

# CHAPTER 18. WILDLAND FIRE

## 18.1 GENERAL BACKGROUND

The wildland fire season in Washington usually begins in early July and ends with precipitation in late September; however, wildland fires have occurred in every month of the year. Drought, snow pack, and local weather conditions can expand the length of the fire season.

People start most wildland fires; major causes include arson, recreational fires that get out of control, smoker carelessness, debris burning, and children playing with fire. From 1992 to 2001, on average, people caused more than 500 wildland fires each year on state-owned or protected lands; this compares to 135 fires caused by lightning strikes. Wildland fires started by lightning burn more state-protected acreage than any other cause, an average of 10,866 acres annually; human caused fires burn an average of 4,404 state-protected acres each year. Fires during the early and late shoulders of the fire season usually are associated with human-caused fires; fires during the peak period of July, August and early September often are related to thunderstorms and lightning strikes.

How a fire behaves primarily depends on the following:

- **Fuel**—Lighter fuels such as grasses, leaves and needles quickly expel moisture and burn rapidly, while heavier fuels such as tree branches, logs and trunks take longer to warm and ignite. Snags and hazard trees—those that are diseased, dying, or dead—are larger but less prolific west of the Cascades than east of the Cascades. In 2002, about 1.8 million acres of the state's 21 million acres of forestland contained trees killed or defoliated by forest insects and diseases.
- **Weather**—West of the Cascades, strong, dry east winds in late summer and early fall produce extreme fire conditions. East wind events can persist up to 48 hours, with wind speed reaching 60 miles per hour; these winds generally reach peak velocities during the night and early morning hours.
- **Thunderstorm activity**—The thunderstorm season typically begins in June with wet storms, and turns dry with little or no precipitation reaching the ground as the season progresses into July and August.

### DEFINITIONS

**Conflagration**—A fire that grows beyond its original source area to engulf adjoining regions. Wind, extremely dry or hazardous weather conditions, excessive fuel buildup and explosions are usually the elements behind a wildland fire conflagration.

**Firestorm**—A fire that expands to cover a large area, often more than a square mile. A firestorm usually occurs when many individual fires grow together into one. The involved area becomes so hot that all combustible materials ignite, even if they are not exposed to direct flame. Temperatures may exceed 1000°C. Superheated air and hot gases of combustion rise over the fire zone, drawing surface winds in from all sides, often at velocities approaching 50 miles per hour. Although firestorms seldom spread because of the inward direction of the winds, once started there is no known way of stopping them. Within the area of the fire, lethal concentrations of carbon monoxide are present; combined with the intense heat, this poses a serious life threat to responding fire forces. In very large events, the rising column of heated air and combustion gases carries enough soot and particulate matter into the upper atmosphere to cause cloud nucleation, creating a locally intense thunderstorm and the hazard of lightning strikes.

**Interface Area**—An area susceptible to wildland fires and where wildland vegetation and urban or suburban development occur together. An example would be smaller urban areas and dispersed rural housing in forested areas.

**Wildland Fire**—Fires that result in uncontrolled destruction of forests, brush, field crops, grasslands, and real and personal property in non-urban areas. Because of their distance from firefighting resources, they can be difficult to contain and can cause a great deal of destruction.

- **Terrain**—The topography of a region influences the amount and moisture of fuel; the impact of weather conditions such as temperature and wind; potential barriers to fire spread, such as highways and lakes; and elevation and slope of land forms (fire spreads more easily uphill than downhill).
- **Time of Day**—A fire’s peak burning period generally is between 1 p.m. and 6 p.m.

Short-term loss caused by a wildland fire can include the destruction of timber, wildlife habitat, and scenic vistas. Vulnerability to flooding increases, due to the destruction of watersheds. Long-term effects include smaller timber harvests, reduced access to affected recreational areas, and destruction of cultural and economic resources and community infrastructure.

## **18.2 HAZARD PROFILE**

### **18.2.1 Past Events**

Since 1979, Snohomish County has experienced only two forest fires of 100 acres or more. A 750-acre fire in the Marblemount area during the El Nino summer of 1997 was attributed to a lengthened growing season, warmer than normal temperatures and heavy windfalls from the previous year’s storms. There is no record of any large wildland fires (greater than 1,500 acres) in the County since 1900. The Washington Department of Natural Resources (DNR) has records of 845 wildland fire starts dating back to 1970. The federal government has records of 210 fires in federal forests in Snohomish County since 1987.

Wildland fires historically were not considered a hazard, as fire is a normal part of most forest and range ecosystems in the temperate regions of the world, including Snohomish County. Fires historically burn on a fairly regular cycle, recycling carbon and nutrients stored in the ecosystem, and strongly affecting the species within the ecosystem. The burning cycle in western Washington is every 100 to 150 years. Controlled burns have also been conducted because the fire cycle is an important aspect of management for many ecosystems. These are not considered hazards unless they get out of control. None of Washington State’s most significant wildland fires have occurred in Snohomish County, although smaller wildland fires have occurred in the region.

