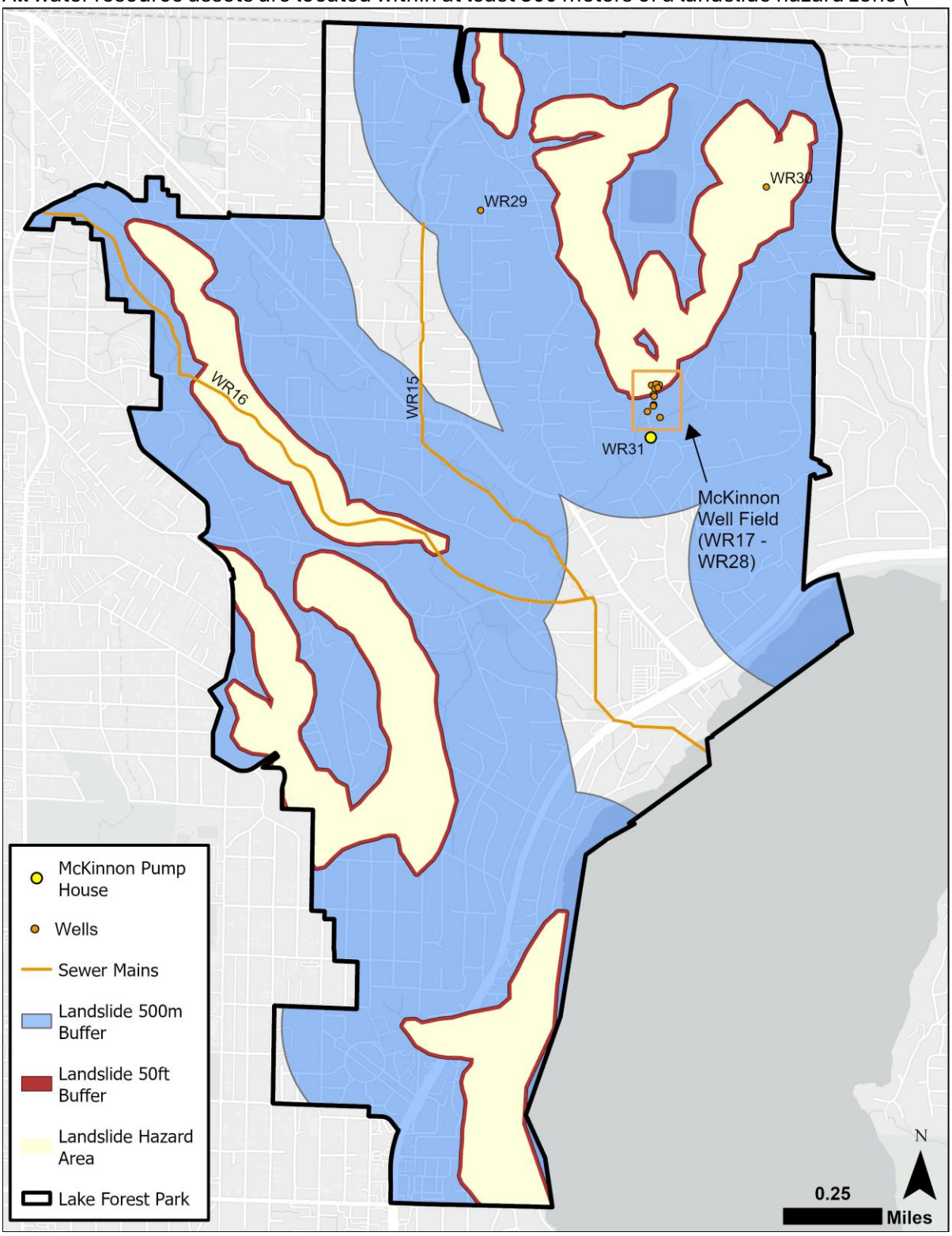

Figure 11). Portions of the Horizon and McKinnon Wellfields lie directly within high-risk landslide areas and are highly exposed to landslides. The Lyon Main also crosses areas of high landslide risk.