### **18.2.2 Location**

Map 18-1 shows wildland urban interface areas (WUIAs) for Snohomish County as defined by the DNR (September 2004). This map is based on data from the current National Fire Protection Association risk assessment (NFPA 299). This data has been updated by the fire chiefs in Snohomish County Fire Zone 11 to better represent the wildland fire risk they are concerned about as first responders. The NFPA 299 hazard ranking process scores the risk and vulnerability of a planning area by looking at the following components:

- Subdivision design (ingress, egress, road width, all season road condition, Fire Service access, signage)
- Vegetation
- Topography
- Other rating factors (weather, history, building separation)
- Roofing material
- Building condition
- Available fire protection (water supply, response time, fire protection systems)

- Utilities

A planning area is ranked as a low, moderate, high or extreme hazard area based on its score.

WUIAs tend to be in the foothills and valleys east of Puget Sound stretching into the lower reaches of the Cascades, where people are present in semi-urban densities. Wildland fire analysis has been done using WUIA data created by the DNR, which analyzed areas with population densities of at least 20 people per square mile, defensible space, access and ingress, water capabilities, fuel supply, weather and topography and speed of response.

### **18.2.3 Frequency**

According to data tracked by the DNR on lands that it is responsible for protecting, Snohomish County has had 794 wildland fire incidents since 1970. This is an average of 20 per year, with a high of 45 incidents in 1974 and 1990 and a low of 1 incident in 1971.

### **18.2.4 Severity**

Potential losses from wildland fire include human life, structures and other improvements, and natural resources. There are no recorded incidents of loss of life from wildland fires in Snohomish County, and the risk from wildland fire has been deemed moderate by the state. Given the immediate response times to reported fires, the likelihood of injuries and casualties is minimal. Smoke and air pollution from wildland fires can be a health hazard, especially for sensitive populations including children, the elderly and those with respiratory and cardiovascular diseases. Wildland fire may also threaten the health and safety of those fighting the fires. First responders are exposed to the dangers from the initial incident and after-effects from smoke inhalation and heat stroke. In addition, wildland fire can lead to ancillary impacts such as landslides in steep ravine areas and flooding due to the impacts of silt in local watersheds.

### **18.2.5 Warning Time**

Wildland fires are typically caused by humans, whether intentionally or accidentally. There is no way to predict when one might break out. Since it is reported that fireworks often cause brush fires, extra diligence is warranted around the Fourth of July when the use of fireworks is highest. Dry lightning may also trigger wildland fires. Severe weather can be predicted, so special attention can be paid during weather events that may trigger wildland fires. If a fire does break out and spread rapidly, residents may need to evacuate within days or hours. Reliable National Weather Service lightning warnings are available on average 24 to 48 hours prior to a significant electrical storm. Dry seasons and droughts are factors that greatly increase fire likelihood. Once a fire has started, fire alerting is reasonably rapid in most cases. The rapid spread of cellular and two-way radio communications in recent years has further contributed to a significant improvement in warning time.

## **18.3 SECONDARY HAZARDS**

Wildland fires can generate a range of secondary effects, which in some cases may cause more widespread and prolonged damage than the fire itself. Fires can cause direct economic losses in the reduction of harvestable timber and indirect economic losses in reduced tourism. Wildland fires cause the contamination of reservoirs, destroy transmission lines and contribute to flooding. They strip slopes of vegetation, exposing them to greater amounts of runoff. This in turn can weaken soils and cause failures on slopes. Major landslides can occur several years after a wildland fire. Most wildland fires burn hot and for long durations that can bake soils, especially those high in clay content, thus increasing the imperviousness of the ground. This increases the runoff generated by storm events, thus increasing the chance of flooding.

## **18.4 CLIMATE CHANGE IMPACTS**

Fire in western ecosystems is determined by climate variability, local topography, and human intervention. Climate change has the potential to affect multiple elements of the wildland fire system: fire behavior, ignitions, fire management, and vegetation fuels. Hot dry spells create the highest fire risk. Increased temperatures may intensify wildland fire danger by warming and drying out vegetation. When climate alters fuel loads and fuel moisture, forest susceptibility to wildland fires changes. Climate change also may increase winds that spread fires. Faster fires are harder to contain, and thus are more likely to expand into residential neighborhoods.

Historically, drought patterns in the West are related to large-scale climate patterns in the Pacific and Atlantic oceans. The El Niño–Southern Oscillation in the Pacific varies on a 5- to 7-year cycle, the Pacific Decadal Oscillation varies on a 20- to 30-year cycle, and the Atlantic Multidecadal Oscillation varies on a 65- to 80-year cycle. As these large-scale ocean climate patterns vary in relation to each other, drought conditions in the U.S. shift from region to region. El Niño years bring drier conditions to the Pacific Northwest and more fires.

Climate scenarios project summer temperature increases between 2°C and 5°C and precipitation decreases of up to 15 percent. Such conditions would exacerbate summer drought and further promote high-elevation wildland fires, releasing stores of carbon and further contributing to the buildup of greenhouse gases. Forest response to increased atmospheric carbon dioxide—the so-called “fertilization effect”—could also contribute to more tree growth and thus more fuel for fires, but the effects of carbon dioxide on mature forests are still largely unknown. High carbon dioxide levels should enhance tree recovery after fire and young forest regrowth, as long as sufficient nutrients and soil moisture are available, although the latter is in question for many parts of the western United States because of climate change.

## **18.5 EXPOSURE**

### **18.5.1 Population**

Population could not be examined by WUIA because census block group areas do not coincide with the fire risk areas. However, population was estimated using the structure count of buildings in the WUIA and applying the census value of 2.65 persons per household for Snohomish County. Using this approach, it is estimated that the population living with WUIAs is 36,514. This represents 5.18 percent of the total county population.

### **18.5.2 Property**

Property damage from wildland fires can be severe and can significantly alter entire communities. Tables 18-1, 18-2, 18-3 and 18-4 display the number of homes exposed to the various wildfire hazard zones within the planning area and their values. The unincorporated County and the cities of Darrington, Granite Falls, Index, Monroe and Snohomish all have assets exposed to wildland fire hazards. The total value of these assets is \$4.46 billion, which represents 4.75 percent of the total assessed value of improvements in the County.

### **18.5.3 Critical Facilities and Infrastructure**

Table 18-5 identifies critical facilities exposed to the wildland fire hazard in the county.

| <b>TABLE 18-1.<br/>SNOHOMISH COUNTY STRUCTURES EXPOSED TO EXTREME WILDLAND FIRE HAZARDS</b> |                   |                     |                     |                     |              |
|---|-------------------|---------------------|---------------------|---------------------|--------------|
| Jurisdiction  | Buildings Exposed | Assessed Value      |                     |                     | % of AV      |
|   |                   | Structure           | Contents            | Total               |              |
| Darrington  | 4                 | \$654,700           | \$459,490           | \$1,114,190         | 0.81%        |
| Unincorporated County   | 305               | \$42,517,700        | \$30,269,960        | \$72,787,660        | 0.20%        |
| <b>Total</b>  | <b>309</b>        | <b>\$43,172,400</b> | <b>\$30,729,450</b> | <b>\$73,901,850</b> | <b>0.08%</b> |

| <b>TABLE 18-2.<br/>SNOHOMISH COUNTY STRUCTURES EXPOSED TO HIGH WILDLAND FIRE HAZARDS</b> |                   |                      |                      |                      |              |
|--|-------------------|----------------------|----------------------|----------------------|--------------|
| Jurisdiction   | Buildings Exposed | Assessed Value       |                      |                      | % of AV      |
|  |                   | Structure            | Contents             | Total                |              |
| Darrington   | 3                 | \$711,000            | \$497,700            | \$1,208,700          | 0.9%         |
| Granite Falls  | 1                 | \$719,100            | \$1,078,650          | \$1,797,750          | 0.4%         |
| Index  | 1                 | \$284,000            | \$284,000            | \$568,000            | 2.5%         |
| Unincorporated County  | 3,879             | \$523,433,250        | \$373,234,410        | \$896,667,660        | 2.4%         |
| <b>Total</b>   | <b>3,884</b>      | <b>\$525,147,350</b> | <b>\$375,094,760</b> | <b>\$900,242,110</b> | <b>0.96%</b> |