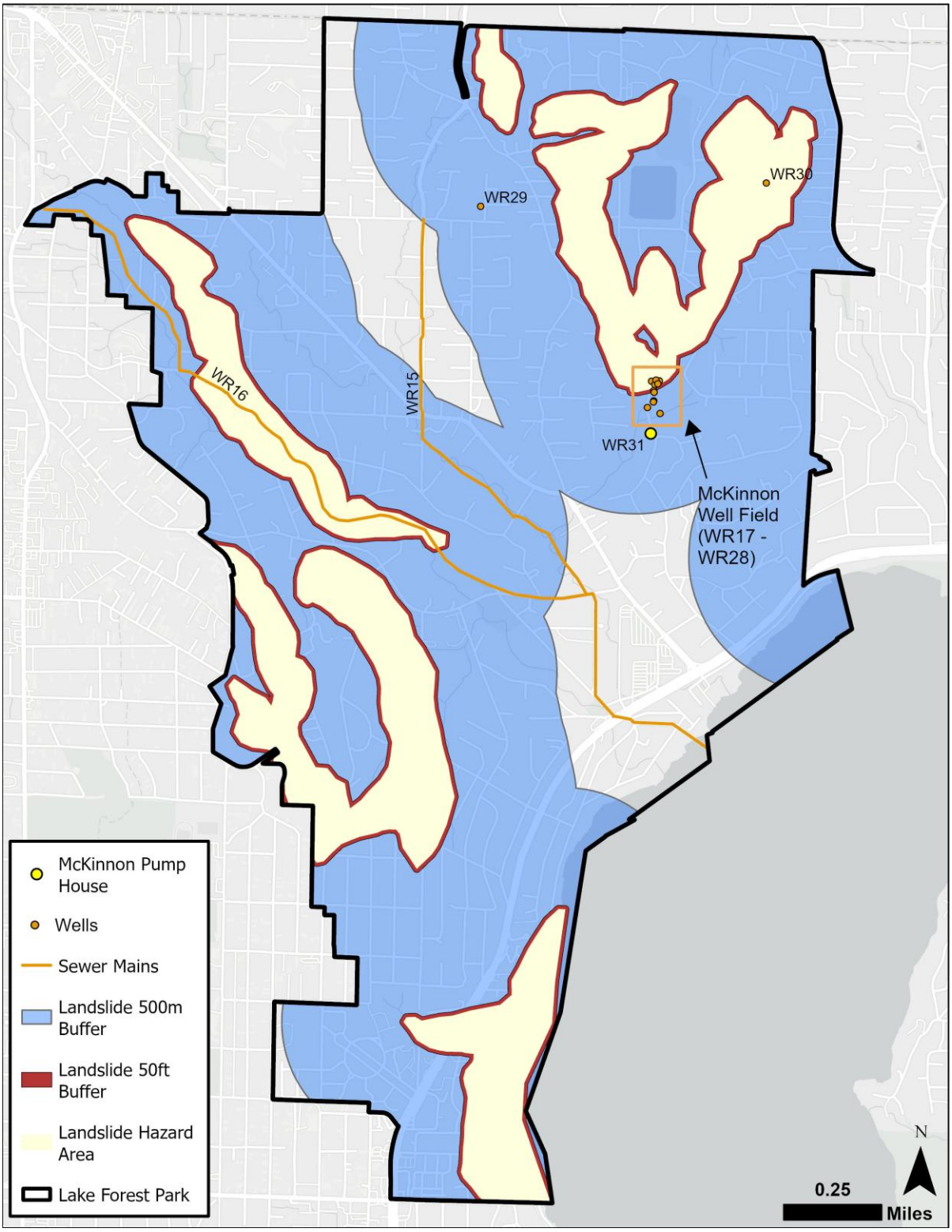


**Figure 11. Water resource assets in landslide risk areas. Map by Cascadia Consulting Group.**

# Sensitivity

**Table 14. Water resources climate hazard sensitivity rankings.**

| Asset type | Extreme Heat | Flooding | Landslide |
|---|---|---|---|
| **McKinnon Pump House** | Medium | High | High |
| **Wells** | Medium | High | High |
| **Stormwater Lines** | Low | Medium | High |
| **Overall Sensitivity** | **Medium** | **High** | **High** |