| <b>TABLE 18-3.<br/>SNOHOMISH COUNTY STRUCTURES EXPOSED TO MODERATE WILDLAND FIRE HAZARDS</b> |                   |                        |                        |                        |              |
|--|-------------------|------------------------|------------------------|------------------------|--------------|
| Jurisdiction   | Buildings Exposed | Assessed Value         |                        |                        | % of AV      |
|  |                   | Structure              | Contents               | Total                  |              |
| Arlington  | 240               | \$65,824,900           | \$50,616,040           | \$116,440,940          | 5.2%         |
| Darrington   | 5                 | \$4,134,800            | \$6,202,200            | \$10,337,000           | 7.5%         |
| Gold Bar   | 38                | \$6,166,300            | \$4,317,610            | \$10,483,910           | 6.0%         |
| Index  | 107               | \$12,827,000           | \$9,754,310            | \$22,581,310           | 97.5%        |
| Monroe   | 83                | \$12,829,800           | \$9,125,810            | \$21,955,610           | 1.0%         |
| Snohomish  | 1                 | \$217,400              | \$326,100              | \$543,500              | 0.0%         |
| Stanwood   | 137               | \$28,298,200           | \$19,910,530           | \$48,208,730           | 5.1%         |
| Sultan   | 882               | \$154,256,800          | \$119,167,360          | \$273,424,160          | 56.5%        |
| Unincorporated County  | 11,421            | \$2,095,192,050        | \$1,481,106,350        | \$3,576,298,400        | 9.7%         |
| <b>Total</b>   | <b>12,914</b>     | <b>\$2,379,747,250</b> | <b>\$1,700,526,310</b> | <b>\$4,080,273,560</b> | <b>4.36%</b> |

| Jurisdiction          | Buildings Exposed | Assessed Value         |                        |                        | % of AV      |
|-----------------------|-------------------|------------------------|------------------------|------------------------|--------------|
|                       |                   | Structure              | Contents               | Total                  |              |
| Arlington             | 1,125             | \$156,214,900          | \$123,674,000          | \$279,888,900          | 12.5%        |
| Gold Bar              | 781               | \$93,463,100           | \$68,733,350           | \$162,196,450          | 92.5%        |
| Granite Falls         | 733               | \$160,343,150          | \$133,336,805          | \$293,679,955          | 71.6%        |
| Marysville            | 538               | \$131,937,000          | \$108,789,690          | \$240,726,690          | 4.2%         |
| Monroe                | 433               | \$104,001,500          | \$81,725,040           | \$185,726,540          | 8.2%         |
| Stanwood              | 502               | \$92,140,200           | \$65,768,040           | \$157,908,240          | 16.7%        |
| Unincorporated County | 10,701            | \$2,202,312,750        | \$1,572,255,050        | \$3,774,567,800        | 10.2%        |
| <b>Total</b>          | <b>14,813</b>     | <b>\$2,940,412,600</b> | <b>\$2,154,281,975</b> | <b>\$5,094,694,575</b> | <b>5.45%</b> |

|                             |            |
|-----------------------------|------------|
| Medical and Health Services | 2          |
| Government Function         | 10         |
| Protective Function         | 21         |
| Schools                     | 30         |
| Hazmat                      | 2          |
| Other Critical Function     | 3          |
| Bridges                     | 146        |
| Water                       | 4          |
| Waste Water                 | 0          |
| Communications              | 0          |
| <b>Total</b>                | <b>218</b> |

Currently there are 15 registered Tier II hazardous material containment sites in WUIAs. During a wildland fire event, these materials could rupture due to excessive heat and act as fuel for the fire, causing rapid spreading and escalating the fire to unmanageable levels. In addition they could leak into surrounding areas, saturating soils and seeping into rivers or into Puget Sound, and have a disastrous effect on the environment.

In the event of wildland fire, there would likely be little damage to the majority of infrastructure. Most road and railroads would be without damage except in the worst scenarios. Power lines are the most a risk to wildland fire because most are made of wood and susceptible to burning. GIS analysis shows 66 sections of Puget Sound Energy transmission lines in Snohomish County. A total of 11 sections cross

fire risk areas and could be vulnerable during a fire event. In the event of a wildland fire, pipelines could provide a source of fuel and lead to a catastrophic explosion.

### **18.5.4 Environment**

Wildland fires can cause severe environmental impacts:

- **Damaged Fisheries**—Critical trout, salmon and steelhead fisheries in the Pacific Northwest can suffer from increased water temperatures, sedimentation, and changes in water quality.
- **Soil Erosion**—The protective covering provided by foliage and dead organic matter is removed, leaving the soil fully exposed to wind and water erosion. Accelerated soil erosion occurs, causing landslides and threatening aquatic habitats.
- **Spread of Invasive Plant Species**—Non-native woody plant species frequently invade burned areas. When weeds become established, they can dominate the plant cover over broad landscapes, and become difficult and costly to control.
- **Disease and Insect Infestations**—Unless diseased or insect-infested trees are swiftly removed, infestations and disease can spread to healthy forests and private lands. Timely active management actions are needed to remove diseased or infested trees.
- **Destroyed Endangered Species Habitat**—Catastrophic fires can have devastating consequences for endangered species. For instance, the Biscuit Fire in Oregon destroyed 125,000 to 150,000 acres of spotted owl habitat.
- **Soil Sterilization**—Topsoil exposed to extreme heat can become water repellant, and soil nutrients may be lost. It can take decades or even centuries for ecosystems to recover from a fire. Some fires burn so hot that they can sterilize the soil.

## **18.6 VULNERABILITY**

Structures, above-ground infrastructure, critical facilities and natural environments are all vulnerable to the wildland fire hazard. There is currently no validated damage function available to support wildland fire mitigation planning. Except as discussed in this section, vulnerable populations, property, infrastructure and environment are assumed to be the same as described in the section on exposure.

All residents of the county are vulnerable to wildland fire to some degree, but particular segments are more vulnerable than others. Some land uses are more vulnerable to wildland fire, such as single-family rural residential, while others are less vulnerable, such as agricultural land, gravel mining, and cemeteries. Critical facilities that are of wood frame construction are especially vulnerable during wildland fire events.

In the event of wildland fire, there would likely be little damage to the majority of infrastructure. Most roads and railroads would be without damage except in the worst scenarios. Power lines are the most at risk from wildland fire because most poles are made of wood and susceptible to burning. Fires can create conditions that block or prevent access throughout the county and can isolate residents and emergency service providers needing to get to vulnerable populations or to make repairs. Wildland fire typically does not have a major direct impact on bridges. However, wildland fires can create conditions in which bridges are obstructed. Many bridges in areas of high to moderate fire risk are important because they provide the only ingress and egress to large areas and in some cases to isolated neighborhoods.

The potential for large wildland fires in Snohomish County is normally small. Improved fire spotting techniques, better equipment, and trained personnel are major factors, as are the county's wet climate and normally low fire fuel conditions. The wet climate and the infrequent occurrence of strong, dry winds

prevent potential fuel from reaching a combustible state. Snohomish County's forests retain moisture and are resistant to an abnormal dry spell.

## **18.7 FUTURE TRENDS IN DEVELOPMENT**

It is assumed that development trends in Snohomish County are not such that there is major concern about development in identified wildland fire hazard zones. The County is equipped with an effective Comprehensive Plan to manage its growth so that expansion into hazard areas is discouraged by the County's land use policy.

## **18.8 SCENARIO**

With increased interface development, a wildland fire in Snohomish County has the potential to cause even greater damage than the Marblemount fire. A 21st century firestorm could burn an area approaching the size of the Marblemount burn, but because of increased development in the area, it would destroy much more property and put more lives at risk.

A major conflagration might begin with a wet spring, adding to the fuels that are already present on the forest floor. Flashy fuels would build throughout the spring. The summer could see the onset of insect infestation. A dry summer could follow the wet spring, exacerbated by dry hot Chinook winds. The Labor Day holiday inevitably brings many hikers and campers to the area. Careless campfires or a tossed lit cigarette, or a sudden lighting storm would trigger a multitude of small isolated fires.

The embers from these smaller fires could be carried miles by hot, dry prevailing winds. The deposition zone for these embers could be deep in the forests and interface zones. Fires that start in flat areas would move more slowly, but wind would still push them. It is not unusual for a wildland fire pushed by wind to burn the ground fuel and later climb into the crown and reverse its track. This is one of many ways that fires can escape containment, typically during periods when response capabilities are overwhelmed.

These new small fires would most likely merge. Suppression resources would be redirected from protecting the natural resources to saving the more remote subdivisions.

The worst-case scenario in Snohomish County would probably coincide with an active fire season in the entire American west, spreading resources thin. "Hot shot" teams would be either exhausted or committed to fighting conflagrations occurring in other areas. They could be unavailable to assist Snohomish County. Many federal assets would likely be responding to other fires that started earlier in the season. While local fire districts would be effective in the urban interface areas, they have limited wildland fire capabilities or experience, and they would have a difficult time responding to the ignition zones. Additionally, starting in the 2003 fire season, air tanker support was cut by one-third. Even though the existence and spread of the fire would be well known, it may not be possible to respond to it adequately. Thus an initially manageable fire could become significant before meaningful resources are dispatched.