## EXTREME HEAT SENSITIVITY

Although extreme heat can accelerate pump motor wear and shorten the lifespan of water utility infrastructure (Water Utility Climate Alliance, 2020), the McKinnon Pump House has a medium heat sensitivity score and remains largely protected due to its modern design, redundant backup power, and a thermally insulated below-grade pump gallery (Lake Forest Park Water District , 2024). Increases in temperature are linked to changes in ground water pH and oxygen concentrations, potentially driving increases in water purification costs, indicating a medium exposure for the wells of Lake Forest Park (Riedel, 2019). While thermal expansion is a concern for mains, the two lines are buried and therefore maintain a low sensitivity to extreme heat.

## FLOODING SENSITIVITY

Floodwaters breaching the McKinnon Pump House could submerge pumps and electrical infrastructure, potentially damaging the equipment or rendering it inoperable (Randle, 2025). Because of this potential point of failure, the McKinnon Pump House has high sensitivity to flooding. Similarly, wells face high exposure because surface runoff can infiltrate wellheads and introduce pathogens and sediments into the drinking water supply (Mapili, et al., 2022). More extreme precipitation events can increase the likelihood that runoff will exceed conveyance capacity of stormwater lines, resulting in overflow flooding into streets and buildings, which warrants a medium exposure rating for stormwater mains (Erickson et al., 2010).

## LANDSLIDE SENSITIVITY

The pump house, wells and stormwater mains all have high sensitivity to landslides, since significant ground movement can inflict severe structural damage, disrupting operations or even causing system failure.

# Overall Vulnerability and Community Implications

The McKinnon Pump House and wells have high climate vulnerability due to their critical role in providing clean drinking water and their exposure to landslide risk. Mains have medium vulnerability given their moderate exposure and sensitivity (Table 15).

**Table 15. Overall vulnerability (exposure + sensitivity) of water resources.**

| Asset type | Exposure | Sensitivity | Overall Vulnerability |
|---|---|---|---|
| **McKinnon Pump House** | Medium | High | **High** |
| **Wells** | Medium | High | **High** |
| **Stormwater Mains** | Medium | Medium | **Medium** |

### Community Implications

Water resources and systems play a critical role for Lake Forest Park residents. Impacts on these systems can lead to widespread issues such as water quality, water scarcity, and stormwater flooding.

Drinking water from wells is stored in three steel reservoirs with a combined capacity of 480,000 gallons. On average, LFPWD customers use about 275,000 gallons of water per day; however, this can surge to 625,000 gallons on hot summer days (Lake Forest Park Water District, 2022). As climate change increases the frequency, duration, and intensity of heat waves, demand on the water provider is expected to rise, placing additional strain on the community. Rising temperatures may also lead to warmer reservoir water temperatures, leading to a higher risk of algal blooms, and increased sediment loads. Combined with reduced snowpack, these factors are projected to reduce water storage across the greater King County region, making it more difficult for Seattle Public Utilities and other water providers to meet demand (King County, 2017).

Increasingly frequent and intense rainfall is expected to raise stormwater runoff in the City of Lake Forest Park, potentially overwhelming systems and worsening flood impacts. Areas with a higher prevalence of impervious surface, such as roads, highways, and buildings, are especially at risk, as these surfaces contribute to increased runoff and prevent water from infiltrating into the ground (Washington State Department of Ecology, 2019). Due to the steep slopes and ravines in Lake Forest Park, excess runoff can trigger or worsen erosion, posing risks to water quality, increasing the potential for property damage, and contributing to more severe flooding (Lake Forest Park, 2018).