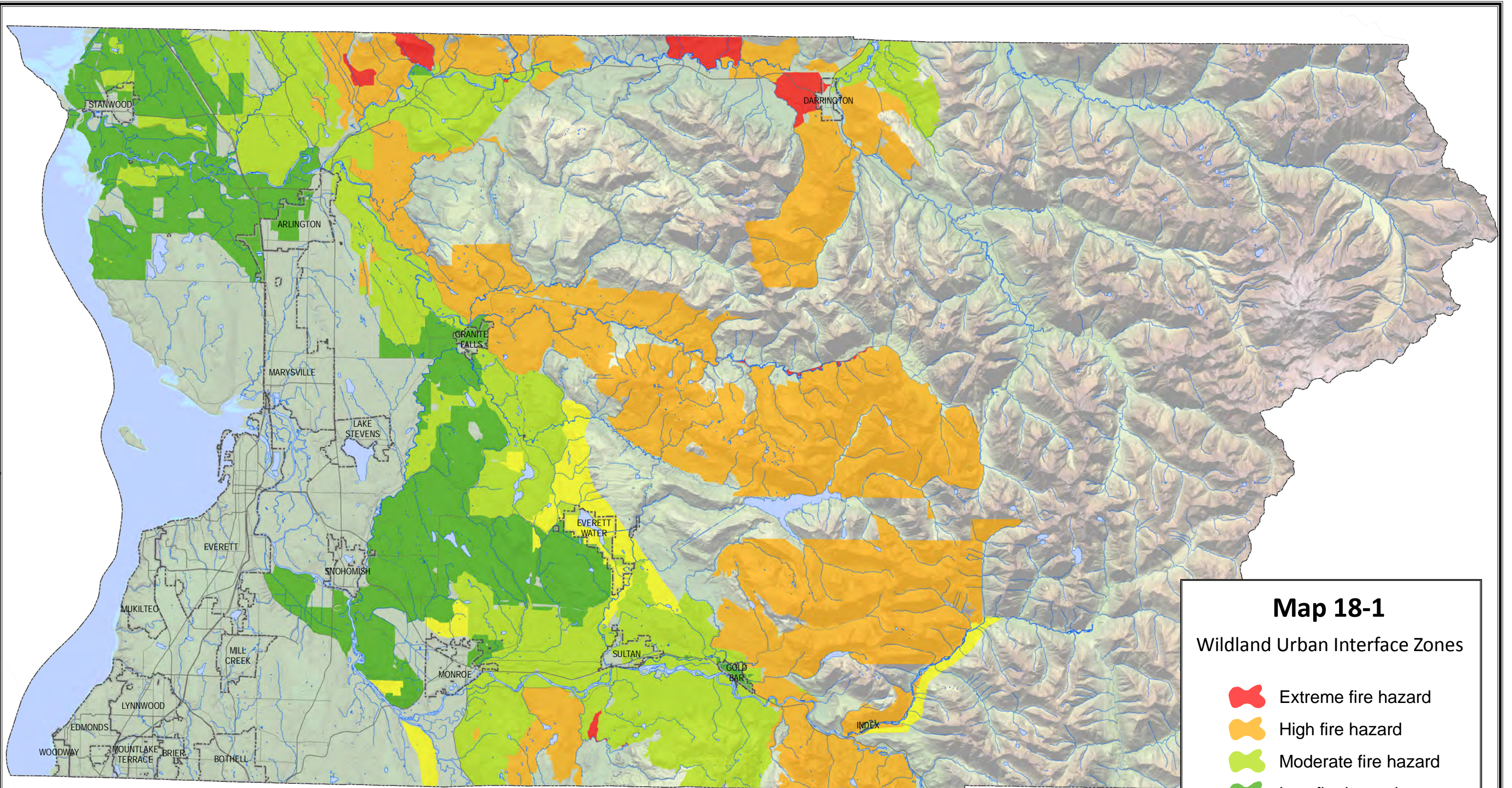
To further complicate the problem, heavy rains could follow, causing flooding and landslides and releasing tons of sediment into rivers, permanently changing the floodplains of the County and damaging sensitive habitat and riparian areas. Such a fire followed by rain could release millions of cubic yards of sediment into streams for years, creating new floodplains and changing existing ones. With the forests removed from the watershed, discharges could double. Floods that could be expected every 50 years may occur every couple of years. And, with streams unable to carry this increased discharge because of increased sediment, floodplains and floodplain elevations would increase. Construction along Snohomish County rivers has been increasing proportionally faster than that of the County as a whole. The number of homes subject to flooding would increase substantially in a post-wildland fire situation. Indirect and longer-term economic losses are difficult to predict, but could double the price tag for such an event.

## 18.9 ISSUES





The major issues of for wildland fire are the following:

- There are a large number of critical facilities (54 percent) that are wood-frame structures in wildland urban interface areas.
- There are large clusters of structures (71 percent) that are wood-frame structures in wildland urban interface areas that are on small lots.
- The perception of wildland fires as a high risk hazard because a major event has not occurred within the planning area.
- Climate change could impact the risk exposure to this hazard in the future.





**Map 18-1**  
Wildland Urban Interface Zones

-  Extreme fire hazard
-  High fire hazard
-  Moderate fire hazard
-  Low fire hazard
-  Potential fire hazard\*

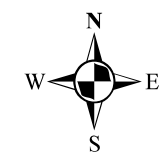
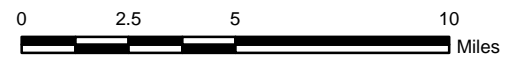
\*Potential fire hazard areas developed by Snohomish County Fire District Planning Partners to better represent Wildfire Risk in Snohomish County.



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Tetra Tech, Inc.  
May 2010

Data Sources:  
Snohomish County  
US Geological Survey  
Washington State Department of Natural Resources  
Division of Geology and Earth Resources



# CHAPTER 19. PLANNING AREA RISK RANKING

A risk ranking was performed for the hazards of concern described in this plan. This risk ranking assesses the probability of each hazard’s occurrence as well as its likely impact on the people, property, and economy of the Snohomish County planning area. The risk ranking was conducted via facilitated brainstorming sessions with the Steering Committee. Estimates of risk were generated with data from HAZUS-MH using methodologies promoted by FEMA. The results of this exercise are used in establishing mitigation priorities for the Snohomish County partnership.

## 19.1 PROBABILITY OF OCCURRENCE

The probability of occurrence of a hazard is indicated by a probability factor based on likelihood of annual occurrence:

- High—Hazard event is likely to occur within 25 years (Probability Factor = 3)
- Medium—Hazard event is likely to occur within 100 years (Probability Factor =2)
- Low—Hazard event is not likely to occur within 100 years (Probability Factor =1)
- No exposure—There is no probability of occurrence (Probability Factor = 0)

The assessment of hazard frequency is generally based on past hazard events in the area. Table 19-1 summarizes the probability assessment for each hazard of concern for this plan.

| TABLE 19-1.<br>PROBABILITY OF HAZARDS |                                 |                    |
|---------------------------------------|---------------------------------|--------------------|
| Hazard Event                          | Probability (high, medium, low) | Probability Factor |
| Avalanche                             | Low                             | 1                  |
| Dam Failure                           | Low                             | 1                  |
| Earthquake                            | High                            | 3                  |
| Flood                                 | High                            | 3                  |
| Landslide                             | High                            | 3                  |
| Severe Weather                        | High                            | 3                  |
| Tsunami                               | Low                             | 1                  |
| Volcano                               | Low                             | 1                  |
| Wildland Fire                         | Medium                          | 2                  |

## 19.2 IMPACT

Hazard impacts were assessed in three categories: impacts on people, impacts on property and impacts on County operations. Numerical impact factors were assigned as follows:

- **People**—Values were assigned based on the percentage of the total *population exposed* to the hazard event. The degree of impact on individuals will vary and is not measurable, so the

calculation assumes for simplicity and consistency that all people exposed to a hazard because they live in a hazard zone will be equally impacted when a hazard event occurs. It should be noted that planners can use an element of subjectivity when assigning values for impacts on people. Impact factors were assigned as follows:

- High—50 percent or more of the population is exposed to a hazard (Impact Factor = 3)
- Medium—25 percent to 49 percent of the population is exposed to a hazard (Impact Factor = 2)
- Low—25 percent or less of the population is exposed to the hazard (Impact Factor = 1)
- No impact—None of the population is exposed to a hazard (Impact Factor = 0)
- **Property**—Values were assigned based on the percentage of the total *value of County facilities exposed* to the hazard event. For this exercise, value is considered as the full replacement cost of a County facility. Impact factors were assigned as follows:
  - High—30 percent or more of the total replacement costs for all facilities is exposed to a hazard (Impact Factor = 3)
  - Medium—15 percent to 29 percent of the total replacement costs for all facilities is exposed to a hazard (Impact Factor = 2)
  - Low—14 percent or less of the total replacement costs of all facilities is exposed to the hazard (Impact Factor = 1)
  - No impact—No facilities are exposed to a hazard (Impact Factor = 0)
- **Operations**—Values were assigned based on the *time required for critical facilities to become 100-percent operational* after a hazard event, also called the “functional downtime.” For this exercise, estimates of functional downtime per facility type are averaged. Levees take longer to repair than revetments or pump stations. Impact factors were assigned as follows:
  - High—Functional downtime of 365 days or more. (Impact Factor = 3)
  - Medium—Functional downtime of 180 to 364 days (Impact Factor = 2)
  - Low—Functional downtime of 180 days or less (Impact Factor = 1)
  - No impact—No functional downtime of facilities (Impact Factor = 0)

The impacts of each hazard category were assigned a weighting factor to reflect the significance of the impact. These weighting factors are consistent with those typically used for measuring the benefits of hazard mitigation actions: impact on people was given a weighting factor of 3; impact on property was given a weighting factor of 2; and impact on the operations was given a weighting factor of 1.

Tables 19-2, 19-3 and 19-4 summarize the impacts for each hazard.

### **19.3 RISK RATING AND RANKING**

The risk rating for each hazard was determined by multiplying the probability factor by the sum of the weighted impact factors for people, property and operations, as summarized in Table 19-5.