# References

American Forests. (2025). *Tree Equity Score*. Retrieved from https://www.treeequityscore.org/map#13/47.76487/-122.28618

Building Innovations Database. (2018, April 10). *Lyon Creek Flood Mitigation Project Restores Salmon Habitat in Lake Forest Park*. Retrieved from Building Innovations Database: https://www.buildinginnovations.org/case_study/lyon-creek-flood-mitigation-project-restores-salmon-habitat-in-lake-forest-park/

CDC. (2024). *Landslides and Mudslides and Your Safety*. Retrieved from https://www.cdc.gov/landslides-and-mudslides/about/index.html

City of Lake Forest Park. (2016). *City of Lake Forest Park Strategic Plan 2016-2020*. Retrieved from Lake Forest Park Washington: https://www.cityoflfp.gov/DocumentCenter/View/6202/Lake-Forest-Park-Strategic-Plan?bidId=

City of Lake Forest Park. (n.d.). *Lake Forest Park Stormwater Management Action Plan (SMAP)*. Retrieved from https://storymaps.arcgis.com/stories/07bceb383a274f168751a9033d2aa52d

City of Lake Forest Park. (n.d.). *Lake Forest Park Hazard Mitigation Plan: Park Plan Annex*. Lake Forest Park.

Climate Impacts Group. (2016). *SECTION 5 How Will Climate Change Affect Landslides, Erosion, and Sediment Transport*. Retrieved from https://cig.uw.edu/wp-content/uploads/sites/2/2014/11/ps-sok_sec05_sediment_2015.pdf

Erickson, A., Weiss, P., Gulliver, J., & Hozalski, R. (2010). *Stormwater Treatment: Assessment and Maintenance*. University of Minnesota, St. Anthony Falls Laboratory. Retrieved from https://stormwaterbook.safl.umn.edu/

Fehr & Peers. (2018). *Lake Forest Park Safe Highways Report*. City of Lake Forest Park.

FEMA. (2020). *FEMA*. Retrieved from FEMA Flood Map Service Center: https://msc.fema.gov/portal/search?AddressQuery=lake%20forest%20park

First Street Foundation. (2021, October 10). *First Street Foundation Releases Nationwide Resilience Report Finding 25% of All Critical Infrastructure and 23% of Roads Have Flood Risk Which Would Render Them Inoperable*. Retrieved from First Street Foundation: https://assets.firststreet.org/uploads/2021/10/PR_Locality-for-release-10.10.21.pdf

G.M., B., Jones, E., L.V., L., & Mirus, B. (2025). *Landslide Inventories across the United States (ver. 3.0, February 2025)*. USGS.

Governor's Salmon Recovery Office. (2022). *State of Salmon in Watersheds PRESSURE: Warming Temperatures Are Altering Salmon Streams*. Retrieved from https://stateofsalmon.wa.gov/executive-summary/challenges/climate/#:~:text=Water%20temperatures%20greater%20than%2064,degrees%20Fahrenheit%20can%20be%20lethal.&text=Without%20actions%20to%20reduce%20water,rivers%20where%20they%20can%20survive.

Guzman, A. (2024). Heavy rains and winds flood roads, topple trees, doubling damage from bomb cyclone. *Fox13 Seattle*.

(2020). doi:https://doi.org/10.1016/j.isprsjprs.2020.02.019

IPCC. (2023). Contribution of Working Groups I, II and III to the Sixth Assessment Report. *Climate Change 2023: Synthesis Report*.

King County. (2017). *Recommendations for King County to Help Ensure Adequate Water Supplies in Response to Climate Change*. King County. Retrieved from https://your.kingcounty.gov/dnrp/library/2017/kcr2896/kcr2896.pdf

King County Department of Assessments. (2024). *Lake Forest Park/ West Kenmore - Area 4*. Retrieved from King County Assessor: https://kingcounty.gov/en/dept/assessor/buildings-and-property/property-value-and-information/reports/area-reports/2024/residential-northwest/-/media/king-county/depts/assessor/buildings-property/reports/area-reports/2024/residential/004.pdf

King County GIS Center. (2016). *Landslide hazards; incorporated KC 1990 / annexed_landslide_sao1990_area*. King County. Retrieved from https://gis-kingcounty.opendata.arcgis.com/datasets/kingcounty::landslide-hazards-incorporated-kc-1990-annexed-landslide-sao1990-area/about

King County. (n.d.). *Drinking Water Emergencies*. Retrieved from https://kingcounty.gov/uk-ua/dept/dph/health-safety/environmental-health/healthy-water-air-soil/drinking-water/emergencies#:~:text=Group%20A%20water%20systems&text=In%20some%20emergency%20situations%2C%20like,treat%20drinking%20for%20emergency%20use.&text