Based on these ratings, a priority of high, medium or low was assigned to each hazard. The hazards ranked as being of highest concern to the County are flood, severe weather, and earthquake. Hazards ranked as being of medium concern for the County are wildland fire and landslide. The hazards ranked as being of lowest concern are volcano, avalanche, dam failure and tsunami. Table 19-6 shows the hazard risk ranking.

**TABLE 19-2.  
IMPACT ON PEOPLE FROM HAZARDS**

| Hazard Event   | Impact (high, medium, low) | Impact Factor | Multiplied by Weighting Factor (3) |
|----------------|----------------------------|---------------|------------------------------------|
| Avalanche      | Low                        | 1             | 3                                  |
| Dam Failure    | Low                        | 1             | 3                                  |
| Earthquake     | High                       | 3             | 9                                  |
| Flooding       | High <sup>a</sup>          | 3             | 9                                  |
| Landslide      | Low                        | 1             | 3                                  |
| Severe Weather | Medium                     | 2             | 6                                  |
| Tsunami        | Low                        | 1             | 3                                  |
| Volcano        | Low                        | 1             | 3                                  |
| Wildland Fire  | Low                        | 1             | 3                                  |

a. Although the statistical data warrant a medium score for the flood hazard's impact on people, a high score was assigned to recognize indirect impacts that floods have on populations who live outside the floodplain, such as impacts on those who work for businesses within the floodplain or must drive through the floodplain during flood events. These impacts are not measurable, yet can be significant.

**TABLE 19-3.  
IMPACT ON PROPERTY FROM HAZARDS**

| Hazard Event   | Impact (high, medium, low) | Impact Factor | Multiplied by Weighting Factor (2) |
|----------------|----------------------------|---------------|------------------------------------|
| Avalanche      | Low                        | 1             | 2                                  |
| Dam Failure    | Low                        | 1             | 2                                  |
| Earthquake     | High                       | 3             | 6                                  |
| Flooding       | Medium                     | 2             | 4                                  |
| Landslide      | Low                        | 1             | 2                                  |
| Severe Weather | Medium                     | 2             | 4                                  |
| Tsunami        | Low                        | 1             | 2                                  |
| Volcano        | Low                        | 1             | 2                                  |
| Wildland Fire  | Low                        | 1             | 2                                  |

| <b>TABLE 19-4.<br/>IMPACT ON OPERATIONS FROM HAZARDS</b> |                            |               |                                    |
|--|----------------------------|---------------|------------------------------------|
| Hazard Event   | Impact (high, medium, low) | Impact Factor | Multiplied by Weighting Factor (1) |
| Avalanche  | Low                        | 1             | 1                                  |
| Dam Failure  | Low                        | 1             | 1                                  |
| Earthquake   | Medium                     | 2             | 2                                  |
| Flooding   | High                       | 3             | 3                                  |
| Landslide  | Low                        | 1             | 1                                  |
| Severe Weather   | Medium                     | 2             | 2                                  |
| Tsunami  | Low                        | 1             | 1                                  |
| Volcano  | Low                        | 1             | 1                                  |
| Wildland Fire  | Low                        | 1             | 1                                  |

| <b>TABLE 19-5.<br/>HAZARD RISK RATING</b> |                    |                                |                              |
|---|--------------------|--------------------------------|------------------------------|
| Hazard Event                              | Probability Factor | Sum of Weighted Impact Factors | Total (Probability x Impact) |
| Avalanche                                 | 1                  | 3+2+1=6                        | 6                            |
| Dam Failure                               | 1                  | 3+2+1=6                        | 6                            |
| Earthquake                                | 3                  | 9+6+2=17                       | 51                           |
| Flooding                                  | 3                  | 9+4+3=16                       | 48                           |
| Landslide                                 | 3                  | 3+2+1=6                        | 18                           |
| Severe Weather                            | 3                  | 6+4+2=12                       | 36                           |
| Tsunami                                   | 1                  | 3+2+1=6                        | 6                            |
| Volcano                                   | 1                  | 3+2+1=6                        | 6                            |
| Wildland Fire                             | 2                  | 3+2+1=6                        | 12                           |

| <b>19-6.<br/>HAZARD RISK RANKING</b> |                |          |
|--------------------------------------|----------------|----------|
| Hazard Ranking                       | Hazard Event   | Category |
| 1                                    | Earthquake     | High     |
| 2                                    | Flooding       | High     |
| 3                                    | Severe Weather | High     |
| 4                                    | Landslide      | Medium   |
| 5                                    | Wildland Fire  | Medium   |
| 6                                    | Avalanche      | Low      |
| 6                                    | Dam Failure    | Low      |
| 6                                    | Tsunami        | Low      |
| 6                                    | Volcano        | Low      |