LaCivita, L. (2024, May 15). *MRSC*. Retrieved from Adapting to Extreme Heat: Can Cities Prepare for a Hotter Future?: https://mrsc.org/stay-informed/mrsc-insight/may-2024/heat-action-planning

Lake Forest Park. (2024). *Climate Action Plan*. Lake Forest Park. Retrieved from https://www.cityoflfp.gov/DocumentCenter/View/12055/Lake-Forest-Park-Climate-Action-Plan-2024

Lake Forest Park Water District . (2024). *Ribbon Cutting – New Pump Facility Building*. Retrieved from Lake Forest Park Water District: https://www.lfpwd.org/ribbon-cutting-new-pump-facility-building/

Lake Forest Park Water District. (2022). *2022 Annual Water Quality Report*. Lake Forest Park: Lake Forest Park Water District. Retrieved from https://www.lfpwd.org/wp-content/uploads/LFPWD_CCR_2023.pdf

Lee, H., Calvin, K., Dasgupta, D., Krinner, G., Mukherji, A., Thorne, P., Trisos, C., Romero, J., Aldunce, P., Barrett, K., Blanco, G., Cheung, W. W. L., Connors, S. L., Denton, F., Diongue-Niang, A., Dodman, D., Garschagen, M., Geden, O., ... Zommers, Z. (2023). *Synthesis Report of the IPCC Sixth Assessment Report (AR6)*. Retrieved from https://www.ipcc.ch/report/sixth-assessment-report-cycle/

Lopes, L., Montero, A., Presiado, M., & Hamel, L. (2024). Americans' Challenges with Health Care Costs. *KFF*.

Mapili, K., Rhoads, W., Coughter, M., Pieper, K., Edwards, M., & Pruden, A. (2022). Occurrence of opportunistic pathogens in private wells after major flooding events: A four state molecular survey. *Science of The Total Environment*. Retrieved from https://doi.org/10.1016/j.scitotenv.2022.153901

McNamara, N. (2017). Burke-Gilman Trail In Lake Forest Park Hit By Landslide. *Patch*. Retrieved from https://patch.com/washington/shoreline/burke-gilman-trail-lake-forest-park-hit-landslide

PennState Extension. (2024, March 7). Heat Stress in Urban Trees. Retrieved from https://extension.psu.edu/heat-stress-in-urban-trees#:~:text=Those%20different%20sources%20of%20heat,dissipating%20heat%2C%20not%20making%20food.

Phair, V. (20214, October 18). Salmon are spawning across the Seattle area. Here's where to see them. *The Seattle Times*.

Riedel, T. (2019). Temperature-associated changes in groundwater quality. *Journal of Hydrology*. Retrieved from https://www.sciencedirect.com/science/article/abs/pii/S0022169419302173

Sapari, H., Selamat, M., Isa, M., Ismail, R., & Wan Mahiyuddin, W. (2023). The Impact of Heat Waves on Health Care Services in Low- or Middle-Income Countries: Protocol for a Systematic Review. *JMIR Research Protocols*, e44702.

Seattle City Light. (2024, July 5). *What Is a Peak Load and How Does It Affect You?* Retrieved from Powerlines: https://powerlines.seattle.gov/2024/07/05/what-is-a-peak-load-and-how-does-it-affect-you/

Shoreline Area News. (2024, December 18). Morning rainstorm flooded parts of Ballinger Way, forcing road closure. *Shoreline Area News*. Retrieved from https://www.shorelineareanews.com/2024/12/morning-rainstorm-flooded-parts-of.html

Snohomish County Public Works. (2006). *Intregrated Stormwater Management Program - Public involvment and Edication Strategy - Public Opinion Research - Individual Homeowners / Upland Areas*.

STORM. (2021). *GSI Guidebook DRAFT*.

Trust for Public Land. (2025). *Heat Severity - USA 2023*. Retrieved from https://www.arcgis.com/home/item.html?id=db5bdb0f0c8c4b85b8270ec67448a0b6

U.S. Census. (2022). *LEHD Origin-Destination Employment Statistics (LODES)*. Retrieved from United States Census Longitudinal Employer-Household Dynamics: https://lehd.ces.census.gov/data/

U.S. Food and Drug Administration. (2022). *Restaurants and Grocers Reopening After Hurricanes and Flooding*. Retrieved from https://www.fda.gov/food/food-safety-during-emergencies/restaurants-and-grocers-reopening-after-hurricanes-and-flooding

U.S. National Weather Service. (2025). *After a Flood*. Retrieved from https://www.weather.gov/safety/flood-after

Union of Concerned Scientists. (2018). *Climate Change, Extreme Precipitation, and Flooding: The Latest Science*. Retrieved from https://www.ucs.org/sites/default/files/attach/2018/07/gw-fact-sheet-epif.pdf

United States Environmental Protection Agency. (2025). *Climate Change Impacts on Transportation*. Retrieved from United States Environmental Protection Agency - Climate Change Impacts: https://www.epa.gov/climateimpacts/climate-change-impacts-transportation#:~:text=In%20coastal%20regions%2C%20rising%20sea,%2C%20ports%2C%20and%20coastal%20airports.&text=Increased%20local%20flooding%20can%20affect,materials%2C%20and%20cause%20traffic%20co

USGS Landslide Hazards Program. (n.d.). *What Are Landslides & How Can They Affect Me?* Retrieved from https://www.usgs.gov/programs/landslide-hazards/what-are-landslides-how-can-they-affect-me

Washington Department of Commerce. (2023). *Climate Element Planning Guidance*. Retrieved from https://deptofcommerce.app.box.com/s/fpg3h0lbwln2ctqjg7jg802h54ie19jx

Washington Department of Commerce. (2023). *Climate Element Planning Guidance*. Retrieved from https://deptofcommerce.app.box.com/s/fpg3h0lbwln2ctqjg7jg802h54ie19jx

Washington Division of Geology and Earth Resources. (n.d.). *Landslide Hazards in Washington State*. Retrieved from https://www2.clark.wa.gov/files/dept/community-

planning/shoreline-master-program/proposal-comments-received/futurewise-cd-2/geo-hazards/landslide-hazards/ger_fs1_landslides.pdf

Washington State Department of Ecology. (2019). *Stormwater & residential pollution*. Washington State Department of Ecology. Retrieved from https://ecology.wa.gov/water-shorelines/water-quality/nonpoint-pollution/stormwater

Washington State Department of Natural Resources. (2017, April 11). *What Are Landslides and How Do They Occur?* Retrieved from https://www.dnr.wa.gov/publications/ger_fs_landslide_processes.pdf

Washington State Legislature Joint Transportation Committee. (2023). *Nondrivers: Population, Demographics, & Analysis*. Retrieved from https://leg.wa.gov/media/41gegl2v/nondriversstudyfinalreportsummaryreport.pdf

Water Utility Climate Alliance. (2020). *Implications of Extreme Heat on Water Utility Staff*. Association of Metropolitan Water Agencies.

Wettstein, Z., Hall, J., Buck, C., Mitchell, S., & Hess, J. (2024). Impacts of the 2021 heat dome on emergency department visits, hospitalizations, and health system operations in three hospitals in Seattle, Washington. *JACEP Open*, e13098.

# Appendix 1. Exposure Rankings

Full exposure tables by individual asset

## Critical Facilities

| Asset | Extreme Heat | Flooding | Landslide |
|---|---|---|---|
| **Library** | High | Low | Low |
| **Police Station** | High | Low | Low |
| **Fire Station** | Medium | Low | Low |
| **City Hall** | High | Low | Low |
| **Brookside Elementary** | Medium | Low | Medium |
| **Lake Forest Park Elementary** | High | Low | Medium |
| **Grocery Store** | High | Low | Low |

## Transportation and Economy

| Asset type | Extreme Heat | Flooding | Landslide |
|---|---|---|---|
| **Bus route 331** | Low | Medium | Medium |
| **Bus route 322 (Overlaps with 372, 522, and 981)** | High | High | High |
| **Route 104** | Low | Medium | Medium |
| **Route 152** | High | High | High |
| **Bridge 1** | High | Low | Low |
| **Bridge 2** | Low | Medium | Low |
| **Bridge 3** | Low | Low | Low |
| **Bridge 4** | Low | Low | Low |
| **Bridge 5** | Low | Medium | Low |
| **Bridge 6** | Low | Medium | Low |
| **Bridge 7** | High | Medium | Low |
| **Town Center** | Low | Medium | Low |
| **Third Place Commons** | High | Low | Low |

## Community Resources and Housing

| Asset type | Extreme Heat | Flooding | Landslide |
|---|---|---|---|
| **Blue Heron Park** | Low | Medium | Medium |
| **Whispering Willow Park** | High | High | Medium |
| **Horizon View Park** | Low | Medium | High |
| **Eagle Scout Park** | High | High | Medium |
| **Lyon Creek Waterfront Preserve** | High | Low | Low |
| **Grace Cole Nature Park** | High | Medium | High |
| **Pfingst Animal Acres Park** | Low | High | Low |
| **Burke-Gilman Trail** | Low | Medium | Low |
| **Shoreline Interurban to Burke Gilman Trail Connector - South** | Low | Low | Medium |
| **Shoreline Interurban to Burke Gilman Trail Connector - North** | High | Low | Low |
| **Woodlands North Apartments** | Low | Low | High |
| **McAleer Creek** | Low | Low | Medium |
| **Lyon Creek** | High | Medium | High |

# Water Resources

| Asset type | Extreme Heat | Flooding | Landslide |
|---|---|---|---|
| **McAleer Trunk** | Medium | Medium | Medium |
| **Lyon Trunk** | Low | Low | High |
| **Well 1** | Low | Low | Medium |
| **Well 2** | Low | Low | High |
| **Well 3** | Low | Low | High |
| **Well 4** | Low | Low | High |
| **Well 5** | Low | Low | High |
| **Well 6** | Low | Low | High |
| **Well 7** | Low | Low | High |
| **Well 8** | Low | Low | High |
| **Well 9** | Low | Low | High |
| **Well 10** | Low | Low | Medium |
| **Well 11** | Low | Low | Medium |
| **Well 12** | Low | Low | Medium |
| **Well 13** | Low | Low | Medium |
| **Well 14** | Low | Low | High |
| **McKinnon Pump House** | Low | Medium | Low |

# Appendix 2. Sensitivity Rankings

## Critical Facilities

| Asset | Extreme Heat | Flooding | Landslide |
|---|---|---|---|
| **Library** | Low | High | High |
| **Police Station** | Low | High | High |
| **Fire Station** | Low | High | High |
| **Town Hall** | Low | High | High |
| **Brookside Elementary** | Low | High | High |
| **Lake Forest Park Elementary** | Low | High | High |
| **Grocery Store** | Low | High | High |

## Transportation and Economy

| Asset | Extreme Heat Sensitivity | Flooding Sensitivity | Landslide Sensitivity |
|---|---|---|---|
| **State Route 104** | Medium | Medium | High |
| **State Route 522** | Medium/High | Medium | High |
| **Bridges** | Medium | High | High |
| **Bus route 331** | Medium | Low | Low |
| **Bus route 322 (Overlaps with 372, 522, and 981)** | Medium | Low | Low |
| **Town Center** | Medium | High | High |
| **Third Place Commons** | Low | Medium | Medium |

## Community Resources and Housing

| Asset | Extreme Heat Sensitivity | Flooding Sensitivity | Landslide Sensitivity |
|---|---|---|---|
| **Parks** | Low | Medium | Medium |
| **Urban forests and trees** | Medium | Low | Medium |
| **Urban trails and paths** | Low | Medium | Medium |
| **Streams** | Medium | High | High |
| **Low-income housing** | Medium | High | High |
| **Adult housing** | Medium | High | High |

## Water Resources

| Asset type | Extreme Heat | Flooding | Landslide |
|---|---|---|---|
| **Water storage tanks** | Low/Medium | Medium | High |
| **Wells** | Low/Medium | Medium | High |
| **McKinnon Pump House** | Low | High | High |

# Appendix 3. Urban Tree Canopy Map